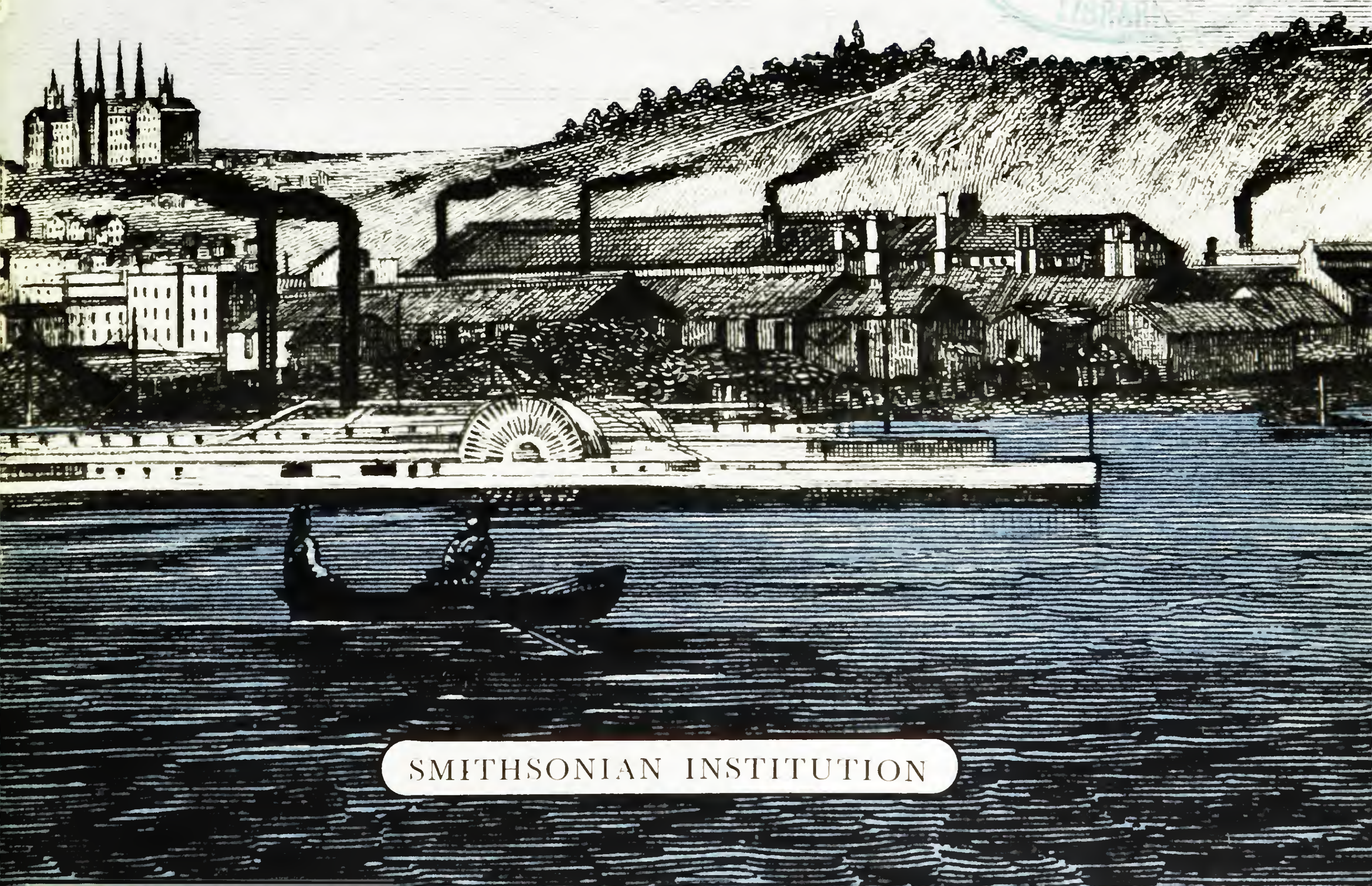
A REPORT OF THE MOHAWK-HUDSON AREA SURVEY

CONDUCTED BY THE HISTORIC AMERICAN ENGINEERING RECORD

Robert M. Vogel, Editor



SMITHSONIAN INSTITUTION

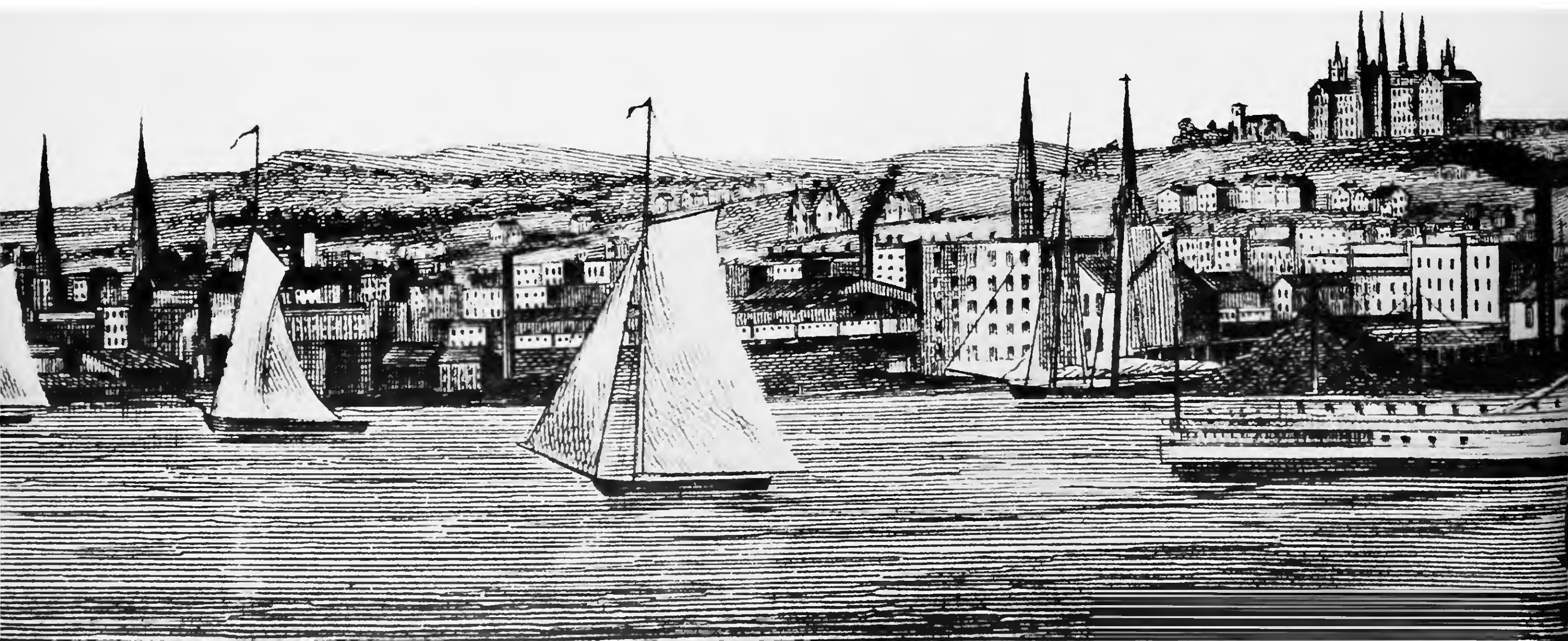
A REPORT OF THE
MOHAWK-HUDSON AREA SURVEY

A REPORT OF THE

Conducted by
The Historic American Engineering Record

Sponsored by
NATIONAL PARK SERVICE
The Historic American Engineering Record
SMITHSONIAN INSTITUTION
The National Museum of History and Technology
AMERICAN SOCIETY OF CIVIL ENGINEERS
National Headquarters and the Mohawk-Hudson Section
NEW YORK STATE OFFICE OF PARKS AND RECREATION
Division for Historic Preservation

SMITHSONIAN STUDIES IN HISTORY AND TECHNOLOGY / NUMBER 26

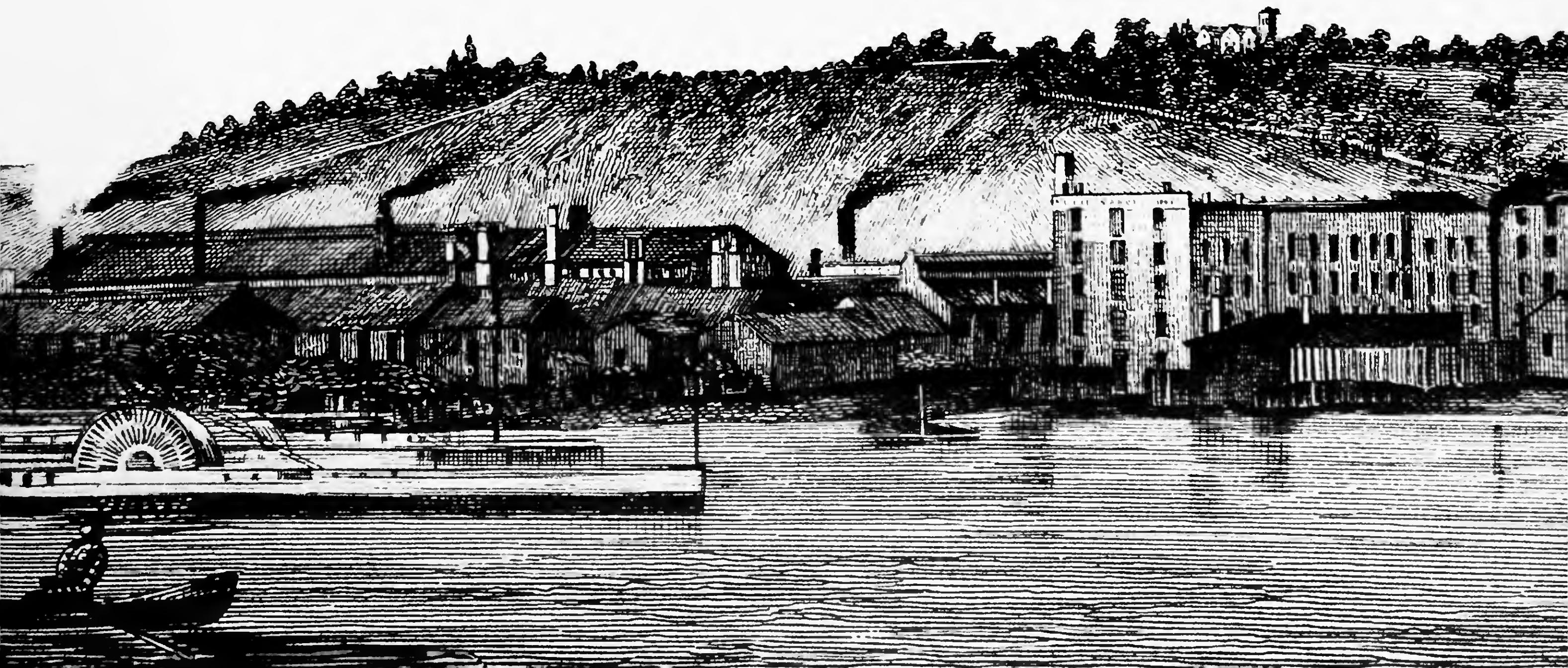


MOHAWK-HUDSON AREA SURVEY

A Selective Recording Survey of the Industrial Archeology of the Mohawk and Hudson River Valleys in the Vicinity of Troy, New York June–September 1969

Robert M. Vogel, Editor

SMITHSONIAN INSTITUTION PRESS / CITY OF WASHINGTON / 1973



SERIAL PUBLICATIONS OF THE SMITHSONIAN INSTITUTION

The emphasis upon publications as a means of diffusing knowledge was expressed by the first Secretary of the Smithsonian Institution. In his formal plan for the Institution, Joseph Henry articulated a program that included the following statement: "It is proposed to publish a series of reports, giving an account of the new discoveries in science, and of the changes made from year to year in all branches of knowledge." This keynote of basic research has been adhered to over the years in the issuance of thousands of titles in serial publications under the Smithsonian imprint, commencing with *Smithsonian Contributions to Knowledge* in 1848 and continuing with the following active series:

Smithsonian Annals of Flight
Smithsonian Contributions to Anthropology
Smithsonian Contributions to Astrophysics
Smithsonian Contributions to Botany
Smithsonian Contributions to the Earth Sciences
Smithsonian Contributions to Paleobiology
Smithsonian Contributions to Zoology
Smithsonian Studies in History and Technology

In these series, the Institution publishes original articles and monographs dealing with the research and collections of its several museums and offices and of professional colleagues at other institutions of learning. These papers report newly acquired facts, synoptic interpretations of data, or original theory in specialized fields. These publications are distributed by mailing lists to libraries, laboratories, and other interested institutions and specialists throughout the world. Individual copies may be obtained from the Smithsonian Institution Press as long as stocks are available.

S. Dillon Ripley
Secretary
Smithsonian Institution

Official publication date is handstamped in a limited number of initial copies and is recorded in the Institution's annual report, *Smithsonian Year*. SI Press number 4795.
Cover: Early view of Troy and the Rensselaer Iron Works Rail Mill from the Hudson. (*From engraving in Library of Congress, Division of Prints and Photographs, Lot 4385 E.*)

Library of Congress Cataloging in Publication Data
Vogel, Robert M.
A report of the Mohawk-Hudson area survey.
(Smithsonian studies in history and technology, no. 26)
"Conducted by the Historic American Engineering Record."
Includes bibliographies.
1. Industrial archaeology—New York—Troy region. 2. Troy region, N. Y.—Industries. I. Historic American Engineering Record. II. Title. III. Series: Smithsonian Institution. Smithsonian studies in history and technology, no. 26.
T22.5.T76V63 690.5'4'0974741 73-9691

For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 - Price: $3.35 domestic postpaid, or $3 GPO Bookstore
Stock Number 4700–00258

Preface

This report, a composite publication, has been prepared with two main objectives in view. Part One constitutes a description of the Mohawk-Hudson Area Survey itself: an account of its rationale, its organization, and the mechanics of its conduct. These matters, some of which may appear obvious and others trivial, when taken together should be a useful guide for future surveys, as well as constitute a record of the summer's activities.

Part Two contains the records of the fifteen structures that were covered by the Survey: copies of the measured drawings of the six primary structures that were measured and drawn, selected photographs of all the structures and the historical accounts of each. These accounts are not intended, in most cases, to be the final word on the development of the particular structure, but rather to be "skeleton" histories serving as a starting point for further research. Exceptions to this are the accounts of the Delaware Aqueduct, the Troy Gaslight Company Gasholder House, and the Watervliet Arsenal Cast-Iron Storehouse, which are believed to be as complete as possible on the basis of known sources. Although several histories of Troy, Albany, and some of the other immediate areas exist, most were written in the nineteenth century and treat industry and technology only incidentally. An all-inclusive history of the Mohawk-Hudson area's industrial development to the present day is bady needed. Nothing would be more gratifying to the Survey's participants than to have this study inspire an analytical project of that nature.

In a seizure of optimism, I began the preparation of this report anticipating that it could be completed in two or three weeks. The grossness of this miscalculation soon became clear, particularly to R. Carole Huberman of the Historic American Engineering Record staff, who undertook the editing and reconciling of the historical accounts. That unrewarding task occupied her for the entire summer and fall of 1970. Further, there appeared many gaps in the collected information, requiring her to conduct a substantial amount of additional research. Ms. Huberman has also contributed heavily to the general arrangement of the report, which, with her other contributions, has added enormously to its clarity and usefulness.

I owe an especial debt of gratitude to two members of the Smithsonian Institution Press staff: Joan Horn, the *Report*'s copy editor, and Series Production Manager Charles L. Shaffer, its designer. The manuscript put into their able hands was so complex, so far from being the routine bundle of copy with a few neat illustrations, that only their quite extraordinary talents have made possible its translation from what would otherwise have been an editorial disaster into what I hope and trust is a cohesive, intelligible publication. If it is neither of these, the fault certainly is not theirs.

ROBERT M. VOGEL

Smithsonian Institution
City of Washington
November 1972

Contents

Part Three: The Record: Transportation

PART ONE

The Survey

The Background

HAER and the Recording of Industrial Structures

The Mohawk-Hudson Area Survey (M-HAS) was conducted during the summer of 1969, using the techniques of industrial archeology,[1] to produce a historical record of a selected group of nineteenth-century engineering structures. For the most part the survey concentrated its attentions in the vicinity of Troy, New York, on the Hudson River 150 miles above New York City. Funding and staff support were furnished by the Historic American Buildings Survey for the sake of determining the feasibility of purely engineering surveys, but the survey was conducted and organized by the Historic American Engineering Record (HAER).

The HAER was organized in 1969 to identify and record, by graphic and verbal means, American structures of all periods having significance in the history of engineering, the M-HAS being its first undertaking. HAER's goals and activities thus almost parallel those of the Historic American Buildings Survey (HABS), established within the National Park Service as a WPA (Works Project Administration) professional project during the Depression. The HABS took advantage of the skills of unemployed architects to record outstanding examples of historic American architecture by measured drawings and photography. The HAER is co-sponsored by the National Park Service, the American Society of Civil Engineers, acting as professional advisor, and the Library of Congress, acting as the custodian and distributor of the records produced. There is likelihood that other of the professional engineering societies will become principals of the HAER as well. The backbone of the field surveys is a corps of engineering and architectural students employed during the summer, the present-day practice followed by the HABS.

[1] The industrial archeologist, as do all others in the various branches of archeology, studies man's past achievements on the basis of physical, rather than written, remains. The concern here is expressly with the remains of technology, engineering, and industry: the products of the industrial era.

The Survey was largely the product of a growing concern among historians of technology over the geometrically increasing rate at which early engineering structures were being demolished under the destructive influences of freeway and urban renewal programs, not to mention the attrition due to normal change with time. Compounding the tragedy is the unfortunate fact that the loss of these structures is actually occurring at a rate proportionately *higher* than the destruction of buildings of other types, simply because most industrial structures are less adaptable to functions other than those for which they were erected. Only rarely can they justifiably be preserved on the basis of continued usefulness once their original purpose has ended.

Historic houses, for example, often are sympathetically preserved by continued existence as dwellings. If too large for convenient functioning by today's domestic standards, or if bypassed by changing neighborhood patterns, they are readily converted into professional offices or institutional headquarters. A historic bridge, on the other hand, can never be anything but that, and once it is no longer needed at a certain place; or cannot cope with modern traffic loadings; or has deteriorated beyond repair; only rarely will its original owner or any organization be willing to carry the continuing maintenance costs for its preservation merely as a monument.

There are other factors that commonly militate against the preservation of industrial structures: unattractive surroundings; poor condition due to lack of maintenance during the final years of use or long abandonment; and in the case of buildings, normally a size too great or a layout too specialized for most adaptive uses. There is also an unpleasant psychological element that clearly influences all historic preservation campaigns of this type. Most industrial structures, particularly factories and mills, railroad structures, bulk processing works and the like, have had traditionally associated with them certain negative characteristics: noise, dirt, bad smells, hard labor, long hours, and other forms of human assault and exploitation. Whether or not such attitudes are justified, either in general or in regard to a particular structure, they do prevail; and it is a consequent fundamental fact of life that the advocate of industrial preservation normally finds his cause bolstered by only the most meager popular support.

The net result of this melancholy array of factors is that since the actual preservation for posterity of the physical evidences of our early technology, industry, and engineering is so rare, we are obliged to resort to a poor second course in order to insure the survival of at least a knowledge of these things. We must substitute for the structures themselves a form of artificial or indirect evidence: deliberately produced graphic and verbal records. The graphic records generally take the form of scale drawings produced by direct measurement or photogrammetry, photographs, and occasionally motion pictures; the verbal records are usually written accounts based on direct observation, prior descriptions, and interviews. In the M-HAS, the recording techniques were in most respects similar to those used for three decades by the National Park Service in recording historic achitecture, but with certain differences necessitated by the differences between pure architecture and engineering structures.

It should be noted that no clear boundary line exists between *architectural* buildings and *engineering* structures, either in general or for particular purposes of definition on a recording project such as the M-HAS. If a structure is defined as any large, generally immobile, man-made assemblage of materials erected to perform a particular function; and if a building is all that but in addition, encloses a volume of space; it is evident that all buildings are structures, but not all structures are buildings. Hence, if a survey is undertaken to record a group of engineering *structures,* buildings and bridges may fairly and equally be included. Less evident is what *engineering* should encompass in this context. Practically, the term has been considered broadly to include not only structures produced by the several recognized branches of professional engineering, but also those related to all branches of industry, transportation, and communication. In fact, one of the most interesting and valuable aspects of an "area" survey of engineering structures is the variety of types and authorships involved. The M-HAS, as will be seen later, recorded structures ranging from actual "buildings" as the Harmony Mills "Mastodon" Mill and the Burden Office Building, to such framed structures as the Hawk Street Viaduct and the Whipple Truss Bridge, to masonry canal locks and such "nonstructures" as the Cohoes system of power canals. The designers of this collective group ran in professional stature from the eminent civil engineer John A. Roebling (the Delaware suspension aqueduct) to an anonymous architect (the Rensselaer & Saratoga Railroad Green Island Shops).

The common element of all these structures was their association with some branch of engineering or industry. Some of the recorded structures—notably the Delaware Aqueduct—were in themselves of primary structural interest and historical significance; others, such as the Burden Office Building, were included because of their association with an important industrial firm. More will be said later about the selection process. It is important to note that in cases like the Burden office, where the line between engineering and architecture becomes fuzzy, a given structure might just as properly be recorded by an architectural as by an engineering survey. Firm distinctions and classifications of this sort are usually unnecessary, however. The Burden Office Building was recorded by a HAER team because it happened to be working in the area. Had a HABS survey been covering Troy, it could also as appropriately have recorded the building. In practical terms, indexes that eventually will be fully cross-referenced between both organizations will make it possible to locate material on any structure, regardless of its type or the sponsorship of the survey. This will be particularly useful in denoting the many engineering structures recorded by the HABS in the years before the advent of the HAER.

Selection of the Mohawk-Hudson Area

In organizing this initial or "pilot" project of the HAER, we felt it vital to select an area that, at once, had a rich engineering heritage, contained a large number of surviving early engineering structures in a wide variety of types, and was not so concentratedly urbanized that logistics would be a problem. The area near the confluence of the Mohawk and Hudson rivers, taking in Troy, Albany, Cohoes, Waterford, and Watervliet was suggested as fulfilling these conditions almost ideally, having had a long and varied industrial development. This development began early in the nineteenth century, flourished to the

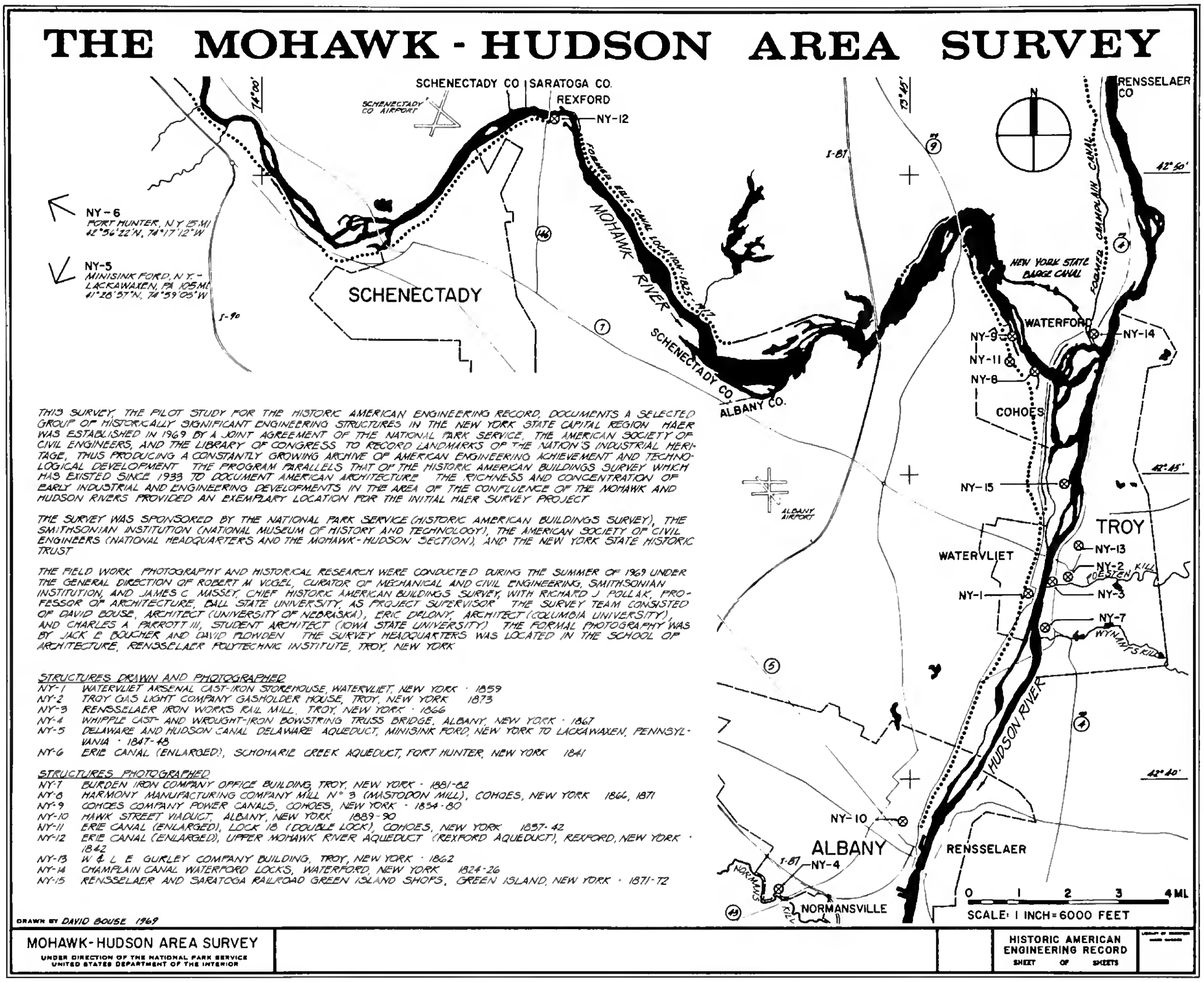


FIGURE 1.—Cover sheet for the Survey drawings. (This drawing was duplicated and included as Sheet 1 of the set of drawings for each of the six Survey structures measured and drawn. All HAER drawings are on file with the Library of Congress, Division of Prints and Photographs.)

twentieth, and then began a slow decline that left in its wake an impressive array of technological relics.

Here was the hub of a conglomerate of early transportation ventures: eastern terminus of the Erie Canal; southern terminus of the Champlain Canal; center of the pioneer Mohawk & Hudson and later the Rensselaer & Saratoga railroads, and head of Hudson River navigation. The Falls of the Mohawk were exploited early at Cohoes in a hydraulic power complex of dams, canals, and textile mills rivaling in scale the largest of New England. For many decades Troy was second only to Pittsburgh as a center of iron and steel production—the Burden Iron Works becoming the largest manufacturer of horseshoes in the world. The first Bessemer steel plant in America was here. The area was at one time or another a nationally important center of stove, bell, and valve manufacture, and the list goes on.

The names of many of America's most prominent early engineers and industrialists are associated with the area through projects they initiated or supervised: Benjamin Wright and Canvass White of the canals; John B. Jervis of the Mohawk & Hudson Railroad; Squire Whipple, pioneer structural theoretician and practical iron bridge builder; Theodore Burr, builder of timber bridges; Henry Burden, Erastus Corning, and Alexander L. Holley, enterpreneurs and innovators in iron, and later steel, production.

FIGURE 2.—The concentration of industry and transportation systems in the Troy area is apparent in this 1881 birdseye view (looking south), in which are seen the Gasholder House (left center), the Rail Mill (center), and Burden's Lower Works (top center), as well as a multitude of other mills and factories. The Erie Canal is on the right. (*Beck and Pauli,* [Birdseye Lithographic Map of] Troy, N.Y. *Milwaukee, 1881, detail.)*

Beyond the vast number of physical survivals of that extraordinary era are several additional industrial monuments having no direct derivation from it, e.g., the singular all-iron prefabricated storehouse of 1859 at Watervliet Arsenal, unquestionably the most remarkable of these. The area altogether is filled with fascination for the historian of American technology and in virtually every way was a perfectly suited location for the proposed survey. An excellent headquarters and drafting facility was available at the School of Architecture, Rensselaer Polytechnic Institute (RPI), Troy; there appeared to be adequate housing for the resident survey team; and there were several public and private organizations as well as individuals having parallel historical interests, from whom it was anticipated assistance mght be obtained.

Planning and Conduct of the Survey

Although nominally the first HAER survey, there had been two earlier surveys with similar goals that, in fact, were HAER precursors in establishing certain procedures, namely, the New England Textile Mill Surveys I and II, of 1967 and 1968. The principal operational sponsors, as with the M-HAS, had been the Smithsonian Institution's National Museum of History and Technology (Division of Mechanical and Civil Engineering (DM&CE)) and the National Park Service's Historic American Buildings Survey.[2] The project's basic objective was to record the physical plant of the textile industry in New England, whose mills were the first American industrial structures. The principal departure from traditional HABS surveys was that as much attention was devoted to the structural, mechanical, and industrial aspects of the mills as to their purely architectural features.

The central organizational framework upon which the M-HAS was assembled was simply an extension of the existing hamonious working relationship between the HABS and the DM&CE. The Committee on History and Heritage of the American Society of Civil Engineers (ASCE) also joined as a funding sponsor, as did the New York State Historic Trust (NYSHT; now [1973] Division for Historic Preservation), the state's official agency concerned with historic preservation and inventorying. The RPI School of Architecture, which provided drafting and office facilities for the Survey's field headquarters, was the fifth principal sponsor. The sources of funds are shown in the Survey budget.

Selection of the structures to be recorded was the first matter of concern, beginning in August 1968 with a two-day exploration of the area by this editor, and the subsequent projecting of a survey with James C. Massey, then Chief of HABS. That fall, by which time the Survey had been fairly established, a long list of structures having potential recording interest was assembled.

In February 1969, the Survey was formally launched with a meeting in Troy of those principally concerned:

Richard S. Allen, NYSHT Survey Consultant.
Neal FitzSimons, Chairman, ASCE Committee on the History and Heritage of American Civil Engineering.
Bernd Foerster, Acting Dean, School of Architecture, RPI, and author of guides to the historic architecture of Rensselaer and Albany counties (presently Dean, College of Architecture, Kansas State University).
James C. Massey, Chief, HABS.
Robert M. Vogel, Curator, Division of M&CE, Smithsonian.
John G. Waite, Jr., NYSHT Historical Architect and former HABS architect.

In one of the season's worst blizzards, the group spent a day and a half tramping about among the sites of most likely interest for the next summer's work, and discussing logistical and organizational detail.

Preliminary (Gross) List of Sites and Structures For Recording, June 1969 (* = actually recorded)

Suggested variously by: Richard S. Allen, Bernd Foerster, James C. Massey, Robert M. Vogel, and John G. Waite, Jr.

Troy	* Burden Iron Works sites
	* Albany and Rensselaer Iron Company sites
	* Gasholder House
	* Gurley Building
	J. M. Warren Building
	Lion Shirt Building
	Piers of Waterford Bridge (first with icecutters)
	Fire houses
Watervliet	* Arsenal—"Iron Building"
	Site of first Whipple trapezodial truss bridge
	Watervliet side-cut locks, Erie Canal

[2] A full account of the objectives and conduct of the 1967 project is in *NETMS I—A Report of the First Summer's Work,* published by the Division of Mechanical and Civil Engineering, Smithsonian Institution, 1968 (out of print). The historical accounts, the measured drawings, and representative photographs from NETMS I and II were published by the National Park Service as *Selections from the Historic American Buildings Survey No. 11,* September 1971, Ted Sande, Editor.

Watervliet-Cohoes	Flight of ascending Erie Canal locks
Watervliet-Green Island	Iron highway bridge and stone railroad bridge
Green Island	* Rensselaer & Saratoga Railroad Shops
	Green Island bridge sites (1830s)
Cohoes	* Harmony Mills complex
	Original Erie Canal locks
	* Enlarged Erie Canal locks (double lock)
	* Extensive power canal system
	* Power canal gate house
	Champlain Canal Locks
	Eddy Valve Works (abandoned)
Cohoes-Waterford	Matton Boat Works
Waterford	* Side-cut flight of locks, Champlain Canal
Albany	Roadbed of Mohawk & Hudson Railroad
	* Iron Whipple bridge (Normanskill)
	Western Union Building
	Delaware & Hudson Railway Office Building
	* Hawk Street Viaduct
Rexford	* Rexford Aqueduct remains, Erie Canal
Fort Hunter	* Schoharie Creek Aqueduct remains, Erie Canal

RENSSELAER COUNTY

Buskirk	Covered timber Howe truss bridge
	Railroad station
Eagle Bridge	Railroad station
Schaghticoke	Black powder works—remains
	Mill houses
	(Buttermilk Falls) (Berlin Iron Bridge Co.) parabolic truss bridge
Johnsville	Railroad station
	(Groton Iron Bridge Co.) iron bridge—1891
Valley-Falls vicinity	Albany Northern Railroad berme

ALBANY COUNTY

Rensselaerville	"Period-piece" village (originally seat of woolen mills)
Alcove	Old mill
Cooksburg	Old mill

COLUMBIA COUNTY

Canaan	Railroad tunnel—1841
Livingston	Burden ore roasting ovens—1870–80
Copake	Iron works buildings
Stottville	(Hudson River Bridge Works) iron bridge—1881
Chatham	(Morse Bridge Co.) Spangler's Bridge—1880
New Lebenon	Tilden Pharmaceuticals buildings (since destroyed by fire)
Stuyvesant Falls	Mill group

SARATOGA COUNTY

Northumberland	Harris (grist) Mill — 1830s (ruins)
Mt. McGregor to Saratoga Springs	Steam and first 3rd-rail-electric railroad—1833 (berme remains)
Half Moon	Anthony baking powder factory
Mechanicville	(Willow Glen) Early concrete interurban railway bridge—1902

SULLIVAN COUNTY, NEW YORK to PIKE COUNTY, PENNSYLVANIA

Minisink Ford, N.Y. to Lackawaxen, Pa.	* Delaware Aqueduct

The Field Team

The heart of a recording survey is, of course, the field team, which measures the structures and translates its field sketches into the formal drawings that make up the principal element of the permanent record. The available funding permitted a team of three plus a supervisor. These men were recruited by the HABS from architectural schools, chiefly by informal communication with the deans. It was already recognized, and has since been confirmed, that even on purely "engineering" surveys, there is rarely any chance of employing *engineering* students for such work because of the sad fact that drawing has been virtually abandoned as a required skill in engineering schools. Consequently, today's students are severely limited in that area, and simply cannot express themselves graphically at a level satisfactory for historical recording work. The M-HAS team consisted of:

Richard J. Pollak, Associate Professor, College of Architecture and Planning, Ball State University. Supervisor.
Eric N. DeLony, graduate, Ohio State University 1968; student architect NETMS II, 1968. Architect.
David L. Bouse, graduate, University of Nebraska 1969; student architect NETMS II, 1968. Architect.
Charles A. Parrott III, Iowa State University. Student Architect.

The team was remarkable for its efficiency and skill, the ultimate evidence of which is the quality of the finished drawings. An innovation introduced by Prof. Pollak was the assignment of each structure to one of the team, who acted as job leader, co-

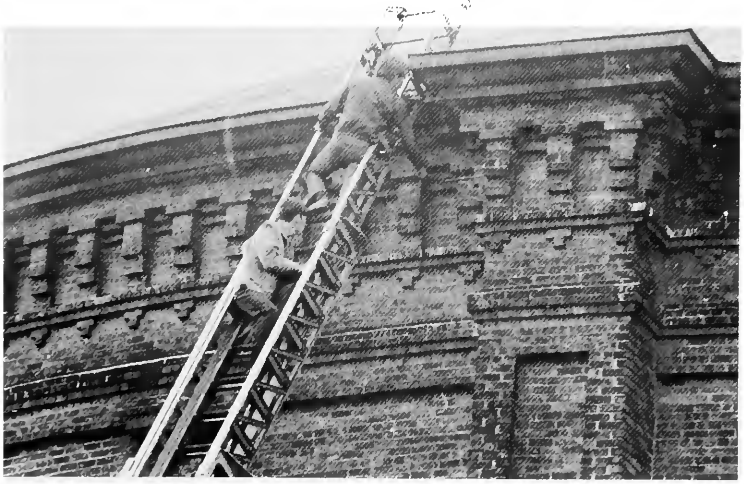


FIGURE 3.—M-HAS team members Parrott and Bouse measuring cornice of the Gasholder House from an aerial ladder truck furnished by the Troy Fire Department, June 1969. (*Pollak*)

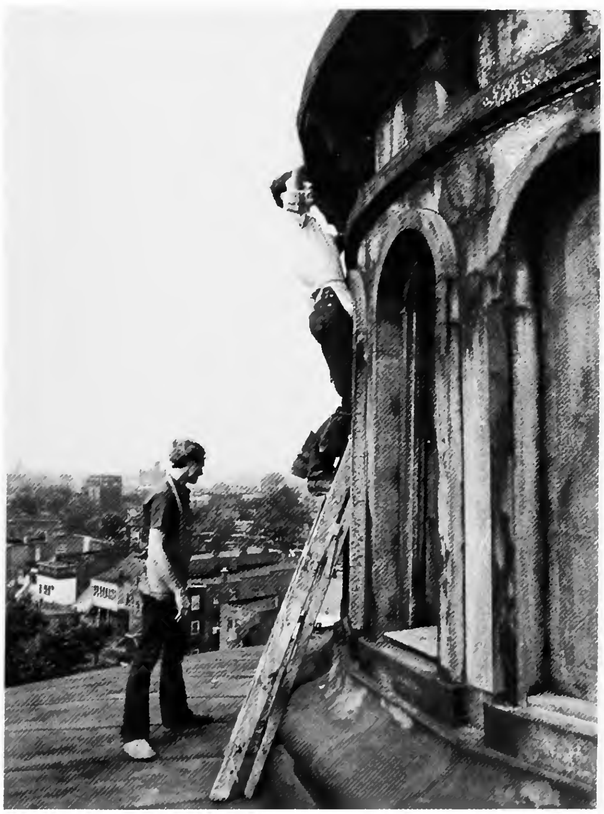


FIGURE 4.—DeLony and Parrott atop the Gasholder House, June 1969. (*Vogel*)

FIGURE 5.—DeLony (top) and Bouse preparing the final survey drawings, RPI School of Architecture, September 1969. (*Vogel*)

ordinating both field work and drafting, resulting in increased efficiency and better morale.

The return of Messrs. DeLony and Bouse after similar work the previous summer was of huge benefit to the project although the spontaneous enthusiasm of Professor Pollak and Mr. Parrott was certainly as great an asset. With the exception of Mr. Bouse, all members of the team returned to HAER surveys the following summer: Prof. Pollak to supervise the State of Virginia Survey; Mr. DeLony to supervise and Mr. Parrott to be an architect on the Baltimore & Ohio Railroad Survey. Mr. DeLony has been on the HAER permanent staff since February 1971.

The Historians

The accumulation of historical documentation on each of the recorded structures was considered, from the outset, of primary importance. Since the scope of the task would have required more of the supervisor's time than was available, it was decided to contract for the work. Three Principal Historians were employed, all having a recognized interest in the area's history as well as professional historical qualifications:

Samuel Rezneck, Professor Emeritus of History, RPI.
Diana S. Waite, former Architectural Historian, HABS; consulting architectural historian.
Richard S. Allen, Survey Consultant, NYSHT; consulting historian.

Each was assigned a group of the finally selected structures, related largely to his own specialized interests, with instructions to prepare a historical account from research in available primary and secondary sources. These contracts were on a flat-fee basis proportioned from the basic funds allotted for the purpose in the Survey budget. Each historian was obliged to determine on the basis of his fee how much time he could afford to expend on the work. In all cases, it is only fair to observe, the product was cheaply bought; the personal interest of all of the historians in their assignments impelled them to far deeper involvement and the production of considerably fuller accounts than could reasonably have been expected. The particular background and orientation of each historian is reflected in the style of his accounts, resulting in a variety of perspectives.

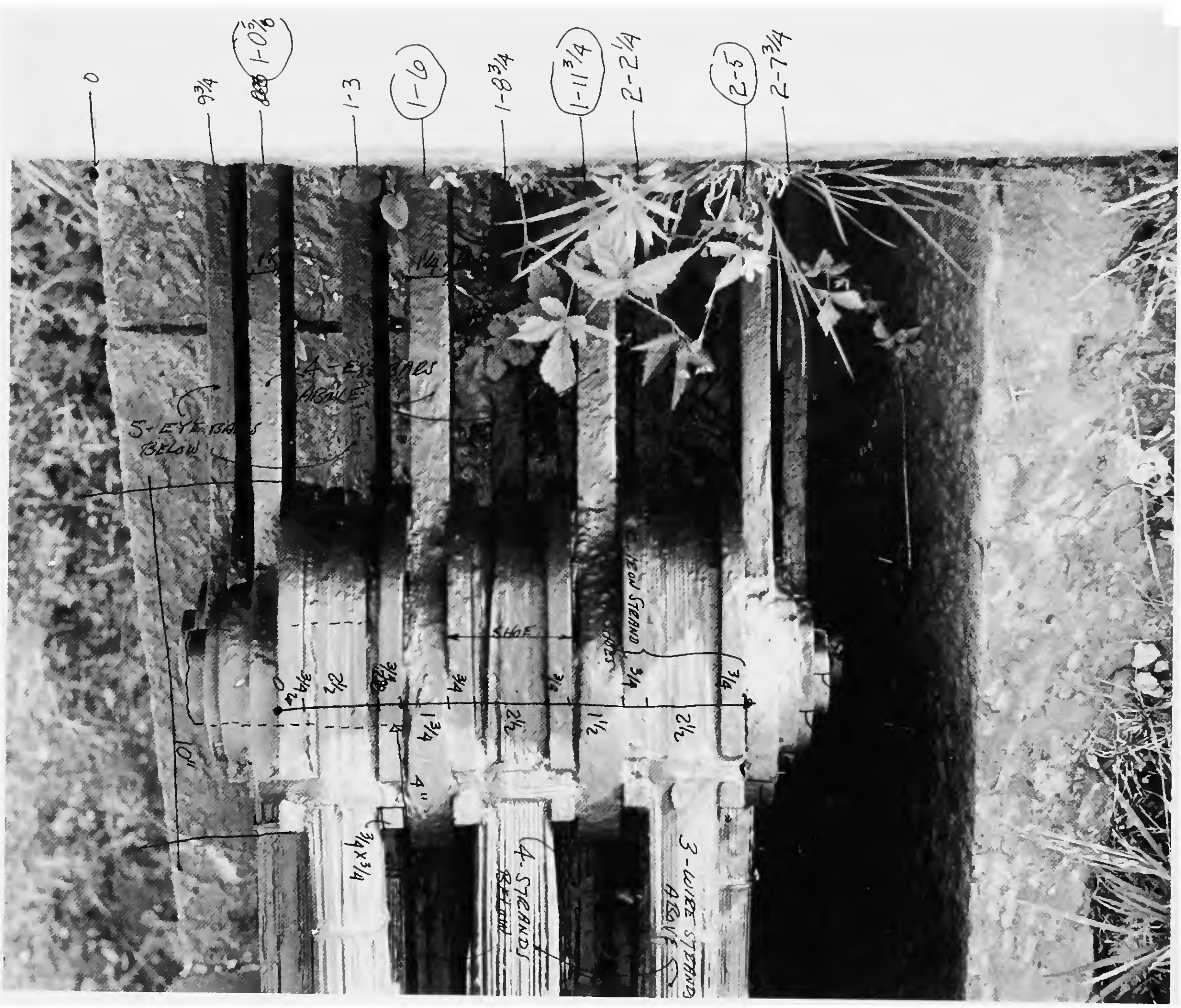


FIGURE 6.—Dimensions recorded directly on an 8- × 10-inch photograph as a means of expediting field measurements (anchorage eye-bars and strand loops, Delaware Aqueduct).

Early in the summer the Hudson River Valley Commission, as a contribution to the Survey, assigned its Historian, Lewis C. Rubenstein, to prepare the accounts of the Watervliet Arsenal Cast-Iron Storehouse and the Rensselaer Iron Works' Rail Mill. Although he gathered a great deal of valuable material on both buildings, his normal duties at the Commission had expanded by summer's end to the extent that he was unable to begin the reports. The report for the Rail Mill and a number of the other accounts that had not been otherwise assigned were written by R. Carole Huberman of the HAER staff, who also performed the basic research for the Watervliet Cast-iron Storehouse, the account of which was written by Selma Thomas.

The historical description of the Delaware Aqueduct was extracted from the editor's monograph, "Roebling's Delaware & Hudson Canal Aqueducts" (*Smithsonian Studies in History and Technology,* number 10), inspired by the M-HAS recording of the structure. Table 1 lists the Principal Historian for each structure.

FIGURE 7.—Field photograph (35 mm) with measuring pole placed against the structure, another method of increasing recording efficiency (abutment face, Whipple Bridge).

The Photography

Photography was by Jack E. Boucher of Linwood, New Jersey, on contract, except for coverage of the Delaware Aqueduct, which was photographed by David Plowden of Sea Cliff, New York. Mr. Plowden was selected because of his familiarity with the structure and the fact that he planned to be at the site in the course of his own work on American bridges. Mr. Boucher, who for many years has photographed for the HABS as a free lancer, is presently on the HABS-HAER permanent staff. In the course of three visits to the area, he took about 130 photographs, most of which are reproduced in this report.

All recent photographs not otherwise credited are by Jack E. Boucher for the Historic American Engineering Record, in most cases on 5″ x 7″ negatives filed in the HAER Collection at the Library of Congress. The same is true for David Plowden's photographs of the Delaware Aqueduct.

Most of the remaining recent photographs are by Eric N. DeLony, HAER; Richard J. Pollak, Ball State University; and Robert M. Vogel, Smithsonian Institution, on 35 mm negatives filed in the Division of Mechanical and Civil Engineering, National Museum of History and Technology, Smithsonian Institution. Copy negatives (5″ x 7″) of some of these are in the HAER files. Other photographers and their affiliations are noted directly in the credit lines.

The sketching of a structure and its elements generally occupies far more time than the actual measurement and recording of dimensions. As a means of reducing recording time of the Delaware Aqueduct, dimensions were recorded directly on previously made photographs of the structure. If an expeditious means could be found for developing such photographs in the field, this method would increase greatly the efficiency of data collecting (Figure 6). Another time-saving device was the photographing (35 mm) of certain elements of the structures—generally relatively simple ones—with a calibrated measuring pole in the view, a time-honored archeological technique. It was possible therefrom to derive a great deal of dimensional data for the final drawing directly from the photograph (Figure 7).

Final Selection of Structures for Recording

At the start of the Survey on 15 June, a list of nearly sixty structures and sites in Rensselaer, Albany, Columbia, and Saratoga counties was on hand for consideration, the combined suggestions of all who had taken an interest in the project (pp. 17–18). Obviously many would have to be eliminated. In order to set the team in immediate motion, however, it was decided that the Troy Gaslight Company's great circular Gasholder House of 1873—unanimously acknowledged to be a structure of primary interest—would be a rational starting point.

A second decision made at the outset was that Roebling's Delaware Aqueduct (1848), a work of exceptional significance in the history of American civil engineering, should be included. Despite the fact that it appeared to be in no immediate jeopardy and was over 100 miles from the survey area, it was considered more efficient to bring in a team as part of this Survey than to mount a special one at some future date.

Beyond that, the process of selection consisted of eliminating those entries on the *gross list* that were essentially structureless sites (e.g., Whipple's first trapezoidal truss bridge, Watervliet); those where later modification had been so extensive that virtually nothing of the original fabric survived (e.g., the early railroad tunnel at Canaan, 1841); and those that were clearly of minor engineering interest (e.g., Matton boat works, Cohoes). The remaining structures were arranged in three priority categories (Table 1). Those in the Priority One group, judged to be of greatest importance, were further subdivided into two groups: structures to be fully measured and drawn (eight); and those for which only selected details would be drawn (six).

Five Priority Two and Three structures also were to be selectively drawn as time permitted. All twenty structures on the *net list* were to be formally photographed. Table 1 reveals the extent to which the initial *net list* was both adhered to and deviated from in the course of the summer's work.

A variety of criteria was used in finally selecting the six principal (marked "F" in Table 1) and ten secondary structures recorded. The particular significance of each is discussed at some length in the individual essays, but it may be of interest to speak here briefly of the different reasons for inclusion. Under the general self-explanatory concept of primary historical importance, fell such structures as the Delaware Aqueduct, already mentioned, and the Cast-iron Storehouse at Watervliet Arsenal. The latter, perhaps the only surviving all-iron building in the country, was built by the Architectural Iron Works of New York, one of the largest and most successful in the industry. While thousands of mid-nineteenth century iron-front buildings remain, the Watervliet storehouse is of especial importance in that the iron is employed in *all* of the building's structural functions: in the form of cast-iron bearing walls, columns, and beams (the latter with tensile assistance from wrought-iron bottom-chord ties), and composite cast and wrought-iron roof trusses. There is not the bastardization of the iron with masonry walls and wood beams that characterizes virtually every other so-called iron building of the period that still stands. As a precursor of metal-framed skeleton structures, the building appears to be unqiue.

The Whipple Truss Bridge in Albany is of importance as the nearly sole surviving representative of a once large family of distinguished ancestry. Although not the first American to build framed bridges of iron rather than wood, Squire Whipple was the first to do so on a large commercial scale, and on the basis of fully rational structural designs. In that sense, he can be described as one of the men most influential in introducing the age of structural iron to the United States. Hundreds of his iron highway bridges were built (most of them in New York State): by Whipple himself; by licensees; and following expiration of his basic patent, by a number of others. Of this number, only two are known to have survived: the Normanskill span and the Whipple truss over Cayadutta Creek, north of Fonda, New York.

Like the Whipple Bridge, the significance of the remaining three principal structures was their being typical in one way or another. The Schoharie Creek Aqueduct was viewed as a structure of consequence, not only because of its scale and architectural quality, but because it was a good example of the massive masonry aqueducts constructed during the great enlargement of the Erie Canal in the 1840s, when permanence was an objective. A property of the New York State Historic Trust, the aqueduct was studied also to furnish the Trust with data for its restoration.

Troy's circular Gasholder House was in the same general category—a representative of a once fairly common class of structure—but here the type itself

TABLE 1.—*Final list of structures* (F=full measured drawings and photography; S=selected drawings and photography; P=photography only; n.d.=not done)

Location	Structure	As planned (20 June) treatment	As planned (20 June) historian	As done treatment	As done historian
	PRIORITY ONE				
Watervliet	Iron Storehouse	S	Rubenstein	F	Huberman/ Thomas
Troy	Gasholder House	F	Waite	F	Waite
	Rensselaer Iron Works Rail Mill	S	Rubenstein	F	Huberman
	Burden Iron Works Office	S	Rezneck	P	Rezneck
Normansville (Albany)	Whipple Cast- & Wrought-Iron Bowstring Truss Bridge	F	Allen	F	Allen
Cohoes	Harmony No. 3 ("Mastodon") Mill	S	Waite	P	Waite
	Power canal system	S	Allen	P	Allen
	Power canal headgate house	S	Pollak	P	Huberman
Rexford	Mohawk River Aqueduct remains, Erie Canal	F	open	P	Huberman
Rotterdam Jct.	Plotter Kill Aqueduct, Erie Canal	F	open	n.d.	
Ft. Hunter	Schoharie Creek Aqueduct remains, Erie Canal	F	open	F	Huberman
Cohoes	Double Lock, Erie Canal	F	Waite	P	Waite
Waterford	Locks, Champlain Canal	F	open	P	Huberman
Lackawaxen, Pa.-Minisink Ford, N.Y.	Delaware Aqueduct, D&H Canal	F	Vogel	F	Vogel
	PRIORITY TWO				
Green Island	Rensselaer & Saratoga Railroad shops	S	Allen	P	Allen
Albany	Hawk Street Viaduct	P	Pollak	P	Rezneck
Livingston vicinity	Burden's ore-roasting ovens (ruins)	S	open	n.d.	
	PRIORITY THREE				
Hoosick Falls	Wood Brothers Factory (agricultural implements)	S	open	n.d.	
Ballston Spa	West's Paper Mill	S	open	n.d.	
Cohoes	Cohoes Rolling Mill	S	open	n.d.	
	NOT ORIGINALLY INCLUDED				
Troy	W. & L. E. Gurley Building			P	Rezneck
	SPECIAL ESSAYS				
Historical Addendum: Ludlow Valve Manufacturing Company					Rezneck
Chronological Notes: Troy Iron and Steel Companies					Allen
Cohoes: the Historical Background					Rezneck

was less widely distributed than the Whipple Truss Bridge, for example, and the survivor is clearly the most spectacular architecturally and interesting structurally of the remaining dozen or so.

Finally, the Rail Mill, while of interest because of its original function and not without a certain architectural merit in the rendering of the gable walls, was selected mainly because it so perfectly typified the ubiquitous brick and heavy-timber machine-shop building of the last half of the nineteenth century. The absolutely classical plan of high main aisle commanded by a traveling crane, low side aisles beneath galleries for the light machine tools, and roof and galleries carried by heavy timber framing, is rapidly becoming extinct.

In the case of the secondary structures, which were only photographed, a somewhat lower order of justification proportional to the lesser investment of time was applied, but their selection was based on the same general philosophy. Certain structures were not drawn simply because of the difficulties involved or their inherent complexity—the Hawk Street Viaduct, for example. Others, like the Cohoes power canals, could be represented better by photographs and existing maps than by drawings.

A factor that inevitably influenced our selection process was the security of the structures. Where there existed a recognizable and imminent threat to a given structure, there was clearly more reason to record it than when it was apparently in safe hands and in good use. On the other hand, the ever-present threats of fire, flood, and other catastrophic possibilities must always be in the evaluator's mind. "Safe hands" and "good use," however, are subject to human whim, economics, and even the death of principals. These considerations, therefore, shaped our attitude toward the Delaware Aqueduct. While it was (and still is) in safe hands, they were only those

FIGURE 8.—Rensselaer Iron Works Rail Mill, 1866, destroyed by fire in October 1969, two months after its recording by the M-HAS. (*Paul R. Huey for [N.Y. State] Division for Historic Preservation.*)

of a private individual. Because of its uniqueness and immense importance, failure to measure it then would have been foolhardy.

The harsh realities of the danger constantly threatening old buildings could hardly have been more vividly expressed than by the total destruction of the Rail Mill by fire in October 1969, barely three months after it had been recorded (Figure 8).

Miscellaneous Matters

The day-to-day operations of the Survey were thoroughly and entertainingly detailed by Prof. Pollak in his bi-weekly reports, *Good News From Troy, N.Y.*, copies of which are filed at HAER headquarters and in the Smithsonian's Division of Mechanical and Civil Engineering. The Survey was overseen by the editor who spent a total of about five weeks in Troy.

The notations (HAER NY-2, HAER NY-12, etc.) on the title pages of the accounts of the sixteen structures recorded are the Historic American Engineering Record numbers, which are consecutively assigned to all structures recorded within each state in the order recorded.

Budget and Costs

A fairly detailed account of the Survey's costs has been set down below and in Table 2. A bright spot was the totally unexpected and generous midsummer donation of $500 by the Mohawk-Hudson Section of the ASCE, which, in view of the general attenuation of the budget was a gift of very real consequence. The various types of "in-kind" assistance by others will be mentioned in the next section.

*The Survey Budget**

SOURCES OF SUPPORT:	
National Park Service	$ 3,597
Smithsonian Institution, National Museum of History and Technology	3,694
American Society of Civil Engineers, National Headquarters	1,000
New York State Historic Trust	2,500
ASCE, Mohawk-Hudson Section	500
GRAND TOTAL	$11,291

PRINCIPAL SURVEY COSTS:		
Miscellaneous supplies, phone, etc.		$ 141
Travel for team: local and field trips		125
Travel for R. Vogel (for overseeing trips)		694
Salaries:		7,840
Team	$5,527	
Supervisor	2,313	
SUBTOTAL		$ 8,800
Historians:		1,600
S. Rezneck	1,000	
D. Waite	300	
R. Allen	300	
Photographers:		891
J. Boucher	761	
D. Plowden	130	
GRAND TOTAL		$11,291

* Direct costs only. Not accounted for are staff salaries and overhead, costs of February 1969 preliminary trip, costs of this report, and other indirect and general support costs.

One of the most interesting and potentially useful secondary results of the Survey was the accounting, maintained by Prof. Pollak, of the time expended on each of the measured structures (Table 2).

From these figures, costs per-sheet-of-drawing have been derived that reveal a number of things about the costs of recording engineering structures. The most striking characteristic of the figures is the disparity among them. The range—between extremes of $489 per sheet for the Gasholder House and $159 per sheet for the Schoharie Creek Aqueduct (a ratio of over 3:1)—seems astonishing until the various factors, accounting for the variation, which indeed are the most instructive elements of this comparison, are examined.

The one factor probably most directly responsible for the difference is that of experience and adjustment. The Gasholder House was the first structure measured; the Schoharie Creek Aqueduct the last. A certain amount of time inevitably was expended at the start of the project in "shaking down," while by summer's end operations in both field and drafting room were being conducted with an efficiency that reflected the experience of twelve weeks. The other major factor was that of physical accessibility. The greatest part of the Gasholder House interior was far above the ground and accessible only by means of a precarious arrangement of ladders and catwalks. Parts of the roof trusses, the most complex element, could be measured only by standing on the

TABLE 2.—*Cost of the survey in terms of per-sheet costs**

Structure	*No. of sheets*	*Time expended (hours)*					*Sheet cost*		
		Measurement	Preliminary drawings	Final drawings	Total	Supervision*	Basis†	Total for structure	Average per sheet
Title Sheet	1			26	26	2	1	$ 91	$ 91
							2	100	100
							3	108	108
							4	157	157
Gasholder House	3	74	135	172	381	29	1	1334	445
							2	1468	489
							3	1577	526
							4	2278	759
Rensselaer Iron Works Rail Mill	3	25	74	82	181	14	1	633	211
							2	699	233
							3	751	250
							4	1083	361
Watervliet Arsenal Cast-Iron Storehouse	5	89	86	252	427	33	1	1494	299
							2	1654	331
							3	1775	355
							4	2557	511
Whipple Bowstring Truss Bridge	3	12	86	91	189	14	1	662	221
							2	728	243
							3	782	261
							4	1132	377
Delaware Aqueduct	3	27	59	97	183	14	1	640	213
							2	706	235
							3	759	253
							4	1096	365
Schoharie Creek Aqueduct	2	13	14	56	83	6	1	290	145
							2	318	159
							3	342	171
							4	497	248
Misc. team time: travel, discussion, etc.					109	8	1	381	
							2	419	
TOTALS	20	240	454	776	1579**	120	1	$5144	$257
							2	5670	284
							3	6091	305
							4	8800	440

* Average hourly rate—team members	$ 3.50	(1579 hours)
Hourly rate—supervisor	4.70	(480 hours)
Survey cost—salaries only	7,840.00	
Total survey cost, except historians and photographers	8,800.00	
Total survey cost, all items	11,291.00	

The supervisor's time was divided approximately: 25% actual field and office supervision of the team (120 hours) and 75% administration, PR, local arrangements, scheduling, etc. (360 hours). Accordingly, 25% of his time and salary have been prorated among the six structures, on the basis of the time for each, to derive costs under bases 2 and 3. His full time and salary are considered in the total project cost figures (Basis 4).

† Basis of cost computations: (1) Team salaries only, *not* including miscellaneous (non-production) time; (2) team + supervisor salaries, not including their miscellaneous time; (3) team + supervisor salaries *including* their miscellaneous time, prorated; (4) *all* project costs except historians and photography, prorated by team hours.

** Includes overtime (paid at straight-time rate).

truss lower chords. The need to record the cornice from a fire truck aerial ladder was a final impediment. The high figure for drafting time is a reflection of both structural complexity and, again, of the considerable amount of slack that can (and should) be anticipated at a project's outset. The Schoharie Creek Aqueduct, conversely, was fairly accessible; the only difficulty there being the need to use a rowboat and ladder to reach certain surfaces. Also in contrast to the Gasholder House was its simplicity. It was, in fact, the least complex of the six structures.

If the two extreme cases are disregarded, the figures take on an entirely different meaning. The range for the four remaining structures runs only from $331 per sheet for the Watervliet Storehouse down to $233 for the Rail Mill. The variation of less than 35 percent is readily accounted for by the relative complexities of the two.

The apparently high sheet costs of the M-HAS (project average $284) initially provoked alarm when viewed against the average figure of about $150 per sheet for traditional HABS architectural surveys, based on the same factors as the comparable M-HAS figures (i.e., team salary plus a portion of the supervisor's). The explanation for the difference in cost is once again a matter of comparative complexity. The average engineering structure is of a higher order of complexity than the average building. (Note that we are speaking of *average,* for here especially, the indistinctness of the territory between purely "architectural" buildings and "engineered" structures is a major point.) Much of this difference has to do with materials and techniques. Until fairly recently, most of the structures surveyed by HABS were built prior to the middle of the nineteenth century and so were free of the more exuberant Victorian ornamental elements in later use. These buildings were essentially simple, the decorative features based largely on linear forms (moldings), a reflection of the fact that wood in the form of planks and timbers was the primary material employed. Such forms are relatively simple to measure and draw. The same can be said of the earlier engineering structures in masonry and wood, up to the period when structural iron was introduced. Cast iron is a material whose principal advantage to the designer was that it was neither axially nor dimensionally restrictive: formed from a molten, fluid mass, iron castings could be produced in almost any size and any configuration, and in almost any degree of structural (as well as decorative) complexity required or desired. Wherever the designer wanted metal, and in whatever form, it could readily and cheaply be placed. For the first time he was freed of the restrictions imposed by the inherent spatial characteristics of masonry and wood. Derivative of the built-up wood patterns from which they were produced, iron castings tend to be essentially sculptural, formed of complex curvilinear and other highly irregular surfaces. Thus they are relatively difficult to measure and draw. A good example is the elaboration required for adequate graphic explanation of the cast-iron gallery beams of the Watervliet Storehouse. There lies the principal cause of the expense of the drawings for the Storehouse and the Whipple Truss Bridge, both of which are composed mainly of intricate castings. It is predictable that later structures of wrought iron and steel, with members formed by *rolling* and therefore once again *linear,* will take relatively less time to record.

A second reason for the high cost of historical engineering versus architectural drawings is the need to record more structural detail. The methods of attaching and joining the relatively simple structural members of a house or small building are so straightforward and generally familiar that there usually is little need for their extensive detailing. Engineering joints are quite another matter, particularly in framed structures. Note particularly the Gasholder House roof truss (Figure 27)—which it was necessary to draw exploded for clear exposition—and the involved lower-chord connections of the Whipple Truss Bridge. Complex when compared to most building elements, even the relatively simple cast-iron cable saddles of the Delaware Aqueduct required a separate detail drawing for explanation.

A final factor resulting in elevated costs was the decision to make ink rather than pencil drawings. An intuitive estimate of the relative time required for the two techniques would be approximately 5:4, or 25 percent more for ink. This factor, however, would affect only the final drawing stage, and so would elevate the total measuring and drawing figures by considerably less—perhaps 15 percent—and the total project cost by less. The ink decision, made at the project's start for the sake of improved clarity, reproducibility, and durability of the drawings, is believed to have been a rational one, justifying the additional cost.

Epilog

Future Work in the Area

An area so rich in engineering history could hardly be adequately covered by a survey in three months with a three man team. Clearly, only the cream was skimmed, and probably not all of it at that. Many, if not all, of the structures and sites on the initial gross list could justifiably receive attention of one sort or another.

That singularly active and enthusiastic professional body, the ASCE Mohawk-Hudson Section, made a substantive contribution to the M-HAS (or rather, to any

---

AMERICAN SOCIETY OF CIVIL ENGINEERS
MOHAWK-HUDSON SECTION

July 1969 Newsletter

A July Newsletter is probably unprecedented, but here is something that can't wait. We want your ideas.

A four-man team is in the Capital District area this summer, collecting data on historic engineering projects. This survey is the first in the country, and is jointly sponsored by ASCE (national HQ), the National Park Service, and the Library of Congress; the Smithsonian Institution and the New York State Historic Trust are also involved in the arrangements. Your Mohawk-Hudson Section Officers have endorsed this survey and have appropriated $500 to help support it. Engineering history has received all too little attention, and we hope that this pilot survey will serve to stimulate similar studies in other parts of the United States.

The preliminary list of the landmarks that the team plans to include in its study appears below. We suspect that some of the Mohawk-Hudson members may know of other engineering landmarks of a by-gone era (not more than about 40 miles from Troy) which they believe to be of significance equal to that of some on this list.

Do you know of any such landmarks?

The survey team will welcome your suggestions, the only stipulation being that they receive your information early enough in August to allow time for fitting into their schedule for visiting the sites; their field work ends shortly after Labor Day.

Please send me any leads that you have--an informal note will do--with instructions as to reaching the landmark, if remotely located. I will promptly forward the information to the team and you will have done your bit for the preservation of engineering history.

Robert K. Palmer

Section Vice President
Troy Bldg, R.P.I.
Troy, N.Y. 12181

Preliminary List: Rexford, Schoharie and other Erie Canal Aqueducts; Cohoes Power and Transportation Canal Systems; Watervliet Arsenal cast iron warehouse; Harmony Mill complex at Cohoes; Burden Iron Works sites; Gas Holder Building at Troy; Whipple Bridge at Normansville; Hawk Street Viaduct at Albany; Gurley factory building at Troy; D & H Car Shops at Green Island; B & A Tunnel at Canaan; B & A Bridges at Green Island.

successor it might have) by suggesting additional area structures of historical significance. A request to the membership for suggestions was made through the kindness of Professor (of Civil Engineering, RPI) Robert Palmer, Section Vice President and newsletter editor, by means of an "Extra" newsletter, here reproduced.

Suggested Historic Structures

Structure	*Suggested by*
Sewage treatment plant, Gloversville. Early (1912) attempt to treat domestic sewage and industrial waste conjointly.	Frank O. Bogedain
Covered bridge, North Blenheim, possibly longest span covered bridge in United States.	Carroll F. Blanchard
Grist mill between Brookview and Rices Corners.	Bernard G. Briggs
Abandoned Rutland Railroad on Route 7 near Vermont border; abondoned New York Central Railroad near Niskayuna.	Bernard G. Briggs
Berlin Iron Bridge Company parabolic truss bridge over Sacandaga River near Hadley.	J. Lawrie Hibbard
Toll Gate House, Western Avenue, Albany.	J. Lawrie Hibbard
Shussan covered bridge over Battenkill, 200-foot span.	J. Lawrie Hibbard
West Point Military Academy structures. Fortifications, 1775–1779; Central Barracks with cast-iron beams, 1845–1850; Administrative Building with 161 foot, 3 inch, masonry tower, 1909.	Lt. Col. William K. Stockdale

Although none of these structures was actually recorded, all appear to be of sufficient consequence that they should be considered if future recording is undertaken in the area.

A final element in any subsequent work should be the elaboration of certain of the M-HAS' recordings. For example, several of the structures that were only photographed should be fully drawn, e.g., the early and extremely important Holyoke water turbines (including the runners inside the casings) in the Harmony No. 3 Mill, the Cohoes Canal Head Gate House, and details of the Watervliet Storehouse. If the area is extended westward, structures in cities like Amsterdam that contain many interesting industrial features, such as mills, specialized manufacturing and processing equipment, and railroad buildings, would be included. A continuation of the Mohawk-Hudson Area Survey could, in short, go on almost indefinitely.

Assistance and Cooperation

In addition to the chief forms of support already mentioned, many other individuals and organizations provided valued assistance. This survey, where much of the recording was of the interior of structures, was entirely dependent upon the cooperation of their owners. It is gratifying to be able to relate that in every single instance, where access to any part of any of the structures was needed, it was granted with considerably more than mere assent. Even where the presence of the team or photographer may have affected operations or required the attendance of a representative of the owner, the Survey party in all cases was accommodated with genuine interest and goodwill. Below are listed all who offered help to the Survey. Included are the professional consultants, all of whom contributed so far in excess of their contractural requirements that they may be regarded as benefactors to the project.

The contributions of several people deserve particular mention. Eric DeLony, as part of his work for Columbia University's unique Seminar in Restoration and Preservation of Historic Architecture, produced a full sheet of additional details of the Watervliet Storehouse roof trusses, which he donated to HAER. Mrs. Frances Van Buren and her staff of the RPI School of Architecture were of continual help during the course of the summer in guiding the team through the problems of daily life, particularly the locating of housing. Special gratitude must be expressed to the men who made equipment available, without which it would have been impossible to reach portions of certain of the structures. The brothers Sage, owners of the Gasholder House, generously provided the ladders needed to make the upper reaches of its interior accessible, while Chief Edward Zapf of the Troy Fire Department, with a large aerial ladder truck, furnished the only practical means of gaining the cornice fifty feet above the ground. Similarly, Watervliet Arsenal Post Engineer John C. Kacharian made available ladders for obtaining access to portions of the Storehouse, and Joseph F. Wolff of the Schoharie Crossing State Historic Site provided not only the necessary ladders for work on the aqueduct, but the necessary rowboat as well.

Those who contributed to the Survey (titles and other information as of 1969) are:

Richard S. Allen, Historian
Frank Bloomfield, Manager, Normanskill Farm (Whipple Truss Bridge)
Jack E. Boucher, Photographer
Edward Chapman, Librarian, RPI
Eric N. DeLony, Architect; Team Member
Peter Dereski, Superintendent, Troy Plant, Republic Steel Corp (Burden site)
Bernd Foerster, Acting Dean of Architecture, RPI; Survey advisor
Richard G. Folsom, President, RPI
Edward H. Huber, President, Lackawaxen Bridge Co., Scranton, Pa. (Delaware Aqueduct)
John C. Kacharian, Post Engineer, Watervliet Arsenal; Secretary, Arsenal Historical Committee
Raymond Lague, Plant Engineer, Ludlow Valve Manufacturing Co. (Rensselaer Iron Works Rail Mill)
H. C. Lumb, Vice President, Corporate Relations, Republic Steel Corp.
William J. Magee, Executive Vice President, Cohoes Industrial Terminal, Inc. (Harmony Mills complex)
Henry T. Maloy, Public Information Officer, Watervliet Arsenal
Keith McPheeters, Dean of Architecture, RPI
James V. Murray, History Officer, Office of Public Information, Watervliet Arsenal
Robert K. Palmer, Vice President, Mohawk-Hudson Section, ASCE; Professor of Civil Engineering, RPI
Thomas Penman, Executive Director, Troy Chamber of Commerce
David Plowden, Photographer
Samuel Rezneck, Professor Emeritus of History, RPI; Historian
Lewis C. Rubenstein, Historian
William and Thomas Sage, President and Vice President, Sage Maintenance & Repainting Corporation. (Troy Gasholder House)
Mark Stevens, Normanskill Farm, Albany (Whipple Truss Bridge)
Archie Stobie, Director, Rensselaer County Historical Society
Selma Thomas, Historian
Frances Van Buren, Secretary to the Dean, School of Architecture, RPI
Edward J. Vandercar, Cohoes City Historian
Diana S. Waite, Historian
Sheila A. Williams, Historian, State University of New York, Albany
Joseph F. Wolff, Maintenance Superintendent, Schoharie Crossing State Historic Site
Edward Zapf, Chief, Troy Fire Department

Appendix

THE M-HAS PROSPECTUS

National Park Service
Smithsonian Institution
American Society of Civil Engineers
New York State Historic Trust

PROSPECTUS

for a Historic American Engineering Record Demonstration Project

MOHAWK-HUDSON AREA SURVEY

New York
Summer, 1969

The long-neglected field of engineering history has slowly, over the past decade, been gaining the attention of scholars. The profession itself has become increasingly active in this direction and several of the major professional societies now have historical programs. During this same period, local history and landmark preservation programs have accelerated. The proposed "Mohawk-Hudson" Area Survey will be a demonstration project of the Historic American Engineering Record, to be conducted under the aegis of the Historic American Buildings Survey in a pioneer program in historical research integrating engineering history, local history and landmark preservation studies into a single research and recording operation. It is proposed that the Mohawk-Hudson Area Study will be jointly sponsored by the National Park Service, the Smithsonian Institution, the American Society of Civil Engineers, and the New York State Historic Trust, with cooperation and assistance from other concerned groups.

Program Constraints

It is realized that initial efforts in this field must perforce proceed deliberately because the methodology must be developed simultaneously with the study itself. Fortunately, the thirty-year experience of the Historic American Buildings Survey (HABS) provides a solid foundation for the technical approach and full advantage is being taken of it. This experience indicates that a field survey is an essential part of a total program in engineering history and the sooner such a survey begins, the more rapid advances can be expected. HABS experience also indicates that a summer pilot study conducted on a scholarly basis will cost a minimum of $13,000 to produce a meaningful body of measured drawings, photographs, and documentation. Funding, in turn, influences staffing which is another constraining factor. Professionals are indeed rare who have a background in history and technology, and who are also familiar with historical survey techniques. One intention of the project is to encourage selected scholars to enter this field.

Mohawk-Hudson Area

The area about the confluence of the Mohawk and Hudson Rivers is remarkable from the standpoint of American engineering history and landmarks. Its technological development began with the start of the 19th century just as the nascent engineering profession was being recognized. The Erie and Champlain Canals, both American technical triumphs, are found here, as is the Mohawk and Hudson Railroad, one of the first in the country. In addition to these transportation routes was an extensive development of the region's water power potential. The numerous waterways in the area demanded bridges and among the more famous men who fulfilled this need were the pioneer structural engineers Theodore Burr and Squire Whipple. Other names associated with the area are Benjamin Wright, John Jervis, Amos Eaton, and Canvass White—all major contributors to the early engineering development of the Nation. Industrial innovators, such as Henry Burden, were active there.

The Historic American Engineering Record Organization

This historical engineering survey has been organized at a national level, by the National Park Service (NPS), the American Society of Civil Engineers (ASCE), and the Library of Congress (LC) under a long range tripartite cooperative agreement. The products of the survey, in the form of drawings, photographs, and documentary material, are to be deposited at the Library for public use and reproduction.

Project Organization

This Mohawk-Hudson survey is being set up under the aegis of the Historic American Buildings Survey as a demonstration study to explore the implementation of the Historic American Engineering Record program, and to measure the public and professional interest in engineering history. The sponsoring organizations and supporting groups will guide the project through an ad hoc advisory committee. The project will be administered by the National Park Service for convenience.

The survey will be carried on in the summer of 1969, tentatively with an office at Rensselaer Polytechnic Institute. The team will consist of engineers and architects, assisted by historians and photographers, drawn from the universities—professors, graduate students and undergraduates. They will produce the records—measured drawings, maps, photographs, and historical research, as well as attempt to establish a methodology for the study of engineering history based on physical remains. The completed records will be placed in the Library of Congress. A publication based on the records is intended. An exhibit is also being considered. Coupled with the rich engineering heritage and many landmarks found in the Mohawk-Hudson Area, there is fortunately much local interest in supporting the HAER project.

The Landmarks for Study

At this time it is not possible to do more than establish a preliminary list of landmarks to be studied. Some will require a thorough field study and measurement as well as document research. For others, photography alone will suffice.

New York State

1. Rexford, Schoharie and other aqueducts, Erie Canal
2. Cohoes Power and Transportation Canal Systems
3. Watervliet Arsenal Cast-Iron Warehouse, Watervliet (1859)
4. Harmony Mill Complex, Cohoes (1836–1880s)
5. Burden Iron Works Sites
6. Gasholder Building, Troy (1873)
7. Whipple Bridge, Normansville (1867)
8. Hawk Street Viaduct, Albany (1890)
9. W. and L. E. Gurley Company Building, Troy (1860s)
10. Green Island Car Shops, D & H RR
11. Canaan Railroad Tunnel, B & A RR (1841)
12. Green Island Bridges, B & A RR
13. Map of sites of historic engineering interest in survey area.

Washington, D.C.
March 1969

PART TWO

The Record: Manufacturing

Cast-Iron Storehouse 1859

Watervliet Arsenal, Watervliet

(HAER NY–1)

Selma Thomas

Location: Building No. 38, immediately southwest of the intersection of Westervelt Avenue and Gibson Street, in the southeast corner of Watervliet Arsenal, Watervliet, Albany County, New York.
Latitute: 42° 43′ 00″ N. Longitude: 73° 42′ 30″ W.
Date of Erection 1859.
Fabricator: Architectural Iron Works, New York, New York: President, James Reed; Superintendent, Daniel D. Badger (in conjunction with designs presented by Major Alfred Mordecai, C.E., commanding officer of Watervliet Arsenal).
Present Owner and Occupant: U.S. Government, Department of the Army, Army Materiel Command.
Present Use: Warehouse and museum of ordnance materiel.
Significance: May be the only remaining all-iron building still used for its original purpose. It is also an early example of prefabricated construction, all of its parts having been constructed by Architectural Iron Works in New York and shipped up the Hudson for erection on the site.

HISTORICAL INFORMATION

Physical History

In 1813 the United States and Britain were engaged in military skirmishes that later historians document as the War of 1812. One of the problem spots to the Americans was the area around present-day Troy, New York. Expecting an attack from the north at Lake Champlain, or from the west, at Niagara Falls, the U.S. Army Ordnance Department (that department of the Army which purchases, manufactures and repairs weapons and ammunition) decided to locate an arsenal in that vicinity. To that purpose the U.S. Government purchased twelve acres of land from James Gibbon and his wife for the sum of $2,585 (Watervliet Arsenal, 1968). This land was on the west bank of the Hudson River, in the village of Gibbonsville, directly across the river from Troy. In later years the name of the arsenal (and the surrounding town) was changed to Watervliet (flooding waters) and the installation grew and achieved national attention under that name.

Watervliet, since its beginning, had been subject to floods from the Hudson. With the construction of the Erie Canal (about 1820), the problem was magnified, since many of the arsenal buildings were below the level of the canal. By the middle of the century, the arsenal had degenerated to a disorganized and disoriented installation as a result of the combined effect of these natural disasters and the failing leadership of Commanding Officer Major John Symington, who had been ill since 1854.

Historical Information: Research material complied by R. Carole Huberman; preliminary notes from Charles Peterson, Lewis Rubenstein, and Robert M. Vogel. Architectural Information: Prepared by David Bouse, Charles A. Parrott III, and Richard J. Pollak.

Perhaps the arsenal's most significant years of growth began under the leadership of Major Alfred Mordecai, commanding officer from July 1857 to May 1861. A civil engineer and member of the Ordnance Board, Mordecai had been sent by Army Ordnance to an ailing installation and his substantial training and experience proved a great aid in the rehabilitation of the arsenal.

Within two weeks of his arrival, Mordecai was making recommendations for building plans to the Chief of Ordnance. In a letter to Colonel H. K. Craig, 10 July 1857, he discussed the need for more "suitable offices" (1416–M–494–498).[3] The existing ones were too small and too near the Canal; the spring flood, an annual event, had left its watermark at four and one-half feet that year. He also noted, in the same letter, the need for a storehouse:

> At an arsenal like this, where it is often necessary to expedite large orders for gun carriages which are not to be kept long on hand, what is chiefly required, as a gun carriage store, is a large shed in which the work may be conveniently sheltered as soon as it is turned out of the paint shop and from which it can be easily removed for shipment.

The need for a storehouse became the more pressing for the arsenal had just begun to manufacture Iron Sea Coast Carriages, and Mordecai immediately began to work on plans for its construction. He wanted "to cover a large space with a shed under one roof and one story high (something like a railway depot) . . . , a shed about 125 feet wide and 250 feet long." Specifying that the warehouse should have room for 300–350 gun carriages, Mordecai also argued that "the floor should be paved with stone and sufficiently raised to secure it from floods and the drainage of the Canal. . . ."

Following the common practice of engineers to consult with various builders and contractors, Mordecai apparently discussed his building plans with James Reed, president of Architectural Iron Works (AIW) in New York, during a chance meeting at West Point. On 29 October 1857, Mordecai made further overtures to AIW when he sent a sketch of a building to Daniel D. Badger, the foundry's superintendent (1416–M–599). In his remarks to Badger, Mordecai enclosed a sketch of the building he needed and invited AIW to submit a design and estimate. He also noted that he wanted a fireproof building and was interested in comparing the costs of iron and brick structures. The initial estimate seemed prohibitive, but by 17 December 1857 Mordecai was able to supply Colonel Craig with a drawing from AIW and his own recommendation regarding the storehouse:

> Thinking that it is desirable to adopt in our Arsenal the modern improvements, to make them durable and fireproof, by the extensive use of cast and rolled iron in their construction, I have had a drawing made of an iron building (1416–M–642).

The design referred to was submitted by AIW and since the $60,000 estimate attached was higher than Army appropriations promised to be, Mordecai invited other bids the following spring and summer. He suggested that if funds proved insufficient for an adequate storehouse, the Army could construct a simple shed. He invited A. H. Vancleve of Trenton [New Jersey] Locomotive & Machine Manufacturing Company, to submit a bid for that reduced structure advising that

> In an unfinished state, as a shed consisting of a roof supported by pillars, it would still be very useful . . [and] I would have the parts so made and arranged that the building could at any time be finished according to the plan. . (1416–M–721).

Interestingly, Mordecai added to his demand for a fireproof building, the request that "it also be ornamental. To answer these conditions," he wrote, "I have procured plans and estimates of iron buildings" (1416–M–838).

In an effort to "answer these conditions," Mordecai procured many plans and estimates. Though most came from iron foundries, the Major also considered a brick building since it would be cheaper; and he received a plan from Harris & Briggs, of Springfield, Massachusetts, that furnished more store room at a lower cost than the iron proposals (1416–M–780–781). For his final plans, however, Mordecai returned to Architectural Iron Works and on 5 January 1859, he announced to Craig: "I enclosed herewith a contract with the Architectural Iron Works Company of New York, for building an iron store house at this arsenal" (see p. 37 for copy of contract).

In the person of James Reed, AIW agreed to build the storehouse on a site to be selected by the commanding officer. The foundation was to be prepared by the Army and the foundry promised to have the building finished "on or before the thirty-first day of August, 1859." It was also subject to inspection by

[3] This notation—Entry 1416; Letter-Book "M"; pages 494–498—is used hereafter for citations from the National Archives Record Group 156 (see Unpublished Sources of Information, p. 37).

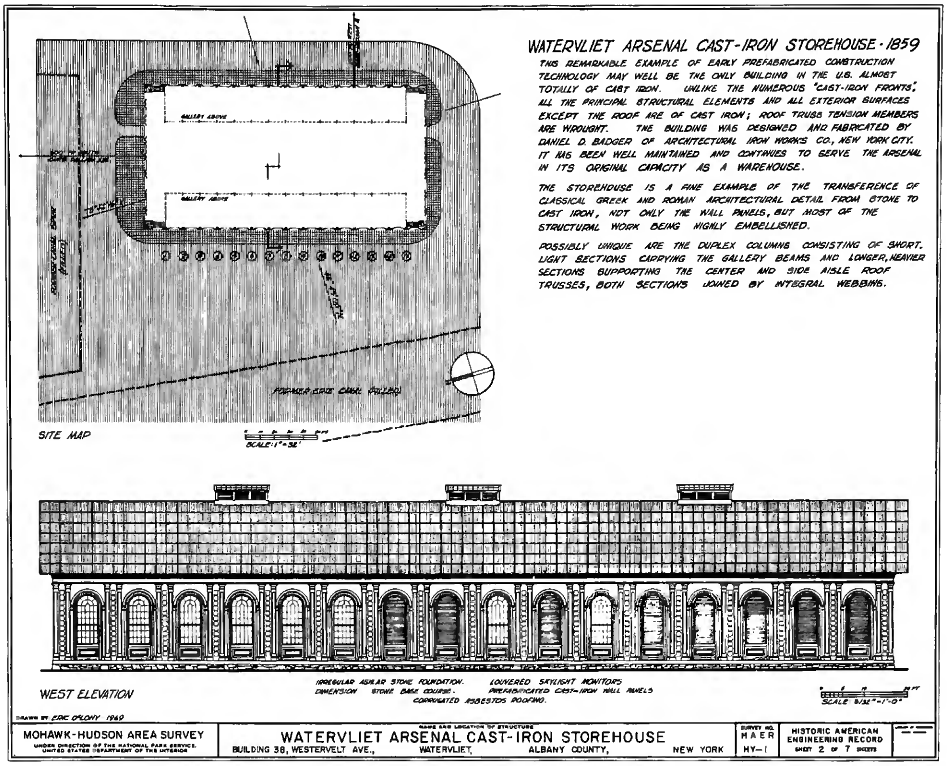


FIGURE 9

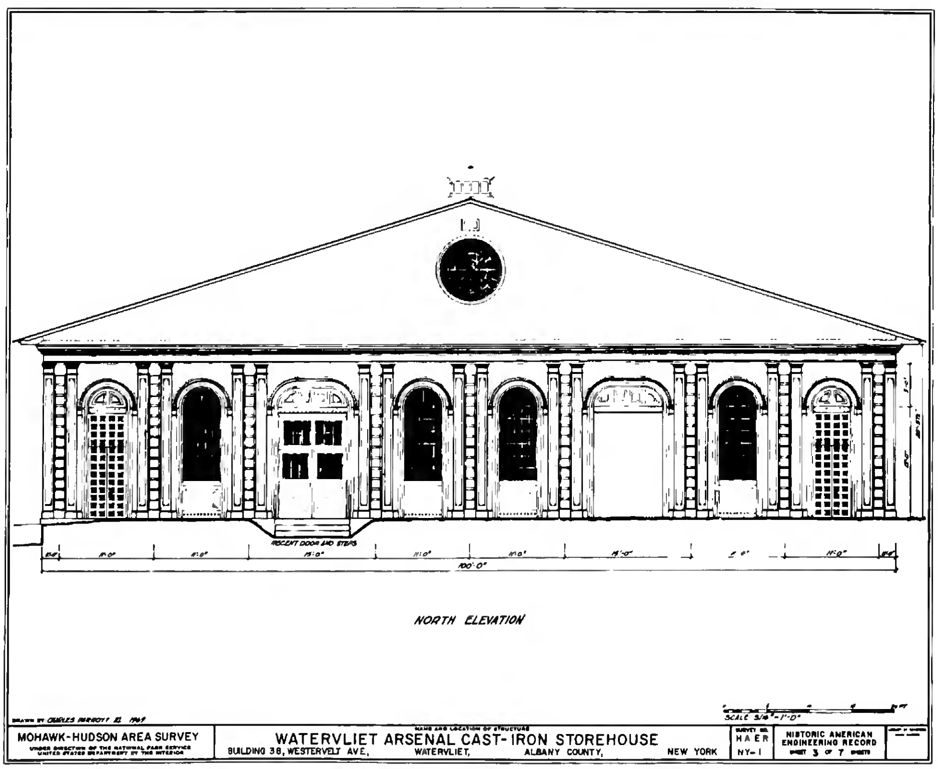


FIGURE 10

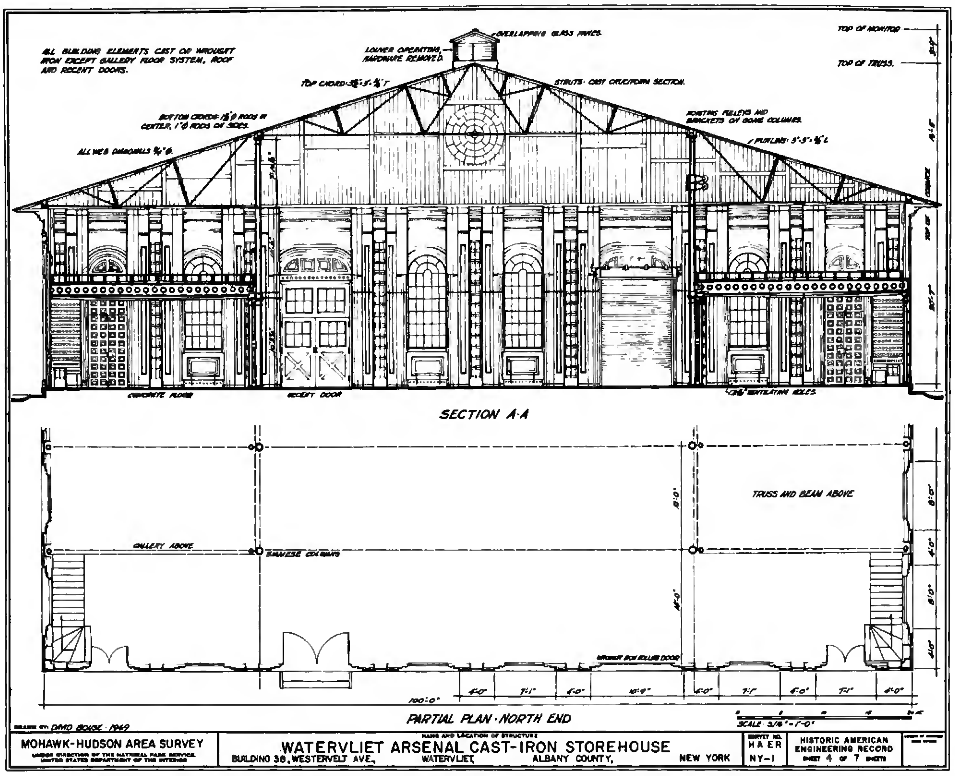


FIGURE 11

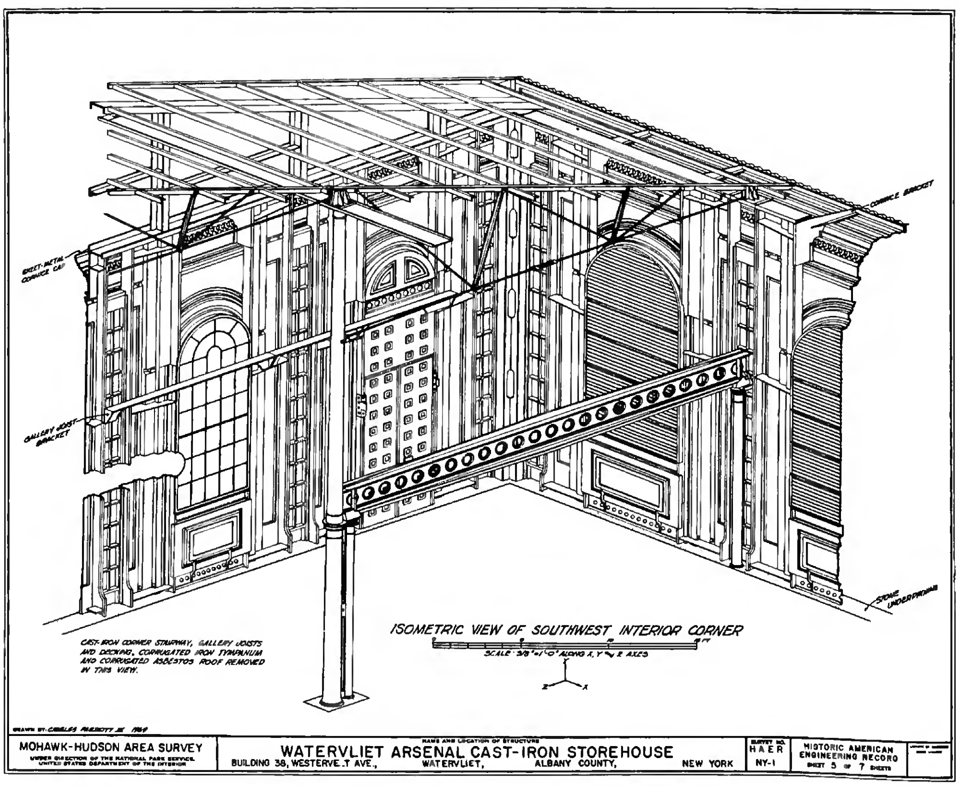


FIGURE 12

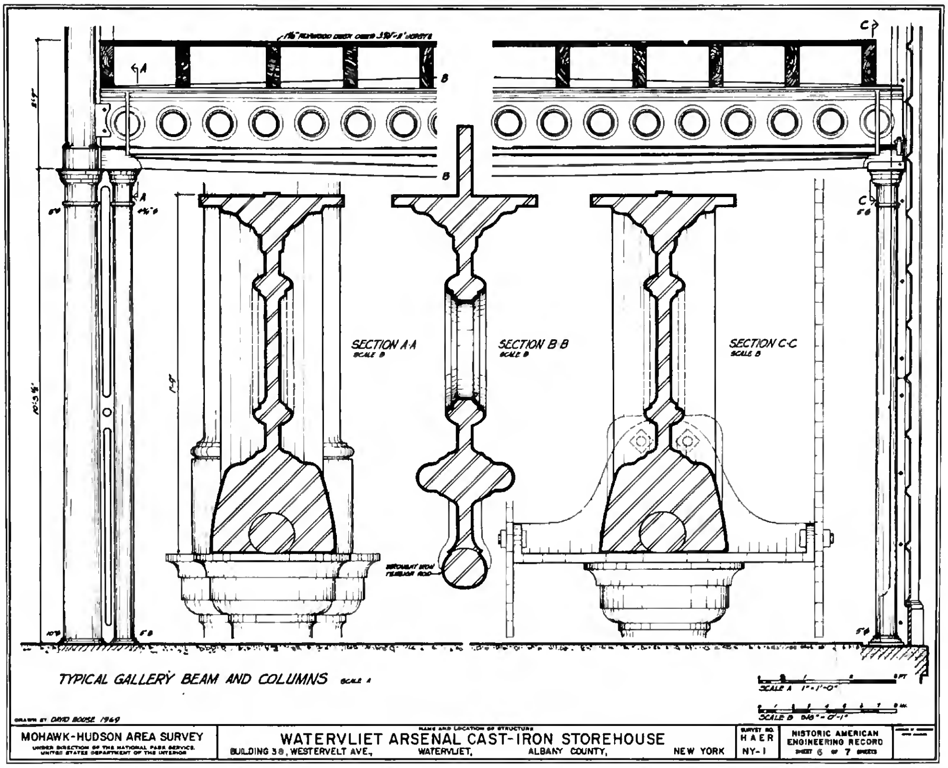


FIGURE 13

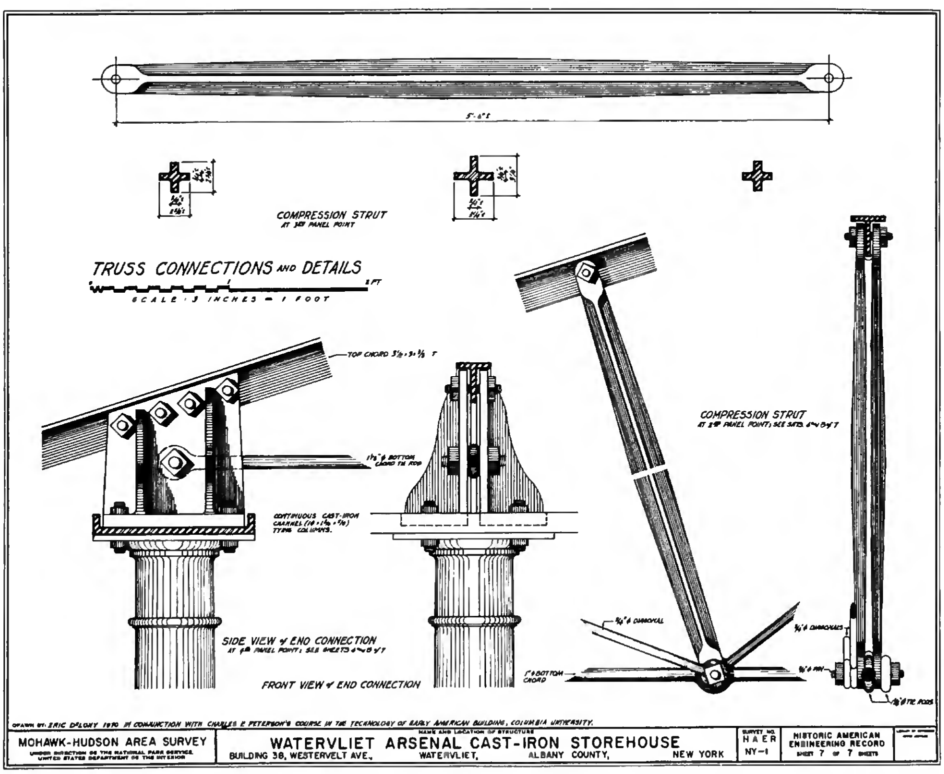


FIGURE 14

the commanding officer. Because of the expense incurred for materials and casting before construction could begin, the United States was to pay almost one-half of the fee before AIW's builders ever arrived at the site.

Army Ordnance agreed to pay AIW a total sum of $47,360, in several installments. The first $10,000 was due when half of the building parts were completed at the foundry in New York. Upon full completion of iron work at the foundry another $10,000 was due; and the third on its delivery to the Watervliet Arsenal. The remainder was promised upon full erection and satisfactory inspection of the storehouse. "The stipulations with regard to the mode of payment," Mordecai admitted, were "unusual." But he added:

> They appear to me proper, inasmuch as the company must incur a very considerable expense before the opening of navigation [around May 1] permits them to deliver the work at the arsenal, and there is a great gain in the cost of the work as well as in time, by letting it be done during the winter (1416–N–1–2).

Mordecai considered the contractual agreements equitable under the circumstances; but to spare the Army any embarrassment he demanded a $20,000 bond from Reed before they were binding.

By 17 March 1859, half of the work at the foundry was completed (1416–N–18–19), and in early May Mordecai notified Reed that the foundation would be ready and dry well before June 1. As the building progressed, Mordecai invited other Ordnance officers to inspect the work and on 16 June 1859, the Inspector of Armories and Arsenals, Lt. Colonel James W. Ripley, recorded his approval of it.

> The position, plan and general appearance of this structure meets my approval and it will be at once an ornament to the grounds as well as a valuable addition to the storage room of the Arsenal (1003: to Craig).

Ripley's comments on the storehouse reveal a satisfaction that was not initially felt by either himself or Mordecai. In the planning and construction of the building, the two men encountered several problems and even clashed over their proposed solutions. When Mordecai first wrote to Craig 10 July 1857 concerning the need for "a shed about 125 feet wide and 250 feet long" (1416–M–494–498), he also specified the exact site on which he wanted to place the structure. Close to the canal, so as to facilitate shipping, and convenient to the machine shops, where the iron carriages were built, the location was on the southeast corner of the arsenal grounds and was already occupied by the arsenal laboratory. While he admitted that the removal of the laboratory might raise "objections," Mordecai nevertheless recommended it because the buliding was "unfortunately placed." Its floor was a good deal below the level of the canal, resulting in flooding and water damage. Mordecai had no hesitation in replacing a brick building with cracked walls and decayed floors with the storehouse, especially since he proposed to raise the foundation level and thereby avoid flooding. He requested, however, "the benefit of consultation . . . with some other officer of experience," and Ripley arrived shortly thereafter to survey the situation.

Ripley agreed with Mordecai that the arsenal was badly in need of a warehouse, but he had different views in the matters of size and location (1003). He preferred "a much larger building . . . say 500 feet long by 200 feet wide" in an area west of the canal, then occupied by a group of timber sheds; and he specified a fireproof structure. Ripley rejected Mordecai's site because it was on low and damp ground. His own choice, however, posed more of a problem since the carriages to be stored would have to be transported across the canal (the machine shops being south of the laboratory) and then up to the level of the timber sheds (to be replaced by the storehouse). The debate over size ultimately was settled by Colonel Craig who preferred the small structure.

> The introduction of Iron Sea Coast Carriages will greatly diminish the space required for their storage, whilst they remain on hand, and their indestructibility will enable us to send them to the Forts nearly as fast as made; thus reducing the necessity of large Stores of these carriages at the Arsenals (6–vol. 18–236–267).

In addition to the choice of size, Craig also sided with Mordecai in regard to location, voicing the opinion that "the movement of heavy carriages to and from high ground would be attended with inconvenience and expense."

With the decision to build a relatively small storehouse on the east bank of the canal, in close proximity to the machine shops, Mordecai once more faced a problem. He now admitted himself reluctant to tear down the laboratory and instead suggested a site north of the paint shops (1416–N–89–92). Ripley again disapproved "on account of its low and damp situation" and Mordecai admitted that Ripley's objections carried "a good deal of force." The final solution came from an earlier decision of Ripley which was entirely incidental to the plans of the storehouse.

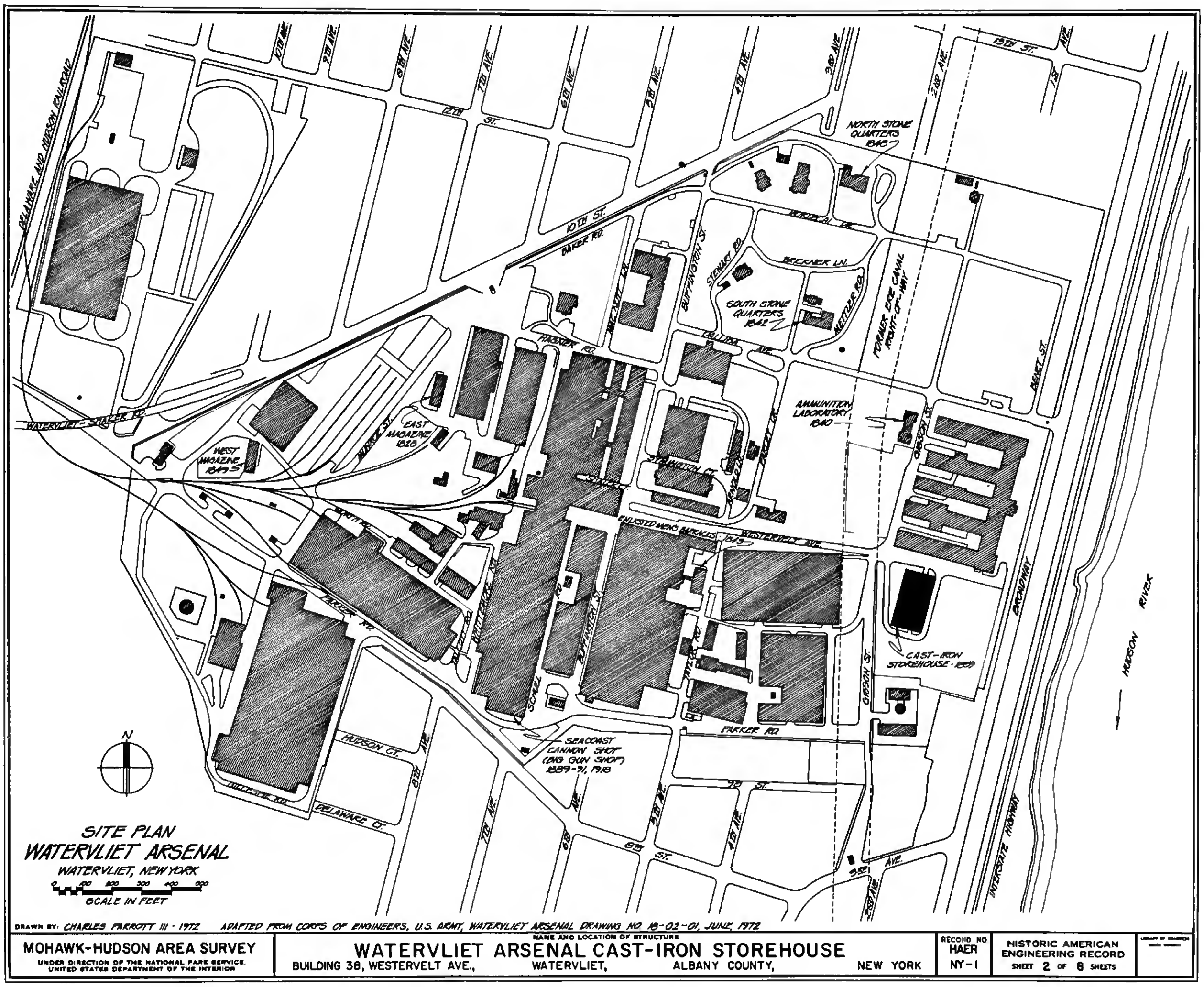


FIGURE 15.—Site plan of Watervliet Arsenal, 1972.

"On the ground adjoining the front of the Arsenal on the south side and facing on the Canal there [was] a lumber yard, on too close proximity to [the] workshops" (ibid.). Ripley proposed to buy the property in the interests of future expansion and permanent improvement. The land was purchased on 7 April 1859 from Albert G. and Harriet D. Sage at a cost of $5,300 and it was here that Mordecai finally decided to locate the storehouse. Little more than 20 feet away from the machine shops, the ground was easily raised to the level of the canal bank, "above the reach of inundation from the river" (ibid.).

Although the question of size and location caused disagreement between the Ordnance inspector and the commanding officer, both men agreed on the need for a fireproof building and both voiced the hope that it would also be ornamental. The choice of a cast iron structure satisfied both these stipulations. Cast iron is made by directly remelting the pig iron that comes from the blast furnace and thus is high in carbon and impurities (Condit, 1960: 280–281). Comparatively inexpensive, it is easy to pour into any mold that can be made from founder's sand. It is also "fairly hard and resistant to abrasion and relatively high in compressive strength." Because it is stronger and proportionally lighter that masonry, cast iron is easier to work with than brick. It is also cheaper to erect because the elements can be factory-produced, which reduces the need for skilled craftsmen on the job. While it will not withstand much tensile stress (the presence of carbon graphite flakes makes it brittle), it can be reinforced by wrought iron which has a much greater tensile strength. Moreover, although it will warp and buckle at high temperatures, it will continue to support its load thus making it a perfect choice of material for a warehouse whose contents are more valuable than its own walls.

At any rate, the choice proved satisfactory in the case of the Watervliet Arsenal storehouse. By 22 July 1859, a little more than two months after on-the-site construction had begun, Major Mordecai instructed the E. & D. Bigelow Company to "commence forwarding [flagging] stone for the iron building" (1416–N–76), suggesting that the iron workers' job was completed by that date. Finally, on 10 November 1859, Mordecai announced "the flagging was finished yesterday" (1416–N–126).

The completed storehouse satisfied all the specifications outlined by Mordecai, and seconded by Colonel Ripley. A long, one-story structure, it was slightly to the south of the workshops where the Iron Sea Coast Carriages were painted. On the east bank of the canal, it was also downhill from the shops so as to facilitate the transporting of the heavy carriages. Relatively safe from fires, the structure was also secure from flood waters as Mordecai had raised the level of the floor above that of the canal.

Architectural Iron Works was able to meet its contractual obligations in a matter of six months. Working at the foundry during the inclement winter months, the designers and the molders produced the parts of the structure for later assembly at the arsenal site. The use of brick would have delayed the process by almost as many months, since all work for a brick structure would have had to be executed on the site. In addition to meeting the Major's demands for a fireproof and decorative structure, therefore, the design in cast iron proved more efficient, in terms of time saved.

Mordecai was generally satisfied with the building, as indicated by a letter of 22 February 1860 answering an inquiry from James Reed regarding the warehouse. He wrote: "I have to say that the building which you put up last summer at this Arsenal has, so far, stood very well" (1416–N–158). The Major registered, in the same letter, a mild complaint that the ventilators had allowed some rain and snow leakage, but for 54 years, the building withstood heavy regional rains. In March 1913, the Hudson River, "exceeding all previous flood records," left a water mark of ten inches on the first floor level of the structure (R.G. 156–Gen. Corres.). No major damage was incurred and the building still functions as it was intended. Due to the arsenal's expansion, however, the cast-iron storehouse is no longer convenient to the manufacturing facilities, and it is now used for dead storage. In addition, some 6,000 square feet of the building have been converted to use as an ordnance museum.

Biographical Information

"During the first half of the nineteenth century the United States procured its engineers from three main sources" (Rae, 1967:331–332, passim). The first was Europe, site of the first notable technological experiments. The second source was the United States Military Academy, at West Point. Founded in 1802 as a training ground for the Army Corps of Engineers, the institution became a full-fledged military academy after the War of 1812; and, at the same time, its engineering curriculum became strongly influenced by the École Polytechnique (from which it recruited some of its early professors). Because of its superior engineering department, the academy attracted many young men who would not otherwise have chosen the military as a career. The Corps of Engineers became the elite corps of the Army and the one usually chosen by top-ranking graduates. Though many engineers left shortly after fufilling their required years of service, as many graduates remained in the military and some of the most distinguished civil engineers of the nineteenth century were Army officers.

The third and largest source of nineteenth century engineers was those self-educated men who received their training on the job. The men who built the Erie Canal, for example, Canvass White, James Geddes, and Benjamin Wright, were local landowners with some training and experience in surveying. Their knowledge of the building craft and their awareness of specific needs to be met combined to provide many remarkably innovative structures.

The iron storehouse at Watervliet Arsenal reflects in many ways the representative skills of America's nineteenth century engineers. An expression of the vernacular in the building arts of the nineteenth cen-

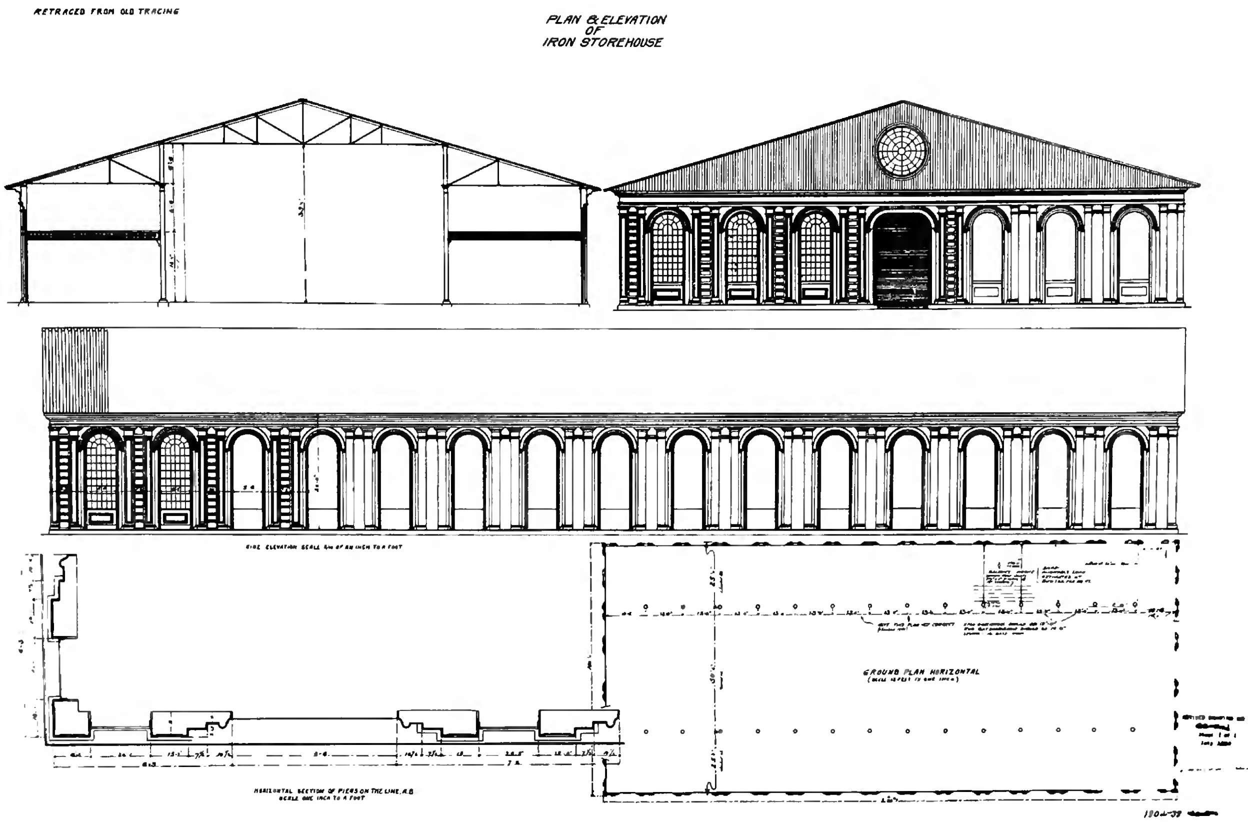


FIGURE 16.—Later copy of an early design drawing of the Storehouse, differing from the final scheme in the roof trussing, lack of siamese [duplex] columns, and in the arrangement and spacing of window and door openings. (*Courtesy of the Post Engineer, Watervliet Arsenal.*)

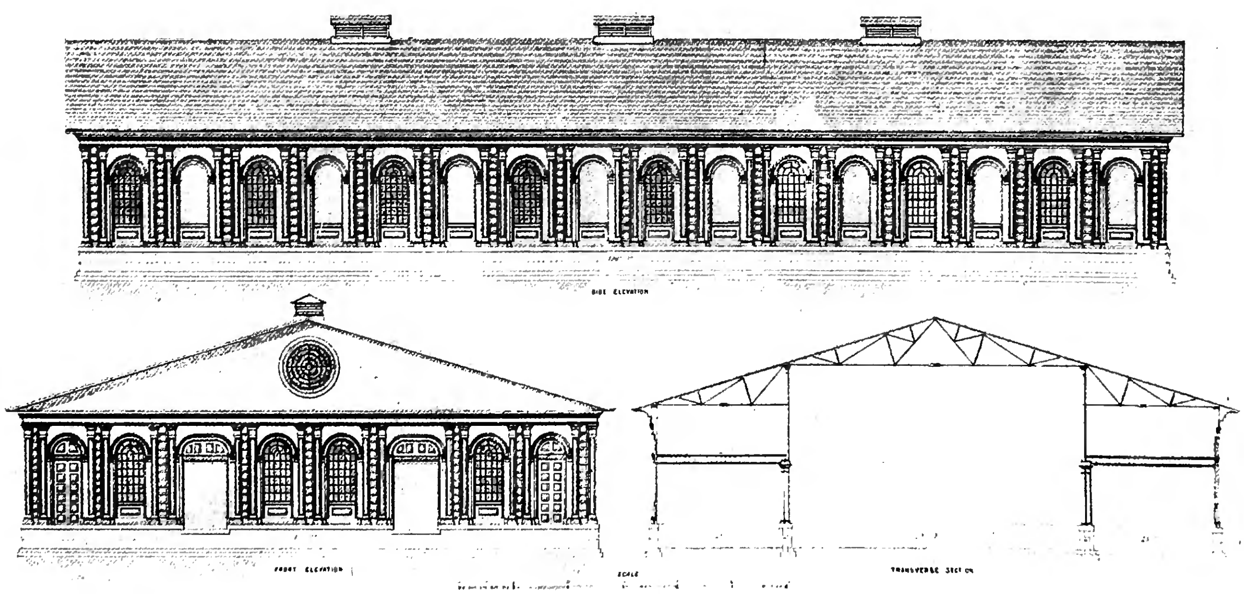


FIGURE 17.—Engraving of the Storehouse from Badger's catalog of 1865, representing the building as constructed.

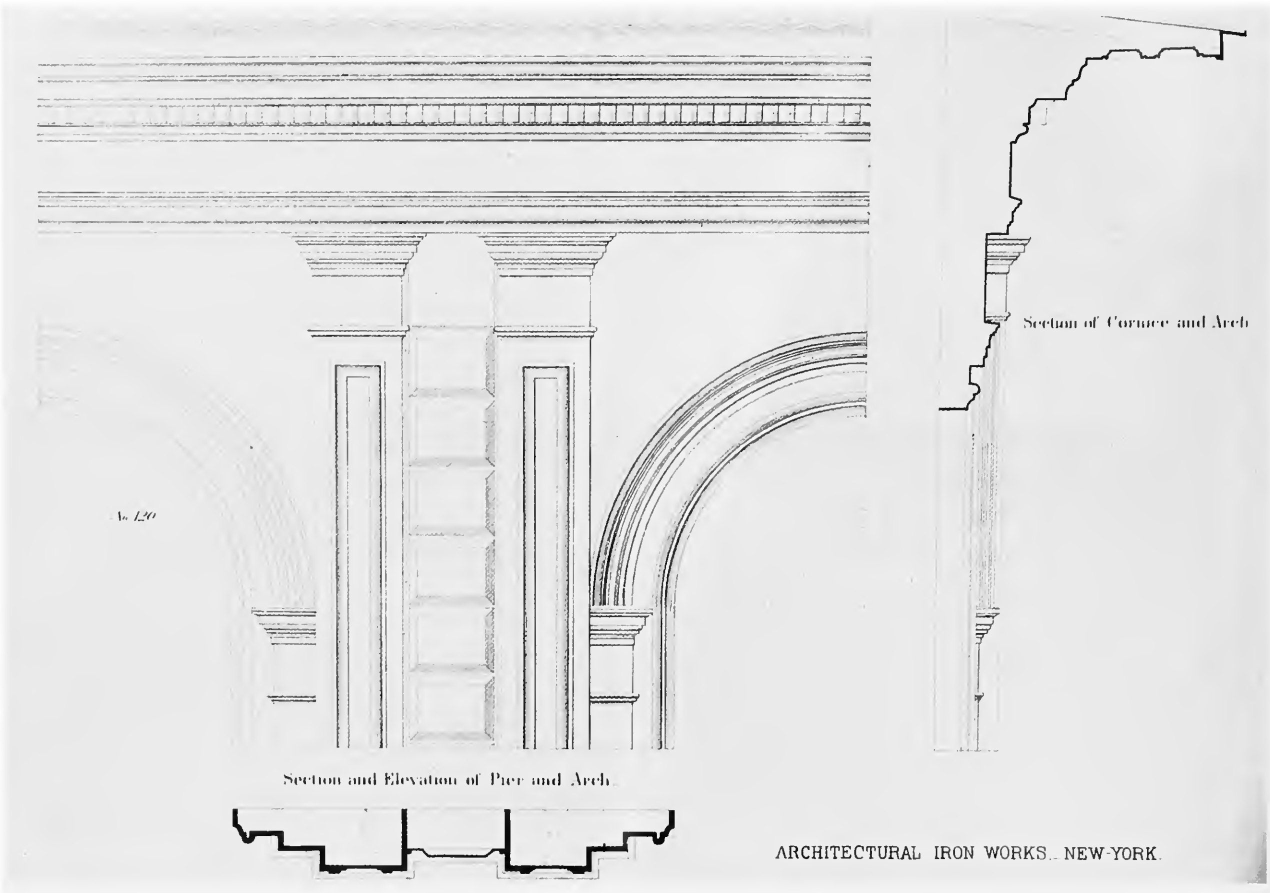


FIGURE 18.—Details of the Storehouse from the Badger catalog.

tury, the warehouse was the product of both the client, Major Alfred Mordecai, and the builder, Daniel D. Badger and Architectural Iron Works.

A client with unusual qualifications, Mordecai (1804-1887) was a graduate of West Point, class of 1823 (DAB; Watervliet Arsenal, 1968:32–37, passim). Appointed to the Academy from his native state of North Carolina, he graduated first in his class and was commissioned second lieutenant, Corps of Engineers, 1 July 1823. A brilliant student, Mordecai became a brilliant ordnance officer, being appointed captain in that department in 1832. In 1855 he was one of three officers sent to study military developments in Europe, especially in the Crimea. Unable to visit the Crimea, the Major nonetheless traveled throughout the rest of Europe and returned to the States with a detailed knowledge of engineering, as well as military, developments.

Appointed commanding officer at Watervliet Arsenal 23 June 1857, Mordecai found the arsenal in a state of substantial decay. Less than two weeks after his arrival, he recommended changes in the building plans to the Ordnance Department. Among these changes was the request for an iron storehouse.

His familiarity with the uses and properties of iron was based on his engineering background reinforced by his observation of the iron structures, especially railway depots, he had seen on his European tour. It served him well in this case and he was able to specify a building suited to his particular needs.

Less than two years after completion of the cast-iron warehouse, civil war broke out. Though Mordecai continued to direct the arsenal—so well that it was better prepared for war than it had ever been—his Southern birth incited much animosity and hostility "from various sources" within the Army. On 2 May 1861, he found it necessary to resign from the Army and shortly thereafter he left the country for Mexico. There he remained until after the war, directing the construction of a railroad running from the Gulf of

ARCHITECTURAL IRON WORKS.

This well known Corporation has been in existence about twenty years, and is the successor of the firm of Daniel D. Badger & Co., who had been for a period of years engaged in the Iron business, and had made a specialty of Iron Work for buildings. Mr Badger, the President of this Company, is regarded as the pioneer of Iron Architecture in America. This Company may therefore claim to be the oldest establishment of its kind in our country, and to have had the largest experience.

The works of the Company are situated in the City of New York on 14th Street near the East River, occupying about fifty lots of 100 by 25 feet each covered with their buildings. The area of these lots and the floors of the buildings exceed four acres. The shops are fitted with all kinds of machinery required for the work to be done, and have every improvement and facility for making Iron Work for all kinds of buildings, as well as for many other purposes.

The various departments are conducted by skilled and experienced workmen, and the Company is thus enabled to perform the several branches of work for all iron structures from the inception, designing, drafting, patterning, casting, fitting and setting, to the final completion for occupancy.

It has the capacity to employ more than a thousand men, and to produce thousands of tons of iron work annually. It will be seen that, for the successful conduct of a business of this magnitude, a large capital, extended facilities and a large experience are needed, and that therefore this establishment possesses many advantages which commend it to the notice of all owners, capitalists and corporations, designing to erect iron buildings of any description.

Iron architecture encountered at the time of its introduction the bitterest opposition from builders, insurance companies, fire departments and the public generally; but it has been persisted in by its originators and tested by use, until at length all objections to it have been removed, and it is now conceded that iron is entitled to be regarded as one of the most useful and enduring of known building materials.

A brief enumeration of the advantages of the use of iron will confirm this assertion.

It possesses the greatest possible strength in proportion to its weight and bulk. Hence, it allows of grace and lightness of construction, the greatest possible amount of beautiful ornamentation; it will be obvious that the cost of elaborate designs in stone or any other durable material executed by the chisel, will exceed that of castings of iron, and hence that iron is cheaper for work of an ornamental character. It may be added that iron admits of more delicate tracery and sharper outlines than any other material.

Iron is of course incombustible, and, though it may be affected by intense heat, it is far more nearly fire proof than stone, granite, marble and other building materials.

One of the great advantages arising from the use of iron is that it admits of unusual rapidity of construction and erection.

The sanitary advantages of the use of iron deserve also to be considered. Occupying but small space in piers and columns, it freely admits the air and light which are both essential to health.

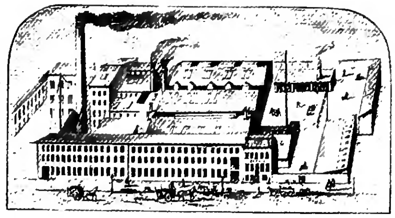
As a final argument in favor of its use, it may be stated that iron always has a value, and the old material finds an immediate sale. When iron work becomes defaced, it can be easily restored to its pristine appearance by a fresh coat of paint.

Iron has of late years been used to advantage and with general approval for many purposes, among which may be enumerated the following: store fronts, hotels, depots, grain warehouses, public buildings, roofs, domes, verandas, balustrades, stairways, columns, capitols, arches, window lintels and sills, sashes, doors, brackets, guards, lamp posts, railings, crestings, bank counters, rolling shutters, venetian blinds, patent lights, sidewalks, bridges, light houses, churches, ferry houses, arsenals, etc., etc.

This company has during the last twenty years erected a great number of iron buildings in all the principal cities and towns throughout our country, of a great variety of styles, designed by the best architects.

Among these may be mentioned the Grand Central Depot, an illustration of which will be seen on this page, Manhattan Market, 800 feet long, 200 feet wide, 100 feet high; Hudson River Railroad Depot, St. John's Park; Kemp Building, Singer's Sewing Machine Company Building, Gilsey House, Seamen's Bank for Savings, Atlantic Savings Bank, etc., in the City of New York, Post Office and Sub-Treasury, Boston Post Building, Stores for Hunnewell estate, Messrs. Fitch, Snow, White, Rich, Gray, Hawley, Folsom & Martin and others in Boston. Congressional Library, Conservatory, etc., in Washington. Buildings in Chicago, Philadelphia, Troy, Rochester, Springfield, New Haven, New Orleans, and indeed in almost every section of our country, and even in distant lands.

Their facilities for furnishing the iron work for building purposes, of a superior quality and finish, are unsurpassed in this country, as their long experience in architect work has been used to the very best advantage, in bringing forward improvements of great importance and architectural beauty. For particulars address the company as above



VIEW OF ARCHITECTURAL IRON WORKS,
New York.

GRAND CENTRAL DEPOT, NEW YORK.
IRON WORK CONSTRUCTED BY ARCHITECTURAL IRON WORKS.

FIGURE 19.—Badger's greatest undertaking probably was the ironwork for Vanderbilt's original Grand Central Depot, 1869–1871, memorialized in the *New Columbian Railroad Atlas and Pictorial Album of American Industry* [opposite plate 75].

Mexico to the Pacific Ocean. Returning to the United States in 1867, he worked for twenty years for coal and canal companies controlled by the Pennsylvania Railroad. He died in Philadelphia in 1887.

If Mordecai's excellent credentials were a result of his West Point training, the varied experience and practice of Daniel D. Badger, founder of Architectural Iron Works, point to another representative example of the nineteenth-century engineer (Condit, 1960, passim; Sturges, 1970: vii–ix, passim). Born in Portsmouth, New Hampshire, in 1806, Badger began his career as a contractor in Boston in 1829. There he engaged in on-the-job training and advanced his building skills. In 1842, he constructed a store building on Washington Street with iron columns and lintels on the first story. Badger did not identify the building, however, and nothing more is known about it. A year later he bought the patent of Arthur L. Johnson of Baltimore for a rolling iron shutter for use with his iron fronts. The shutter afforded protection to the wide show windows which the new structural material made possible. With success, Badger found Boston too small a market and he moved to New York in 1846. There he built his foundry, Architectural Iron Works, on Duane Street between 13th and 14th Streets.

Badger advertised his product widely and business flourished from 1850 to 1870. Responding to the concept of mass production, which was gaining increasing importance in many industrial areas, he employed a standard structural system that adapted nicely to urban building requirements. He repeated this system with no essential change from one structure to another—consciously imitating the more costly

FIGURE 20.—The appearance of the Storehouse has remained practically unchanged during its lifetime: south and east faces, May 1875 (top); east face, August 1972 (bottom). (*Top: Courtesy of the Public Information Office, Watervliet Arsenal; bottom: Boucher.*)

stone architecture of the period. "With his team of anonymous architectural designers, modelers [pattern makers] and molders [Badger] sought to reproduce . . in iron whatever could be produced in stone" (Sturges, 1970: viii).

The iron foundry nevertheless produced its own impressive style of urban architecture; and the structural uniformity of most of Badger's commercial buildings makes a general description possible (Condit, 1960:31). Most of them were from two to six stories high, the stories ranging in height from nine to fourteen feet; spandrel depth was usually two feet. Column spacing in the facade was usually six feet; and the hollow columns were seldom less than twelve inches in diameter. Interior framing generally consisted of iron columns and timber floor beams.

Illustrations of Iron Architecture (in Sturges, 1970) is the 1865 catalog of Badger's Architectural Iron Works. In its preparation Badger made many mistakes: inaccuracies in dates, dimensions, and structural detail abound. He did not err in the choice of his lithographers (Sarony, Major & Knapp, New York), however, and the *Illustrations* are themselves a work of art. Nonetheless, Badger's impressive heritage does not lie exclusively on the pages of his catalog. He was a pioneer in the use of prefabricated construction—of which the Watervliet iron storehouse is an excellent example—and his exploitation of iron technology anticipated, in a crude fashion, the steel frame of the twentieth century skyscraper. One of many self-trained engineers of that period, Badger's contributions are not unique. They are significant, however, for the technological developments which they represent and for the building skills which they summarize.

Though Badger named his foundry Architectural Iron Works, the basic sameness in structure and obvious derivation of style do not denote any architectural ingenuity. His use of iron, on the other hand, in both facades and framing, reveals an innovative and daring engineering mind; and his buildings enrich engineering history.

Addendum

NATIONAL ARCHIVES, RECORD GROUP 156.
RECORDS OF THE WAR DEPARTMENT,
ORDNANCE CONTRACT, REED, J. M.

Iron Store House, Watervliet Arsenal, 1859, MS
J. M. Reed
President of Architectural Iron Works of New York
Contract for an Iron Store House at Watervliet Arsenal

Articles of Agreement between Major Alfred Mordecai, of the Ordnance Department Commanding Watervliet Arsenal, on behalf of the United States, and Mr. J. M. Reed, on behalf of the Architectural Iron Works in New York for building an Iron Store House at Watervliet Arsenal:

1. The Architectural Iron Works agree to build at Watervliet Arsenal an Iron Store House, conformably to the drawings and specifications signed this day by the contracting parties above mentioned, and deposited with the Commanding Officer of Watervliet Arsenal.

2. The Site for the Said building is to be selected by the Commanding Officer of the Arsenal, and the foundations for the building are to be prepared by the United States. The Work on the foundation is to be commenced as early in the Spring of the present year as the Season will permit, and to be continued with due diligence, so as not to delay unreasonably the erection of the superstructure, after the materials for the latter shall have been delivered at the Arsenal.

3. The building is to be completed on or before the thirty first day of August 1859.

4. The work on the building is to be subject to inspection, in all its Stages, by the Commanding Officer of Watervliet Arsenal for the time being, and by Such persons as he may appoint for that purpose; and it is to be executed, as regards both Materials & Workmanship, in a Manner satisfactory to the said Commanding Officer, or the inspector appointed by him, having regard to the drawings and Specifications above referred to.

5. The United States agree to pay to the Architectural Iron Works, for the said building completed according to the foregoing stipulations the sum of forty seven thousand three hundred and sixty dollars, which is to be paid in installments as follows: that is to say: *First:* The Sum of ten thousand dollars is to be paid on the completion of one half of the iron work of the building at the Company's works in the City of New York. *Second:* The further sum of ten thousand dollars is to be paid on the completion and reception of the whole of the iron work at the said works in New York. *Third:* The further sum of ten thousand dollars is to be paid on the delivery of the whole of the iron of the building, at Watervliet Arsenal. *Fourth:* The remainder of the Stipulated price of the work is to be paid on the completion of the building and its acceptance by the Commanding Officer of the Arsenal as aforesaid.

6. The valuation of the work on which the first installment of ten thousand dollars is to be paid shall be made by the Commanding Officer of Watervliet Arsenal, or by an inspector appointed by him for that purpose.

7. If the money appropriated by Congress and applicable to the construction of the building should not be sufficient for making the final payment of the work on the completion of the building, the party of the Second part shall not be entitled to receive or claim from the United States any interest on the amount of which payment may be deferred until funds are provided for the purpose.

8. No Member of Congress shall be admitted to any share in this Contract or receive any benefit to be derived therefrom.

9. This Contract shall not be considered in force until the party of the Second part shall have made a Bond to the United States, with good Security, in the Sum of twenty thousand dollars, for the faithful completion of the work; nor until this contract and the said bond shall have been approved by the Secretary of War.

Done at Watervliet Arsenal the fifth day of January 1859.

Watervliet Arsenal (Signed) Architectural Iron Works
January 5th 1859 By J. M. Reed, Presdt.
(Signed) A. Mordecai
Major of Ordn.

[Bond Follows]

Sources of Information

UNPUBLISHED

Araklian, R. J., LTC, CE. "Analysis of Existing Facilities." Paper submitted by the Executive Secretary, Installation Planning Board, Watervliet Arsenal, Watervliet, New York, June 1969. [Multilithed from typed copy.]

National Archives Record Group 156: Records of the Office of the Chief of Ordnance. Entry 3, Miscellaneous Letters, Endorsements, and Circulars, volumes 50, 51.

———. Entry 5, Letters (Sent) to the War Department, volume 12.

———. Entry 6, Letters, Telegrams, and Endorsements Sent to Ordnance Officers and Military Storekeepers, volumes 18, 19.

———. Entry 20, Register of Letters Received (1857–1861).

———. Entry 21, Letters Received 1858, volume 28, 7 April (295M); 1858, volume 28, November 3 (385M). [Original letters from Major Alfred Mordecai to the Chief of Ordnance, as indicated in Register, Entry 20.]

———. Entry 176, Military Service Histories of Ordnance Officers, pages 42, 44.

———. Entry 1003, Special File 1812–1912, Reports of Inspections of Arsenals and Depots. (Inspection reports of 9 August 1858, 11 June 1859, and 5 June 1860).

———. Entry 1020, Register of Drawings.

———. Entry 1416, Watervliet Arsenal Letters (Sent) Book "M" and Letters (Sent) Book "N."

———. [No entry number] General Correspondence 1894–1913. New Series 1894. Letters 30025D/441 and 30025D/227.

PUBLISHED

Condit, Carl W. *American Building Art: The Nineteenth Century*. New York: Oxford University Press, 1960.

———. "Buildings and Construction." Pages 367–392 in volume 1 of *Technology in Western Civilization*. Edited by Melvin Kranzberg and Carroll W. Pursell, Jr. New York: Oxford University Press, 1967.

Dictionary of American Biography [DAB]. New York: Charles Scribner's Sons, 1935.

Fogerty, William, FRIBA. "Conditions and Prospects of Architecture in the U.S." *Van Nostrand's Engineering Magazine,* volume 14 (January 1876), page 70.

New Columbian Railroad Atlas and Pictorial Album of American Industry. New York: Asher and Adams, 1875.

Rae, John B. "The Invention of Inventions." Pages 331–332, in volume 1 of *Technology in Western Civilization*. Edited by Melvin Kranzberg and Carroll W. Pursell, Jr. New York: Oxford University Press, 1967.

Sturges, W. Knight. "Cast Iron in New York." *Architectural Review*, volume 114 (October 1953): 233–237.

———, editor. *The Origins of Cast Iron Architecture in America* (including "Illustrations of Cast Iron Architecture Made by the Architectural Iron Works of the City of New York," Daniel D. Badger, President (1865), "Cast Iron Buildings: Their Construction and Advantages," James Bogardus (1856)). New York: DaCapo Press, 1970.

Watervliet Arsenal. *A History of Watervliet Arsenal 1813–1968*. Watervliet, New York, 1968.

U.S. Congress. "Report of the Secretary of War" (John B. Floyd, December, 1859), *Senate Executive Document,* volume 3, no. 2, serial set 1025, 36th Congress, 1st session, 1859–1860.

———. "Report of Major Alfred Mordecai of the Ordnance Department." *Senate Executive Document,* volume 15, no. 60, serial set 1037, 36th Congress, 1st session, 1860.

ARCHITECTURAL INFORMATION

General Statement

Architectural Character: A building detailed in Renaissance Revival style, proportioned for stone, but prefabricated almost entirely of cast- and wrought-iron components in New York City by the Architectural Iron Works. The parts were then shipped up the Hudson River and assembled by that company on site.

Summary Description: A rectangular warehouse 100′–0″ x 196′–0″ containing 16 transverse bays and three longitudinal aisles. In addition to a ground floor, the outer aisles each contain a gallery in the 14 inner bays. The structure, as built, is nearly identical to the one in Badger's catalog, *Illustrations of Iron Architecture made by the Architectural Iron Works of the City of New York,* 1865, Plates 12, 13.

Condition of Fabric: Good to excellent.

Structural Description

Foundation: Cut limestone sill over random rubble footings on perimeter. Interior columns have ashlar bases dressed similarly to the sill.

Wall Construction: Cast-iron panels connected by flathead, countersunk machine screws through flanged and lipped surfaces, only the countersunk heads appearing on the exterior. The paired cast-iron pilasters, ½-inch thick, are part of load-bearing channels that provide stiffening for the walls and support one end of the gallery roof trusses on the side walls. Corner pilasters are built up box columns. The fenestrated panels and the rusticated detail between the pilasters, both generally 5⁄16-inch thick, are nonloadbearing. The walls on end and side elevations are topped, respectively, by horizontal plates forming an asymmetrical "H" section and by a shallow horizontal channel, providing additional longitudinal stability and supporting the gallery-truss ends.

The end-wall gables are sheathed with corrugated iron framed with various structural sections above the top plates of the end walls. The end walls subsequently were stiffened by the addition of welded-steel frames each composed of two struts spanning between each end column and the wall plate, at cornice level.

Structural System: The fourteen 12-foot interior bays and two 14-foot exterior bays are delineated by transverse cast- and wrought-iron Fink trusses over the center aisle and modified Fink trusses and composite beams over the side (gallery) aisles. The center-aisle trusses span about 50 feet, the side-aisle trusses and beams about 25 feet. Both trusses are about 8 feet deep, maximum. Both center and side-aisle trusses share the same colinear top chord. All truss members and purlins are wrought iron

FIGURE 21.—Storehouse: *a*, North elevation; *b*, west elevation; *c*, detail of west elevation from the northwest; *d*, east elevation from the northeast.

except for the cast-iron cruciform compression struts. Turnbuckles allow the tensile stress on the 1-inch-diameter rod of the lower chord to be adjusted. All truss connections are bolted.

Longitudinal stability, in addition to that provided by purlins, perimeter plates, and walls, is provided by shallow channel plates, which unite the trusses atop the two rows of interior columns. These plates also provide seats for the center-truss end connections.

The columns that jointly support the center and side-aisle trusses are 28′–6¾″ high and taper from 10 inches to 6½ inches in diameter. The 16 wood gallery joists, 3¼″ x 11″ at 19 inches on center, are supported by the shorter section of the unique, integrally webbed, duplex (or siamese) columns on the inside and single columns at the exterior wall. These columns are both 5 inches in diameter.

The composite gallery beams are principally cast iron, containing 22 circular openings in the web. A 2½ inch wrought-iron rod, integral with the bottom flange of each beam, provides the tensile strength. These beams are ±27 inches deep at midspan. They are nearly identical to the "tension rod girder no. 273" in *Illustrations of Iron Architecture,* plate 63.

The siamese columns and composite beam between the fifth and sixth bays from the north on the east have been replaced by a steel beam and two steel columns.

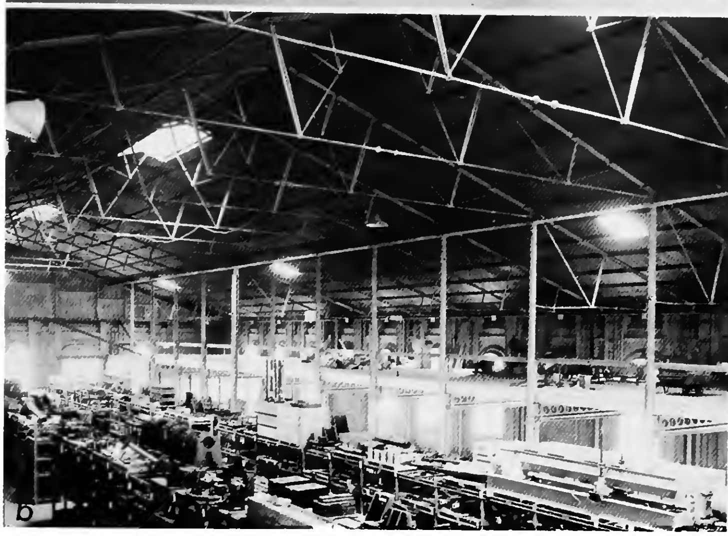
Architectural Description

Floor Plans: The ground-floor plan is virtually a single area. The 100′–0″ transverse dimension is divided into two 25-foot side aisles and a 50-foot

FIGURE 22.—Storehouse: *a,* Inside of original cast-iron rolling door; *b,* outside of original door (now secured), south face; *c,* window detail, south face; *d,* personnel door, south face; *e,* vehicular door, south face; *f,* circular window, south gable end; *g,* detail of cast-in builder's plate.

center aisle, and the 196′–0″ longitudinal dimension into sixteen bays (14 12′–0″ inner bays and 2 14′—0″ outer bays), by two rows of siamese columns. The side aisles each contain a gallery floor the length of the inner 14 bays. As evidenced by the gallery floor-joist brackets on the interior of the end walls, the galleries originally were the full 16 bays in length. It may partially have been the removal of these end-bay gallery sections that necessitated the subsequent stiffening of the end walls with steel braces.

Stairways: Cast-iron stairways, one in each corner, lead to the gallery level. In a single run they turn 90 degrees in the lower five steps. The risers are perforated with circular openings while the treads



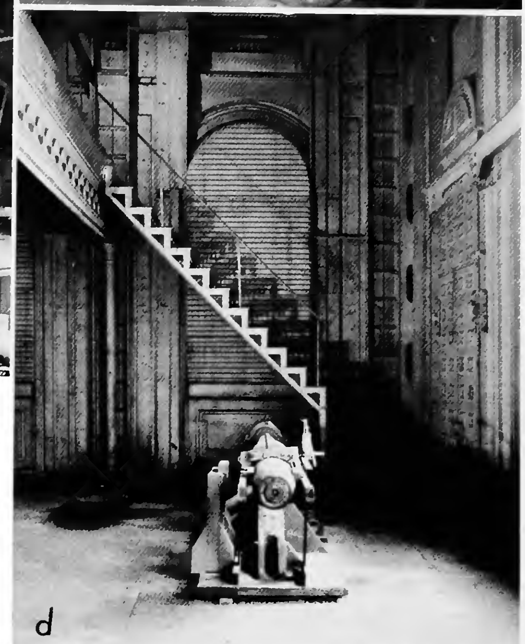


FIGURE 23.—Storehouse: *a,* General interior view from the west gallery, looking north; *b,* general interior view of north end and east side from the west gallery; *c,* detail of southeast stairway; *d,* detail of southeast stairway.

contain a grid pattern of quatrefoil and circular openings.

Openings: Doors: The gabled, end elevations are divided into eight bays. Nos. 1 and 8 contain windowless cast-iron personnel double doors with coffered surface ornament. These doors are not now operative. Bays 3 and 6 contain wider doorways. Originally each had a rolling, iron vehicular door, 8 feet wide, two of which still remain, although inoperative, in the respective westerly bays (for a description of their operation see "Mechanical Equipment"). The easterly rolling doors have been replaced by double, wood, half-glazed doors with glazed transoms. This door is at grade level on the south elevation and up three steps on the north.

Windows: The openings on the side elevations are randomly either glazed or closed with fixed iron plates. From the left, the openings in bays 1, 2, 3, 4, 5, 6, 9, and 11, west elevation; and bays 5, 7, 9, 10, 11, 13, 14, and 15, east elevation, are glazed, with iron frames and muntins. Each of the remainder is covered with five cast-iron plates, serrated to appear as closed louvers. Originally, the eight windows and eight panels on each side alternated. Windows 1, 2, and 3 of the west elevation are presently boarded. A few windows on the west elevation have been modified to double hung sash. The end elevations contain windows in bays 2, 4, 5, and 7. The fixed, semicircular-arched, single sashes each contain 30 lights below the semicircular portion. In the semicircular portion the vertical muntins are continued in a circumferential pattern to contain an additional six lights delineated by radial muntins. In each end-wall gable is a 7-foot-diameter round window containing circumferential and radial muntins delineating 41 lights. The round windows originally pivoted on horizontal axes for ventilation, but the operating hardware has been removed.

Roof: Shape, Covering: Gable roof with a slope of 1:3, corrugated asbestos replaces the original covering.

Eave, Entablature: On the side elevations the entablature and coffered eave soffit is comprised of single castings supported by iron brackets bolted to the vertical load-bearing channels of the exterior wall and spaced 6 to 7 feet apart. An unusual angle is attached to the outermost part of the eave. This angle has its horizontal leg formed in a wave pattern with an amplitude of 6 inches. This is the amplitude of the existing corrugated-iron covering of the gables, which is original. Thus it is quite likely that the original roof covering was the same type and size of

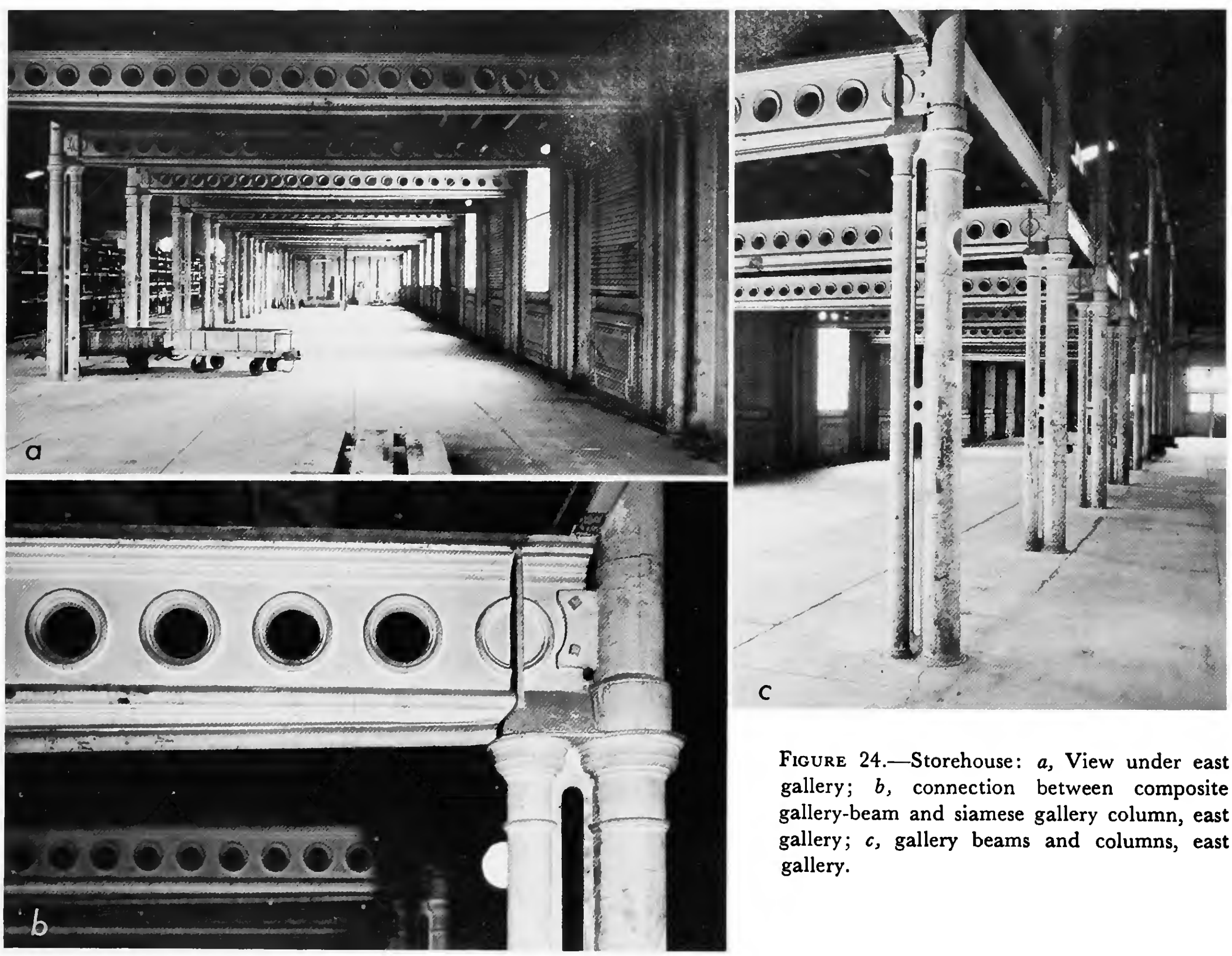


FIGURE 24.—Storehouse: *a*, View under east gallery; *b*, connection between composite gallery-beam and siamese gallery column, east gallery; *c*, gallery beams and columns, east gallery.

corrugated iron. On the end elevations the cornice is separately cast and bolted to shorter brackets similarly located and spaced.

Monitors, Skylights: Three combination ventilation monitors and skylights are located at approximately the quarter points on the roof ridge. The sides and ends of the monitors (except two ends which have been replaced with blank panels) contain adjustable iron louvers from which the operating hardware has been removed. The roofs of the monitors contain lapped glass pane skylights which replace a corrugated covering, like that formerly on the main roof, since the same wave patterned angle remains attached to the monitor eaves. Each roof slope also contains four corrugated fiberglass skylight sections set within the corrugated asbestos roof panels in a horizontal line.

Flooring: The concrete ground floor replaces the original stone flagging. A 1⅛-inch plywood deck has replaced 1⅛ x 4-inch wood decking on the galleries.

Wall Finish: The building exterior was painted light gray in 1969, similar to its original color. By 1971 the exterior had been repainted buff. Interior iron surfaces are painted a metallic silver. Interior faces of the wall panels in general reciprocally reflect exterior detailing and decorative features.

Notable Hardware: Several columns above the gallery level on the west side support pivoting, cast-iron, cantilevered jibs fitted with hoist rope pulleys for raising and lowering material to the gallery level.

Mechanical Equipment: Lighting: Originally there was no provision for other than natural light through the alternating glazed openings on the side elevations and the four windows and round window on the end elevations. Additional natural light has been provided by the monitor and roof skylights. Area electric lights have been installed on every third column, aimed to light the center aisle.

Plumbing and Heating: No systems incorporated.

Ventilation: Ventilators incorporated into the monitors and round windows have been mentioned above. In addition, the bases of the nonload-bearing window panels on all elevations contain a row of 2¼-inch diameter ventilating holes.

Rolling Iron Vehicular Doors: Operated by original (although inoperative) sprocket pulley, chain, and hand crank. The door is made up of a shutter of horizontal iron slats hinged together. To open, the shutter was reeled around an iron windlass driven by the sprocket pulley on one side, aided by a counterweight suspended from a pulley on the other. This "rolling iron shutter," an early and particularly emphasized Badger product, is similar to the one in *Illustrations of Iron Architecture* (Badger's plate 29, in Sturges, 1970).

Site

Orientation: N 16°E—S 16°W (with true north) along the longitudinal axis.

Setting: Southeast corner of Watervliet Arsenal. Approximately 145 feet tapering to 75 feet east of the filled bed of the former Erie Canal. A (now filled) basin of the former canal was located about 45 feet north of the building. The Hudson River parallels the building about 475 feet to the east. A state highway, parallel to the river, passes along the east boundary of the arsenal about 275 feet east of the building. Brick buildings, directly west and across the former canal site, house various machine and gun shops.

Gasholder House 1873

Troy Gas Light Company, Troy

(HAER NY-2)

Diana S. Waite

Location: Northwest corner of Jefferson Street and Fifth Avenue (formerly Fifth Street), Troy, Rensselaer County, New York.
Latitude: 42° 43′ 10″ N. Longitude: 73° 41′ 30″ W.
Date of Erection: 1873.
Designer: Frederick A. Sabbaton (1830–1894), engineer.
Present Owner and Occupant: Sage Maintenance and Repainting Corporation.
Present Use: Storage of heavy equipment.
Significance: The Gasholder House of the former Troy Gas Light Company is one of the few remaining examples of a type once common in northeastern urban areas. Sabbaton was a prominent New York State gas engineer. Originally sheltering an iron holder for coal gas, the brick gasholder house is an imposing structure from a significant period in the history of Troy. The handsome exterior reflects the standing of the company that for twenty-seven years held a monopoly on the manufacture of illuminating gas in the city.

HISTORICAL INFORMATION

Physical History

Engineer: Frederick A. Sabbaton, a specialist in the construction of gas works, was superintendent of the Troy Gas Light Company from 1862 to 1890. A gas engineer, well known throughout New York State, Sabbaton came from a prominent family of engineers. His father, Paul A. Sabbaton, a close friend of Robert Fulton, prepared plans and specifications for the *Clermont,* and at the time of his death was also a gas works engineer. Frederick Sabbaton's two brothers and his two sons were all employed as gas engineers. Sabbaton at various times supervised, constructed, and owned gas works in Connecticut, Massachusetts, and throughout New York State. He was also involved in the manufacture of aniline colors (which were made from coal tar) and designed a gas governor valve.

Original and Subsequent Owners: In the block on which the structure is situated, the Troy Gas Light Company (TGL Co.) owned lots 55 through 79. The gasholder house itself was situated on lots 71, 73, 75, 77, and 79. The history of ownership of this property is reflected in the land records of the Rensselaer County Recorder's Office, Troy, New York, as shown on bottom of page 45.

Original Purpose and Construction: A gasholder house is a structure that surrounds an iron gasholder, in which gas is stored until needed. Originally most gasholders were constructed without houses. In the early 1870s, however, the construction of gasholder houses began in upstate New York, following a practice already fairly common in the Northeast, particularly New England. The gasholder house in Troy bears a builder's plaque dated 1873, and the structure appears on an insurance map published in 1875.

Historical Information: Additional data by Robert M. Vogel and Charles Granquist. Architectural Information: Prepared by Richard J. Pollak.

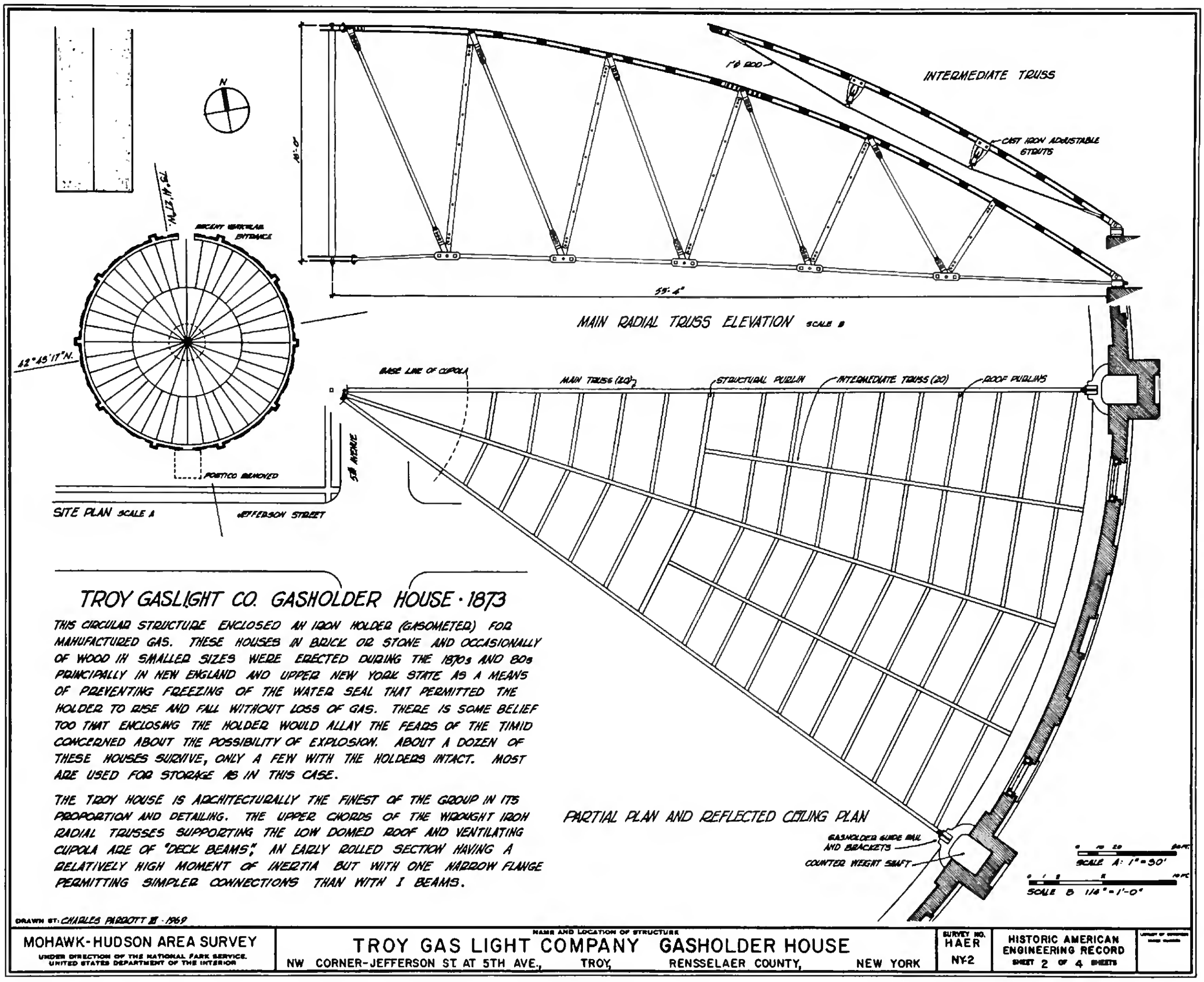


FIGURE 25

Lots	*Transfer Date*	Seller *Purchaser*	*Liber*	*Page*	*Recording Date*
57,59,61 63,65,67	12 Nov. 1866	Maria J. Cushman *TGL Co.*	134		20 Nov. 1866
69,71	14 Nov. 1866	Jonas C. Heart and Catherine, his wife *TGL Co.*	134	369	10 Dec. 1866
73,75	Jan. 1867	Thomas B. Carroll and Caroline B. Carroll *TGL Co.*	134	536	2 Feb. 1867
77,79	6 Feb. 1867	William S. Sands and Eliza, his wife *TGL Co.*	133	79	13 Mar. 1867
–	19 Oct. 1943	New York Power & Light Corp. *Oscar C. Buck*	686	167	20 Nov. 1943
–	29 Apr. 1968	Oscar C. Buck *Sage Maintenance & Repainting Corp.*	1196	252	24 May 1968

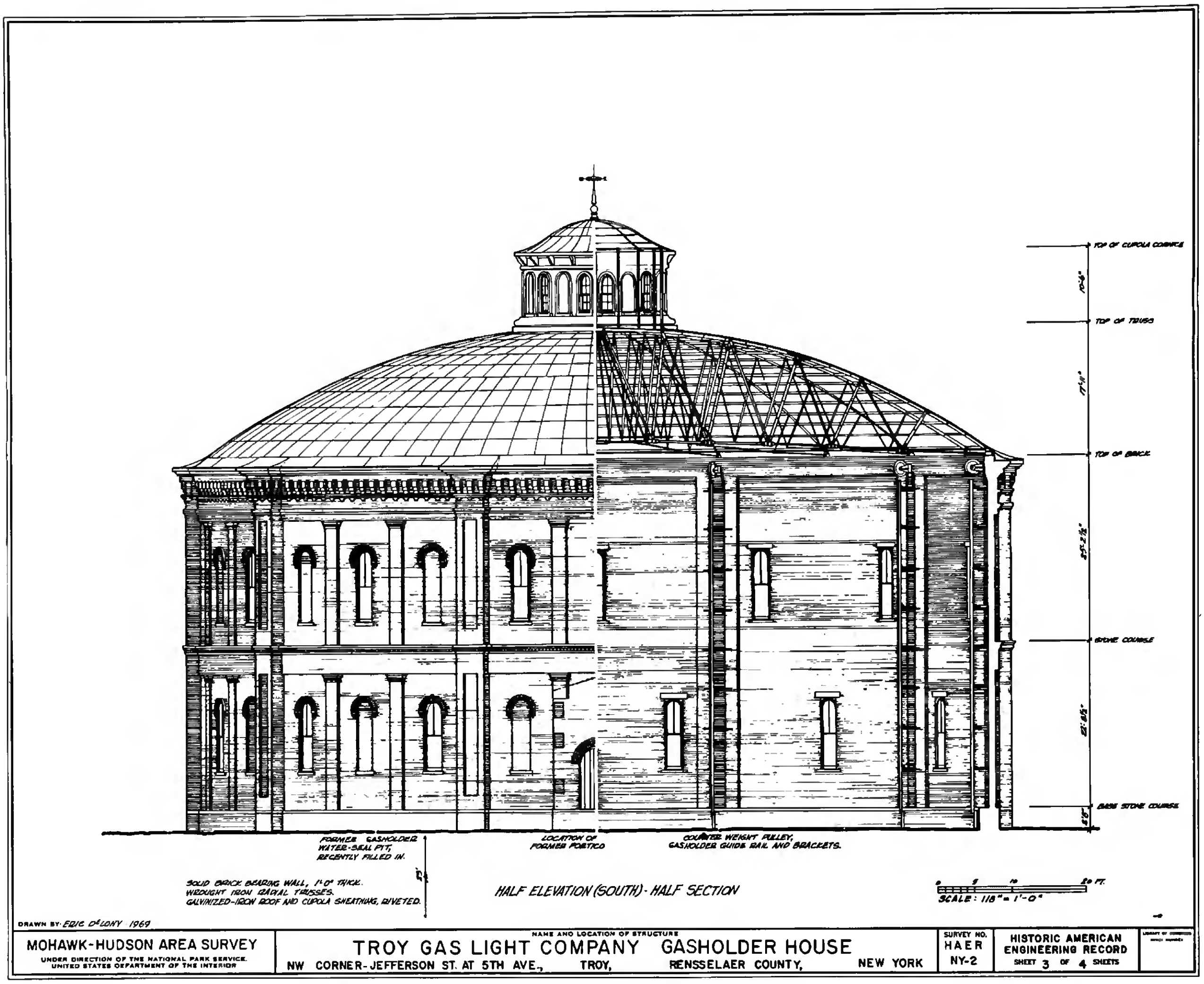


FIGURE 26

Gasholder houses were constructed for a variety of reasons. The structure protected the iron holder from the elements and enabled it to be built of thinner plates since the holder itself would not have to withstand wind pressure. Wind pressure acting on one side of the holder; snow loads on the top of the holder; and icing of the guide and counterbalance pulleys all tended to interfere with the holder's free and consistent vertical movement. The enclosure also prevented freezing of the water in the holder pit that formed a seal to prevent loss of gas, while allowing the holder to rise and fall. There is some belief too that enclosing the holder would allay the fears of the timid, anxious about explosion. The house was also considered an economical measure by reducing the condensation of gas in the cold weather and was seen as an attractive architectural element of the gas works complex.[4]

[4] Gasholder houses were constructed in England as early as about 1825, although the mild climate would not commonly necessitate them. Recently, at the demolition of a small circular house at the Bean Ing woolen mills in Leeds, researchers were able to discover that only two other gasholder houses (and a possible third) had been built in the county. The Bean Ing House was 40 feet in diameter, of brick, with an iron-plate domed roof supported by sixteen T-shaped iron ribs. (*Architectural Review,* November 1970, pages 275–276.) A very large gasholder with brick house was built at Erdberg, near Vienna, in 1886, having an inside diameter of 208 feet. (*Scientific American Supplement, 26 March 1887, pages 9354–9355.*)

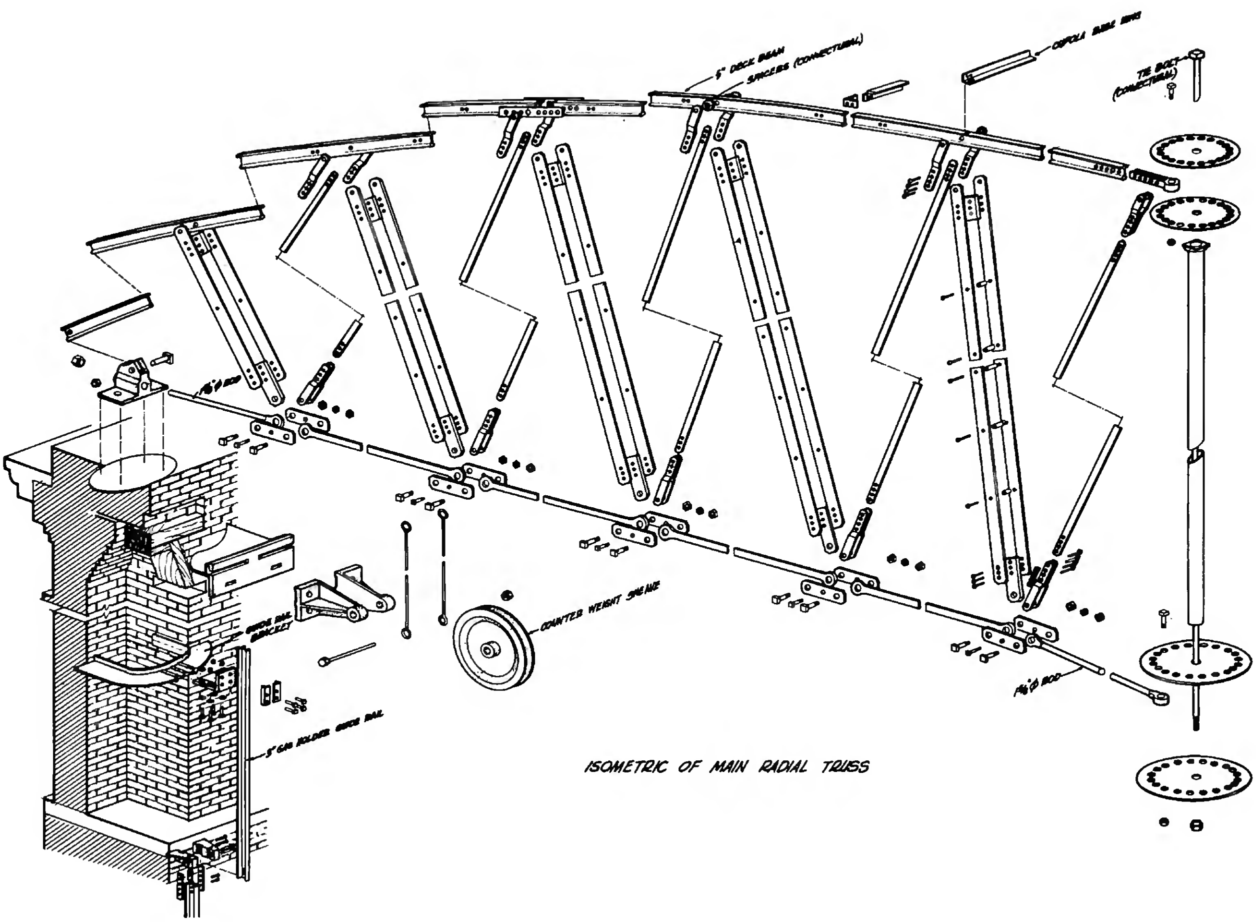


FIGURE 27

Gasholders still are sometimes called "gasometers," an old-fashioned term surviving the industry's early period when the holder also was used to measure the gas by graduations on the tank's side. By the 1870s the term "gasholder" was preferred since separate meters were then in use for measurements. The Troy Gas Light Company had been using meters as early as 1855, if not before.

Iron gasholders were usually double- or single-lift types, although a triple-lift type was also constructed by some companies. *The New York Times* (7 April 1872) described how the holders looked and worked:

> To the untutored eye they present the appearance, when fully distended, of circular castles or forts, without portholes, embrasures or sally ports, or to the less military mind they might suggest selections of two enormous boilers, one sliding within the other, and set vertically into the ground. This [ground] tank [or pit] contains sufficient water to prevent the gas from escaping under the edge of the holder. When exhausted, the sections slide one within the other, like a telescope when shut up, and the whole affair sits down in the tank so that the top is nearly on a level with the surface of the ground. As the gas is let in and the pressure increases, the huge iron cylinders rise up and the inner one slides up until the holder is fully extended. These are called telescopic holders. Some are made with only a single section, or "single lift" as it is called. The average dimensions of holders approximate seventy feet in diameter with height of about 60 feet, and a capacity of less than 850,000 [cubic] feet.

The Troy holder was a telescoping two-lift type. Its top section had a diameter of 100 feet and a height of 22 feet, and the lower section had a diameter of 101 feet-6 inches and a height of 22 feet. It had a capacity of 330,000 cubic feet of gas. The gas passed through inlet and outlet lines 12 inches in diameter. The weight of the holder provided the pressure of the gas in the mains; at the Troy holder the pressure was 4½ inches. Gas pressures were too low to be practically measured by the conventional pressure-standard of pounds-per-square-inch and so was expressed in terms of the height of a column of water, in inches, that the pressure would support, i.e., so many "inches" (of water column).

The underground tanks of the gasholders were made of stone, brick, concrete, or cast or wrought iron. The brick tank under the Troy holder had a diameter of 103 feet 2 inches and was 23 feet deep. Together the Troy holder, tank, and house were valued in 1892 at $68,093.95. The various mechanical problems resulting from the cold climate were ultimately overcome by improving the holder and thereby eliminating the need of a house.

The dozen gasholder houses that are known to survive in upstate New York and New England were built in the 1870s, with the exception of one in Concord, New Hampshire, dated 1888.

Location	*Date*	*Material*	*Present use*
Attleboro Falls, Mass	?	Brick	Storage
Salem, Mass.	1873	Brick	Gasholder (unused) house
South Boston, Mass.	?	Brick	Storage
Valley Falls, R.I.	?	Stone	Utility company garage
Warren, R.I.	?	Brick	Utility company garage
Concord, N.H.	1888	Brick	Gasholder (unused) house
Concord, N.H.	?	Wood	Gasholder (unused) house
Albany, N.Y.	?	Brick	Utility company garage (demolished 1971)
Saratoga Springs, N.Y.	?	Brick	Utility company garage
Seneca Falls, N.Y.	?	Brick	Automobile showroom
Syracuse, N.Y.	?	Brick	Glass and paint store
Troy, N.Y.	1873	Brick	Warehouse and garage
Batavia, N.Y. (2)	?	Brick	Storage

Alterations and Additions: Originally the Gasholder House had a small, one-story brick porch located in the center bay of the south side facing Jefferson Street.

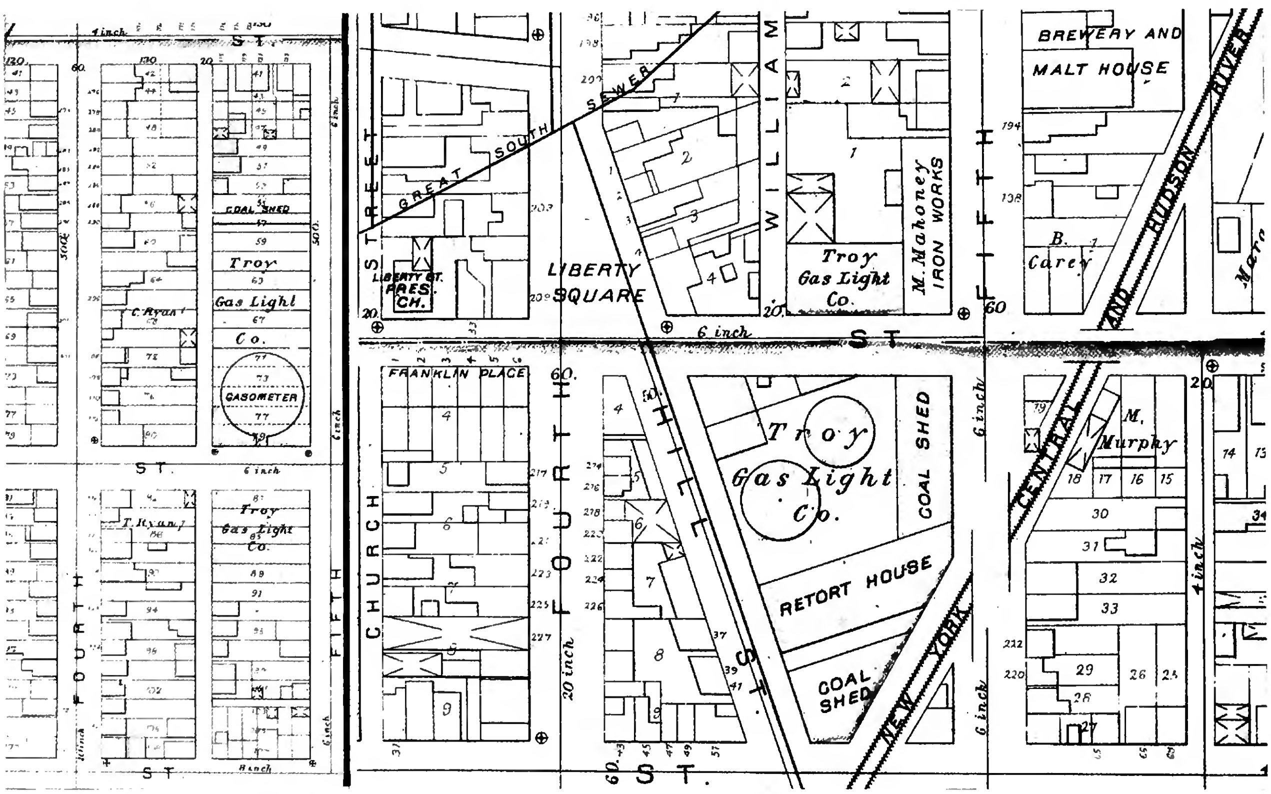


FIGURE 28.—Map: *a,* Fifth and Jefferson site, 1881; *b,* site of Liberty Street Works, Troy Gas Light Co., two blocks north of Fifth and Jefferson. (*a: Hopkins, 1881, plate 55, detail; b: plate 50, detail.*)

FIGURE 29.—View of the Gasholder House from the northeast.

The porch has been removed but the markings on the brick of the gasholder house wall suggest that the porch had a gabled roof. Judging from other gasholder houses extant in New England, this room was used for an entranceway and as a governor room. According to an 1875 atlas, the house originally had "windows all around"; some of these have been bricked in. The present owners have cut a large entrance into the central bay of the north side for truck access. By 1892 a boiler house and a purifying house had been constructed north of the Gasholder House; in 1910 a separate governor house was built.

The Gasholder House at Jefferson Street was in operation in 1912, and was probably taken out of service during the 1920s when a new central plant was built at Menands. In 1930 the holder itself was removed and sold as scrap metal. The house subsequently was used for storage by Oscar C. Buck, a circus manager, and for marching practice by local bands. It is used for storage and as a garage by the present owner. The works at Liberty Street was in service in 1892 but not in 1912, when it probably had been superseded by a new works built at Smith Avenue.

The Troy Gas Light Company, which first supplied the city with illuminating gas in 1848, maintained a monopoly for the manufacture of gas in Troy until 1875 when the Troy Citizens Gas Light Company was founded. Ten years later, in 1885, the Troy Fuel Gas Company was founded. On 11 October 1889 these three companies were consolidated to form the Troy Gas Company. The Troy Electric Light Company, founded in 1886, merged with the Troy Gas Company about 1893, followed by the merging of the Beacon Electric Light Company in 1908. In 1926 the Troy Gas Company joined with the Mohawk Hudson Power Corporation, which in turn joined with the Niagara-Hudson Power Corporation in 1929.

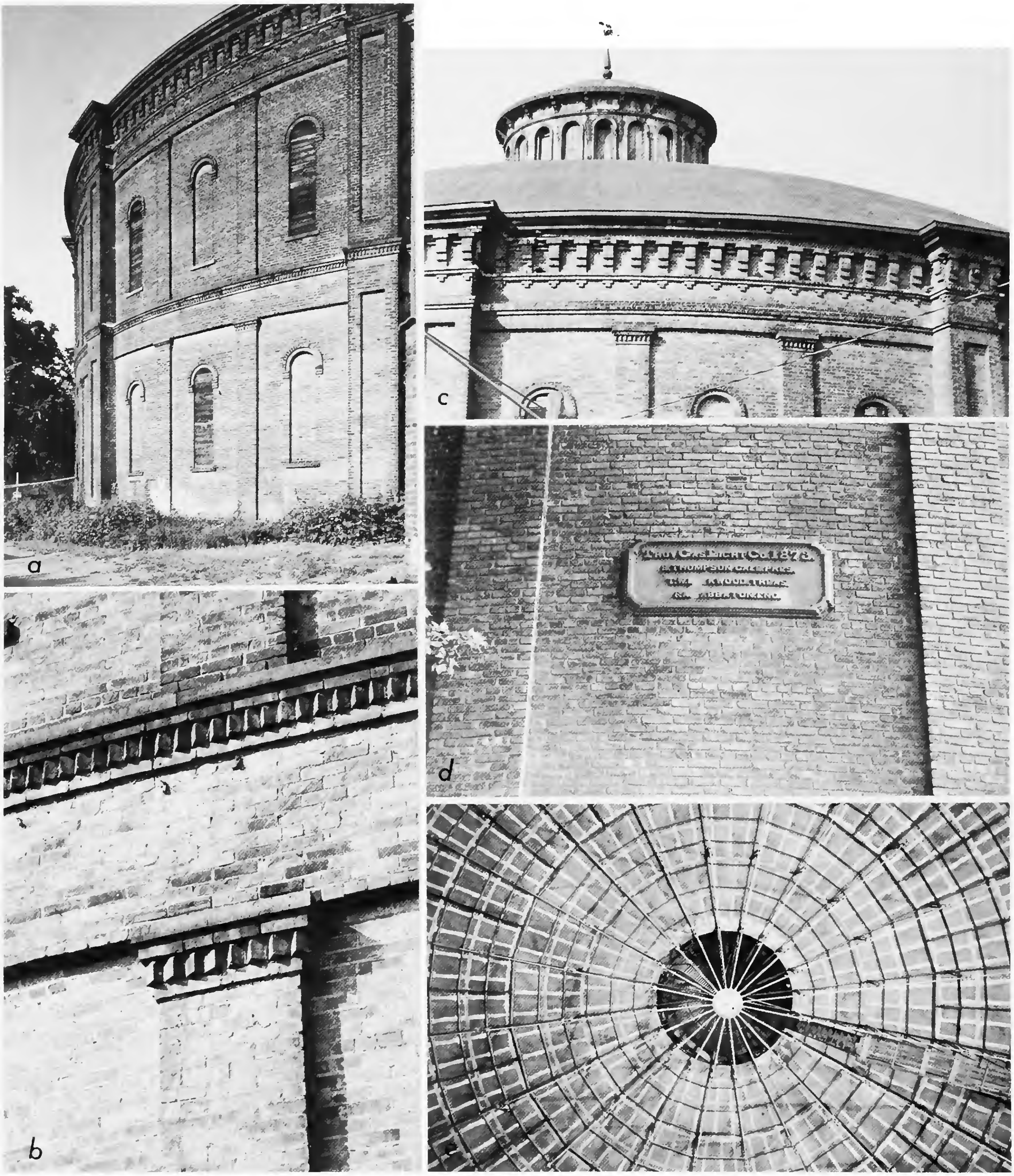


FIGURE 30.—Gasholder House: *a,* Partial west elevation; *b,* details of the pilaster and belt-course brickwork; *c,* the cornice and cupola from the east; *d,* tablet on the south face; *e,* the radial roof trussing from below.

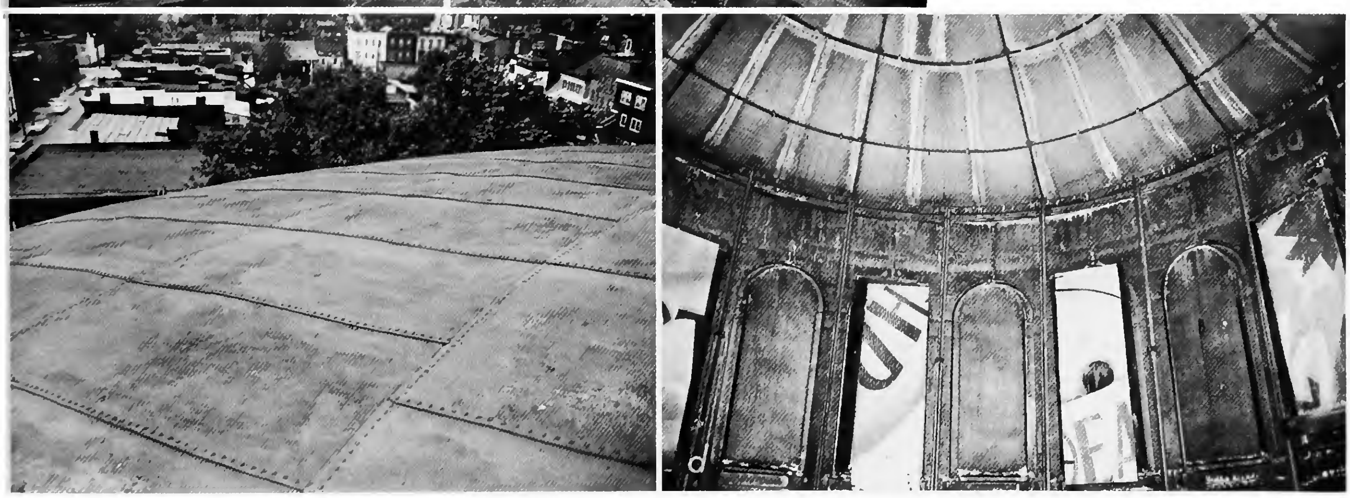



FIGURE 31.—Gasholder House: *a-b,* The cupola and roof sheathing has survived as soundly as it has, despite the weathering of much of the original galvanizing, because of the inherent rust resistance of the wrought-iron sheet; *c,* roof plates; *d,* interior of the cupola (alternate "windows" are blind, painted on the exterior in imitation of sash; a ventilating cupola was a vital necessity on gasholder houses to prevent the accumulation of gas under the roof). (*Vogel*)

History of the Physical Plant

The Troy gasholder and its house were just one facet in the manufacture of illuminating gas. The other elements of the works of the Troy Gas Light Company were located about two blocks northeast of the holder on the irregularly shaped block bounded by Liberty, Fifth, Hill, and Washington Streets and by the tracks of the New York Central Railroad. This block was the original site of the works of the Troy Gas Light Company, which was chartered in 1848.

At the time the Gasholder House was constructed, there were several buildings used for the manufacture of coal gas on that block. Extending along Fifth Street to the corner of Liberty Street was a coal shed. It was rectangular in plan, approximately 200 feet along Fifth Street and 34 feet along Liberty. The shed was of brick, with iron doors along Fifth Street; it had a wooden cornice, measured 28 feet to the eaves and had a "skylight" running the entire length of the roof. Although the Sanborn map (1875) indicated "skylight," it would be more reasonable to assume that it was a "monitor" because: (1) there was need for ventilation of the stored coal; (2) there was no need for light; (3) it was uncommon for a skylight to run the full length of a roof; (4) a nontechnical map publisher might be apt to call a monitor a skylight; and (5) the same atlas indicates that the roof of the Rensselaer Iron Works Rail Mill also contains a "skylight," shown on both buildings by the same convention (parallel dotted lines). The rail mill had a monitor roof at that time.

Adjoining the south end of the coal shed was the heart of the system, the retort house, trapezoidal in plan, measuring roughly 200 feet by 50 feet, with its longitudinal axis running east to west. A brick structure with iron roof beams, this building measured 22 feet to the cornice, which was of brick or metal. In the retort house the coal was burned to produce crude gas.

Fronting on Hill Street and adjoining the retort house at its southwest corner was the condenser building. This was a small rectangular brick building of one story, approximately 10 by 20 feet with a brick or metal cornice. In the condensers tar was separated from the crude gas.

Adjoining the condenser building on the north was the exhauster building, which contained a 12 horsepower engine to drive the exhauster, or pump, that forced the gas through the system and ultimately into the holders. Opening off the north side of that building was another small building housing a 75 horsepower steam boiler. These two buildings were also of brick and were one story high each.

In the open space in the center of the block, north of the retort house and west of the coal shed, there were two iron gasholders, each approximately 50 feet in diameter, neither protected by a gasholder house.

At the northwest corner of the lot was the purifying building, where sulphur was removed from the gas. This building was a two-story brick structure with an iron roof and a brick or metal cornice. The building measured approximately 35 x 40 feet. Adjoining this building on the south was a two-story brick structure containing the meters and the steam-heated office.

At the south end of the lot was another coal shed. This was also of brick and measured 24 feet to the cornice. A tar well also was located there. In the 1870s the company burned gas coal supplied by Freeman Butts of Cleveland, Ohio. All the buildings on the block described above have been razed; only portions of a brick wall now remain.

The company also had a coal shed on a dock at the foot of Division Street, one block north and seven blocks west of the works. Approximately 130 feet north of the Gasholder House was another coal shed, which still stands. It extends from Fifth Avenue west to the alley, a distance of approximately 100 feet, and is about 30 feet wide. Between that shed and the Gasholder House there originally were gas pipes scattered about. The area was enclosed by picket and board fences.

Sources of Information

Unpublished

"History Diagram, Drawn by K. W. Heldt, Jan. 1932, Drg. No. 2236–40, Niagara Hudson System, Western, Central & Eastern Division, Northern New York Utilities Inc." Public Relations Office, Niagara Mohawk, State Street, Albany, New York.

Interview with Mr. McColl, Niagara Mohawk Power Corp., North Albany, New York.

Public Service Commission, Case 2682: "In the Matter of the Application of the TROY GAS COMPANY under section 69 of the Public Service Commission Law for authority to issue Capital Stock and convertible notes." State of New York, P.S.C. Second District, Division of Capitalization, Report, 10 November 1913.

Plaque on the Gasholder House, dated 1873, which states that E. Thompson Gale was president and T. W. Lockwood was treasurer of the Troy Gas Light Company, and that F. A. Sabbaton was the engineer.

Published

American Gas Light Journal and Chemical Repertory, volume 18 (2 May 1873), pages 148–149, and volume 20 (2 May 1874), page 157.

Anderson, George Baker. *Landmarks of Rensselaer County.* Syracuse: D. Mason & Co., 1897.

"Gas and Gas-Making." *Harper's New Monthly Magazine,* volume 26, pages 14–28.

Hopkins, G. M. *City Atlas of Troy, New York.* Philadelphia, 1881.

New York Times, 7 April 1872.

R. D. Wood & Co. *Water & Gas Works Appliances.* Philadelphia, 1896.

Sanborn, D. A. *Insurance Maps of the City of Troy, New York, Including West Troy and Green Island.* New York, 1875.

Troy Daily Press. 1873, 1894.

Troy Directory. 1861–1894.

Troy Gas Light Co. *Rules and Regulations of the Troy Gas Light Company, for the Introduction of Gas and for Extensions and Alteration of Gas Fittings. . . .* Troy, 1855.

Weise, Arthur J. *History of the City of Troy.* Troy: William H. Young, 1876.

————. *Troy's One Hundred Years 1789–1889.* Troy: William H. Young, 1891.

ARCHITECTURAL INFORMATION

General Statement

Structural Character: This is one of the largest gasholder houses still standing in the United States. None of the original gasholder remains except the guide rails and counterweight pulleys. The tank has been filled in, leaving only the space above grade level for use. Cylindrical one-story structure with ten radial bays and low dome surmounted by a cupola.

Condition of Fabric: Fair to poor.

Description of Exterior

Overall Dimensions: Outside diameter: 109′–2″; 47′–11″ to top of brick cornice.

Foundations: Not accessible; probably stone.

Wall Construction, Finish, and Color: The red brick bearing walls are of American bond with a header course every seven courses. The bricks have the following identifying marks: MB, RBco, and BLEAU.

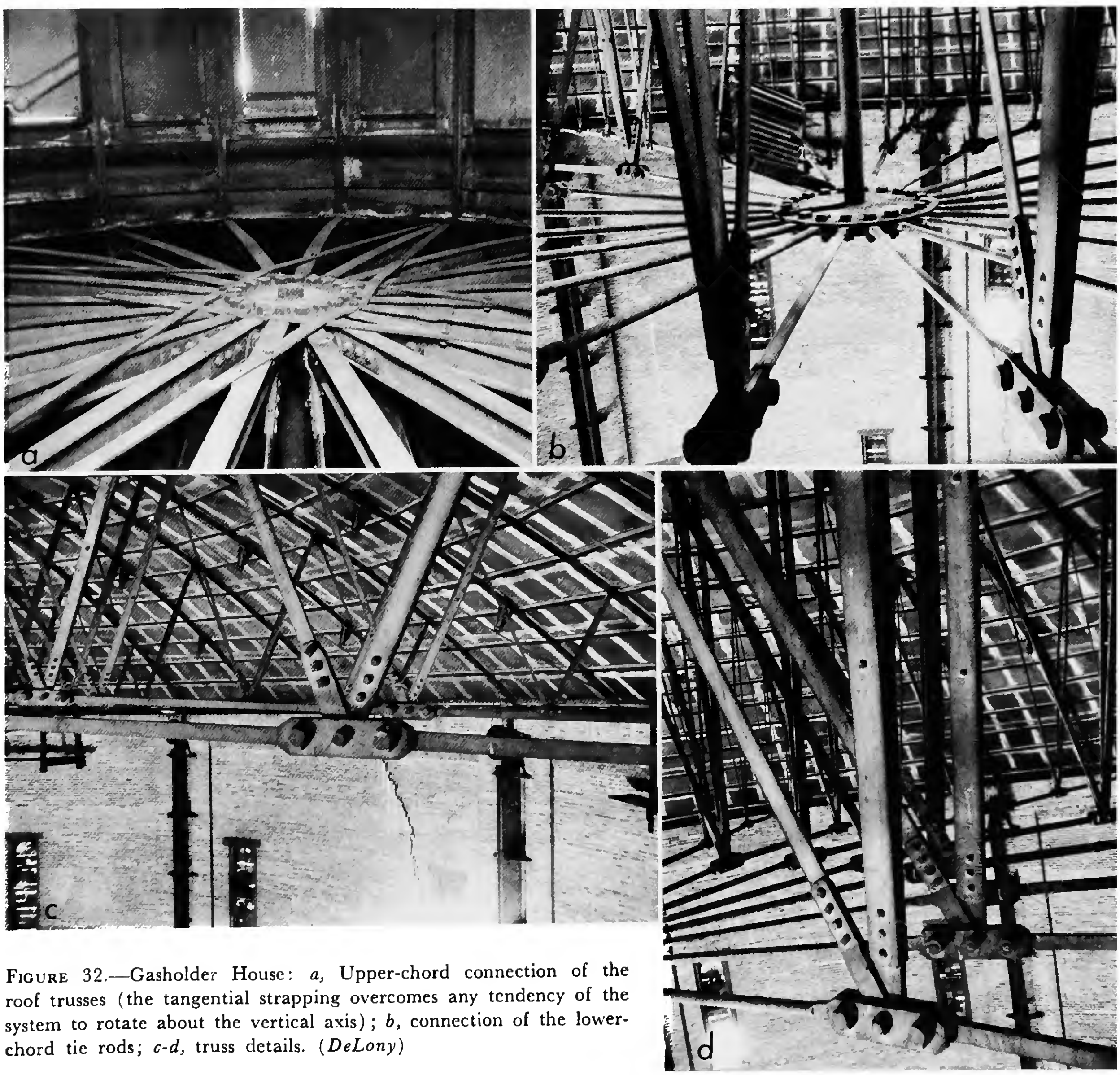


FIGURE 32.—Gasholder House: *a,* Upper-chord connection of the roof trusses (the tangential strapping overcomes any tendency of the system to rotate about the vertical axis); *b,* connection of the lower-chord tie rods; *c-d,* truss details. (*DeLony*)

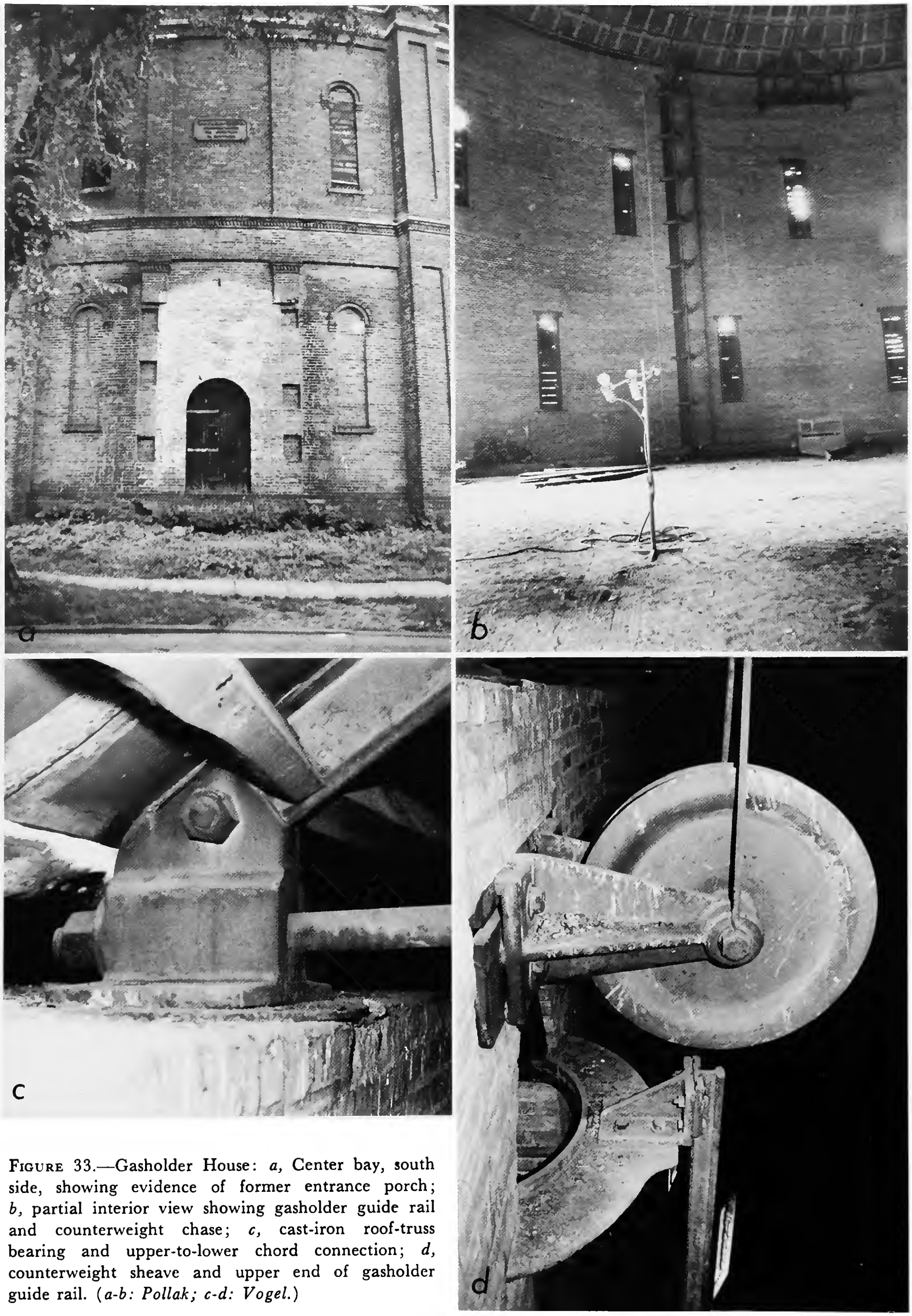


FIGURE 33.—Gasholder House: *a*, Center bay, south side, showing evidence of former entrance porch; *b*, partial interior view showing gasholder guide rail and counterweight chase; *c*, cast-iron roof-truss bearing and upper-to-lower chord connection; *d*, counterweight sheave and upper end of gasholder guide rail. (*a-b: Pollak; c-d: Vogel.*)

Structural System, Framing: The wrought-iron roof trusses were probably fabricated by Phoenix Iron Company, Philadelphia. There are twenty major and twenty minor trusses radiating from a central point. The bottom chords are adjustable, and the trusses are supported on the circular brick bearing wall which has pilasters at the truss bearing points. Each truss has a 1:7 depth-span ratio.

Governor Room: Stone foundations and wall markings give indication of a brick "porch" originally at the south entrance, which contained the gas-pressure governor.

Openings: Doors and Doorways: The original wooden frame and door are on the south face, but a later wooden frame and door were added on the north.

Windows: The frame and sash of the double-hung windows are of wood, boarded up at present.

Roof: Shape and Covering: The low dome is covered with $\frac{1}{32}$- to $\frac{1}{16}$-inch galvanized-iron trapezoidal panels, overlapping 2 inches, with stitch rivets one inch on center. They are stitch riveted to purlins 11 inches on center.

Cornice and Eaves: Brick corbeled cornice with galvanized metal eaves.

Cupola: Galvanized sheet-iron cupola, 19′–2″ outside diameter, divided into 20 bays. There are double-hung, wooden windows in alternate bays. The alternate blind panels are painted with windows in imitation of the actual ones.

Description of Interior

Floor Plan: Circular plan 104′–0″ in diameter. The original gasholder tank has been filled with blast furnace slag to the level of the exterior grade. The tank would have been about 23 feet deep, enough to accommodate the two-lift gasholder, each section of which was 22 feet high.

Stairway: Leading to the level of the trusses at the cornice is a stairway cantilevered from the interior wall. It is supported by cast-iron brackets and has wood treads and cast-iron handrails. There is a radial catwalk leading from the balcony to the cupola.

Special Decorative Details: The brickwork is embellished, especially the cornice. The two rows of windows, beltcourse, and pilasters create a well-proportioned two-story illusion. The beltcourse and pilaster capital bricks are diagonally lain in a saw-tooth moulding. Shallow brick hoods accent the window arches. The cupola repeats the rhythm of the brick wall surface.

Site and Surrounding

Setting: An area of mixed use, principally commercial and low-income residential.

Outbuildings: Northwest of the Gasholder House is a simple rectangular brick building, with timber trussing, 6 bays by 12 bays. At present it is used as a warehouse; the interior has recently been remodeled.

Rail Mill 1866

Rensselaer Iron Works, Troy

(HAER NY–3)

R. Carole Huberman

Location: Foot of Adams Street and Hudson River, north of Poesten Kill, Troy, Rensselaer County, New York.
Latitude: 42° 43′ 15″ N. Longitude: 73° 41′ 50″ W.
Dates: Erected 1866; major alterations after 1904; burned October 1969.
Designer: Alexander L. Holley, C.E., M.E. (1832–1882).
Last Owner: Triple-A Machinery Company, Cleveland.
Last Occupant: Ludlow Valve Manufacturing Company (Patterson-Ludlow).
Significance: A typical example of nineteenth-centry masonry and heavy-timber factory construction; part of an important nineteenth-century iron works.

HISTORICAL INFORMATION

Corporate History

The rail mill of the Rensselaer Iron Works, eventually part of one of the largest nineteenth-century iron and steel manufacturing complexes (Albany & Rensselaer Iron & Steel Company), played an important role in the heavily industrial economy of Troy.

Troy's first rolling mill was erected on the south side of the Poesten Kill by the Troy Vulcan Company in 1846. That company was succeeded by the Troy Rolling Mill Company in 1852 and sold to the illustrious and inventive iron manufacturer Henry Burden, who in 1853 conveyed the property to the Rensselaer Iron Works, owned by John A. Griswold & Company. Until 1875 the Rensselaer Iron Works was owned by John A. Griswold & Company, a firm consisting of Griswold, Erastus Corning, Jr., and Chester Griswold. It was under this ownership that the Rail Mill was built on the north side of the Poesten Kill in 1866. The following year the Albany Iron Works, owned by Erastus Corning & Company, consolidated with the Rensselaer Iron Works. In 1868 the Bessemer Steel Works, owned by Winslow, Griswold, and Holley since 1863, and Erastus Corning & Company merged with the Rensselaer Iron Works; the titles were transferred to John A. Griswold & Company. By 1870 the Rail Mill had been converted to produce steel rails. In 1875 the Albany Iron Works, the Bessemer Steel Works, and the Rensselaer Iron Works were incorporated as the Albany & Rensselaer Iron & Steel Company, thus embracing one of the oldest iron works in the United States and the pioneer Bessemer plant in America. The principal shareholders were Erastus Corning, Jr., Chester Griswold, and Selden Marvin.

Ten years later, in 1885, the corporation was reorganized as the Troy Iron & Steel Company. The rail mill was abandoned in 1896 and re-occupied by the following year by the Ludlow Valve Manufacturing Company. Ludlow ostensibly was the last occupant of the structure. Triple-A Machinery Company

Historical Information: Material compiled by Lewis Rubenstein. Architectural Information: Prepared by Charles A. Parrott, III; additional data by Robert M. Vogel.

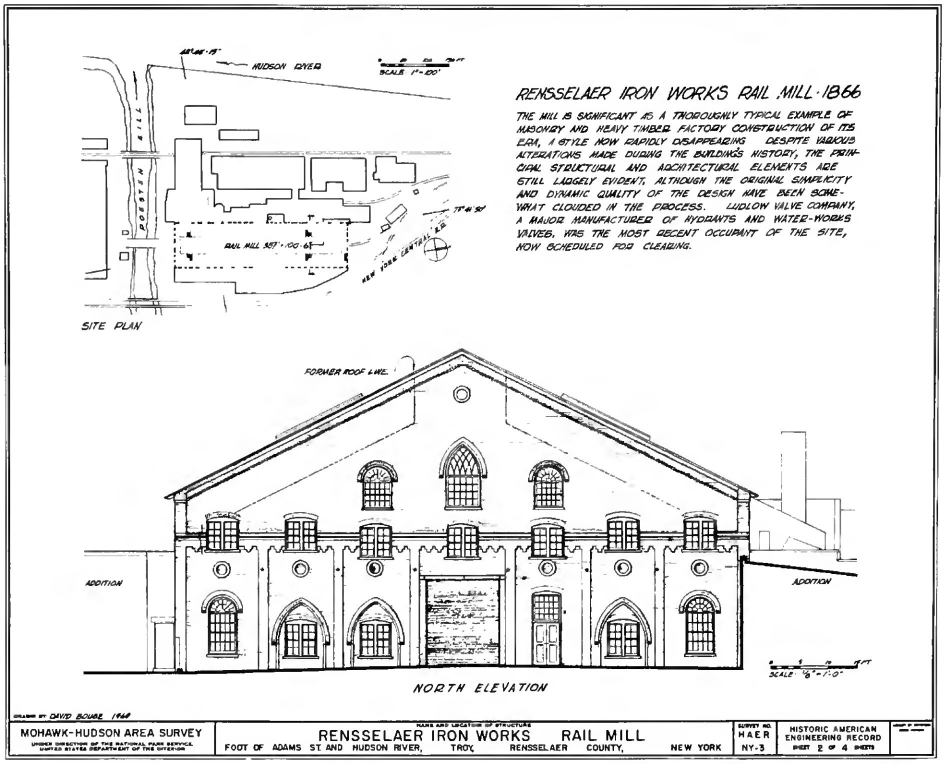


FIGURE 34

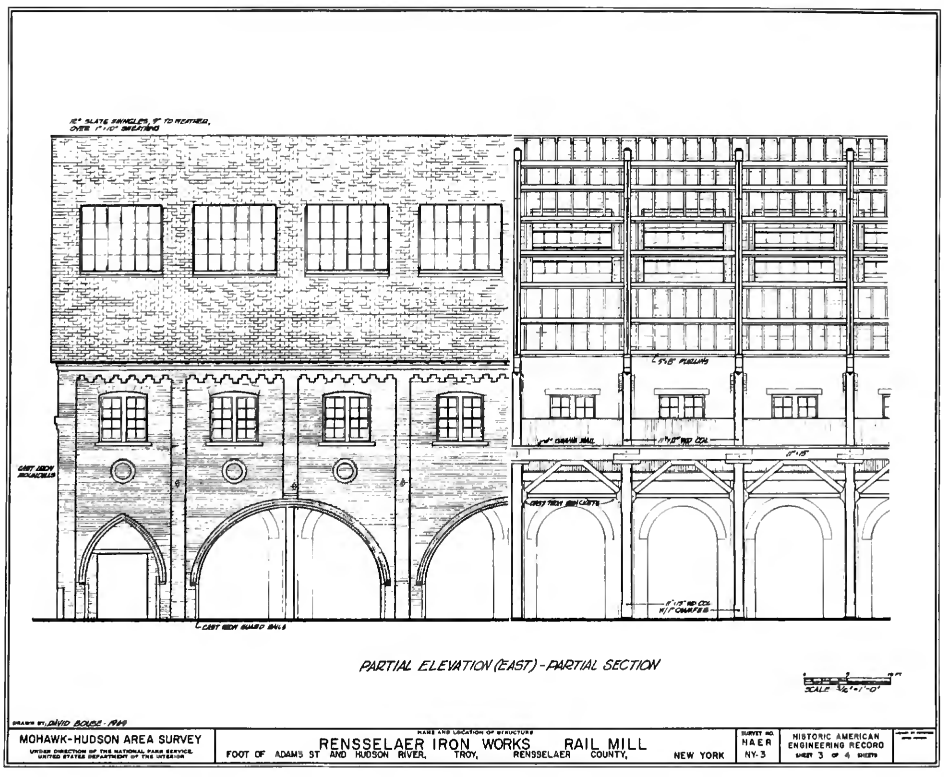


FIGURE 35

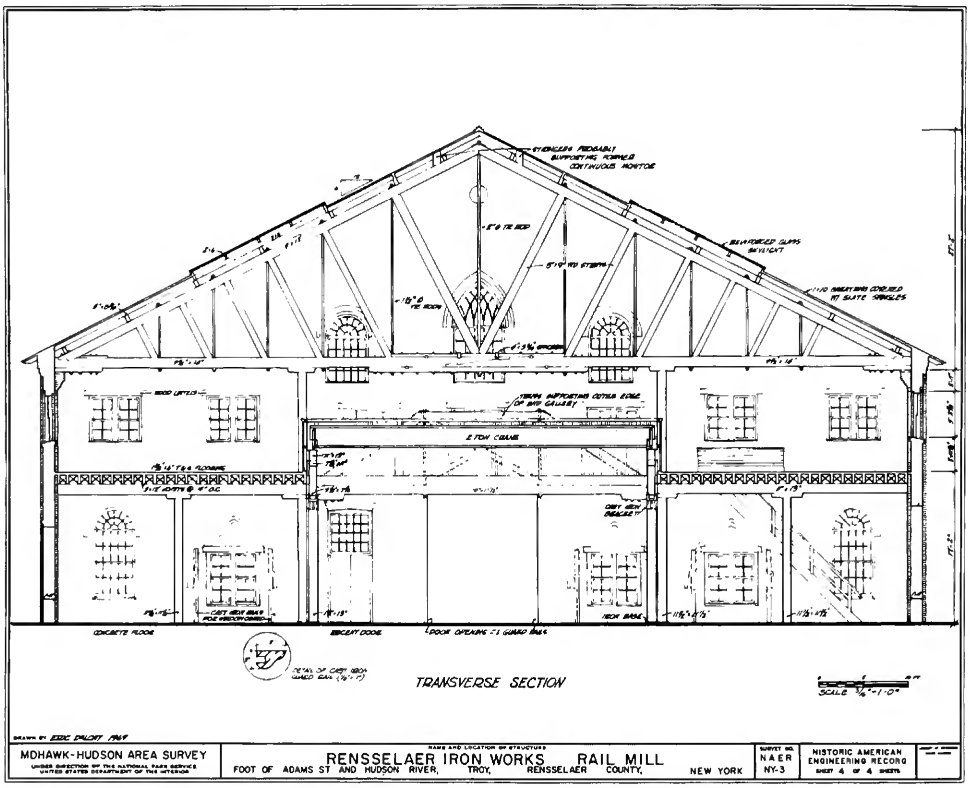


FIGURE 36

controlled Ludlow from 1960 to 1968 as Patterson-Ludlow. The plant was dismantled during the summer of 1969 and the building destroyed by fire the following fall.

Physical History

Date Stone: Northeast corner: 1866.

Alterations and Additions: The roof was raised after 1903 (Sanborn Map Company, 1903) at which time the monitor was replaced by skylights and the gallery-level windows were added immediately beneath the cornice on the heightened side walls, penetrating the belt-course on the north gable end. Ancillary buildings were connected to the main mill structure; the large open archways were filled in or otherwise altered at various times.

Operational History

Although Holley had obtained the American rights for the Bessemer steel process in 1863, the mill originally was intended for rolling iron rails, and did so until 1868. It was idle for several months during conversion to the rolling of steel rails, which commenced early in 1869 (John A. Griswold Papers, Griswold to Babcock, 1868–1869).

Property of the Albany & Rensselaer Iron & Steel Company, Troy, New York [5]

[partial listing]

RAIL MILL

Brick Building 100 x 400 feet
10 Rail heating furnaces and boilers attached
Three-high 21-inch train, 3 stands of rolls
2 Sturtevant blowers
Rolls for pattern steel rails, 35 to 71 pounds [per yard]
Also rolls for rounds of iron and steel of large sizes
3 duplex Worthington pumps
3 straightening presses }
2 rail punches } Each with separate engines
3 circular saws }
Fairbanks 10-ton scales for rails
Gustin's patent straightening machine for hot bed
Main engine: 800 horse power, 36 x 44 [inches, cylinder size]
Blower engine: 15 x 22 [inches, cylinder size]

[6] John A. Griswold Papers, 28 pages (n.d.: probably 1875); up-dated by hand, page 20.

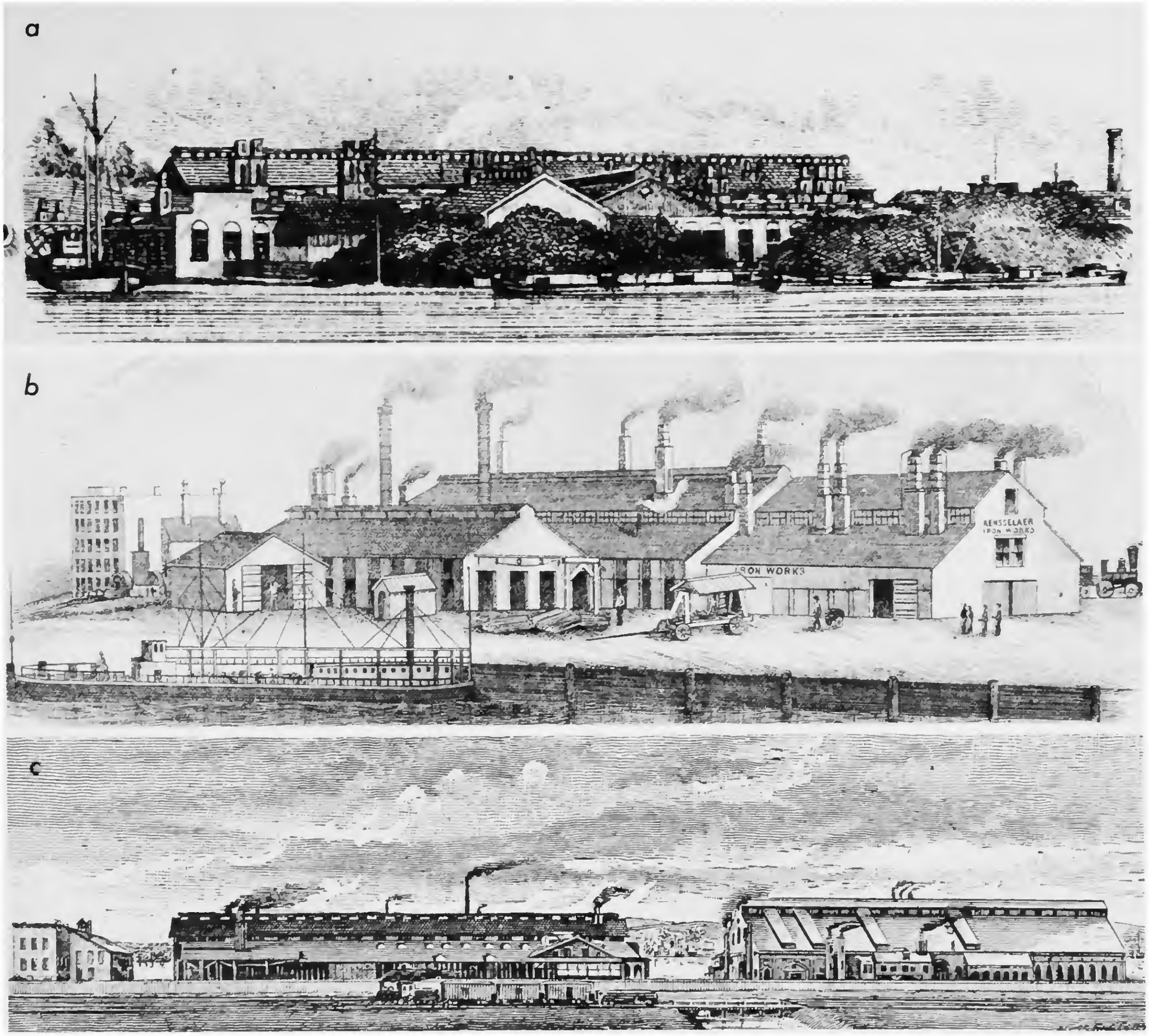


FIGURE 37.—Early views of the iron works: *a-b*, View from the river; *c*, view from the city side. The squat brick chimneys were from the rail-heating furnaces, seen in the plans of the mill (Figure 38*a*, *b*). The original monitor roof shows in all views. (*a: John A. Griswold papers, box 2, folder 97; b: Barton, 1869 [1858]; c: Weise, 1886, page 312.*)

SHEAR ROOM

1 Engine: 15 x 22 [inches, cylinder size]
3 Double plate shears
3 Double header lathes
1 Disc Press
1 Heating Furnace
2 Grind Stones
1 Double Emery Wheel
1 Fairbanks Scale
Dimpfel blower and machine for cutting axles, etc., etc.

TANK HOUSE

Brick building adjoining rail mill, elevated wrought-iron tank, capacity 25,000 gallons. Auxiliary boiler with steam on at all times when mill is not running and connected to 2 duplex Worthington pumps having hose attachment.

An extensive, illustrated account of the Albany & Rensselaer Iron Company by Alexander Holley and Lenox Smith appeared in 1880 in *Engineering* in which the rail mill is specifically described.

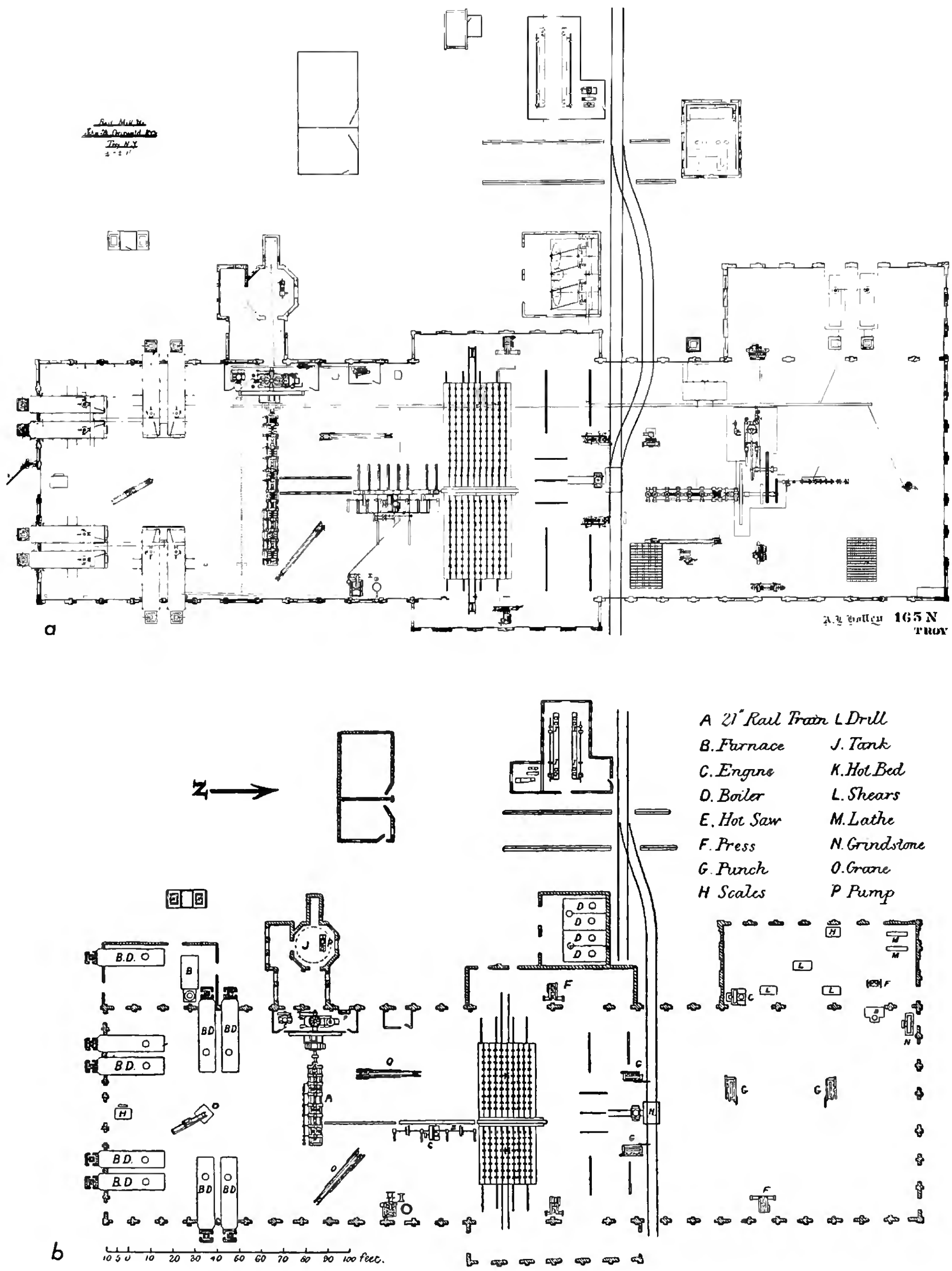


FIGURE 38.—Rail Mill: *a,* Design plan by Alexander Lyman Holley, c1866. All machinery in the mill was driven by steam engines. Two large beam engines driving the principal roll trains are shown, as well as a sizable family of smaller ones. All were supplied by the interconnected battery of ten horizontal boilers combined with reheating furnaces, arranged in pairs around the mill's periphery. The mill, as built, differed slightly from the plan in the number of its door and window openings. *b,* Plan of the mill, 1880, showing various alterations, resulting probably from the change from rolling iron rails to steel (the entire roll train with engine and boilers has been removed from the north end). (*a: Holley Collection; b: Holley and Smith, 1880, page 590.*)

. . . A brick building 375 ft. x 98 ft. with wings [Figures 38, 40]. There are ten coal-fired heating furnaces, each having a horizontal overhead boiler 5 ft. x 22 ft., with return flues. There are five auxiliary boilers, like those in the Bessemer department. The train is 21 in., three-high, with three stands of merchant rolls arranged to deliver to the rail sawing and finishing apparatus. The whole mill can thus be utilized as a merchant mill for medium and heavy work, when this pays better than rails; or both rails and merchant steel can be produced on different turns, when there is not demand enough for either product to alone fill the mill. The rail-train engine, vertical and condensing, has 3 ft. stroke and a 44 in. cylinder with Corliss valve gear, revolutions 80, boiler pressure 70 lb. The Gustin hot-curving apparatus is employed. . . . The rails, being uniformly curved without twisting by hand movement, are nearly straight when they get cold, and so require little cold straightening; they are therefore not subjected to that distortion and weakening which formerly caused so many fractures at the gag-marks. The double hot-bed with finishing machines are of good type and capacity. Eighty 7-in. blooms are charged into the ten furnaces per "round," and there are seven rounds per turn, thus producing 1120 rails per 24 hours. The heating coal, which also produces the greater part of the steam for the engines, is 460 lb. per ton of rails. The wing at the finishing end of the rail mill is devoted to the manufacture of 120 tons per week of agricultural shapes, such as harrow discs, etc. Materials and product are at this group of works received and delivered by the New York Central & Hudson River Railway on one side, and by the Hudson River on the other side.

Historical Associations

Industrial Development: The historical position of the Rensselaer Iron Works in Troy can be established and understood within the context of American industrial development by Holley and Smith's description. They list several key factors which encouraged the growth of an extensive nineteenth-century complex, 150 miles up the Hudson from New York City. (Actually, the seed of industry in the south Troy area was John Brinkerhoff's nail factory, established at the mouth of the Wynants Kill in the late eighteenth century, and his rolling mill, built on the north bank of the stream in 1807.) The Hudson itself and the "remarkable pass at West Point" (the only major break in the Appalachian Chain) were the first factors on Holley's list. Troy, at the head of the Hudson's tidal waters, provided linkage with transportation systems to east, west, north, and south; three miles of wharves lined its waterfront; and a network of railroads radiated from it—the New York Central, Boston & Albany, Delaware & Hudson, Troy & Boston, and the Boston & Hoosac Tunnel—connecting Troy to anthracite and bituminous coalfields 200 miles west, to the Lake Champlain ore mines 100 miles north, to the limonite beds 30 to 60 miles south and east, and to numerous markets. The Erie Canal, as well, afforded cheap transportation to the Great Lakes and westward. Flowing up the Hudson from New York City came a steady supply of immigrant labor, seeking whatever work the entrepreneurs could provide. Good markets for merchant and specialized iron and steel in New England and New York were as accessible as the sources of raw material and labor. Further, as the territories in the West filled in following the Civil War, there was an increased demand for manufactured goods such as steel rails and farm implements that were already being produced by Troy industries.

The Monitor: The reputation and productivity of the Rensselaer Iron Works can be emphasized by the part it played in fabricating iron plates for the *Monitor* during the Civil War. An 1880 account of the building of the ship notes the company's participation (Sylvester, 1880:22).

Among the ennobling acts of patriotic men during the several dark crises of the late Civil War, is the memorable service rendered the government by John A. Griswold, of the Rensselaer Iron-Works, and by John F. Winslow, of Albany Iron-Works, who, profoundly impressed with the deplorable ineffectiveness of wooden vessels of the United States Navy, earnestly urged upon the authorities the construction of that novel iron-battery, the *Monitor,* invented by John Ericsson. For not only did these men strongly advocate the building of the vessel, but they had the courage and enterpise to willingly hazard their reputations and money in building their experimental warcraft.

Contracts were let expediently to Corning, Winslow, & Company and to the Rensselaer Iron Company for all the rolled-plate armor and rivets to be used in construction of the ship. Work began immediately and proceeded with rapidity. The *Monitor* was launched 30 January 1862, only 101 days after the contract date.

Biographical Information

Alexander Lyman Holley: An engineer who has been recognized as the father of modern American steel manufacture, Alexander Holley was born 20 July 1832 in Lakeville, Connecticut. His father, Governor of Connecticut in 1357, manufactured cutlery. At an

71

THE

Albany and Rensselaer Iron and Steel Co.,

TROY, N. Y.,

PROPRIETORS OF

The Albany Iron Works, The Rensselaer Iron Works

The Bessemer Steel Works, The Fort Edward Blast Furnace,

The Columbia Blast Furnace.

MANUFACTURERS OF

RAILROAD SPIKES.

Railroad, Car, Truck, Engine and Street Car Axles; Fish Plates;
Bolts and Nuts for Fish Joints, all sizes; Merchant
and Angle Iron;

MERCHANT, BAR AND SPRING STEEL,

Sleigh-Shoe Steel, Tire Steel, Steel Shafting, Steel Crow Bars,
Boiler Rivets, Finger Bars and Shapes;
Agricultural Steel, all kinds.

CULTIVATOR AND SAFE STEEL CUT TO PATTERN.

Special Drop Forging, Gun and Cotton Roller Steel.

BESSEMER STEEL RAILS.

All orders addressed to us will receive prompt attention.

NEW YORK OFFICE, 56 BROADWAY.

FIGURE 39.—Advertisement, c1882, of the combined iron and sheel companies, which incorporated two basic iron furnaces as well. With the amalgamated firm and Burden's, the number of iron and steel works in the area was reduced to two. (*Files of Division of Mechanical and Civil Engineering, Museum of History and Technology, Smithsonian Institution.*)

early age Holley exhibited an extraordinary talent for writing and drawing as well as a keen understanding of the machinery in his father's factory. He also had a particular interest in locomotives. Before graduating from Brown University in 1853, he had already invented a steam engine cut-off. From 1853 to 1854 he was a draftsman and machinist at the famed Corliss & Nightingale steam engine works in Providence, Rhode Island, where he worked on an experimental (and spectacularly unsuccessful) locomotive equipped with the Corliss valve gear. From 1854 to 1855 he was employed by the New Jersey Locomotive Works in Jersey City; at this time, Holley edited the journal *Railroad Advocate* with Zerah Colburn, superintendent of the locomotive works. In 1856 he bought Colburn's interest and edited the journal alone, changing the title to *Holley's Railroad Advocate.* He soon enlisted Colburn's support, and the journal became *Holley and Colburn's American Engineer.* After only three issues publication was suspended. Holley and Colburn then went ot Europe to study foreign railroad practice, publishing a comprehensive report upon their return in 1858.

From 1858 to 1863 Holley was actively writing and traveling. He patented a variable cut-off valve for steam engines and a rail chair in 1859; the following year he prepared a list of engineering terms, definitions, and drawings for *Webster's Dictionary.* During this period he was scientific editor of *The New York Times,* for which he wrote over 200 articles on engineering and traveled to Europe as a correspondent. As a technical consultant to Edwin Stevens, he went to England in 1862 to investigate ordnance and armories, a subject on which he subsequently wrote a treatise.

Holley's most noteworthy activities began, however, when he went to England in 1863 for Corning, Winslow, & Company to obtain information and the American rights for the Bessemer steelmaking process (which were subsequently combined with the conflicting Kelly patents). Holley supervised the establishment of the first Bessemer plant in the United

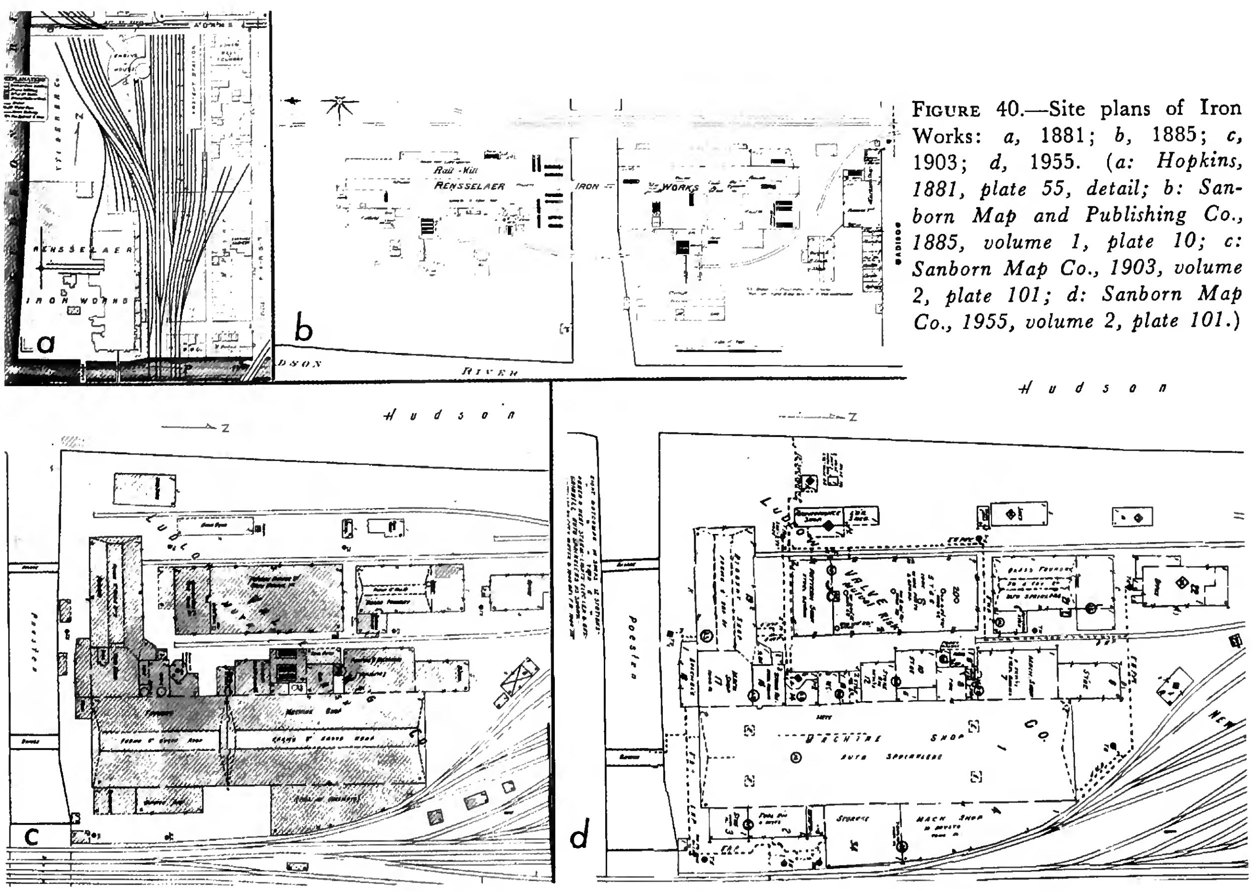


FIGURE 40.—Site plans of Iron Works: *a,* 1881; *b,* 1885; *c,* 1903; *d,* 1955. (*a: Hopkins, 1881, plate 55, detail; b: Sanborn Map and Publishing Co., 1885, volume 1, plate 10; c: Sanborn Map Co., 1903, volume 2, plate 101; d: Sanborn Map Co., 1955, volume 2, plate 101.*)

FIGURE 41.—Interior of the mill, 1958, occupied by Ludlow. (*Courtesy of Ludlow Valve Manufacturing Company.*)

States at Troy, New York, in 1865, and its enlargement in 1867, as well as other Bessemer works throughout the country. Holley devoted the rest of his life to the development and refinement of the Bessemer process. He became the foremost steel-plant engineer in the United States and conducted an extensive consulting practice in the design of iron and steel plants and equipment. Of the sixteen patents he obtained, ten were related to improvements in the Bessemer manufacturing process.

In 1875 Holley helped to organize, and served on, the U.S. Board for testing structural materials. He lectured on the manufacture of iron and steel from 1879 to 1882 at Columbia College School of Mines. His technical writing, profuse and seminal, included forty-one articles on American iron and steel, written in collaboration with Lenox Smith for the London journal, *Engineering*. Among his other professional activities, Holley was founder and president of the American Institute of Mining Engineers, founder and vice-president of the American Institute of Mechanical Engineers, and vice-president of the American Society of Civil Engineers. Holley died in Brooklyn on 29 January 1882. A bronze bust by J. Q. A. Ward memorializes him in Washington Square in New York City.

John A. Griswold: The principal partner in the Rensselaer Iron Works, Griswold was born in Nassau, New York, in 1818 and came to Troy in 1839 where he lived with his uncle, General Wool. In 1850 he was elected Mayor of Troy. Griswold's Civil War effort included not only his cooperation in building the *Monitor,* but also his activity in raising regiments.

In 1862 he was elected to the United States Congress as a War Democrat and subsequently served in the House of Representatives, 1863 to 1867, as a Republican; he is appropriately identified with the Committee of Naval Affairs. In 1868 he was defeated for the governorship of New York. Griswold served as a trustee of the Rensselaer Polytechnic Institute. He died in October 1872.

Sources of Information

Unpublished

John A. Griswold papers. Manuscripts, New York State Library, Albany, New York.

A. L. Holley collection. Manuscripts, Division of Industries, National Museum of History and Technology, Smithsonian Institution, Washington, D.C. [Holley's plan of Rail Mill.]

Published

American Iron and Steel Association. *The Ironworks of the United States.* Philadelphia, 1876.

Barton, William. *Map of the City of Troy and Green Island, N.Y.* Troy, 1869. [Map printed 1858, bound later.]

Beers, S. N., and D. G. *Atlas of Rensselaer County.* Philadelphia, 1876.

Dictionary of American Biography. New York: Charles Scribner's Sons, 1933.

Holley, Alexander L., and Lenox Smith. "The Albany and Rensselaer Iron and Steel Works, Troy, New York." *Engineering* (London, 24 December 1880), pages 590–592.

Hopkins, G. M. *City Atlas of Troy, N.Y.* Philadelphia, 1881.

New York State Engineer's Report, 1869. Albany, 1870.

Sanborn Map Company. *Insurance Maps of Troy, Renssalaer County, New York.* 2 volumes. New York, 1903.

———. [*Insurance Maps of*] *Troy, New York.* 2 volumes. New York, 1955.

Sanborn Map & Publishing Company. [*Atlas of*] *Troy.* 2 volumes. New York, 1885.

Sylvester, Nathaniel. *History of Rensselaer County, New York.* Philadelphia: Everts and Peal, 1880.

Weiss, Arthur J. *The City of Troy and Its Vicinity.* Troy: Edward Green, 1886.

———. *History of the City of Troy.* Troy: William H. Young, 1876.

Figure 42.—North elevation of Rail Mill showing outline of the original monitor roof in the gable end.

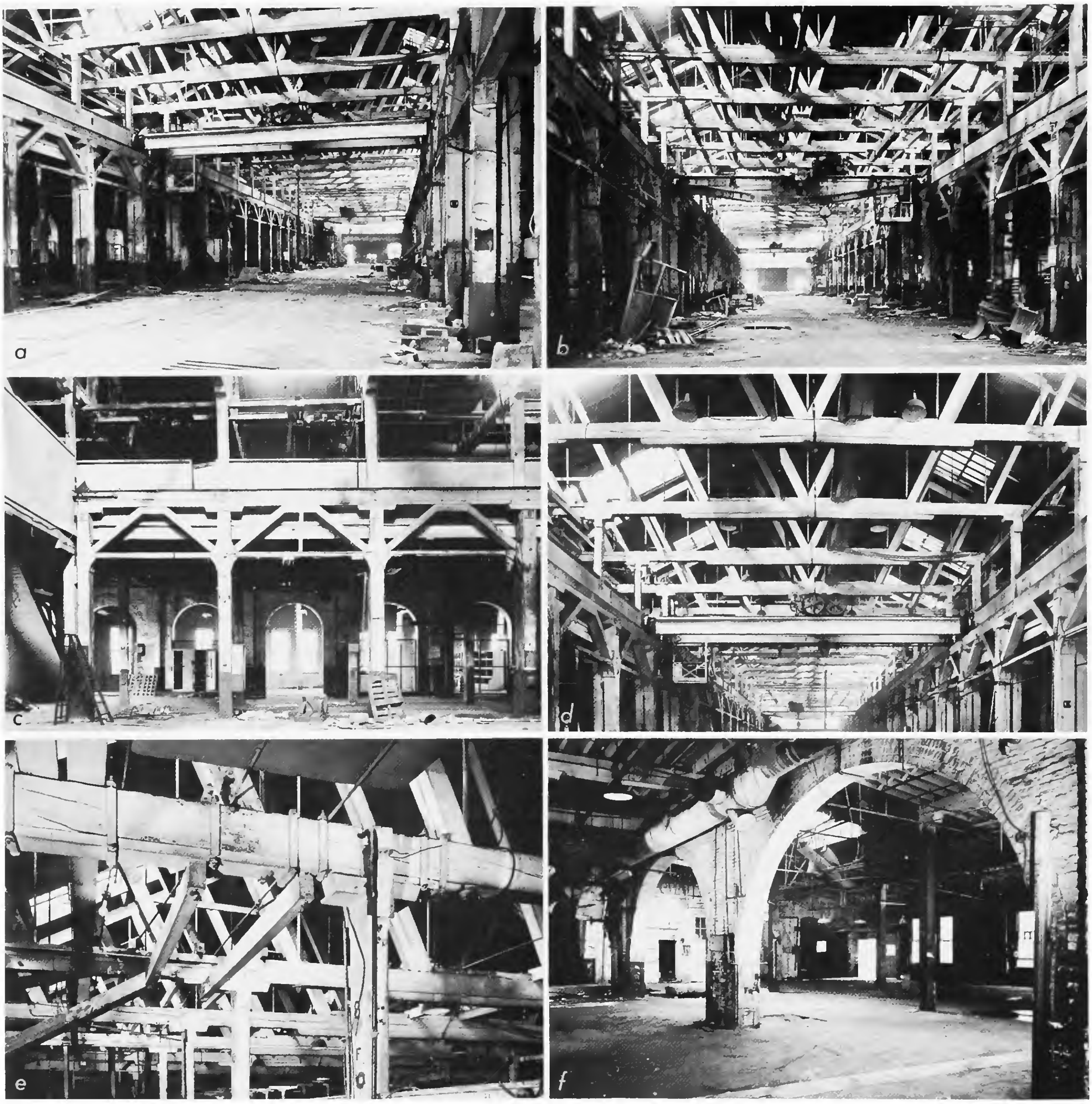


FIGURE 43.—Rail Mill: *a,* Main aisle, looking south (the side galleries and craneway framing probably were constructed simultaneously with the roof change, sometime after 1903, during Ludlow's early occupancy); *b,* main aisle, looking north; *c;* gallery for light machine tools and original arched window openings, now opening into one-story addition (the end balconies are an unusual feature); *d,* roof-framing detail, looking south; *e,* roof-framing details from north end of east gallery, looking southwest; *f,* double-bay arches in north end of west wall, opening into original lean-to wing.

ARCHITECTURAL INFORMATION

General Statement

Structural Character: Typical masonry and heavy timber construction.

Condition of Fabric: Structurally sound, in average condition for a heavy-industrial plant of its age.

Description of Exterior

Number of Stories: One with full perimeter gallery.

Number of Bays: 29 in length.

Overall Dimensions: 99 feet x 379 feet.

Layout, Shape: Rectangular with several appended wings on the sides.

Wall Construction, Finish, and Color: Solid red-brown brick bearing walls 16 inches thick with 4-inch pilaster projections on interior and exterior.

Structural System: The roof is carried by composite heavy-timber and iron (or steel) trusses, the bottom chord scarffed at the center. The gallery's outer edge is supported by wood posts that continue upward to the roof-truss bottom chords. On the inside face of each column is a similar column supporting the heavy-timber crane rails, at the gallery floor level. Knee braces and horizontal struts, set into cast-iron pockets on the side faces of the crane columns, brace the entire system longitudinally.

Openings: Doors and Doorways: In the north elevation is a large central materials doorway with steel I-beam lintel and rolling door, and a man-door in the first bay to the west of center with fixed 5-over-5 sash above, all recently installed. There are also three former archways with pointed-arch heads, probably originally to pass the chimney breeching of the combined rail-heating furnaces-boilers. These are now partially bricked in and are occupied by twin 4-over-4 double-hung sash under segmental brick heads. The side walls of the original block are pierced in each bay by round-arch openings, some leading to the later wings, some closed off or filled with doors or windows. As was common in rolling mills of the period, these openings originally were not provided with doors, the fullest ventilation being sought in warm weather and adequate warmth in the cold being furnished by radiation from the furnaces and hot metal in work. In the north end of the west wall are three round-arch openings, each spanning two bays, that open into an original wing on the northwest corner, now incorporated into the later wings.

Windows: In the upper level of the north end the original windows, which have shallow brick hood detail, consist of a central pointed-arch window with regular mullions and congruently arched fan mullions, flanked by two round-arch windows with double-hung sash, 10-over-10 glazing and fanlights. Cast-iron roundels above the open archways may originally have provided additional ventilation, but later were filled with masonry. When the roof was raised, twin, double-hung windows were added with 4-over-4 wooden sash set into segmental arch frames at the gallery level. In the side elevations these windows appear regularly, one pair per bay, immediately under the raised cornice. In the north gable end, the windows, set at two different levels, break into the original beltcourse.

Roof: Shape, Covering: The north wall clearly shows that the original roof was approximately 8 feet lower than the existing plank-sheathed, slate-shingled roof and had a central monitor. (The south wall does not exhibit the line of the lower monitor roof as does the north; therefore, it can be inferred that

FIGURE 44.—Rail Mill, section of floor of northeast corner of building. Log sections, of undetermined length, probably were employed as an inexpensive and relatively durable surfacing, anticipating (or imitating) commercially produced end-grain-block industrial flooring; or perhaps what is seen here are the ends of a cluster of close-driven pilings that formed the foundation for a heavy machine.

Figure 45.—Rail Mill: *a,* Arches and gallery framing, northeast corner; *b,* datestone [1866], northeast corner, facing north; *c-d,* ruins of the mill after the October 1969 fire; *e,* ruins of the office buiding. (*a: Pollak; b: Vogel, c-d: Paul R. Huey, for [N.Y. State] Division for Historic Preservation; e: Chester H. Liebs, for NYSDHP.*)

no part of the south wall is original, and that possibly this wall is not in its original location.) The wood trusses and possibly the gallery framing date from the raising of the roof. There is a 10-foot by 17-foot flush skylight within each bay of the roof.

Cornice, Eaves: The cornices on the side walls are similar to the corbeling and coursing of the original beltcourse on the north gable wall. The later cornice on the north end wall has an interesting corbel of trapezoidally shaped brick.

Description of Interior

Floor Plan: A single production area with a center and two side aisles is formed by the two rows of gallery and crane columns. Various wings open directly into the main area. The perimeter gallery is approximately 27 feet wide and 17 feet above ground floor. Two 20-ton bridge cranes command the main aisle.

Stairways: Five wooden stairways provide access to the gallery space from the ground floor.

Flooring: The ground floor is concrete; the gallery floor is of wooden plank on joists.

Wall and Ceiling Finish: The walls and timber system are painted.

Heating: None originally (see "Openings: Doors and Doorways," above) and none evident now. Various forms of space heaters probably were used by Ludlow.

Site and Surroundings

Setting: With its long axis almost directly north-south, the Rail Mill was part of a once thriving industrial complex located between the New York Central Railroad tracks (now Penn Central) on the east and the Hudson River on the west. The Poesten Kill cuts through the site just south of the mill.

Outbuildings: Machine shops and storage buildings were connected to the original mill along both sides for its entire length. To the north and west are various other Ludlow buildings.

Historical Addendum

Ludlow Valve Manufacturing Company, Troy

Samuel Rezneck

The Ludlow Valve Manufacturing Company, by its very name, indicates clearly the roots and rationale of its existence. The name Ludlow was that of the man who created the company by virtue of a patented invention that was its principal asset. The term "valve" in the title refers to the device whose manufacture was to become the principal purpose and product of the company. It provided a tight and secure means for controlling the flow of liquid or gas through pipe lines. Pipe lines and networks were to become, almost as much as the railway, principal indexes of technological progress in nineteenth-century America. Moreover, a consequence of the increasing urbanization of American society was the requirement of an adequate supply of water and gas, distributed through mains in the streets and structures of even the smallest towns. Only their concealment beneath the surface prevented these pipes from being as prominent a feature of the scene as the rails and electric wires which have disfigured, as much as they have served, the community. All are an equally characteristic measure of the mobility of man and his products which is the distinctive feature of modern society, especially in the cities.

Henry G. Ludlow's inventive ingenuity contributed at once to the necessities of city living and to the origin and growth of an important industry in the city of Troy. With Henry Burden, inventor of the horse shoe machine, and Mrs. Hannah Montague, the somewhat lengendary originator of the separate man's collar, Ludlow gave a special character and significance to Troy's industrial role in the nineteenth century. The decline of these key industries, too, has affected and aggravated the condition of Troy in the present period. The Ludlow Manufacturing Company is now (August 1969) undergoing a removal that will leave Troy with little of its old, historic, industrial pattern. One small valve plant, the Ross Valve Manufacturing Company, now remains in Troy as a reminder of its one-time importance in this field. Then there had been a half-dozen valve manufacturers in the immediate area and Ludlow had been the largest in the nation, if not the world. Ironically, but also interestingly, the buildings that once housed the Ludlow Company are now empty for the first time. In 1896, they had been abandoned by the Rensselaer Iron Works when its subsidiary, the Troy Iron & Steel Company, contracted its operations before closing down completely, shortly thereafter. In 1897 these buildings acquired a new occupant in the expanding Ludlow Valve Manufacturing Company. At the time of this writing they are in a shabby state of disrepair, with little prospect of a new tenant. They give promise of decay, deterioration, and destruction, which further intensifies the ghost-like character of south Troy, unless revived under an urban renewal scheme. [Destroyed by fire in October 1969, the building's fate is no longer in question (ed.).]

Henry Ludlow's early experience prepared him for his career as a valve inventor and manufacturer. Born in Nassau, New York, in 1823, the son of a lawyer and judge, Ludlow was educated in the schools of Oswego, New York. He was graduated as an engineer from Union College in Schenectady in 1843 and entered the field of gas manufacture in Philadelphia. For a number of years he directed the construction of gas plants in various cities. He became a member of the firm of Dungan, Streeter, and Company, which specialized in this business. While supervising the building of a gas plant in Poughkeepsie, New York, Ludlow became interested in the development of a valve that employed a single disc, or gate, with wedge and bar to keep it firmly in place when closed. This was patented and later Ludlow improved the device which was patented and publicized as the "Double Disc Parallel Seat Gate Valve." A "Slide Gate" fire hydrant was added to the patented valve, these devices becoming the basis of Ludlow's business activity for the remainder of his life.

Interested in initiating their manufacture, Ludlow settled in Lansingburgh, just north of Troy, where he began in a small way in the first years of the Civil War. According to oral legend, he would cross the only bridge then spanning the Hudson to Waterford, where he had castings made in a small foundry. He machined and assembled these into valves and apparently sold them himself. The Ludlow Valve Manufacturing Company was founded in 1861, but formal manufacture did not begin until 1866 in a small shop in Waterford. Business grew, and in 1872 it was moved to larger quarters in Lansingburgh. At this time, Ludlow acquired the business assistances of a Lansingburgh insurance man, John T. Christie, who became treasurer and subsequently president of the Ludlow Company.

Thus was added another complex metal product to the substantial list of horse shoes, stoves, bells, surveying and scientific instruments, rails, and railroad hardware for which the Troy area became noted in this period. All of them required, aside from basic materials, relatively complex machinery and male labor skilled in the mechanical arts. The last was supplied by the flood of immigration from Europe, which brought to Troy and to the United States in general a vast reservoir of labor, both skilled and unskilled. Troy, along with its neighbors, Cohoes and Watervliet, became in this period a polyethnic community, in which a relatively small middle class, predominantly Anglo-Saxon and Protestant, employed and controlled a considerable variety of other, primarily Catholic, ethnic groups, among them Irish, German, and French-Canadian. Although friction between upper and lower classes developed on a social and political level, divisive elements aligned principally on an economic basis. Labor conflict and unions thus appeared early in the area's industrial relations and gave rise over the years to difficulties which may in the long run have weakened and undermined industry in Troy and its neighboring communities.

The valve industry possessed some peculiar characteristics, particularly in relation to its market. This was, almost from the first, national in scope and consisted primarily of gas and water utility companies, both public and private. A special kind of salesmanship was required, combining technical, business, and even political skills. Each city's needs had, as it were, to be individually appraised and supplied with suitable and often specially designed valves. Standardization of product was difficult, if not impossible. Competition among makers was keen, and a certain degree of political persuasion was often a consideration in the final award of contracts. Winning municipal business of this type carried with it a certain advantage of priority in subsequent repairs and replacements.

Other valve producers located in the Troy area at this time. Among these was the Eddy Valve Company of Waterford, which claimed an even earlier origin at midcentury as a foundry for castings, probably including those for Ludlow's valve. Isaac Eddy's son, George Washington, devised a "taper-seat" valve in 1873 and later on a "Mohawk" hydrant. Thus began a rival valve concern which, under the ownership of the principal business family of the region, the Knickerbackers, survived until its recent absorption by an Ohio company. Another valve manufacturer was the Rensselaer Company, which began as a scale manufacturer. By 1887 it was located in Cohoes, across the Hudson from Troy, and it too, developed a line of valves. The firm was later merged with the Ludlow Company in a final effort to revive the industry.

In 1896, the Ludlow Valve Manufacturing Company made another move, to the plant in south Troy. It was not only larger but also better situated than the Lansingburgh works with reference to railroad and river transportation. On the site, located on the Poesten Kill at its junction with the Hudson River, was an extensive complex of structures, once the seat of the Rensselaer Iron Works.

In its new works Ludlow prospered and expanded into the largest valve manufacturer in the United States. It catered to a world market through a large network of sales agencies, which included a Canadian Ludlow Company in Montreal. This growth was due to the accelerated expansion of urban population, the growing demand of the oil industry for pipe line valves, and to continuing good management. Upon Henry Ludlow's retirement in the early 1890s, he was succeeded as president by John T. Christie, but more important was the appearance in the firm of Christie's son-in-law, James H. Caldwell. A graduate of Rensselaer Polytechnic Institute in 1886, Caldwell was the scion of a family that had developed the gas manufacturing industry in the South. He combined technical and business skills and applied them for more than forty years to the Ludlow valve business. Henry Ludlow's only son, however, was not interested in valve making, but instead became a founder and dominant figure in the Troy Record, Troy's only surviving and successful newspaper.

Significantly, the Ludlow Company underwent a change of ownership in that period which was to have serious consequences at a later period. Henry Ludlow, on retiring from active management, wished to dispose of his large interest in the company. The purchasers were a group of New York capitalists, among them the lawyer Samuel Untermeyer and his brothers, Marcus Stine, and Max Nathan. Thus was introduced an element of absentee ownership and management, which was content with profits, as long as presidents Christie and Caldwell were able to produce them. These absentee owners, however, were reluctant to invest capital in necessary technological improvements of the products and processes of manufacture. The difficulty became more serious in the 1930s when James H. Caldwell retired and, more particularly, when growing depression cut into both production and profits. The problem of management now became acute and was resolved only partially when the Untermeyer group of New York designated Caldwell's son-in-law, Livingston W. Houston, also a graduate of Rensselaer Polytechnic Institute, as president.

Houston introduced severe cuts and economies into Ludlow operations, but the effects of continued depression were not easily overcome. There was a serious loss of business, when the oil companies adopted more compact steel valves replacing the cumberson cast iron ones. Ludlow valves were left primarily with a declining market in water and gas installations. In 1935, Houston left Ludlow and became treasurer, then president, of Rensselaer Polytechnic Institute. Nevertheless, it was Houston, perhaps because of past family associations, who after World War II engineered the sale of the Untermeyer interests to a local group consisting of himself and other Troy investors. Ludlow was once more a locally owned company, as it had been in the beginning. The problem now was whether the company could be rebuilt and restored to its one-time leadership in the valve industry. This purpose determined the direction and intensity of effort during the next two decades. Despite some early success, the program and its objectives failed, ending in bankruptcy and final liquidation after 1960.

During this period Houston served as chairman of the Board of Directors. Of necessity, he was compelled to devote his major efforts to the Rensselaer Polytechnic Institute presidency; therefore, he could only influence and direct the company's business from a distance. The main quest of the Troy ownership group was for a competent president to manage Ludlow effectively in a difficult time. In this they never really succeeded. A succession of presidents followed one another, proving either too weak or too assertive, and none seemed effectual. Perhaps also there was a lack, aside from business management, of adequate technical direction, especially vital in an industry based on technology. A further impediment to efficient operations was the difficulty of product standardization, resulting from widely varying customer requirements and a large repair business from old, nonstandard systems. As a result, large stocks of patterns had to be maintained, and large production runs were uncommon.

World War II brought a temporary and special kind of boom in Ludlow's fortunes with a demand for special naval and maritime equipment. The United States Navy financed a foundry for steel castings as a wartime addition to the Ludlow plant. However, the problems returned after the war, perhaps in even more acute form. Many factors were at work, causing difficulties and retarding development. New plants had come into existence in the South and West, with greater advantages of location, access to materials and markets, and more advanced methods. Labor relations in Troy were troublesome as half a dozen separate unions in an old industry pressed for better wages but resisted technological innovations by slow downs. The conditions of divided and ineffective management persisted, as the search for a permanent and energetic president continued. Working capital was tight, allowing little if any surplus for improvements.

Interestingly, in 1954, came a last great effort to assure survival and even some hoped-for improvement, through a merger with the Rensselaer Valve Company of Cohoes. Claiming almost equal antiquity and character, Rensselaer was in almost equal difficulty. Much of the hope and promise lay in the acquisition of another line of valves and hydrants and in some improved machinery, as well as in the superior management available. More important, however, was the prospect of achieving economies and the reduction of personnel by a physical consolidation of the two concerns in the Ludlow plant.

The dismantling of the Rensselaer works was, however, delayed. In the meantime both plants continued separate operations, and the distance between them alone made cooperation difficult. The costs of removal were great and intensified the shortage of working capital. Annual losses were more frequent than earnings. A fateful step in the history of the Ludlow Company occurred when it was forced to negotiate a substantial loan, exceeding a million dollars, with a New York factoring organization, James Talcott and Company. It proved too great a burden, and early in 1960 the Talcott company initiated foreclosure proceedings against Ludlow. The works were immediately closed, throwing out of work the remaining 450 employees, of an earlier 800 divided between the Ludlow and Rensselaer plants.

Court proceedings for bankruptcy and possible reorganization began, and the problems of the company were aired both in court and in the press. Somewhat belatedly, the unions became concerned about the jobs of their members. There was a conflict of interests between the outside factoring organization interested only in their loan, and the local ownership group, which hoped for a resumption of activity. In the complex testimony that emerged, the unhappy state of the company was revealed.

Total assets were reported at nearly $3.5 million, divided among physical facilities, valued at some $1.5 million, and inventories, accounts receivable, and cash. Against this, liabilities were estimated at about $2 million, of which nearly half was represented by the Talcott claims. There was, however, a substantial backlog of orders to warrant resumption of operations.

The last years of this old company thus began in the shadow of bankruptcy and controversy. The resumption policy won out in 1960 when the Troy group sold its interests for a nominal sum to a Cleveland purchaser representing the Triple-A Machinery Company, in the used and scrap machinery business. Triple-A assumed all liabilities and for several years, until October 1968, operated the company on a much reduced scale, as a division of a subsidiary, Patterson Industries. The handicaps of absentee ownership plus all of the old difficulties proved too great, however, and in 1968, the plant was dismantled. Usable equipment was removed to East Liverpool, Ohio, where production is to be continued under the hybrid name, Patterson-Ludlow. The real import of the name Ludlow, with its history of a century is, however, gone. Another of Troy's nineteenth-century industries, once prospering and successful, has come to an end with a final whimper.

Sources of Information

Consultations with and considerable company materials obtained from:

L. W. Houston, former president of the company and chairman of the board.

Edwin A. Weinberg, former vice-president and works manager.

Raymond Lague, superintendent of the plant in its last days and supervisor of its final break-up and removal from Troy.

Numerous news stories in the Troy press, illustrating both the triumphs and the travails of the company.

Catalogs and other publications of the Ludlow and Rensselaer Valve Companies.

Weise, A. J. *The City of Troy and Its Vicinity*. Troy, 1886.

————. *Troy's One Hundred Years*. Troy, 1891.

Office Building 1881

Burden Iron Company, Troy

(HAER NY–7)

Samuel Rezneck

Location: Between First Street and Hudson River, site of former Lower (Steam) Works. Now on grounds of the Republic Steel Plant, Troy, Rensselaer County, New York. Latitude: 42° 42′ 36″ N. Longitude: 73° 41′ 58″ W.
Date of Erection: 1881–1882.
Designer: Unknown.
Present Owner and Occupant: Republic Steel Corporation.
Present Use: Warehouse for machinery parts and miscellaneous storage.
Significance: An interesting example of nineteenth-century American industrial-commercial architecture, and one of the few remaining structures of the Burden Iron Company, an early giant of the United States iron industry.

HISTORICAL INFORMATION

Original and Subsequent Owners: The chain of titles for the land of the Upper (Water) Works is recorded in the Rensselaer County Recorder's Office.

Seller / *Purchaser*	*Liber*	*Page*	*Recording date*
Stephen Van Rensselaer / *George Gardner and others*	4	456	8 Jan. 1808
Clarissa Adams and others / *Troy Iron & Nail Factory Company*	11	140	13 Oct. 1823
William P. Van Rensselaer / *Troy Iron & Nail Manufacturing Co.*	67	110–111	6 Apr. 1847
William P. Van Rensselaer / *Henry Burden*	83	463–469	12 Aug. 1852

The Burden Iron Company was liquidated in 1940 and the lower site acquired by the Republic Steel Corporation.

Architectural Information: Prepared by Richard J. Pollak.

Corporate History

The *physical plant* of Burden's works was known as the Burden Iron Works from the time that Burden became its sole owner in 1848. It was owned and operated, however, by the *corporate entity* or firm of Henry Burden & Sons (after 1864, H. Burden & Sons). When reorganized in 1881, a decade after Burden's death, both firm and plant were restyled Burden Iron Company. All references herein to structures and events are thus to "Works" or "Company," according to whether they are pre- or post-dating 1881. (See "Chronological Notes," p. 96.)

One significant, small brick building remains on the site of what was once a great industrial complex located on the east side of the Hudson River in south Troy. It was built after the Civil War as an office building to serve the entire works that had developed over more than half a century. What was once a vast and unique example of American heavy industry is gone after a long period of unsightly deterioration. On its site now stands only a more modern blast furnace, that until recently operated somewhat irregu-

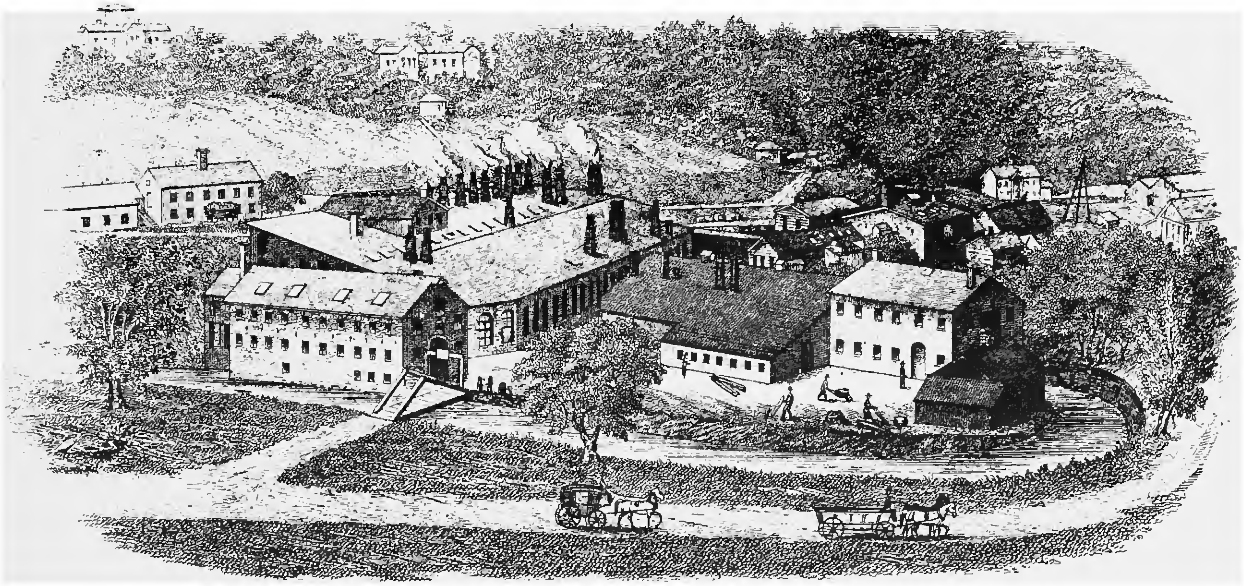
FIGURE 46.—Henry Burden (1791–1871). (*American Artisan, 1 February 1871.*)

larly as a subsidiary of the Republic Steel Corporation, and is now (1970) decommissioned permanently. How did the Burden Iron Company originate and develop over more than a century? What were its unique contributions both to Troy's growth and to the nation's industrial evolution? How and why did it come an an end? These are questions of broad social and human, as well as technical and economic, importance, and the answers to them comprise a vital part of the total record, supplementing the evidence of the single remaining building, which once contained the company business offices.

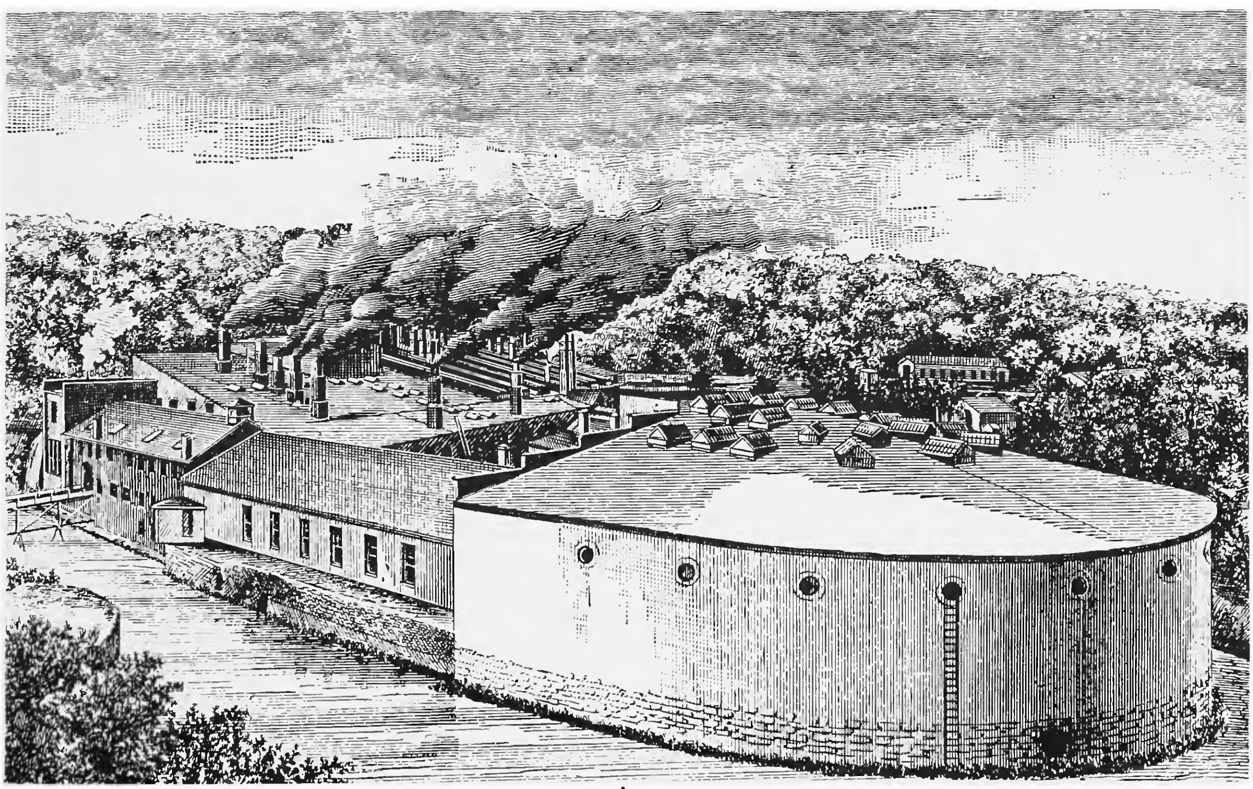
Iron-making in the Troy area had its beginnings between 1807 and 1809, when Troy proper was barely two decades old, with the erection of two small iron plants on a water-power site along the Wynants Kill, as it tumbled down 200 feet of cascades across a narrow littoral and into the Hudson River. This power had been used for grist and saw mills since the seventeenth century. Only Albany existed then as a settlement, and Troy was not founded until 1789. The capital for the early iron works came of necessity from Albany, but the power sites lay on Troy's side of the Hudson. Their products were primarily nails, spikes, and merchant or bar iron. One of these plants was established by John Brinkerhoff, and it ultimately developed into what was known as the Albany Iron Works, under the later ownership and management of Erastus Corning and John F. Winslow. These men played a large role in the growth of iron-making in this area, and during the Civil War joined with another Troy iron-maker, John A. Griswold, owner of the Rensselaer Iron Works, in contracting for the construction of the *Monitor* and other iron-clads. [The hull plates of the *Monitor,* built in Brooklyn, were rolled in Troy.] During the war Corning, Winslow, and Griswold also formed a company to acquire the American rights to the Bessemer patents and eventually constructed a Bessemer steel plant in south Troy, probably the first in the United States (see p. 56). This is a story by itself, deserving separate treatment. As a neighbor to Burden's on the Wynants Kill, the Troy Steel and Iron Company, as it was later known, thus grew out of a similar small beginning, and it contributed to the heavily industrial character of Troy during the nineteenth century.

The Burden industry originated in 1809, when several capitalists from Albany acquired a water-power on the Wynants Kill for the establishment of an iron works to manufacture bar iron, nail rods, hoop iron, and other metal products. A decade later it had become the Troy Iron & Nail Factory Company, with a capital of $96,000, divided into sixteen shares. These were held by half a dozen men, among them the original founders, John Converse, E. F. Bachus, Isaiah and John Townsend, and Colonel Nathaniel Adams. (One of Henry Burden's sons was later to be named after Isaiah Townsend.) Colonel Adams was the factory agent, and the small industrial village that had grown up about these iron works was called Adamsville.

Henry Burden came on this industrial scene a few years later, in 1822, as superintendent of the Troy Iron & Nail Factory. Born in Dunblane, Scotland, in 1791, he had arrived in Albany in 1819 as an immigrant mechanic with training in drawing and engineering, and recommendations from the United States Minister in Britain to Stephen Van Rensselaer, Thomas Benton, and John C. Calhoun. Van Rensselaer welcomed him to Albany, and for a time Burden engaged in the development of agricultural machinery, including an improved plow and



a

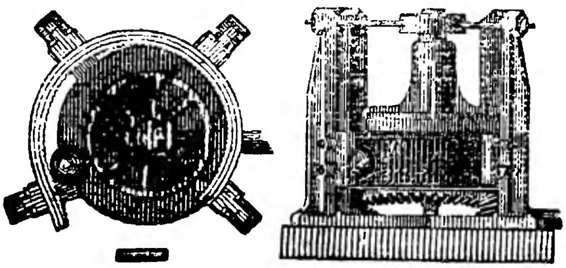


b

FIGURE 47.—Early views of the Upper Works, looking southwest from across the Wynants Kill: *a,* Troy Iron and Nail Factory, c1858; *b,* Burden Iron Company, c1885 (this view, the one most frequently reproduced featured the famed "horseshoe-shaped" horseshoe warehouse). (*a: Barton, 1869 [1858], plate 9; b: Weise, 1886, page 42.*)

MACHINERY.

Henry Burden's Patent Revolving Shingling Machine.



THE Subscriber having recently purchased the right of this machine for the United States, now offers to make transfers of the right to run said machine, or sell to those who may be desirous to purchase the right for one or more of the States.

This machine is now in successful operation in ten or twelve iron works in and about the vicinity of Pittsburgh, also at Phœnixville and Reading, Pa., Covington Iron Works, Md., Troy Rolling Mills, and Troy ron and Nail Factory, Troy, N. Y., where it has giv- universal satisfaction.

Its advantages over the ordinary Forge Hammer are numerous: considerable saving in first cost; saving in power; the entire saving of shinglers, or hammersman's wages, as no attendance whatever is necessary, it being entirely self-acting; saving in time from the uantity of work done, as one machine is capable of working the iron from sixty puddling furnaces; saving of waste, as nothing but the scoria is thrown off, and that most effectually; saving of staffs, as none are used or required. The time required to furnish a bloom being only about six seconds, the scoria has no time to set, consequently is got rid of much easier than when allowed to congeal as under the hammer. The iron being discharged from the machine so hot, rolls better and is much easier on the rollers and machinery. The bars roll rounder, and are much better finished. The subscriber feels confident that persons who will examine for themselves the machinery in operation, will find it possesses more advantages than have been enumerated. For further particulars address the subscriber at Troy, N. Y. P. A. BURDEN.

Railroad Spikes and Wrought Iron Fastenings.

THE TROY IRON AND NAIL FACTORY, exclusive owner of all Henry Burden's Patented Machinery *for making Spikes*, have facilities for manufacturing large quantities upon short notice, and of a quality unsurpassed.

Wrought Iron Chairs, Clamps, Keys and Bolts for Railroad fastenings, also made to order. A full assortment of Ship and Boat Spikes always on hand.

All orders addressed to the Agent at the Factory will receive immediate attention.

P. A. BURDEN, *Agent*,
Troy Iron and Nail Factory, Troy, N. Y.

an early cultivator. Van Rensselaer was a great landlord and patron of science and practical technology, who in 1824 founded the Rensselaer School in Troy to fulfill Amos Eaton's innovative program for the "application of science to the common purposes of life." This subsequently evolved into the present Rensselaer Polytechnic Institute.

PATENT RAILROAD, SHIP AND BOAT Spikes. The Troy Iron and Nail Factory keeps constantly for sale a very extensive assortment of Wrought Spikes and Nails, from 3 to 10 inches, manufactured by the subscriber's Patent Machinery, which after five years' successful operation, and now almost universal use in the United States (as well as England, where the subscriber obtained a patent) are found superior to any ever offered in market.

Railroad companies may be supplied with Spikes having countersink heads suitable to holes in iron rails, to any amount and on short notice. Almost all the railroads now in progress in the United States are fastened with Spikes made at the above named factory—for which purpose they are found invaluable, as their adhesion is more than double any common spikes made by the hammer.

All orders directed to the Agent, Troy, N. York will be punctually attended to.

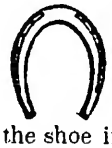
HENRY BURDEN, *Agent.*

Spikes are kept for sale, at Factory Prices, by I. & J. Townsend, Albany, and the principal Iron merchants in Albany and Troy; J. I. Brower, 222 Water St., New York; A. M. Jones, Philadelphia; T. Janviers, Baltimore; Degrand & Smith, Boston.

*** Railroad Companies would do well to forward their orders as early as practicable, as the subscriber is desirous of extending the manufcturing so as to keep pace with the daily increasing demand.

ja45

PATENT MACHINE MADE HORSE-SHOES.



The Troy Iron and Nail Factory have always on hand a general asssortment of Horse Shoes, made from Refined American Iron.

Four sizes being made, it will be well for those ordering to remember that the size of the shoe increases as the numbers—No. 1 being the smallest. P. A. BURDEN, *Agent*,
Troy Iron and Nail Factory, Troy, N. Y.

FIGURE 48.—Burden advertising. Burden's name had become well established by the late 1840s, on the basis both of the products of his works and his innovations in ironworking machinery. After 1848, when he had acquired sole ownership of the works, his eldest son, James A. [not P. A.], performed the duties of agent or general manager. (American Railroad Journal: *a: volume 22 (1849), page 236; b: volume 20 (1847), page 223; c: volume 22 (1849), page 239.*)

From 1822 to his death in 1871, Henry Burden devoted himself to the expansion of the iron works, which became virtually his own creation, in name, ownership, and character. He passed on a greatly enlarged plant to his two surviving sons, James A. and I. Townsend, the first of whom displayed much of his father's inventive ability and directive capacity. It is noteworthy that, while the small beginnings of the Troy Iron and Nail Factory were the work of a group of men, the great growth of the Burden industrial complex was essentially the achievement of one man, Henry Burden himself.

Henry Burden's contribution was two-fold. In the first place, it was managerial. Burden displayed a great capacity both for internal management and for the required business relations with expanding domestic and foreign markets. In the second place, he was technically innovative, and became indeed one of the principal inventors in nineteenth-century America. A painting of eminent American inventors in the 1860s shows Henry Burden in company with such other figures as Eli Whitney, Robert Fulton, and Samuel Morse.

Burden's inventive career in the iron industry began early. By 1825 he had already patented a machine for making wrought-iron nails and spikes. This branch of manufacture, for which the plant had originally been established, continued to be important to the end. In 1835, however, Burden's inventive talent turned to a new area, the machine manufacture of horseshoes. This industrial innovation, for which Burden's became famous, elevated Troy to the horseshoe capital of the nation and of the world. Henry Burden made successive improvements, for which he obtained patents in 1843, 1857, and 1862. The horseshoe machine was acclaimed as one of the technical marvels of the age, capable of turning out 3,600 horseshoes per hour, complete

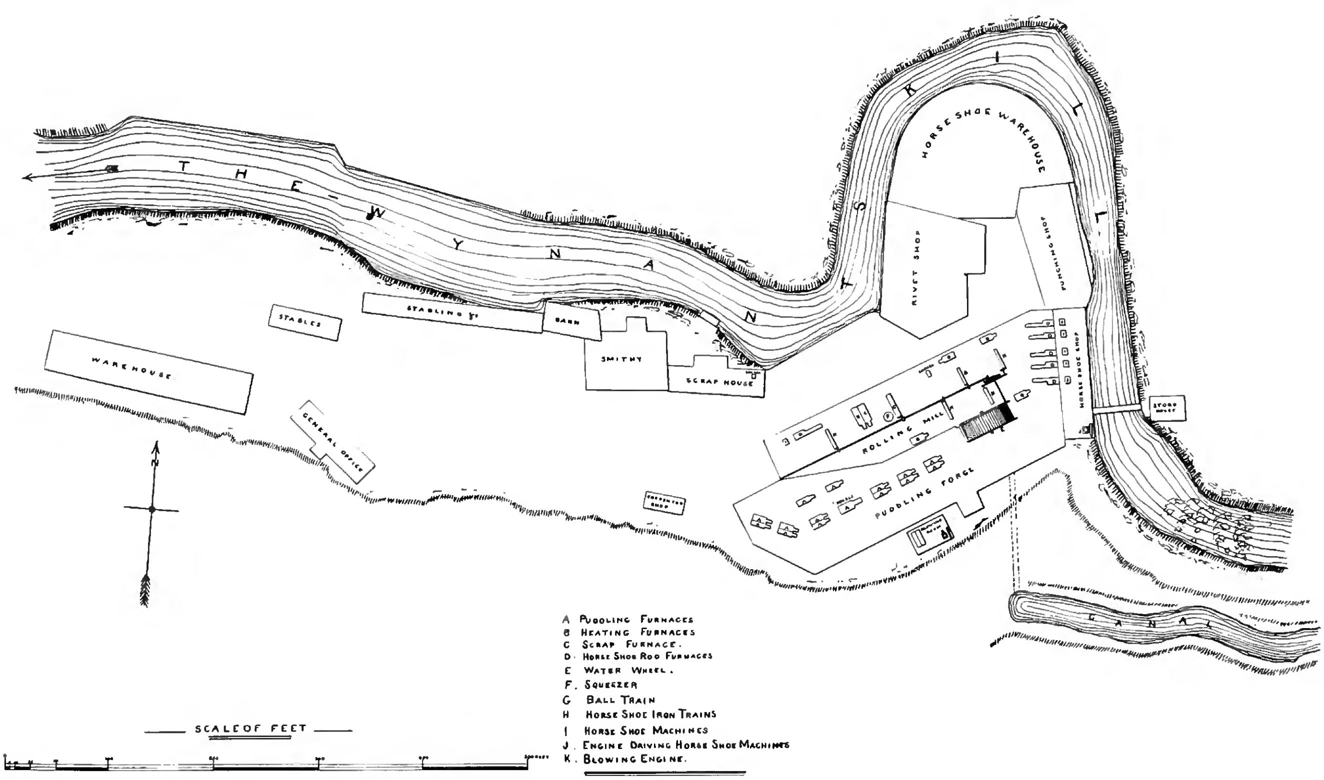
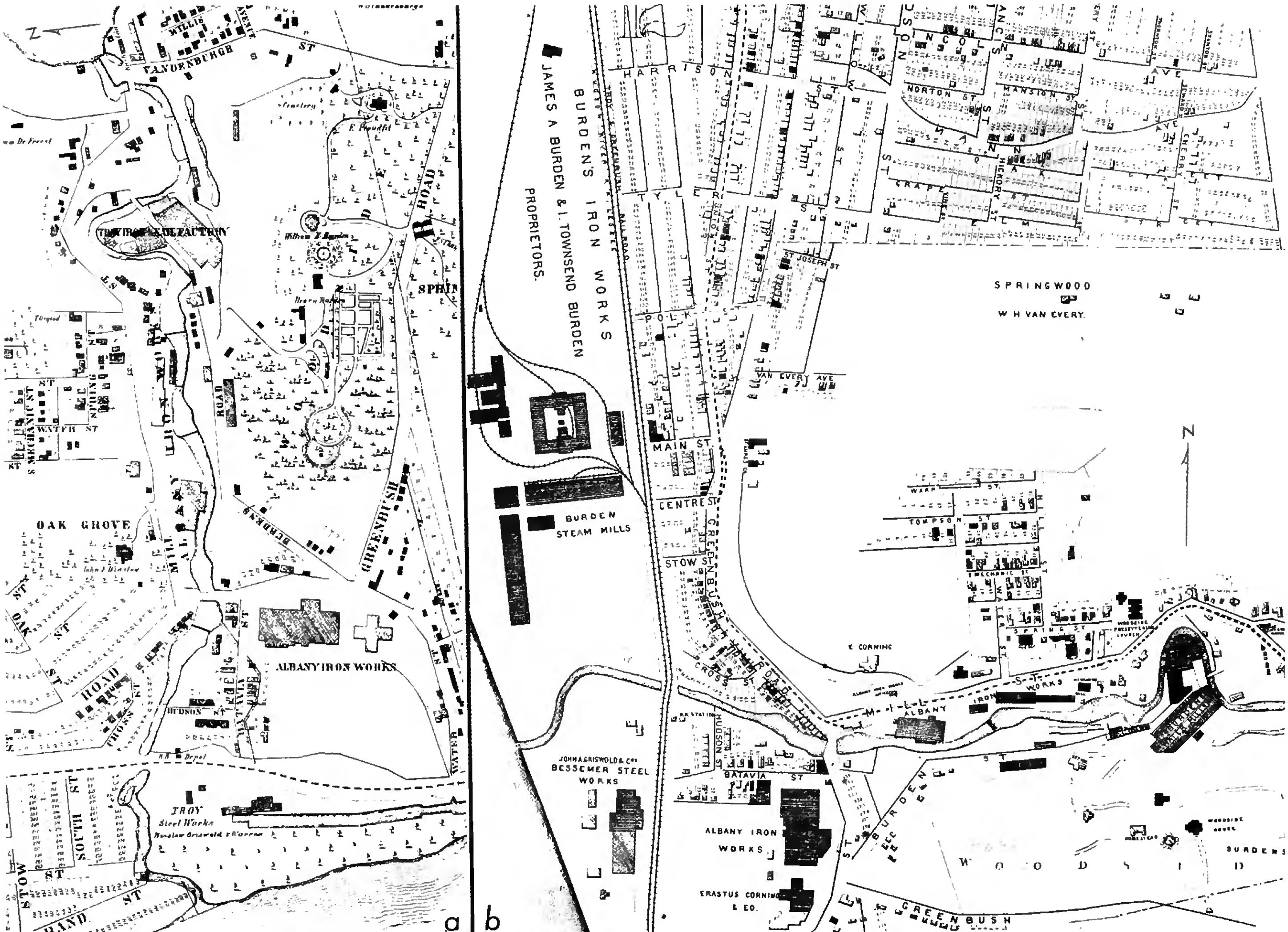


FIGURE 49.—Plan of the Upper Works produced c1875 by Alexander Lyman Holley, eminent iron works engineer, for an unknown purpose—possibly a proposed modification. If the plan reflects actual conditions, it is clear that, contrary to lore, at least by this date the great water wheel drove not all of the Upper Works machinery but only the horseshoe roll-trains. The meander of the Kill, into which the horseshoe warehouse was built, has in recent years been straightened, its former course now barely evident. (*A. L. Holley Collection.*)



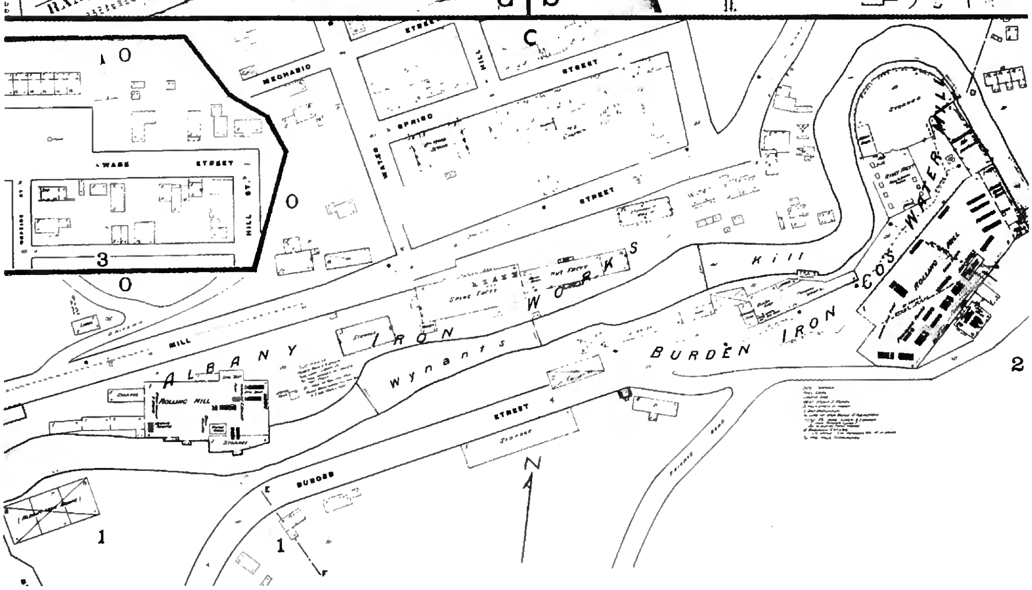


FIGURE 50.—Upper Works site plans of Burden Iron Works: *a,* 1858; *b,* 1873; *c,* 1885. (*a: Barton, 1869 [1858], plate 3, detail; b: Young and Blake, 1873; c: Sanborn Map and Publishing Co., 1885, volume 1, plate 3.*)

from the iron bar to the finished shoe without the touch of a hand or external process.

The fame and use of this machine spread to Europe, and, unhappily, machine-made horseshoes facilitated the conduct of large-scale wars in Europe and America during the nineteenth century, from the Crimean and the Austro-Italian wars in the 1850s on. It was particularly instrumental during the American Civil War, in adding to the North's great industrial advantage over the South. One of the principal objectives of Southern raids was the seizure of Burden-made horse and mule shoes in Northern supply stocks. Toward the end of the war, among a wild outpouring of Southern plots centered in Canada, an attempt was contemplated to secure designs of the horseshoe machine in Burden's Troy plant in order to set up a factory in Atlanta. Sherman's capture of Atlanta frustrated the attempt.

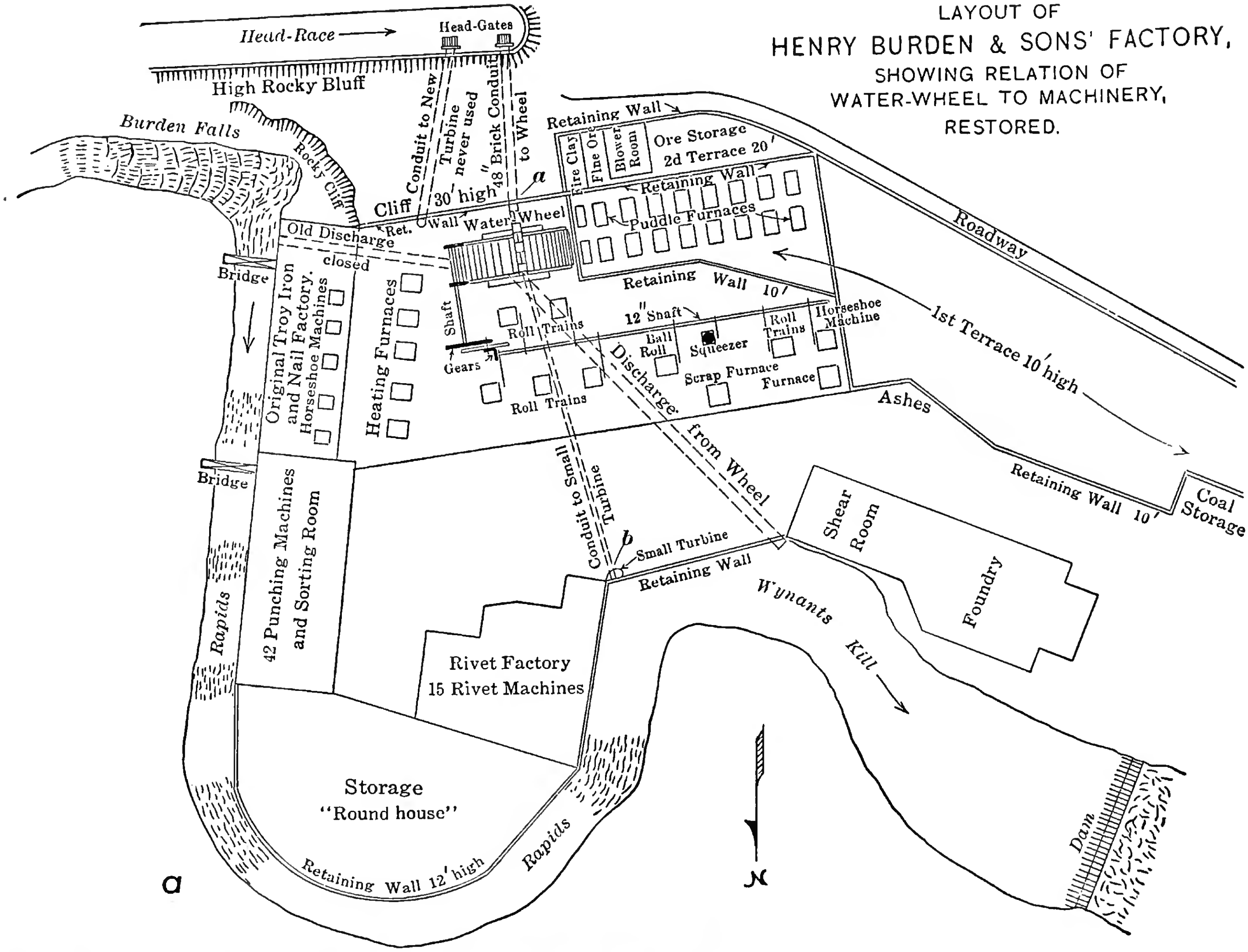
In 1859, on one of his visits to Europe, Burden arranged for the sale of the British rights to the horseshoe machine to the Chillington Company. He noted, ironically, that the British product was to be advertised as "Burden's Hammered Horse and Mule Shoes," in which the word "hammered" replaced "machine." The process included the heavy blow of a hammer on each shoe, instead of its passing through a flattener, which Chillington contended would make the shoe "more straight," and "in addition tickling the fancy of the advocate of Hammering." With the European prejudice in favor of hand operations, advocacy of "machine" operations was "in no country of any benefit to the sale of the shoes." The object of this compromise was apparently to enable the British to enjoy the benefits of both worlds, machine-made as well as hand-made.

Burden's inventiveness seemed to have no bounds. In 1840 he patented what was probably his most significant contribution to the iron industry. This was the rotary concentric squeezer, which substituted mechanical squeezing for the forge hammer in converting the ball of puddled iron into blooms. It was acclaimed by the U.S. Commissioner of Patents as the first truly original American invention in iron-making. It also caught the fancy of British observers, who reported to Parliament in 1854 on the merits of the process. This invention, like others, became the subject of wide imitation and litigation in the industry generally. Burden derived the greatest benefits from his innovations by their effective exploitation in his own expanding plant rather than from the collection of royalties.

Still another of Burden's inventions grew out of his combined mechanical skill and business perceptiveness. On one of his visits to England he had observed the shift from flat rails to "H" or "I" types. The latter required a different type of spike for nailing the rails down to the ties. The spike had to be bent or hook-headed, and in 1840 he developed a machine for its manufacture. Such spikes became a major product of the Burden firm, paralleling the expansion of railroads. It is noteworthy that Burden's iron manufactures met the needs of a kind of dual age, in which both the horse and the railroad were prominent. The hook-headed spike machine became the subject of a prolonged litigation between Burden and his industrial neighbor in south Troy, Corning and Winslow's Albany Iron Company. Initiated in 1842, the suit dragged on for a quarter of a century, from court to court, reaching the Supreme Court of the United States. It became a major *cause célèbre* of American business. Winning a vindication of his patent at great expense, Burden, however, won meager compensation for damages. A pamphlet of 1866 on the Burden case complained bitterly of the delays and costs of the law in America.

Although primarily preoccupied with the iron industry, Henry Burden also applied his talents to navigation and the development of marine steamboats. As early as 1833, he designed the "cigar boat," 300 feet long, based on a cigar-shaped double hull and equipped with large paddlewheels. The first model, appropriately named *Helen,* after his wife, was accidentally sunk in the Hudson River. Burden continued, however, to have faith in the unusual concept. He boasted to his wife in 1842, in a letter from England, that Mr. Lardner, a famous technical publicist, had lectured on this boat in England, and "he assured me that nothing created such universal excitement throughout all Europe as did the notice of my boat." A few years later Burden advocated large steamers, of 15,000 tons, for the Atlantic crossing. The *Great Eastern,* launched by Brunel about a decade later, was a partial fulfillment of this proposal. In 1846 Burden became the promoter of "Burden's Atlantic Steam Ferry Company," which was established in Glasgow for the operation of large steamships. Perhaps fortunately, it did not materialize, and thereafter Burden was able to confine himself to his original enterprise, the Iron Works.

The invention of improved iron-making machinery punctuated the growth and success of Burden's career as an iron master. He regularly acquired more shares



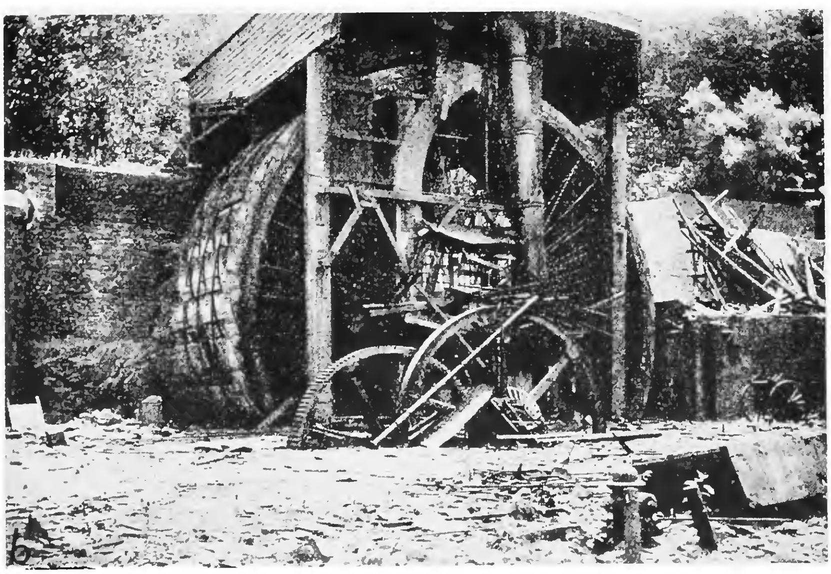
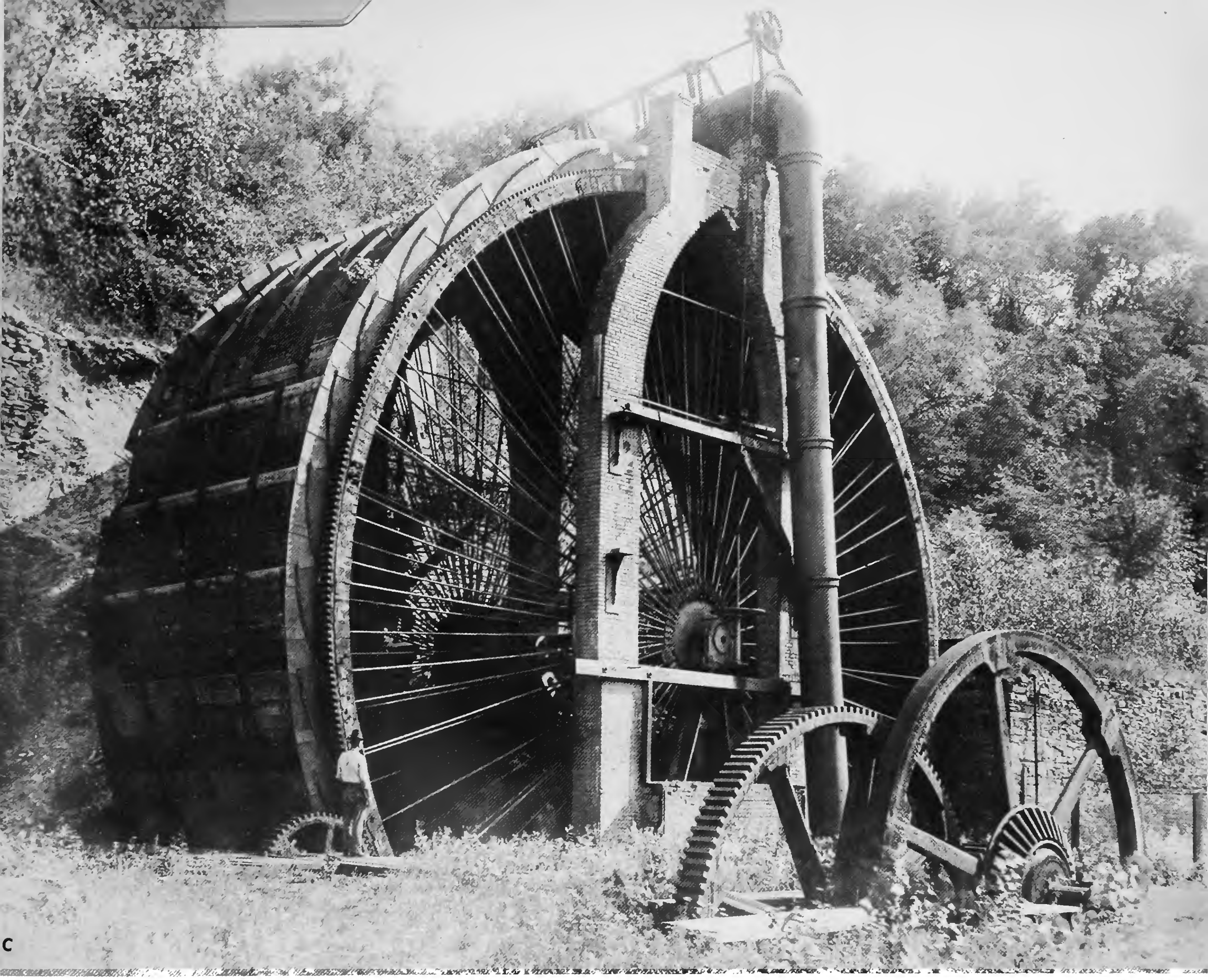


FIGURE 51.—The Great Burden Water Wheel was historically treated by F. R. I. Sweeny in the *Transactions of the American Society of Civil Engineers* in 1915: *a*, Sweeny's plan of the Upper Works; *b*, Sweeney's view of the wheel after dismantling of the Works was nearly complete, c1899; *c*, the wheel, c1900, fully exposed. The hand regulating-wheel is just above the main bearing; at the right is the flywheel for maintaining the speed of the rolls under varying loads; on the same shaft is the bevel gear that drove the jackshaft driving the roll trains (see Figures 49, 51*a*). The Great Wheel collapsed in 1914 and the final remnants were scrapped just prior to World War II. *d*, The wheel in its last agonies, c1930. (*a: Sweeny, 1915, page 710; b: Sweeny, 1915, page 711; c: courtesy of Rensselaer Polytechnic Institute Library; d: courtesy of National Museum of History and Technology, Smithsonian Institution.*)


c


d

FIGURE 52.—Iron Works site: (*above*) Only the pit and end of the supply conduit in the bank mark the site of the Burden Waterwheel today; the Upper Works site has practically reverted to nature; (*below*) general view, 1971. (*Vogel*)

of the Troy Iron and Nail Company, until by 1835 he owned half of the stock. Most of his expanding financial interest in the business was received as compensation for the assignment to the firm of the rights to his iron machinery patents. By 1848 he was full owner of the works, which thereafter were corporately styled Henry Burden and Sons. In the meantime the works were steadily enlarged (Figure 50). Until the Civil War they were located on the slope of the hill above the Hudson River and were powered by Wynants Kill water. In 1851 they reached their greatest capacity when Burden designed and installed the "Niagara of Water Wheels," the most powerful, if not the largest in the world, to derive several trains of rolling mills. An overshot wheel with a capacity of 500 horsepower,[6] it was 60 feet in diameter and 22 feet wide. It had thirty-six buckets, each 6 feet 3 inches deep, and made two revolutions per minute. One of the industrial wonders of America, the Burden wheel inspired, among other things, a series of senior theses by students of nearby Rensselaer Polytechnic Institute, which were at once reverential and scientific in character. Even in its decaying state after abandonment about 1900, the wheel commanded interest as a sight to visit along with the Cohoes Falls on the Mohawk River across the Hudson River (Figure 51). A caption on a picture postcard of the wheel printed c1907 reflects the contemporary local sentiment, "A movement was begun to take the wheel to pieces, but the Trojans desired that it be left standing as a monument to the skill and enterprise of him who had developed in their midst a most useful and powerful industry" (files of Museum of History and Technology).

The Wynants Kill as a power source had the advantage of a steady flow of water from a chain of lakes to the east of Troy, but Burden further improved its regularity by developing a series of reservoirs in its lower stretches, including one on top of the hill overlooking the wheel. Long neglected, these reservoirs are now sluggish bodies of water choked with vegetation, a sad reminder of earlier, more useful days.

By the time of the Civil War the complex of structures known as the Upper or Water Works had reached its capacity, and still the demand for expansion grew. Beginning in 1862, a new complex of works was constructed on a forty-five acre farm lying between the railroad and the river. This was to be known as the Lower or Steam Works, as the blast furnace blowers and all of the other iron works machinery was driven by large steam engines. Coal, iron ore, and lime flux were brought in by rail and river. Burden, in fact, at that time acquired large tracts of land in Vermont, which contained ore and marble for flux. Materials came also from northern and eastern New York State.

The Burden firm thus became an early example of an integrated iron works, encompassing all stages of manufacture from raw materials to pig iron to finished products. A contemporary description of the works by his daughter, Margaret Burden Proudfit, in *Henry Burden* provides a detailed account of this American industry, under one management, at its peak toward the end of the nineteenth century. Pages 70–77 of that account are reprinted below.

The little wooden mill which he [Burden] entered as a superintendent long ago disappeared to give place to his larger works, which today, were they to stand in one alignment, would occupy a tract of land a mile in length. This immense establishment comprises two works—the "upper works," or water-mills, on the Wynants Kill, a short distance east of the Hudson River; and the new works, called the "lower works" or steam-mills, located on the "farm company" property, and the "Hoyle farm" embracing about forty-five acres of land between the Hudson River railroad and the river, extending from the Wynants Kill to the Clinton foundry.

The "upper works" embrace the following buildings:

A rolling-mill and puddling forge, 358 x 136 feet.
A horseshoe factory, two buildings, one 125 x 34 feet, and one 120 x 50 feet.
A rivet factory, 120 x 80 feet.
A horseshoe warehouse, semi-circular, 168 x 120 feet containing 16 large bins, in which can be stored 7,000 tons of horseshoes.
A scraphouse and shop, 175 x 50 feet. Here are also the general business office, a supply store, a rivet warehouse, the stables, etc.
The "lower works," or the new works, embrace the following structures:
Two blast furnaces, each 65 feet high and 16 feet at their boshes, with two casting-houses, each 92 x 47 feet.
Two stockhouses, each 114 x 65 feet.
An engine room, 85 x 50 feet.
A puddling forge, 492 x 83 feet.
A rolling-mill, 421 x 96 feet.
A swaging shop, 271 x 45 feet.
A punching shop, 253 x 45 feet.
A horseshoe warehouse, 318 x 60 feet.
A square building, containing offices, showroom, etc., 96 x 96 feet.

[6] The horsepower of the wheel is variously given as ranging from 500 to 1,000. Sweeny (1915) in 1914 calculated it at 278 assuming a hydraulic efficiency of 84.25 percent.

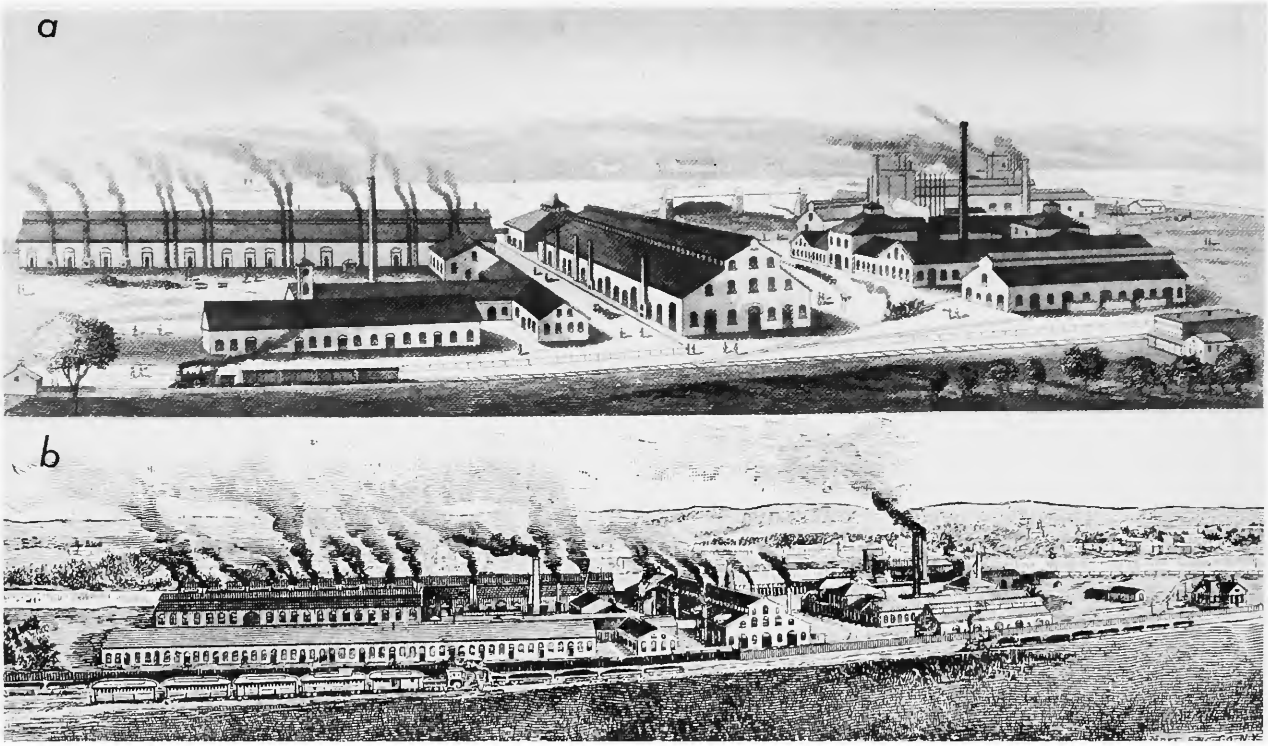


FIGURE 53.—Views of the Lower Works. The Office Building, 1881, is in the bottom view, far right. (*a: Lossing, 1876, opposite page 220; b: Weise, 1886, page 44.*)

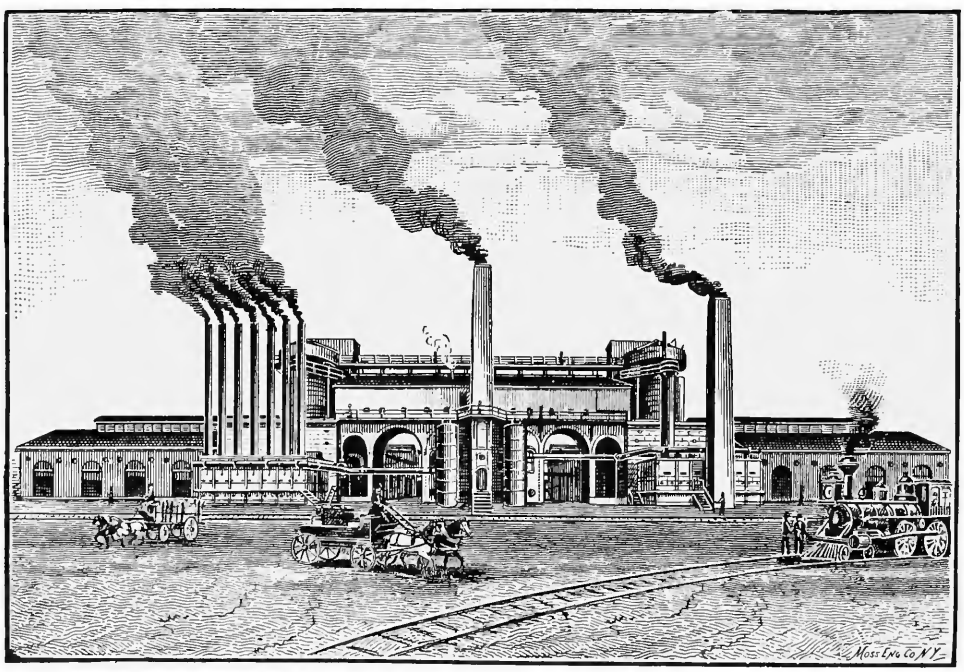


FIGURE 54.—The twin blast furnaces, Lower Works of the Burden Iron Company. (*Weise, 1886, page 45.*)

A machine shop, 140 x 57 feet.
A blacksmith shop, 130 x 55 feet.
A foundry, 250 x 57 feet.
A pattern shop, 85 x 55 feet.
A tin and plumbing shop, 64 x 55 feet.
A building containing a supply store, draughting-room, laboratory, etc., 105 x 55 feet.
An iron warehouse, 167 x 55 feet.

The erection of these works began in 1862, several buildings of which have been recently completed. This property has a river frontage of nearly a mile in extent, and an average elevation of eleven feet, being one foot higher than the track of the Hudson River railroad, east of it. The ground, before the erection of these great buildings, was low, and on account of periodical freshets made dangerous to persons residing thereon. At great expense, these low grounds have been filled up and made valuable to the owners. The depth of water in the river adjacent to the works was shallow and full of bars, but by dredging, an average depth of about fourteen feet has been obtained and made H. Burden & Sons' dock accessible to the largest vessels plying on the upper Hudson.

ACRES OF MACHINERY

For the manufacturing purposes of these extensive mills a great amount of machinery is required. Could all the machines which are now in constant operation in these buildings be placed together in an open space of ground, it is more than likely that they would occupy more than a half score of acres of ground. Not to refer to their respective dimensions, the various classes of machinery found in the upper and lower works combined are the following:

Sixty puddling furnaces.
Twenty heating furnaces.
Fourteen trains of rolls.
Three rotary concentric squeezers.
Nine horseshoe machines.
Twelve rivet machines.
Ten large and fifteen small steam engines.
Seventy boilers.
One large water-wheel, already described.

In and about the buildings of the lower works is a network of railroad tracks, upon which daily are to be seen moving trains of cars conveying iron ore, kaolin, sand, stone, etc., to the different departments, or being loaded with horseshoes and merchant-iron for distant purchasers. For shifting these cars from place to place, H. Burden & Sons own a locomotive, which is in constant requisition.

The steam derricks used for unloading coal from boats in the river, which attract so much of the attention of passengers on the passing steamboats, when going by the docks of the lower works, the invention of the late William F. Burden, are very ingenious contrivances, peculiar to these mills. Each one of these labor-saving appliances consists of two lofty wooden frames, placed one at the dock and the other at the rear of the coal-heap, some 300 feet distant. A strong wire cable is stretched over these frames, on which an iron carriage travels to and fro, carrying a self-dumping iron bucket, which has a capacity for holding about a ton of coal. The power is furnished by a steam engine near the rear frame which hoists the bucket filled with coal from the boat to the cable and conveys it back to the point where is fastened the tilting apparatus that overturns its contents upon the pile.

Alongside of these mammoth heaps of coal are seen vast deposits of iron ore. These are chiefly brown hematite and the dark magnetic ore of Lake Champlain. Here, too, are piles of a fine quality of limestone, brought from Hudson, N.Y., which is used as "flux" to aid in the fusion of the ores.

THE ROMANCE OF MAKING HORSESHOES

The processes by which the mined iron ore is melted and moulded, the cast metal puddled and cut into small bars, these reheated and fashioned into long, narrow rods, to be passed to the horseshoe machines, are of peculiar interest to a spectator, and seem to him, like a dreamy romance, full of strange incidents and unthought-of dispositions. Step by step let him follow these different metallurgic operations, if he wishes to discover what are the secrets which are behind the smoky curtain that nature here places about these great furnaces and dusky forges. Entering the engine-room he inspects the admirable action of the two splendid engines, each of 250 horse-power, projecting a stream of air for the blast of the furnace; and here also are two Worthington pumps for supplying with water the boilers and other machinery of the mills. Here he sees the carefully kept hydrometrical, thermometrical, and barometrical statistics, the number of the total "charges" of ore as regards their character and weight, the amount of coal and of limestone, the quality and the quantity of the pig-iron made, the pressure and the temperature of the blast, and other important data. The blast furnace that to him had a close resemblance to the high walls, strong towers and lofty battlements of an ancient castle, as he first viewed it from the windows of the cars on the Hudson River railroad, he now sees is a massive brick and stone structure, sixty feet in height. Alongside of the extensive heaps of iron ore and limestone are groups of men filling handbarrows, which with their contents will soon be hoisted to the top of the furnace. Before doing this, the ore in the barrows is weighed. Stepping upon the platform of the "elevator," upon which have been run several of these barrows of ore and limestone, he soon is carried upward until the fuming breath of the heated furnace fills his nostrils and warns him of the internal fires raging within its capacious depths. Here he sees a chimney-like structure over the mouth of the furnace supported by six iron columns, each of which marks a division into which at set intervals a certain number of barrows of ore, limestone, and coal are dumped in order to keep the furnace filled evenly to its mouth. Through this great quantity of burning and melting material is a heated blast of air pouring night and day the year round, and the molten metal flowing down into the hearth below where it is tapped and run-off into the casting-house. Over the floor of this building is spread a covering of sand

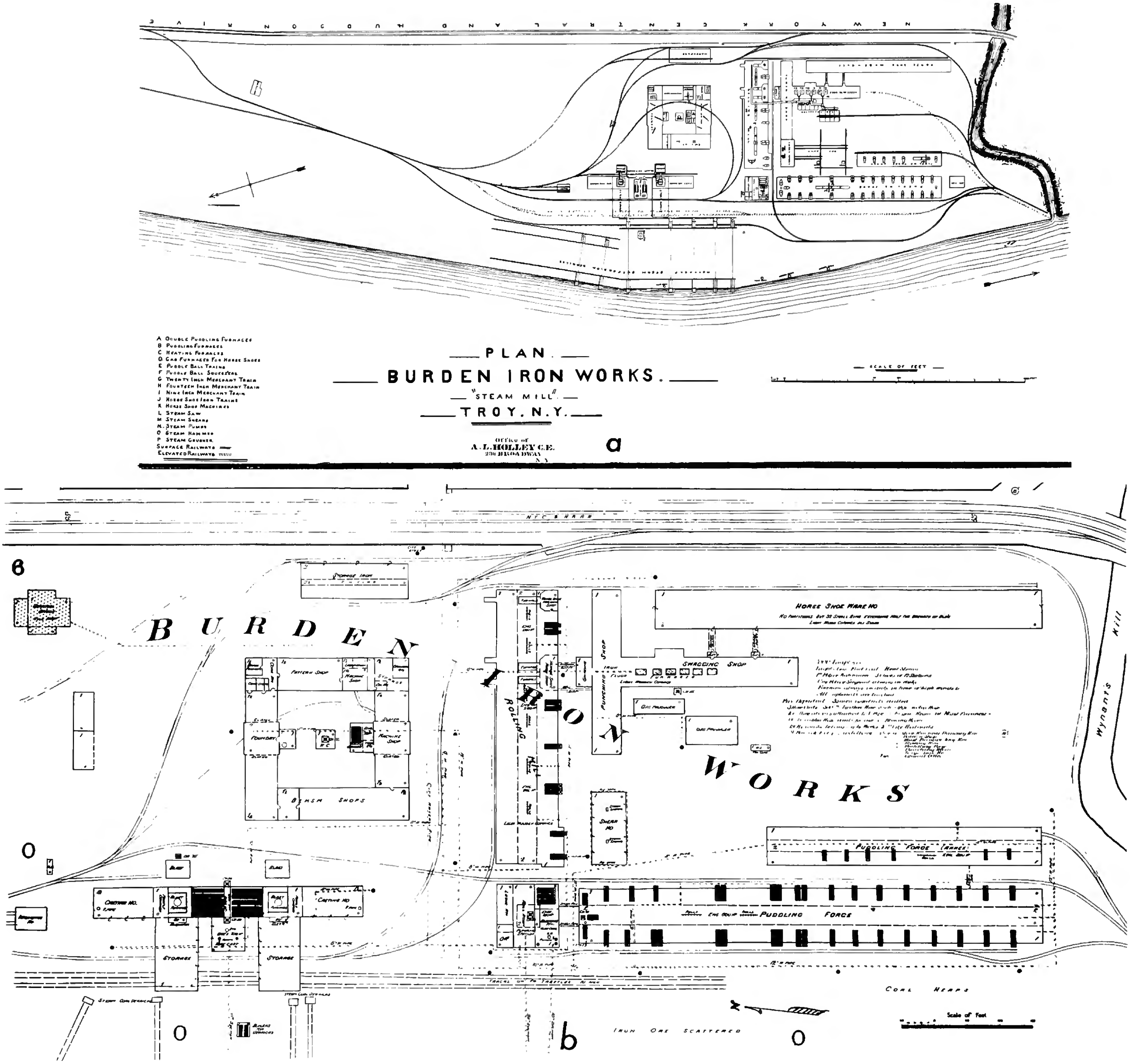


FIGURE 55.—Lower Works site plans of Burden Iron Works by A. L. Holley: *a,* c1875; *b,* 1885. (*a: A. L. Holley Collection; b: Sanborn Map and Publishing Co., volume 1, plate 5.*)

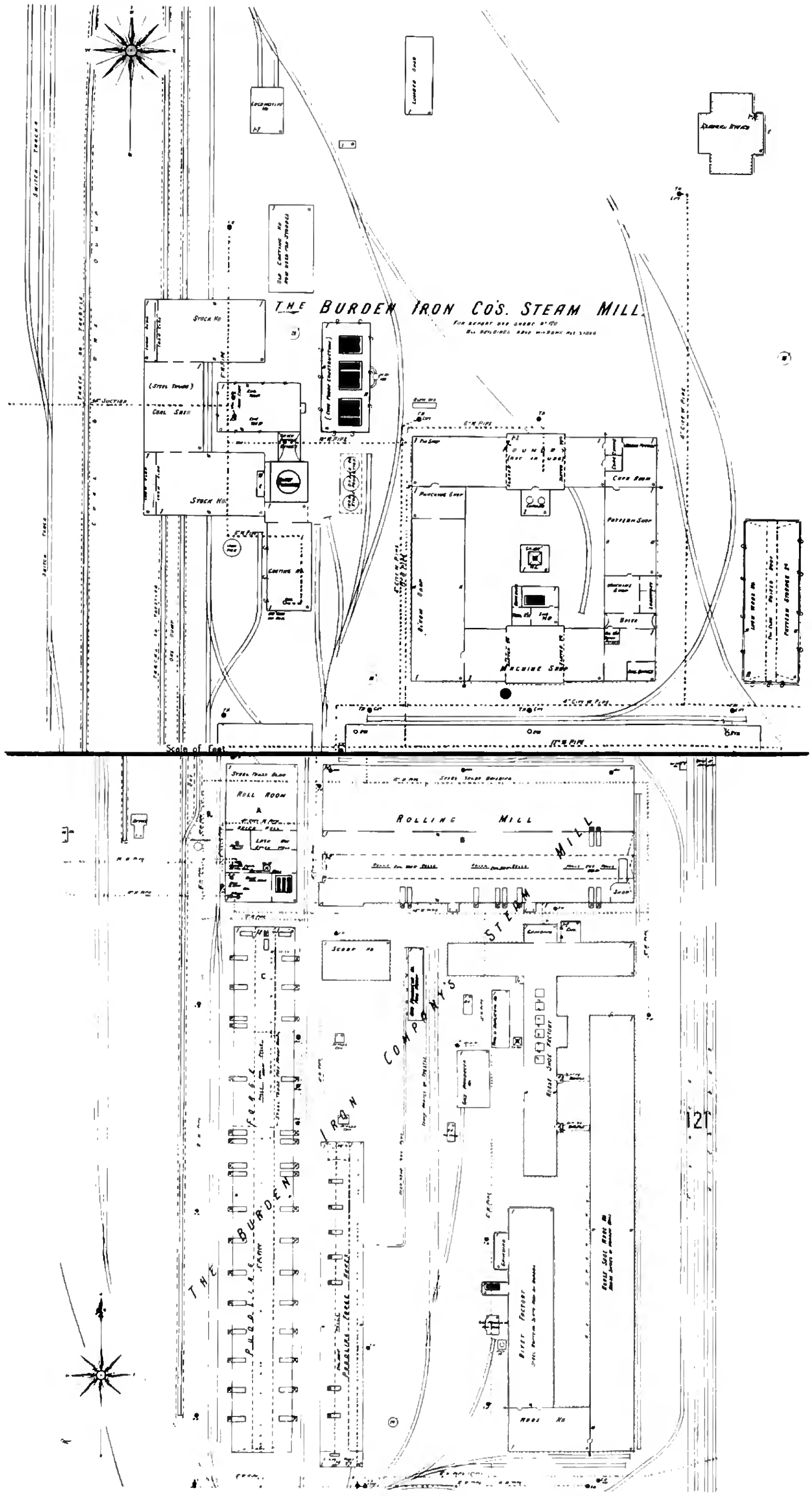


FIGURE 56.—Site plans of Lower Works of Burden Steam Mill, 1903. (*Sanborn Map Co., 1903, volume 2, plates 119–120.*)

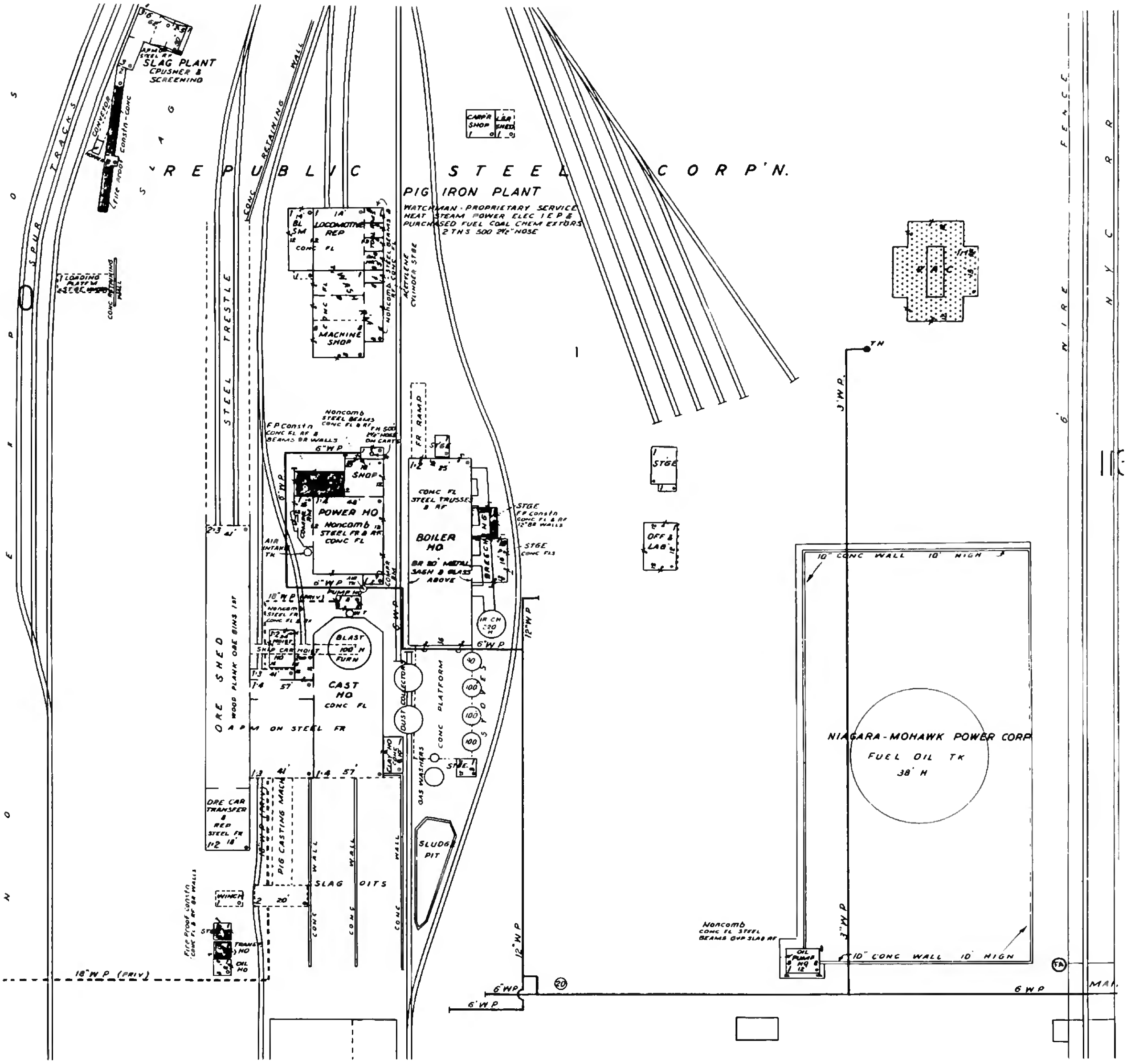


FIGURE 57.—Recent Lower Works site plan, 1955, reflecting what will probably be the last iron/steel manufacture in the Troy area. (*Sanborn Map Co., 1955, volume 2, plate 119.*)

two or three feet deep, which is called "the pig-bed." Longitudinal trenches are made in this bed, which are termed "sows," from which at right angles are formed smaller trenches of "pigs." When the molten metal flows from the furnace it runs through and fills these trenches, where it slowly cools, and when taken out it is known as pig-iron.

THE WONDERS OF THE PUDDLING FORGE

The chemical elements of pig-iron are such as to render it unfit for any serviceable use in these mills, and it therefore undergoes another process of melting in the puddling furnaces, where it is subjected to currents of air and flame while agitated by tools in the hands of the puddler. This manipulation brings it in contact with oxygen, which drives out the carbon in the pig-iron, leaving the metal afterward in a decarbonized condition.

In this temple of Vulcan—the puddling forge—the visitor beholds a scene of stirring activity seldom witnessed elsewhere. Scattered in groups or dispersed singly through this spacious building are hundreds of brawny men, with faces bedewed with perspiration and begrimed with coal dust, nude to their waists, their feet incased in heavy hobnailed shoes, and their strong hands turning, thrusting, pulling, and piling the molten of fashioned iron in ways innumerable amid the heat, the smoke and the short-lived splendor of a thousand red-hot metallic sparks. Here are sooty-faced men stirring through the open doors of flaming furnaces, glowing incandescent masses of iron that blind one's eyes with their fervent brilliancy; others again are taking great balls of puddled metal from the furnaces in iron buggies and casting them into the devouring jaws of the rotary concentric squeezers, from which, as unpalatable morsels, they are ejected in the shape of compact blooms which are immediately taken up red-hot as they are, and thrust between a pair of revolving cylinders, placed one above the other, and furnished with grooves of various sizes through which the bloom is run forward and backward, until it is shaped into a long bar of crude iron. The bars which have already cooled are then carefully tested by placing the end of each one on an anvil, where it is cut and bent before it receives its classification. These are then carried on cars to a great pair of iron shears, where they are cut as if they were ribbon, into pieces about three feet in length. These pieces, a number of them called "a pile," are again placed in furnaces, where they are reheated and again taken out and passed through the roll trains, whence they issue, like long fiery serpents, in narrow bars, and passed to the horseshoe machines.

SIXTY HORSESHOES MADE IN A MINUTE

Watch this wonderful piece of mechanism at work, which in a second of time makes a horseshoe. Before you are two strong frames between which are four revolving shafts geared together and getting their motion from a pulley-wheel. On the shaft most exposed to view, you see three cams, one of which raises a cutting level, another lifts a bending frame on which is a bending tongue, and the third works the flattening pieces. This shaft also gives motion to the feed rollers. The center shaft revolves an iron wheel upon the periphery of which, at opposite points, are two iron dies to give form to the upper or concave side of the shoe—the side that is next to a horse's hoof. Another shaft in like manner revolves a die which gives form to the lower part of the shoe. These several dies are curved in form and "mash" into each other, at each revolution of the shafts. The shaft which carries the shaping apparatus has also two cams for working side levers which close in the heels of the shoe, the creasing shaft bears an iron block to which are attached the "creasers."

Observe now the rapid movements of these shafts and their appurtenances. Gliding like a fiery serpent, you see a red-hot bar of iron, moving toward the machine, on the feeding rollers. Already the iron jaws of the monster are opening to catch between its incisive teeth this glowing rib of iron. The end of the bar has passed to the opposite side of the ravenous automaton's mouth, which is the proper measurement of the length of the intended shoe—the cutter comes up and severs it, and for an instant stops the feed; the bending tongue raises up and is pushed against the cut bar and bends it between two forked cams; it is then caught between the upper and lower dies, taking their impression, the bending tongue falls back, and the side levers close in the heel-ends. While yet upon the center shaft die, a partial revolution carries it against the creasing die, where it is creased and receives the indented marks for the nail-holes. A little farther around, it is taken from the lower die by two knives and falls down and is then carried by an endless chain of linked pieces of malleable iron to the punching-room. In the latter are seen a long line of men seated astride of the saddles of the punching machines making the nail-holes through the indented marks previously put in the creased part of the shoes. Thence they are conveyed in hand-cars to the swaging furnaces in which they are placed before they are swaged.

Boys are at work here, taking with tongs the heated shoes from the furnace and putting them singly on the revolving dies of the swaging machine. After the heated shoe is seated upon one of these dies, it is carried to the top of the machine where it is stopped for a moment; a top die descends on it and two side steels swage the sides of the shoe, removing all bulges and making the outside edges of the shoe perfectly smooth; thence it is carried farther to the opposite side of the machine where there are two other side swedges which swedge up the heels of the shoe, thence it is carried beneath the machine where a wiper removes it from the die and the shoe falling upon an endless band of malleable plates is carried to the south end of the swaging shop where it is dropped off to cool and to be rigidly inspected before being transferred in hand cars to the bins of the shoe warehouse. The shoes when packed for shipping are then taken out, weighed and packed in kegs, in each of which are to be found 100 pounds of perfectly made horseshoes.

Above the lower openings of the great bins in the horseshoe warehouse are the printed names of the pattern and size of the different classes of shoes. There are three patterns of Burden's improved swaged horseshoes, namely, the light, medium, and heavy. As the visitor's eye glances along the long line of the bins, he sees the sizes marked as follows: Horseshoes "fore," Nos. 0, 1, 2, 3, 4, 5, 6, 7; and "hind" of the same sizes; mule shoes, Nos. 1, 2, 3, 4, 5.

SHOES FOR MORE THAN TWELVE MILLIONS OF HORSES

The stupendous manufacturing resources of H. Burden & Sons' establishment are really only comprehended by the visitor when he asks how many horseshoes the machines he has so intently watched produce annually. The answer that the works have a capacity for making 600,000 kegs, or about 51,000,000 shoes, is to him almost too amazing to be believed, and yet he has himself looked upon the practical evidences of this great power of production. The two warehouses, one at the upper and the other at the lower works, have storage capacity for more than 250,000 kegs. The nine horseshoe machines in use, which he has witnessed in their separate operations, can make sixty shoes in a minute. As he pictures to himself this army of twelve millions of horses that can be annually shod with the shoes made at these works, he realizes the important and useful character of the wonderful machine designed by HENRY BURDEN. Where are these shoes sold? Everywhere throughout the United States and Canada. Here in the lower warehouse a visitor, a day or two ago, could have seen hundreds of these kegs filled with shoes, their marked destinations being San Francisco, Cal., and Portland, Oregon. These shoes for their excellence of quality and finish have a world-wide reputation, and this single establishment, to which Troy points with pride, manufactures more horseshoes than all the other works in the world put together.

One can still picture these works spewing forth streams of smoke and soot over the whole of south Troy, which comprised a remarkable example of a nineteenth-century industrial settlement, with grocery stores and saloons on almost every street corner. Even in their present quiescence, the surviving houses still bear the grime of an age of coal. Here were collected over the century the diverse components of the first wave of immigration that populated this country and filled its mills and shops with labor. There were the early families of Scottish, English, and Welsh mechanics, many brought over by Burden, who gave their name to Scotch Hill. More numerous were the Irish immigrants who occupied the streets and alleys in the valley below. To complete, as it were, the character of industrial feudalism which the whole possessed, there was the Woodside Presbyterian Church, built by Henry Burden in memory of his wife. Over all, on top of the hill, stood Woodside, the manorial house occupied by the master, Henry Burden, and his family.

At its peak, the Burden Iron Company employed more than 1400 men, with an annual output of 600,000 kegs containing more than fifty million horseshoes. It was the largest factory of its kind in the country, probably in the world. In addition, the Burden company turned out vast quantities of railroad spikes, rivets, and other iron products. "Burden's Best" became a trade name for iron of high quality.

The vast Burden complex, both as a productive mechanical plant and as a flourishing business organization, was largely the accomplishment of Henry Burden himself during a dedicated lifetime between 1822 and 1871. It was soon thereafter troubled and even threatened with dissolution, although it survived another half a century before its final disintegration. The first source of difficulty was internal, deriving from interfraternal friction. There were only two surviving brothers of an original four, to whom the succession passed even before the father's death. They were James A. and I. Townsend Burden, who were quite different both temperamentally and in their suitability for industrial management. The older, James A., apparently inherited his father's mechanical as well as business skill, but I. Townsend, the younger son, was more inclined to lead the life of a rich man's son, driving fine fast horses and traveling luxuriously and widely.

In the original partnership of Henry Burden & Sons, both sons owned equal shares and had independent as well as conflicting ideas on management. Friction was therefore inevitable and threatened the very partnership itself by 1881. What might have happened to the whole Burden business under these circumstances is problematical. For good or for ill, a way out was found through incorporation and reorganization as the Burden Iron Company, the basis of which was actually an effort to cover over division in the family. Under it James, with a somewhat larger share of stock ownership, became president, and I. Townsend had to be content with a smaller interest and virtually no authority. The capitalization was $2 million. Actual management was turned over to a third man, John L. Arts, who had worked at Burden's from boyhood. He became general manager on the ground, since both brothers were now away from Troy much of the year, living in New York City. Thus early did the Burden family dissociate itself from Troy and from the actual operation of the plant and direct it from a physical as well as social distance.

Even incorporation did not solve the problems of the Burden business. In 1889 I. Townsend entered suit against his brother James, to put the company under a receivership. The internal affairs and quarrels of the family were aired in open court during a prolonged hearing, and the proceedings were published in all their lurid details. It came out for example that, after the father's death, the company had suffered decline and deterioration. The early patents for Burden's machines had expired, and competition in horseshoe manufacture had become intense to the detriment of the Burden business. Only James' mechanical ingenuity saved the day as a new improved swaging machine restored a kind of leadership in the horseshoe field and the remote and expensive iron ore obtained in Vermont from lands acquired in the Civil War years was replaced by cheaper, better ore brought from the Adirondacks. With the fortunes of the company improved, the suit was dismissed.

The Burden company acquired, as it were, a new lease on life and prosperity, and flourished for a few

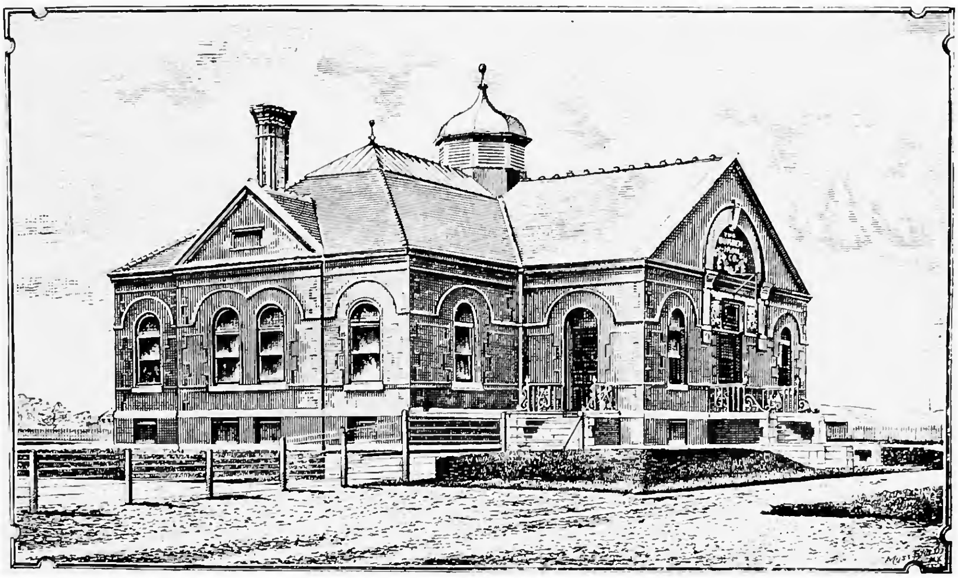


FIGURE 58.—The Burden Office Building, looking northwest (*Weise, 1886, page 47.*)

FIGURE 59.—Burden Office Building, east and north elevations.

decades longer, despite continued friction between the brothers. Even the erection of an office building in 1882, an interesting example of nineteenth-century business architecture and the principal surviving physical relic of this one-time iron company in Troy, was the source of disagreement. It is evident from this intrafamily squabble that divided management was to remain a chief source of weakness in the company, to which were added in due course technological stagnation and the changing geography and composition of the American iron industry, particularly after 1900, which left Troy behind as an iron center.

Consequently, gradual decline soon set in and spread out over half a century. Well before 1900 the upper water-works became uneconomical. It was eventually abandoned to a sad state of deterioration, including the slow ruin of the magnificent water wheel. Production was concentrated in the lower steam-works. Here too, changes became evident after 1900. Horeshoes, once the principal Burden product, diminished in importance, although as late as 1933 United States Army horses were still shod with Burden shoes. Nevertheless, a company catalog of 1920 entitled *Burden Iron and Its Uses,* did not even mention horseshoes. Instead, it argued for the superiority of wrought or puddled iron, particularly of Burden quality, over steel, for many purposes. The principal products were now advertised as [boiler] stay and engine bolts, rivets, and chain iron, and in addition to "Burden's Best," were lesser grades of merchant iron. In the modern age of steel it was not possible for Burden's manufacturing iron specialties alone to maintain the scale of operations developed in the nineteenth century.

The decline of Burden's was part of a general slowdown of Troy's role as an iron-making center. The steel works and other heavy metal establishments either suspended or were sharply curtailed as the pull of the West, with better access to coal, ore, and markets, asserted itself. As an older center of iron manufacture, Troy's technology and machinery tended toward obsolescence, and its labor was perhaps more turbulent and troublesome. Management too tended to become less driving and dynamic.

In this connection the role and association of the Burden family with this enterprise during its last phase are especially noteworthy. Henry Burden's sons, James A. and I. Townsend, continued to manage the works until their death. Both lived during their last years in New York City, and Woodside was only their address for occasional visits to Troy. James A. died in 1906 and I. Townsend in 1913. The last Burden president of the company was James A. Burden, Jr., who died in 1932. The family was now fully established in New York City, where its descendants still enjoy social prominence.

In 1925 the Burden company ventured into a new field of activity, the Hudson Valley Coke & Product Corporation, located on the Burden site, for the manufacture of coke, gas, and pig iron. James A. Burden, Jr., was chairman, with immediate direction in new, but changing, hands. It was not, however, very successful.

By 1934 the Burden Iron Company was in obvious difficulties and apparently in receivership. The Burdens were now listed as trustees, while William E. Millhouse, formerly the general superintendent, was both president and treasurer. The officers changed frequently, although a Burden appeared as a trustee until 1939, when even that remote connection was apparently severed. The Burden Iron Company was making desperate efforts to operate during those years of depression in reduced circumstances and to discover new products. Failure was impending, and by 1940 the company was in liquidation.

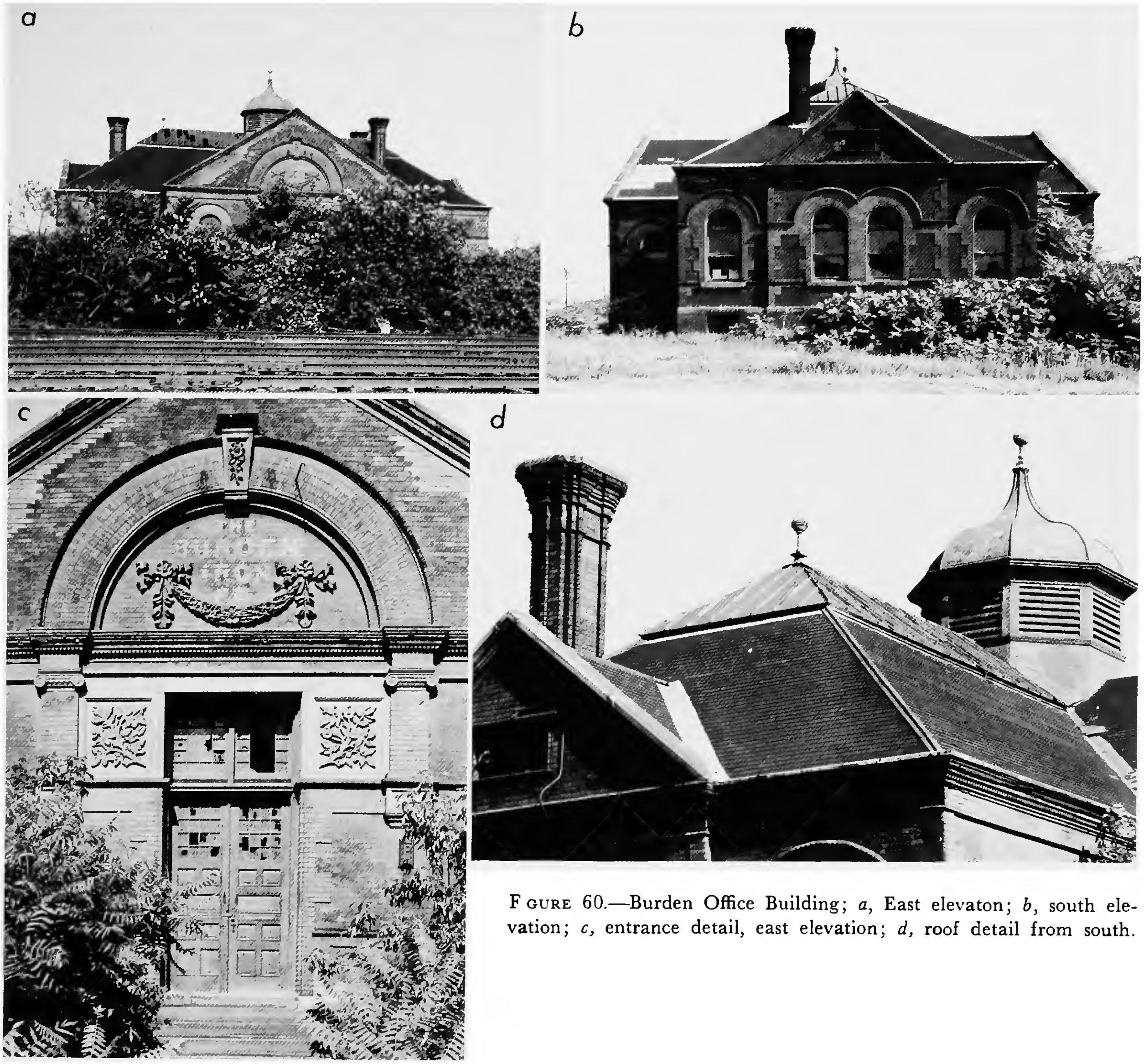
The Republic Steel Corporation acquired the Burden blast furnace, built in 1925, and has operated it since then. In November 1940 the Burden Office Building, the lone survivor of this one-time vast plant (except for the furnace and a few decrepit storage sheds), was emptied of its accumulation of company records. They were turned over to the Division of Manuscripts of the New York State Library in Albany for preservation. Thus ended the long history of an industrial establishment which had been originally created in the infancy of Troy and of American industry. It had thrived for a century and then suffered decline for a generation longer. Its end was only part of a general process of decline which affected other industries in Troy, both metal and textile.

Sources of Information

Unpublished

Burden Company papers. Manuscript Division, Albany, New York. New York State Library.

Troy. Rensselaer County Clerk's office. Deeds and land grants of the Burden family and the Burden Company.



F GURE 60.—Burden Office Building; *a,* East elevaton; *b,* south elevation; *c,* entrance detail, east elevation; *d,* roof detail from south.

Troy. File in office of Republic Steel Corporation, now occupying and using the "lower mill" site for a blast furnace.

New York City. Consultation with Mrs. Wesley Metcalf, research associate to Mr. W. A. H. Burden.

A. L. Holley collection. Division of Industries, National Museum of History and Technology, Smithsonian Institution, Washington, D.C.

Published

American Artisan, 1 February 1871. New York.

American Railroad Journal, volumes 20 (1847), 22 (1849). New York.

Barton, William. *Map of the City of Troy and Green Island, N.Y.* Troy, 1869. [Map printed 1858, bound later.]

Burden Iron and Its Uses. 30 pages. Troy: Burden Iron Company, 1920. [Catalog of iron products and description of Works; brief history.]

Lossing, Benson J. *The American Centenary.* Philadelphia: Porter and Coates, 1876.

Proudfit, Margaret Burden. *Henry Burden, His Life.* Troy, 1904.

Sanborn Map Co. *Insurance Maps of Troy, Rensselaer County, New York.* 2 volumes. New York, 1903.

————. [*Insurance Maps of*] *Troy, New York.* 2 volumes. New York, 1955.

Sanborn Map and Publishing Co. [*Atlas of*] *Troy.* 2 volumes. New York, 1885.

Sweeny, F. R. I. "The Burden Water-Wheel." *Transactions of the American Society of Civil Engineers,* volume 79, paper 1343 (1915), pages 708-726.

Uselding, Paul J. "Henry Burden and the Question of Anglo-American Transfer in the Nineteenth Century." *Journal of Economic History,* volume 30, number 2 (June 1970), pages 312-337.

Weise, Arthur J. *The City of Troy and Its Vicinity.* Troy: Edward Green, 1886.

Weise, Arthur J. *One Hundred Years of Troy.* Troy: William H. Young, 1891.

Young, William H. and Blake. *Map of the City of Troy, N.Y.* Troy, 1873.

Various articles in Troy newspapers, especially regarding Burden suits.

Various articles on the Burden Water Wheel are in the files of the Division of Mechanical and Civil Engineering, National Museum of History and Technology, Smithsonian Institution, Washington, D.C.

THE BURDEN IRON WORKS

Henry Burden, a native of Scotland, and educated there in engineering and drawing, and who came to the United States in 1819, was the first inventor of a machine for making spikes. He settled in Troy, New York, where iron-works in which he became interested, had been established as early as 1813. Mr. Burden became connected with them in 1822, when they were owned and worked by an incorporated company under the name of the "Troy Iron and Nail Factory." The works were then small, but through the energy, industry and inventive genius of Henry Burden, they rapidly increased in importance. He was successively superintendent and agent of the works, and president of the Company. After many additions had been made to the establishment, the works were entirely re-built on a much larger scale.

Before his settlement in Troy, Mr. Burden had invented a plow and a cultivator. In 1825, he patented a machine for making ship-spikes which, up to that time, had been made by hand. On the same machines countersunk railroad spikes for flat rails were afterward made. About 1830, he invented a machine for making horse nails. In 1834, he was granted a patent for an improvement in the method of constructing steamboats and other vessels. The year before, he built at the Troy Iron Works a steamboat 300 feet in length with paddle-wheels 30 feet in diameter, which, on account of its shape, was called the "cigar boat." He anticipated the younger Brunel in advocating the construction of ocean steamships. In January, 1846, a prospectus of "Burden's Atlantic Steam Ferry Company" was issued at Glasgow, Scotland, in which it was declared that the present Atlantic steamers [of the Cunard line,] magnificent though they be, are as inferior in their results to what they may become, as a well appointed stage coach is to a railway train.

In 1840, Mr. Burden obtained a patent for a process of his invention for making "hook-headed" railroad spikes. He had used the process several years before the patent was granted. The same year he obtained a patent for a machine for rolling puddled iron balls, called the "Burden Rotary Squeezer," which caused important changes in the process of manufacturing iron throughout the world. At one time about three-fourths of all the puddled iron made on the earth, passed through these machines.

Mr. Burden's greatest invention was the machine for making horse-shoes, which was first patented in 1835. An improvement was patented in 1853; and in 1857 he obtained a patent for another horse-shoe machine, which was again improved and patented in 1862. As fast as Mr. Burden's inventions were perfected, they were put into operation in the works at Troy. In those works ship-spikes, hook-headed railroad spikes, and horse-shoe nails were first made by machinery. There Burden's Rotary Squeezer was first put in operation: and there horse-shoes were first successfully made by machinery.

From time to time Mr. Burden purchased stock in the Troy Iron and Nail factory, until the entire interest was finally acquired by him. His three sons, William F., James A. and I. Townsend Burden, whom he had educated to the business, were associated with him as partners. The business was largely increased. They purchased ore mines and lime-stone quarries—lime-stone quarries—acquired property in coal mines, and built on the river bank in the southern suburbs of Troy, new works far surpassing the old ones in magnitude and appointments. The name of the establishment was changed to *Burden Iron Works,* and the firm name became "Henry Burden and Sons." Mr. Burden died in January, 1871; his eldest son, William F. Burden, had died December 7, 1867. The works are now owned by the two surviving brothers, who retain the firm name of Henry Burden and Sons.

The old establishment called the "Upper Works," or "Water Mill" are in the valley of the Wynantskill, a short distance from the Hudson river. They consist of the following buildings: a rolling-mill and puddling forge under one roof in a brick building 358 by 136 feet; a horse-shoe factory in two buildings, which are 125 by 34 feet, and 120 by 50 feet respectively; a rivet factory 120 by 80 feet; a semi-circular horse-shoe ware-house 168 by 120 feet, divided into sixteen large bins capable of holding 7,000 tons of horse-shoes; scrap-house and shops 175 by 50 feet; the general office, supply store, ware-house for rivets and spikes, stables, et cetera. In these works is a celebrated overshot water-wheel, designed and built by Henry Burden, in 1851. It is 60 feet in diameter, and 22 feet in width. It has 36 buckets each six feet deep, and has a horse-power of 1200. It is believed to be the largest water-wheel in the world.

The "Lower Works," or "Steam Mills" are on the bank of the Hudson river, a short distance from the other works. There the Messrs. Burden own an extensive tract of land, with a river front of nearly a mile, affording ample room for receiving materials and shipping the products.

The Lower Works were built in 1862, and consist of two blast-furnaces each 60 feet in height, and 16 feet in diameter at the base, with two casting houses each 92 by 47 feet, two stock houses each 114 by 65 feet, and one engine-room 85 by 50 feet. There is a puddling forge in a building 492 by 83 feet; rolling-mill 421 by 96 feet; a square building containing blowing-room, offices, et cetera, 96 by 96 feet; machine-shop 140 by 57 feet; black-smith-shop 130 by 55 feet; foundry 250 by 57 feet; pattern-shop 85 by 55 feet; tin and plumbing-shop 64 by 55 feet; a building 105 by 55 feet, containing supply store, draughting-room, "duplicates" room, et cetera, and an iron ware-house 167 by 55 feet.

Adjoining the rolling-mill building, is a horse-shoe factory consisting of two buildings respectively 130 and 150 feet in length, and a horse-shoe warehouse 200 by 60 feet. This portion of the works is devoted to the manufacture of the new swaged horse-shoe on machines invented by James A. Burden, for which he obtained a patent in January, 1876. The different departments of these works are connected with each other by railroad tracks over which the material to and from each is hauled by a locomotive owned by the firm, who also own many freight cars. Shipments from the works are made by boats from their wharf, or by railway cars placed on their switch by the railway companies.

In the Upper and Lower *Burden Iron Works* combined, are sixty puddling furnaces; twenty heating furnaces; fourteen trains of rolls; three rotary squeezers; nine horse-shoe machines, each of which can make sixty horse-shoes a minute; twelve rivet machines, each of which can make eighty boiler rivets a minute; ten large and fifteen small steam-engines; seventy boilers; hook-headed railway spike machinery; and the great water-wheel just described.

The Messrs. Burden own a hematite ore mine in Vermont, and a charcoal blast-furnace in the same State; also an interest in the magnetic ore mine of the Port Henry Iron Ore Company on Lake Champlain, and coal interests in Pennsylvania. The products of their works at Troy, are pig-iron; "H. B. & S." and "Burden's Best" merchant iron; horse and mule-shoes; boiler rivets and railroad spikes.

The capacity of the *Burden Iron Works* is 40,000 tons of iron annually, not including pig. The bulk of this is converted into horse and mule-shoes, the works having a capacity for making 600,000 casks of 100 pounds each, of horse-shoes a year. They employ 1,400 persons in the establishment.

FIGURE 61.—Contemporary description of Burden Iron Works. (*Lossing, 1876, pages 217-220.*)

ARCHITECTURAL INFORMATION

General Statement

Character: A moderately decorative office building in an eclectic style.

Condition of Fabric: Poor; interior gutted.

Description of Exterior

Overall Dimensions: Approximately 60′ by 40′ (structure not measured).

Layout, Shape: One-story, Greek cross plan.

Wall Construction, Finish, and Color: Red brick in running bond, laid in red mortar. Brick quoining. Floral, classical-revival detailing on the entrance wall and Ionic pilaster capitals of light red sandstone.

Structural System: Brick bearing walls; wooden roof framing.

Stoop: A light red sandstone stoop at the main (east) entrance.

Chimneys: Three brick pilastered chimneys with decorative corbeled cages from fireplaces that formerly heated the rooms. All mantels and other interior details have been removed.

Openings: Doors and Doorways: Wooden door frames with nonoriginal wooden doors.

Windows: Wooden window frames within brick, round arches, one-over-one double-hung sashes. The semicircular fanlight areas subdivided into small, square panes. The sills are of light red sandstone.

Roof: Shape and Covering: Cruciform, hipped roof, with asphalt shingles. The north and south arms have a gabled dormer at each end and a skylight at the peak.

Cornice and Eaves: Brick cornices; galvanized metal eaves.

Cupola: Red-painted, galvanized iron, louvered cupola at crossing, with ogee roof and bulbous finial.

Site and Surroundings

The Office Building is located at the Burden company's former Lower or Steam Works, occupied in 1862. All that remains of the operations are the Office Building, two or three brick storage buildings and the 1925 blast furnace now operated by Republic Steel. [Operations ceased in 1972.—ed.] The remainder of the site has been cleared and is occupied by piles of raw material for the furnace and piles of the small pigs of iron that are its product.

The Upper or Water Works is today totally abandoned, its rather pleasantly parklike atmosphere broken by an occasional ruin of one of the once numerous brick buildings. The site of the famed waterwheel is identifiable only by the pit, excavated from the native stone, in which the lower part of the wheel worked, and the brick penstock outlet sixty feet above (Figure 52).

Chronological Notes

Troy's Iron and Steel Companies

Compiled by Richard S. Allen

Section One: Albany Iron Works Group

1807 *Albany Rolling & Slitting Mill* of John Brinkerhoff & Co. of Albany. Built on site of DeFreest fulling mill on north side of lower fall of Wynants Kill.
1826 Purchased for $5,280 by Erastus Corning. John T. Norton associated with Corning in this.
1826 *Albany Nail Factory* of Norton & Corning.
c1830 Norton left. James Horner became partner with Corning.
1838 John F. Winslow joined the firm.
1838 *Albany Iron Works* of Corning, Horner & Winslow.
1849 Steam mill erected on south side of Wynants Kill. Gilbert C. Davidson and Erastus Corning, Jr., admitted as co-partners.
1861 Style changed to Corning, Winslow & Co. Made railroad (rail) chairs, rifled cannon, plates for the *Monitor*.
1864 Style changed to Cornings & Winslow.
1867 Style changed to Erastus Corning & Co.
1875 Consolidated with Rensselaer Iron Works to form:
Albany & Rensselaer Iron & Steel Co. Incorporated 1 March by Erastus Corning, Chester Griswold and Selden Marvin.
1885 Reorganized as:
Troy Steel & Iron Company.
1855–1887 Erected three blast furnaces on Breaker Island; operated four separate plants.

Section Two: Rensselaer Iron Works Group

1846 *Troy Vulcan Company.* Composed of Le Grand Cannon & Co.'s rolling mill and Johnson & Cox's furnace. Rolling mill on south side of Poesten Kill, west of track of Troy & Greenbush Railroad.
1852 *Troy Rolling Mill Company* purchased property 15 October and sold it 1 November to Henry Burden.
1853 *Rensselaer Iron Company* received property from Burden.
1854 John F. Winslow purchased Rensselaer Iron Company and transferred it to
Rensselaer Iron Works. (Property of John A. Griswold & Co.: J.A.G., Erastus Corning, Erastus Corning, Jr., Chester Griswold)
1866 Rail mill erected on north side of Poesten Kill.
1868 Consolidated with Bessemer Steel Works.
1875 Combined with Albany Iron Works to form:
Albany & Rensselaer Iron & Steel Company. (q.v., Section One)

Section Three: Burden Iron Works Group

1809 John Converse and others built rolling and slitting mill on south bank of Wynants Kill at upper fall. Property became:
1813 *Troy Iron & Nail Factory* of Troy Iron & Nail Factory Company. Ruggles Whiting, John Converse, Nathaniel Adams, E. F. Bachus, and Henry W. Delevan.
1822 Henry Burden became superintendent of works.
1835 Henry Burden owned half interest.
1848 *Burden Iron Works* of Henry Burden & Sons formed as Burden became sole owner.
1862 Burden's "Lower Works" or "Steam Mill" constructed.
1864 Reorganized as H. Burden & Sons.

1881 *Burden Iron Company.* Incorporated 30 June by James A. and I. Townsend Burden and John L. Arts.

c1898 "Upper Works" closed down.

1940 Firm liquidated.

c1940 *Republic Steel Corp.* (of Cleveland, Ohio). Purchased site and 1925 blast furnace, which was operated until 1972.

Section Four: Bessemer Steel Works Group

1863 Alexander L. Holley in England; purchased American rights to Bessemer steel process for Corning, Winslow & Co.

1863 *Bessemer Steel Works* of Winslow, Griswold & Holley.

1864 2½-ton plant built immediately south of mouth of the Wynants Kill. Designed by Holley; first in U.S.

1865 First steel produced 16 February.

1867 Plant enlarged to 5-ton daily capacity.

1868 Plant nearly destroyed by fire. Transferred to John A. Griswold & Company and rebuilt (see Section Two).

Number 3 ("Mastodon") Mill 1868 and 1872

Harmony Manufacturing Company, Cohoes

(HAER NY–8)

Diana S. Waite

Location: 100 North Mohawk Street, Cohoes, Albany County, New York. Latitude: 42° 46′ 0″ N. Longitude: 73° 42′ 30″ W.
Dates of Erection: North section: 1866–1868; south and central sections: 1871–1872.
Architect: D. H. Van Auken, C.E.
Present Owner: CCCS Corporation.
Present Occupant: Cohoes Industrial Terminal Corporation.
Present Use: Various manufacturing purposes by ten companies.
Significance: Known locally as the Mastodon Mill, the Harmony No. 3 Mill is exceptionally interesting for its decorative architectural treatment, uncommonly elaborate for an industrial structure. Although the building is nearly 1100 feet long, its finely articulated facade, mansard roof, and central tower make it a well-scaled element of the Harmony Mills complex, which includes mill buildings, power canals, workers' houses, and commercial structures. Harmony is one of the finest examples of a large-scale textile mill complex outside of New Engand, and it has played an important role in the economic development of Cohoes.

Architectural Information: Prepared by Richard J. Pollak; additional data by Robert M. Vogel.

HISTORICAL INFORMATION

Physical History

Dates of Construction: Ground was broken for the north section in late May or early June 1866. The first machinery was run in the factory on 1 January 1868. Cotton was taken into the pickers on 1 February 1868.

Architect: A Cohoes architect and civil engineer, Van Auken was also the engineer for the Cohoes Company, which supplied water for power to various Cohoes mills, including those of the Harmony Manufacturing Company.

Original and Subsequent Owners: One account of the Harmony Mills states that the Cohoes Company held title to the lands on which the Harmony Mills were located until 1915 (Clark, 1952:43). However, records in the office of the Recorder of Albany County indicate that the transfer must have taken place at an earlier date (see top of page 100).

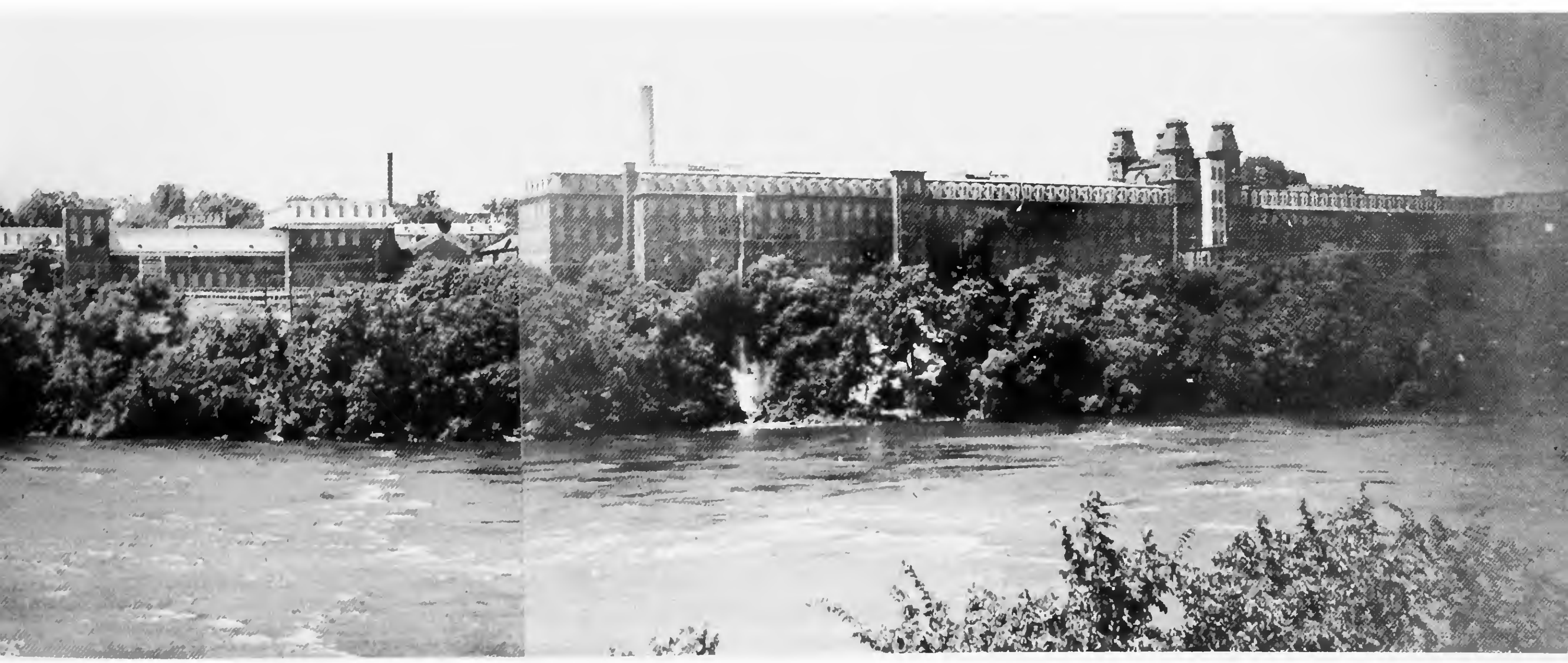
Builder: John Land had the contract for carpentry and joiner work, a large job in that two million feet of lumber were used. In order to proceed with his work, it was reported, that

> Mr. Land is now building a large shop, 150 by 40 feet, in which he designs to put a steam engine, to run planes and saws, which will greatly facilitate the work. (*Cohoes Cataract,* 16 June 1866).

Original Purpose and Construction: In excavating for the foundation of the north section of the building, the bones of a mastodon were found. Subsequently the mill became popularly known as the "Mastodon Mill." The skeleton of this mammoth was presented to the State of New York, and it still remains on display at the State Museum in Albany. An 1868 article in the *Cohoes Cataract* described the mill and its construction:

> The main building is 565 feet long, 77 feet wide, and five stories high, with a fireproof wing of the same height 100 feet long and 50 feet wide, in which the pickers are placed.
>
> To prepare the foundation and wheel pits, there were removed 40,000 [cubic] yards of earth and rock.
>
> In the erection of the building the following material was used: 1,000,000 yards of stone, 3,000,000 brick, 4,500 yards of sand, 30,000 bushels of lime, 1,000,000 lbs. cast and wrought iron, 800,000 ft. hemlock planks, 500,000 ft. pine timber, 45,000 ft. southern pine flooring, 400,000 ft. pine ceiling, and 1,000 kegs of nails.

FIGURE 62.—Panoramic view of the Harmony Mills on the brow of the Mohawk River, with the "Mastodon" Mill on the right. (*Vogel*)



Transfer date	Seller / *Purchaser*	Liber	Page	Recording date
13 Mar. 1911	Harmony Mills, N.Y. / *Harmony Mills, Mass.*	301	52	20 Mar. 1911
31 Aug. 1937	Harmony Properties Inc. / *Industrial Properties Inc.*	887	410	2 Sept. 1937
29 June 1938	Industrial Properties Inc. / *Day Court Builders Inc.*	901	105	30 July 1938
30 June 1967	Day Court Builders Inc. / *Cohoes Assocs. Ltd.*	1910	219	6 July 1967
30 June 1967	Cohoes Assocs. Ltd. / *CCCS Corporation*	1910	233	6 July 1967

The motive power, equal to 1,200 horse power, is furnished by the [three] Boyden Turbine wheels made by the Ames Manufacturing Co., of Chickopee [sic.], Mass. [Figure 66*a*] They are all geared to one shaft ten inches in diameter, on which are six pulleys, each 12 feet in diameter, and 26 inch face.

These wheels and shafts connected, have 100 tons cast iron, 70 tons wrought iron, and 3½ tons brass and bronze, and are all made and fitted with all the care and accuracy of fine machinery. They drive over two miles of shafting and 1,400 pullies, besides those connected with the machines.

There are six main belts driving from the water wheel shaft, one to each room. These belts are of double leather 24 inches wide, and their united length is 950 feet; there are also over 10 miles of other belting of various widths.

The mill is warmed by over five miles of small pipe supplied with steam generated by three boilers situated some distance south of the mill.

It is lighted by 1,000 gas lights supplied by four miles of gas pipe. The machinery is all of the most approved kinds, which could be found in England and America, and includes 70,000 yarn spindles, and 1,500 fast looms. When all running, it will produce 60,000 yards of cloth per day.

The mill at that time was the largest in Cohoes and one of the largest in the United States. A report of 1873 (Bean, 1873:21–24) described the operations in each section of the mill:

The first floor of this portion of the Mill is occupied in part by the wheel-pit as aforesaid, the remainder is devoted to repairing machinery, and cleaning, folding, and baling the printing cloths, produced by these mills. The cloth is baled by means of machines, similar in operation to a hay press. The contents of each bale measured 1,800 yards.

West of this section of the building, and communicating therewith, is another large building, built of stone, and brick, and iron, and perfectly fire-proof, constituting

THE PICKER ROOM

This building is filled with costly and heavy machinery of brass, and steel, and iron, for opening, picking, and preparing the raw cotton for the different operations necessary to change it into elegant fabrics suitable for 'the trade.'

THE WEAVE ROOM

is on the second floor. The noise of this vast apartment, 70 x 600, with its 1,000 looms and 300 operatives, is perfectly deafening. And the effect upon a person unaccustomed to the scene is something like that experienced when standing on the brink of Niagara, or near a ponderous and mighty moving railway train. The whole number of looms in the entire Mill is 2,700. A remarkable feature here, is the absence of all visible shafting—the intricate machinery receiving motion from the shafting on the floor below. The weavers, nearly all of whom are females, tend from three to five looms each, according to experience and ability. The walls of the room at their line of junction with the ceiling are decorated with a plain gold border, and the air of neatness and taste which pervades the entire establishment, would do credit to any well appointed parlor.

THE CARD ROOM

is directly above the Weave Room, and also extends the entire length and width of this section of the building, and is occupied by ingenious and complicated carding machines and their accessory contrivances, employing in their proper management, hundreds of men, women, and boys and girls.

THE MULE ROOM

This apartment is occupied by sixty self-operating mules, each sixty-five feet long. Each operative tends two mules. These self-acting machines, with their thousands upon thousands of rapidly revolving spindles, drawing out, twisting and winding up myriads of delicate threads with infallible precision and unerring certainty, with no hand to direct or control their operations, present to the beholder a most convincing exemplification of what the wonderful mind is able to contrive and accomplish.

THE SPOOLING AND WARPING ROOM

is in the fifth story. The operatives here are mostly boys and girls. One set of hands are busily engaged winding the thread from the 'cop' as it comes from the Mule Room, upon spools, by means of a winding apparatus. Others are making the 'warp,' which process combines operations of

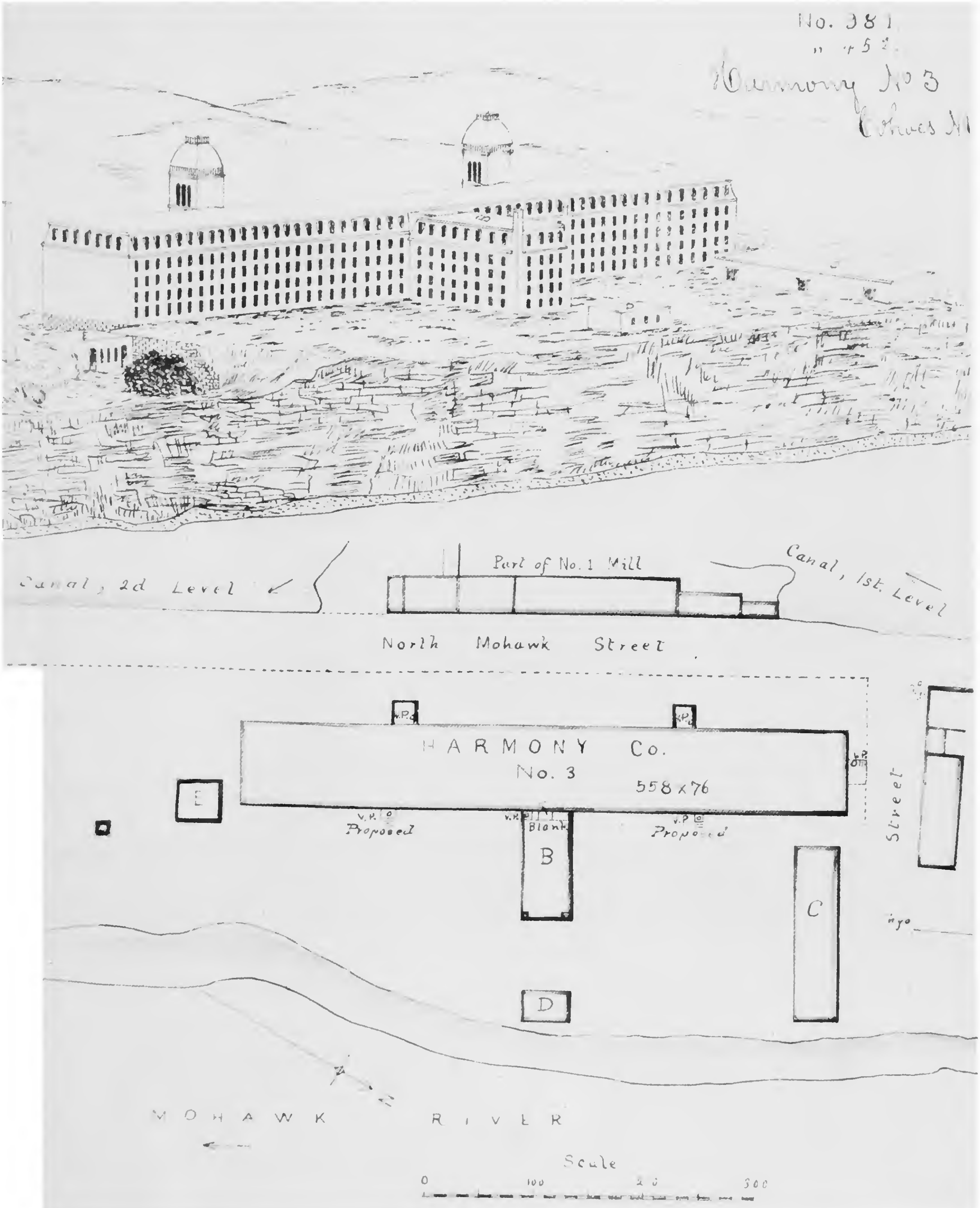


FIGURE 63.—Early view and plan of the Harmony No. 3 Mill, c1870, before enlargement. From a fire insurance survey. (*Courtesy of Factory Mutual Engineering Corporation.*)

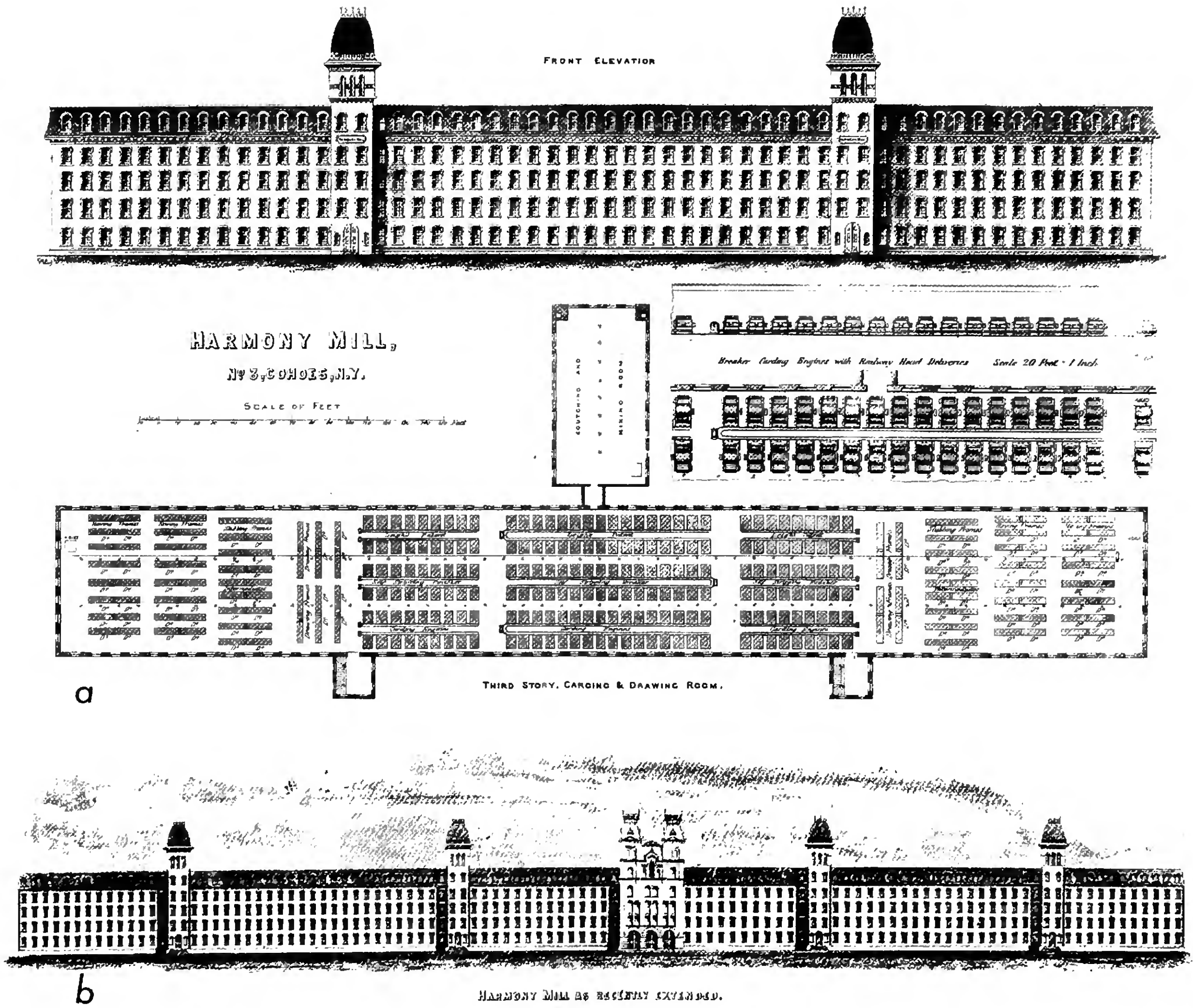


FIGURE 64.—Harmony No. 3 Mill was selected to exemplify the ultimate development in American cotton mill technology by the eminent British textile engineer, Evan Leigh: *a*, c1870, the initial configuration; *b*, the full mill, enlarged to the south, was illustrated in Leigh's second (later) volume. Today the stair-tower caps are gone, although the spectacular decorative features of the central block fortunately have been left intact. (Leigh, 1873: *a: volume 1, plate 20; b: volume 2, plate 39, top.*)

sizing, drying, &c. The machinery of this room, although less intricate than the 'mule' of carding machine, is a very admirable and effective combination of mechanism. Throughout the entire extent of this spacious apartment, not a single supporting column obstructs the view, as the self-sustaining properties of the French roof, which forms the sides and ceiling of the room, render such appliances unnecessary.

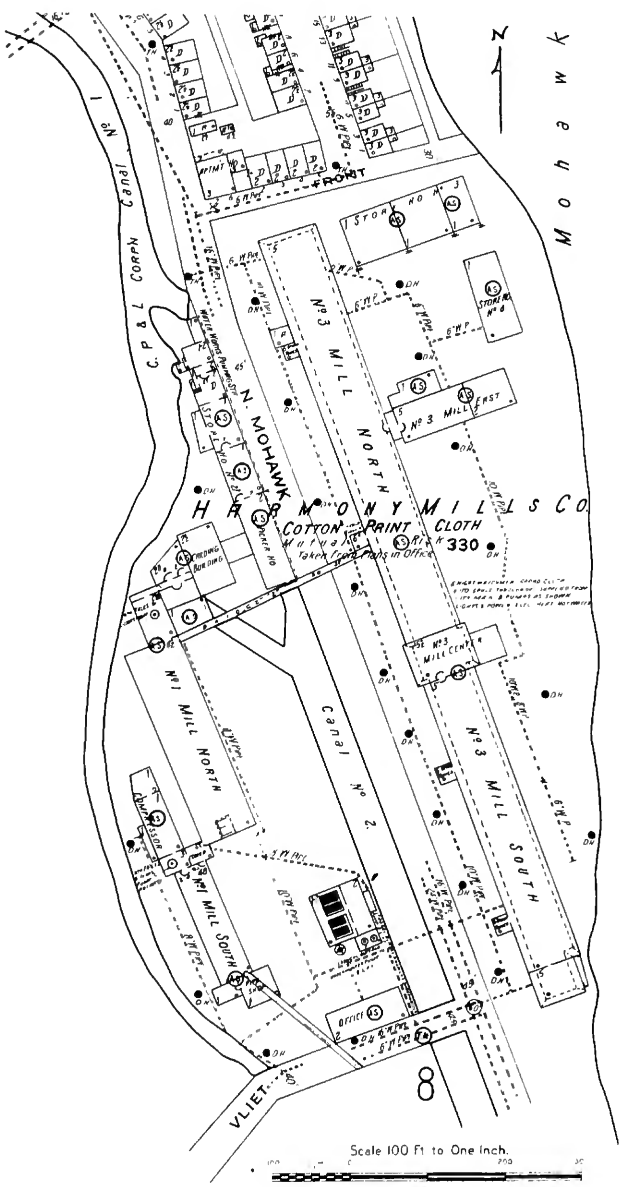


FIGURE 65.—Site plan of Mills Nos. 1 and 3 in the Harmony complex, at the height of the corporation's development. (*Sanborn Map Co., 1925, sheet 27.*)

Additions: In 1871 an addition to the mill was begun. This addition was part of the original total scheme for the No. 3. The second section was to be constructed to the south after the first was in operation. This addition, completed in 1872, was 76 feet wide and 510 feet long. The operations of this section of the mill were described thus in 1873 (Bean, 1873:24):

The basement, which is fire-proof, contains the wheel-pit and a large room adjacent, which is used for opening, picking, and lapping cotton. This room contains 3 openers and lappers, 3 finishing lappers and 96 40-inch carding engines, from which a lap is made for the finishing cards, passing thence by an elevator to the third story, in which are 96 finishing cards, 16 railway heads, 16 drawing frames, and 96 slubbing and roving frames, from which the roving is carried to the mule spinning room in the fourth floor, where are 60 self-operating mules, each sixty-five feet long; the yarn is carried thence to the fifth story, which contains the frame, spinning, spooling, and warping machines; there the yarn is carried to the sizing room on the first floor and prepared for the weave rooms, which occupy the balance of the first and the whole of the second floor. The cloth is then carried to the central tower, where it is examined, measured, baled, and shipped for market. It is the intention of the company to make wide and fine Muslin in this portion of the Mill, in imitation of the best French Dress Goods. This section of the Mill contains 130,000 spindles and 2,700 looms, and produces 700,000 yards per week.

Corporate History

The Harmony Manufacturing Company, later known as the Harmony Mills, was incorporated in 1836. Various prominent business men were among the founders of the company, including Peter Harmony, after whom the company was named.

In 1837 the first mill for cotton spinning was erected on a plot of land that became the nucleus of the holdings of the company. This operation was not, however, a financial success, and in 1850, the property was sold to Garner & Co. of New York and to Alfred Wild of Kinderhook. Garner & Co. operated mills in Rochester, Newburg, Wappinger Falls, and Rockland, New York, and in Reading, Pennsylvania. Thomas Garner also held a controlling interest in the Cohoes Company. A bronze statue of Garner by Millman, a Boston sculptor, was placed after Garner's death in a niche in the central tower of the mill, where it still stands.

Robert Johnston, who had previously managed a cotton mill for Nathan Wild in Valatie, New York, a

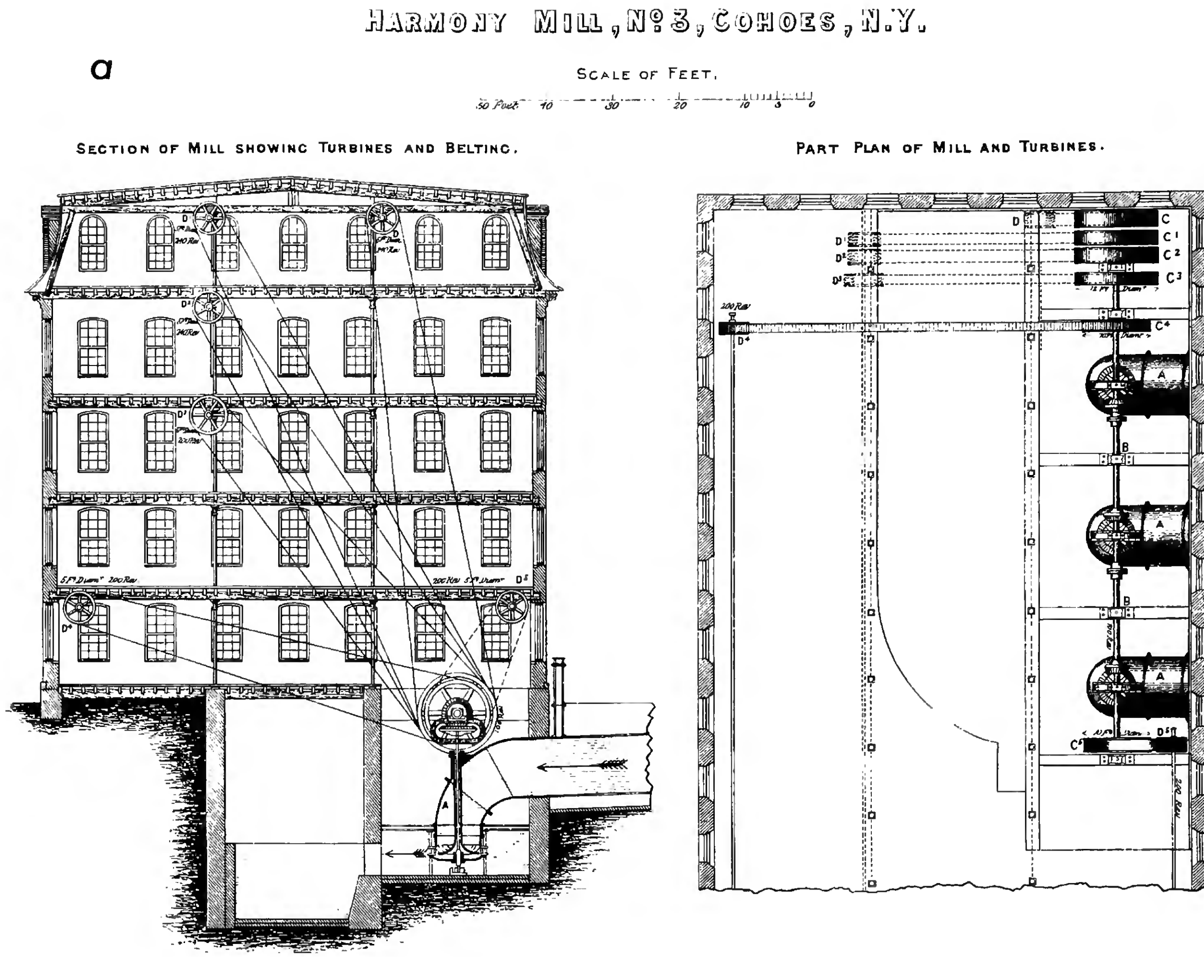
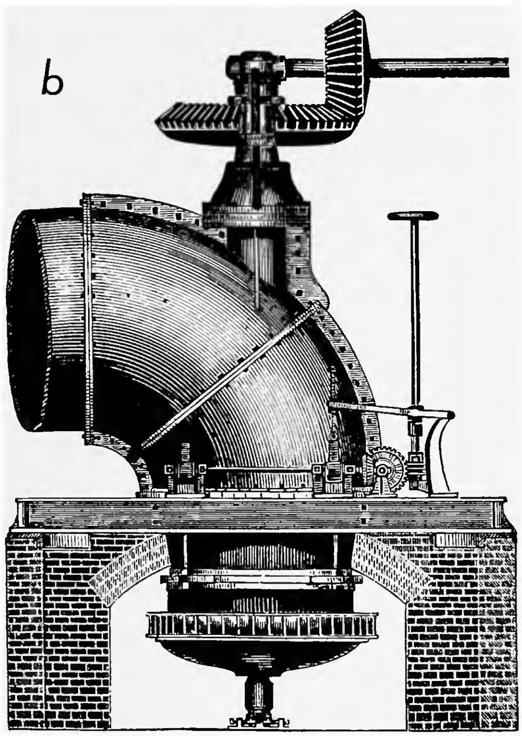
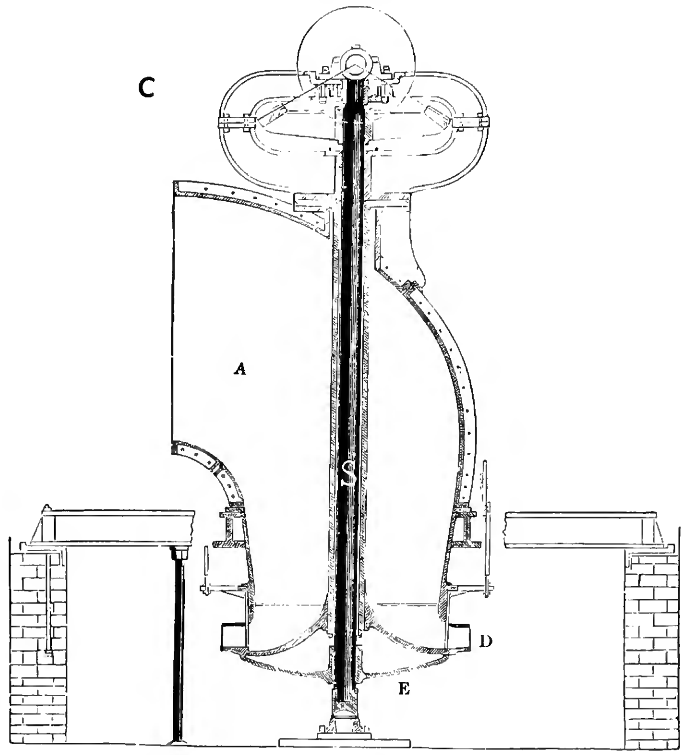


FIGURE 66.—*a,* The "Mastodon's" great vertical turbines, at the time among the largest in the United States, and the American system of transmitting the drive to the main line shafts on each floor by leather belt, were given particular notice by Leigh. Only about half the available hydraulic drop between the power canal and the river was utilized in the turbines (see Figure 62, which shows leakage from the tailrace discharging from the bluff below the mill). *b-c,* Boyden-type turbine by the Holyoke [Massachusetts] Machine Company. Holyoke was the major builder of the Boyden turbine, an improvement on Fourneyron's fundamental outward-flow type. Boyden's first wheel was used at the Appleton Mill in Lowell in 1844, the type soon becoming a near standard in the textile industry for major installations, retaining that position until about 1880. Holyoke built 32 Boyden turbines between 1873 and 1876, the two 800-horsepower units for Harmony, with 102-inch-diameter runners, being the largest of the group. The runner is shown at D-E, the water entering through the induction pipe at A and discharging at D. (*a: Leigh, 1873, volume 1, plate 21; b-c: Holyoke Machine Company, 1876, pages 8–9.*)





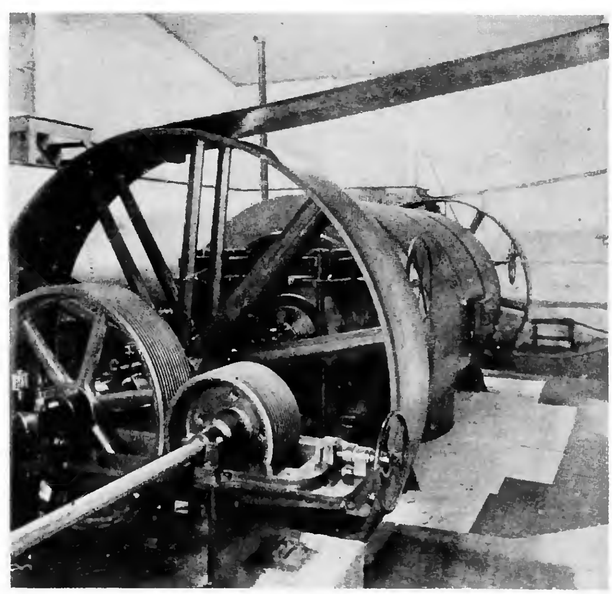


FIGURE 67.—From about 1890, horizontal-shaft turbines in light boiler plate casings replaced vertical wheels in cast-iron housings (the term "waterwheel" persisted among both manufacturers and users long after turbines had completely displaced wheels, and even today it is commonly heard in mills). This unit probably replaced one of Harmony's very early waterwheels. The grooved friction wheels in the foreground permitted a fire pump to be engaged with the main drive while the turbine was operating at full speed. (*Swain Turbine & Manufacturing Co., 1897, page 15.*)

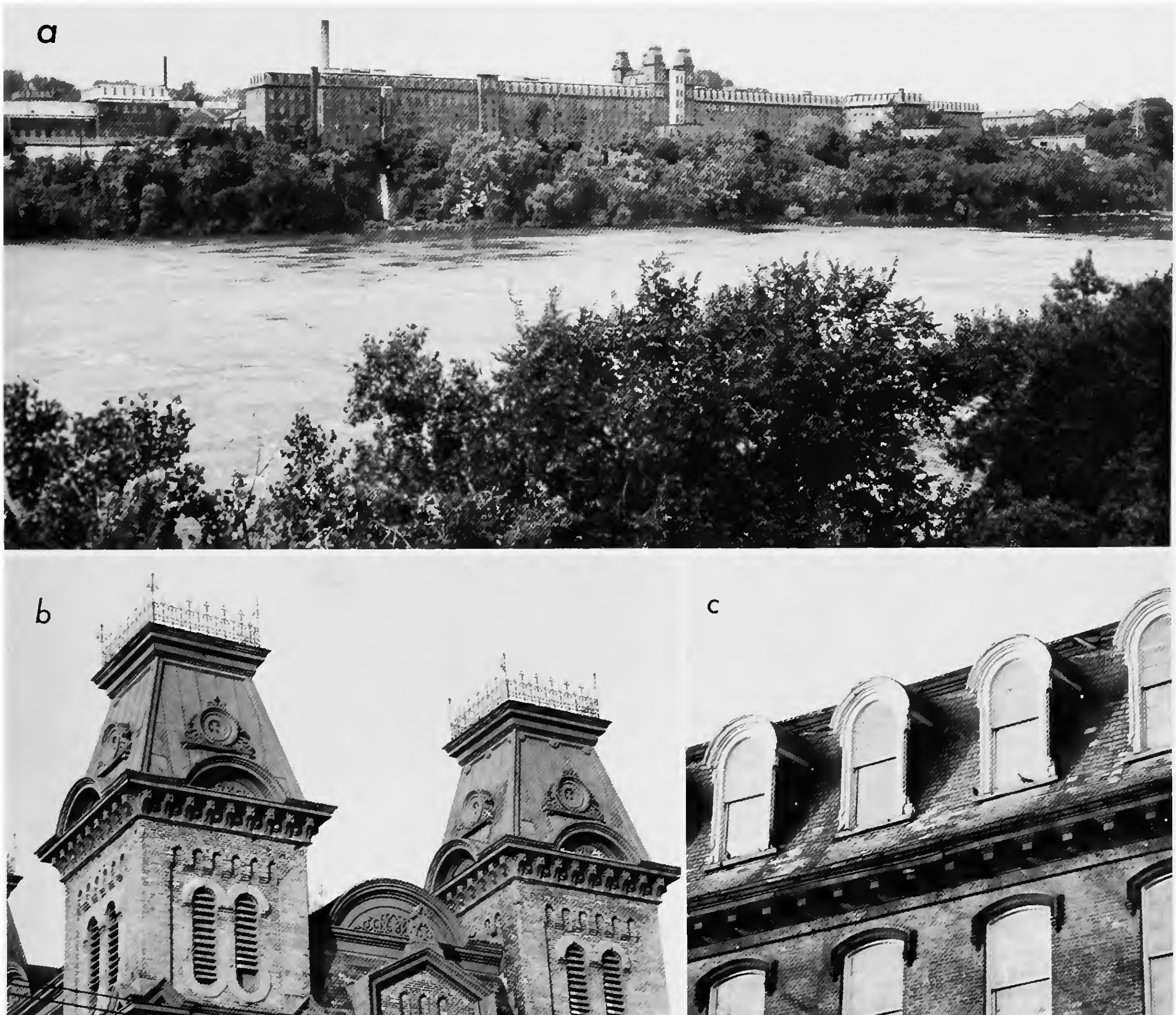
FIGURE 68.—Principal face of the Harmony No. 3 Mill from the northwest: central and south blocks.

was appointed by Wild's son, Alfred, agent of the Harmony Mills. Johnston, and his son David J. Johnston, so successfully managed the mills that in 1873 the Harmony complex was described as "the richest, the largest, and the most complete Cotton Manufacturing Establishment on the American continent" (Bean, 1873:16).

The Harmony Mills took a great interest in the well-being and surroundings of its employees. The company built tenements for its workers. The streets, which were lined with shade trees, reputedly were kept very clean; the sidewalks were paved with asphalt; and a Sunday school and afternoon worship services were sponsored by the company. The company's very influential role in the development of Cohoes was acknowledged by a contemporary writer (Masten, 1877:241):

The existence of a manufacturing concern of such magnitude has of course been of the utmost benefit to Cohoes in a business point of view, and contributed largely to its prosperity. Through its means large accessions have been made to the population, and the constant expenditures made by the corporation in wages, in the erection of buildings and in various improvements have been of marked advantage to the commercial interests of the place.

After Robert Johnston died in 1890 and David J. Johnston in 1894, D. S. Johnston in 1903 became the third generation of his family to hold the position of agent of the company. In 1910 Garner & Co. sold its interest in the Harmony property and in the Cohoes Company as well. The mills were purchased by the Saco-Lowell and Draper Corporation of Hopedale, Massachusetts, major manufacturers of textile machinery. The Harmony Mills Corporation was liquidated between 1932 and 1937, and the real estate



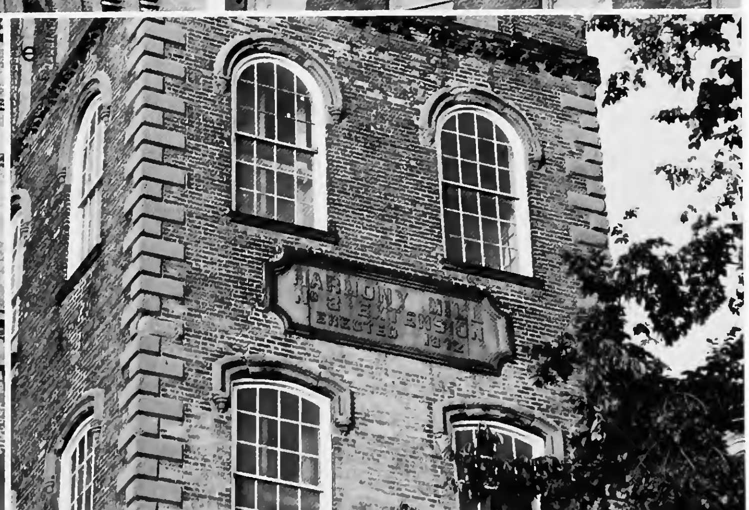


Figure 69.—Harmony No. 3 Mill: *a,* View across the Mohawk River of the rear (east) elevation; the south addition did not have the separate wing for the picking (cotton opening) machinery as did the original north section (see Figure 63); *b,* detail of central-block tower roofs; *c,* mansard and dormers, attic story, west elevation; *d,* the bronze statue memorializing Samuel Garner, Harmony's principal developer, is a unique embellishment for an industrial strurcture; *e,* tablet on the north stair tower, south block.

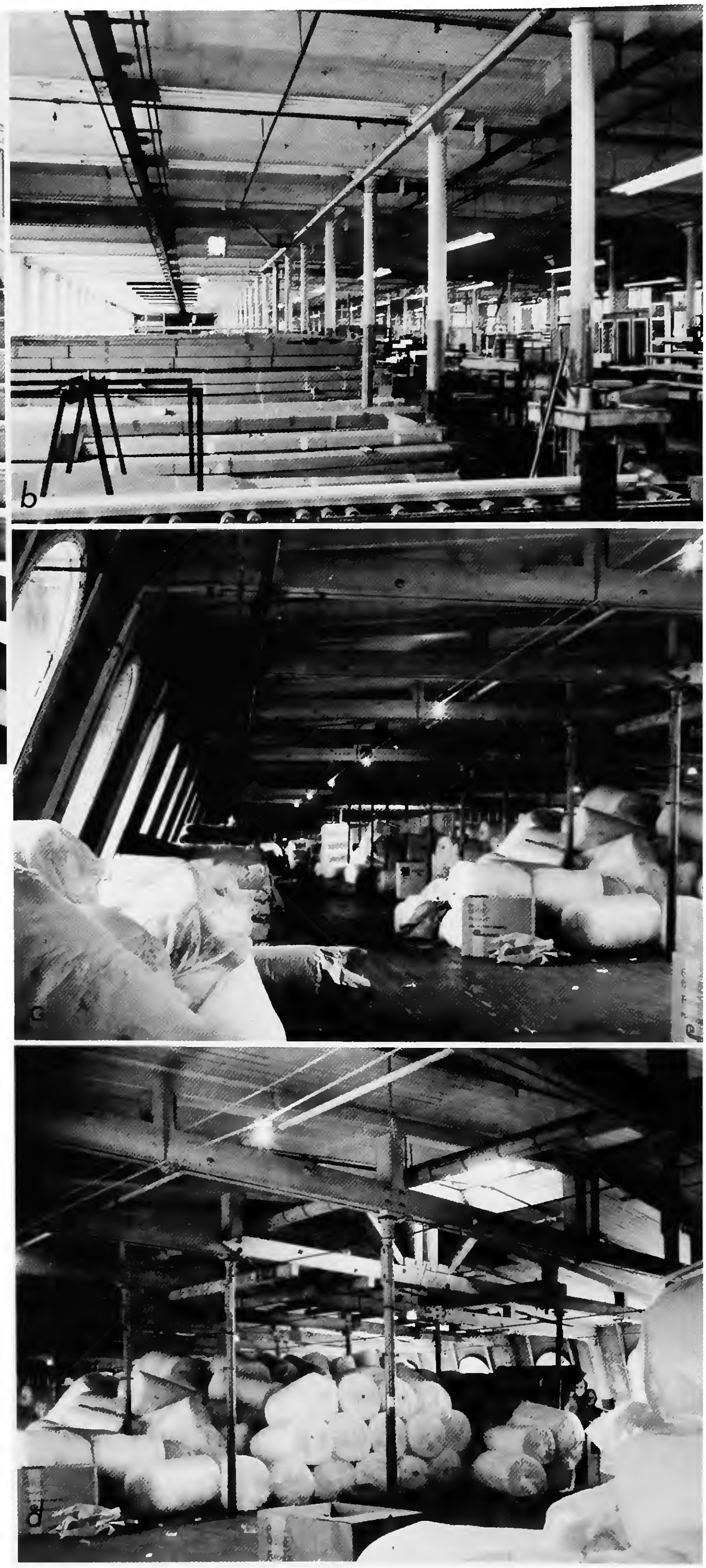


Figure 70.—*a,* Typical stairway and stair-tower entrance door. *b,* Typical interior, second floor. Why alternate (original) cast-iron columns have been replaced by ones of wood with heavier cast-iron caps is not known. *c,* Attic story, looking south. The mansarded attic enjoyed a great popularity with mill engineers during the 1870s, as a means of gaining an additional operating floor with full ceiling height—in opposition to the traditional pitched roof. By the end of the decade, however, it had become clear that the same advantage was available simply by carrying the masonry walls up another story, eliminating the expense and fire hazard of mansard framing and the elaborate wood cornice below. *d,* View in the attic looking southwest. The low-pitched roof is supported not on trusses, which would have provided a full clear floor area, but on double rows of columns as the floors below. The flats on the column caps originally carried bearing hangers for the longitudinal line shafts that drove the machinery.

FIGURE 71.—General view of the Holyoke turbines and wheel room, south block in Harmony No. 3 Mill. The installation is original, although the turbine runners (the rotating elements) were undoubtedly replaced several times during their operating life. These units are similar to those installed in the north block, now removed, but were twice as powerful, hence two rather than three units (see Figure 66*a*). The cast-iron service bridges between the turbines were for oiling the main bearings and the gears.

properties were sold. The No. 3 Mill was sold along with some other buildings for $2,500.

Sources of Information

Unpublished

Adams, Elmer L. "History of the Harmony Mill, Cohoes, N.Y." Typewritten copy at the Troy Public Library, New York.

Clark, Edward J. "Economic History of the Harmony Mills of Cohoes, New York." Master's Thesis, Graduate School, Siena College, 1952.

Telephone conversations with William Magee, Manager, Cohoes Industrial Terminal Corporation, and with his secretary.

Old views in the collection of the Cultural and Historical Society of Cohoes. Material unavailable at time of writing.

Published

Bean, William. *The City of Cohoes, its Past and Present History, and Future Prospects: Its Great Manufactories.* Cohoes: The Cataract Book and Job Printing Office, 1873.

The Cohoes Cataract. 1866, 1868.

Holyoke Machine Co. *Illustrated Catalogue.* Holyoke, Massachusetts, 1876. [Copy in Division of Mechanical and Civil Engineering, National Museum of History and Technology, Smithsonian Institution, Washington, D.C.]

Howell, George R., and Jonathan Tenney, editors. *History of the County of Albany, N.Y., from 1606 to 1886.* New York: W. W. Munsell & Co., 1886.

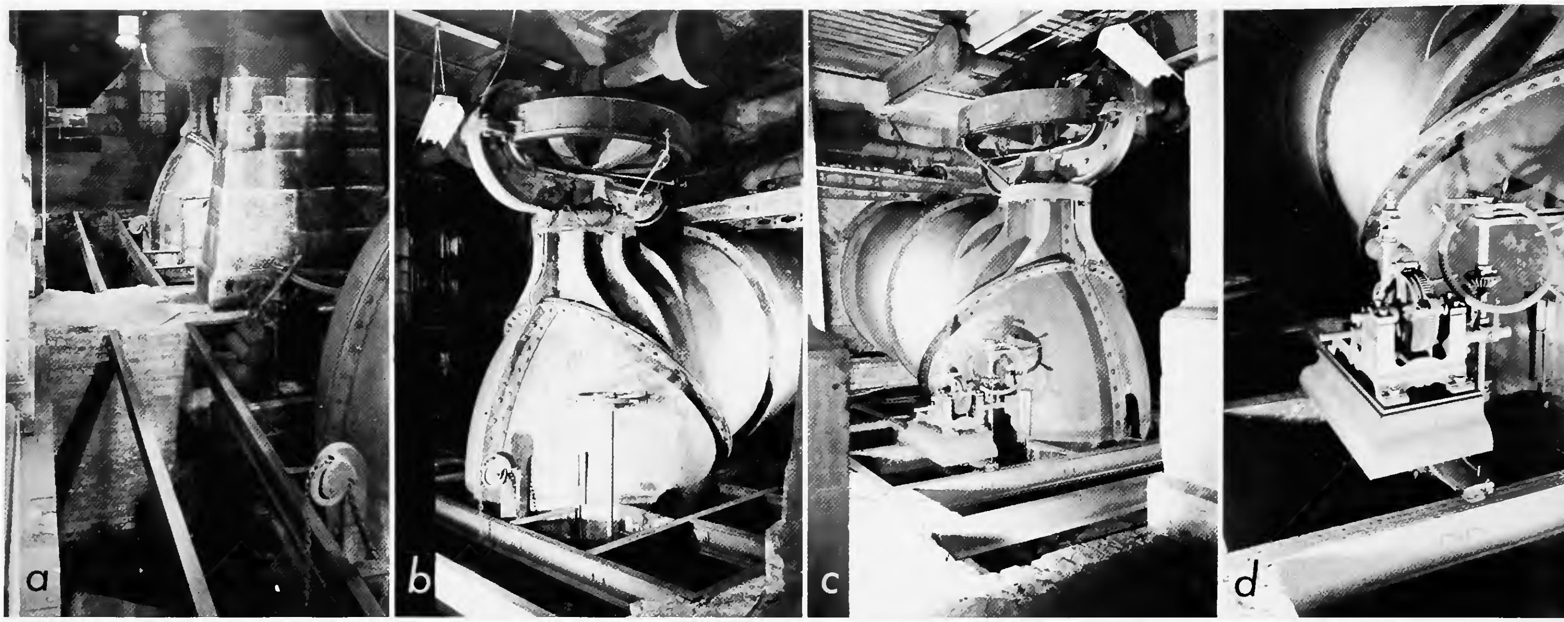


Figure 72.—Harmony No. 3 Mill: *a,* View into the wheel pits. The water, after passing through the turbines, was discharged downward and into the river below the mill. *b,* For distribution to the mill, the motion of the vertical turbine shafts was turned to the horizontal by large cast-iron mortise bevel gears that also increased the speed. The teeth of the turbine gear (hidden by the protective shrouding) are of hard wood, set individually into mortises in the gear body. These engage the iron teeth of the jack-shaft or driven gear, visible in upper left. The wood absorbed vibration, resulting in quiet, smooth operation. The hand wheel operated the turbine control gates, whose position was shown on the indicator to the left of the shaft. *c,* General view of the north turbine. *d,* Snow-type mechanical governor for maintaining the turbine speed constant despite varying load. The centrifugal flyballs sensed the shaft speed and engaged ratchets to open or close the control gates, admitting more or less water as the turbine load increased or decreased. The hand wheel permitted manual override if needed.

Leigh, Evan. *The Science of Modern Cotton Spinning.* 2nd edition, 2 volumes. Manchester, England: Palmer & Howe, 1873.

Masten, Arthur H. *The History of Cohoes, New York, from Its Earliest Settlement to the Present Time.* Albany: Joel Munsell, 1877.

Sanborn Map Co. [*Insurance Maps of*] *Cohoes, New York.* New York, 1925.

Swain Turbine & Manufacturing Co. *Water Wheels* [*Turbines*], *Mill Gearing, Shafting, Pulleys, etc.* Lowell, Massachusetts, 1897. [Copy in Division of Mechanical and Civil Engineering, National Museum of History and Technology, Smithsonian Institution, Washington, D.C.]

ARCHITECTURAL INFORMATION

General Statement

Architectural Character: The Mastodon Mill is an unusually elaborate example of Victorian textile mill construction. The two principal blocks, north and south, built several years apart, are similar and coaxial. Each is of five stories including the usable Mansard attic, plus full, usable basement. At the approximate third-points, projecting from the principal (west) face of each section, are two six-story stair towers originally surmounted by convexo-Mansard roof caps, since removed. Projecting to the

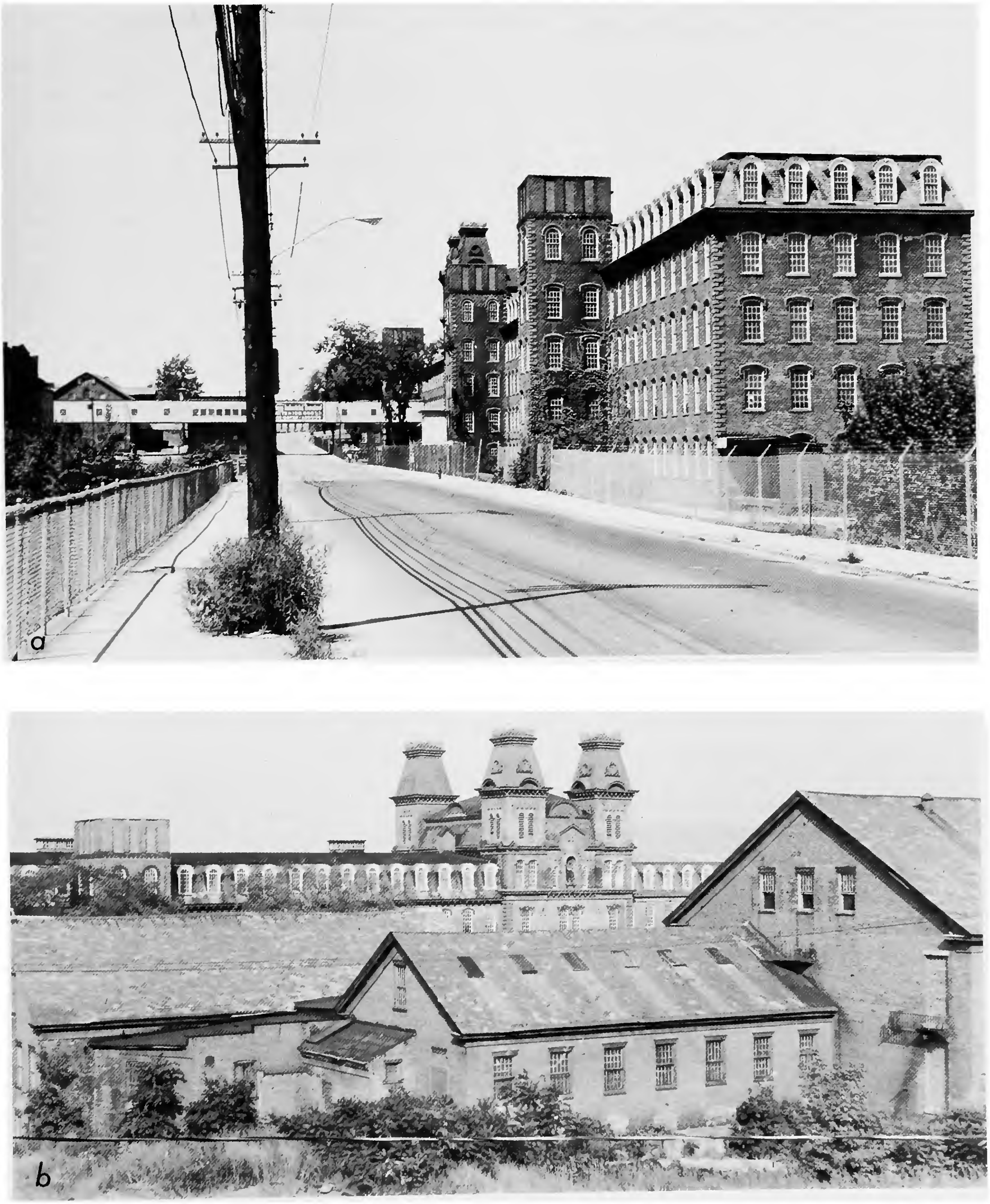


FIGURE 73.—*a*, View north along North Mohawk Street; *b*, view to the east of the Mastodon Mill over the contrasting roofs of the earlier No. 1 Mill. (*Vogel*)

rear of the early (north) section and at right angles to it is a five-story wing originally constructed for the picking-and-opening machinery. It was common cotton-mill practice to place the picking machinery in a separate wing, isolated from the main mill by fireproof doors, because of the considerable liability of fire in the pickers. Pickers operated at high speed, the stones and other bits of rubbish in the raw cotton frequently striking sparks when passing the metal parts of the machine, igniting the mass of cotton.

When the south section was built, it was joined to the original section by a large central pavilion, projecting slightly beyond the front and rear faces of the main blocks, with a high Mansard roof rising one story above the main roofs. At each corner of the pavilion is a highly detailed square tower capped by a straight Mansard roof crowned with decorative ironwork. A niche at the fifth story level contains a heroic bronze statue of Samuel Garner, standing, marked on its base "GARNER."

Condition of Fabric: Fair to good.

Description of Exterior

Overall Dimensions: Approximately 1100 feet by 75 feet. North section 56 bays long; south 51 bays; both three bays wide divided by two rows of cast-iron columns.

Foundation: Cut granite blocks laid in random ashlar.

Bearing Walls: Standard red brick in running bond. Quoins, window heads and sills of sandstone in the north (early) section and cast iron in the central and south sections. Most of the molding and detail of the central pavilion is sheet metal.

Structural System: Standard slow-burning mill construction of heavy timber lateral beams supporting structural floor planks; cast-iron columns at the beam third-points.

Openings: All frames, doors and sash, wood; all sash double-hung, 12-over-12. All openings segmentally arched except dormers and doorways, which are full-arched.

Roofs: Mansard faces: slate; pitched portions: built up. Form described above. Sheet metal cornice and eaves.

Description of Interior

Floor Plan: Five floors of large open space are interrupted only by the cast-iron columns. The fifth floor has slanting walls and dormers created by the Mansard roof.

Mechanical Equipment: In the basement of the south section are the two original Holyoke hydraulic turbines and a governor. The turbine runners (moving parts), however, have probably been replaced several times. According to its *Illustrated Catalogue* (1876:5), the Holyoke Machine Co. built two 102-inch Boyden-type turbine water wheels, 800 horsepower each, for the Harmony Mill in Cohoes. "The economical use of water is not its [the turbine's] only . . . excellence; for it is the most substantial and permanent of the fixtures of a mill, and all the parts can be inspected without being taken apart. It occupies but little space above the wheel-pit; and all its connections being made watertight, the room may be kept dry and clean." These were the largest wheels on the company list to that date and nearly the most powerful.

The governor was manufactured according to Snow's patented design in Bennington, Vermont. Although the turbines are not used, as the mill is no longer powered by water, they remain entirely intact and are excellent specimens of typical nineteenth-century hydraulic power machinery. The original turbines in the north half of the mill have been removed. The two surviving turbines in the south half are unmarked, but are unquestionably the pair by Holyoke, which was one of about four builders of large Boyden wheels.

Stairways: The four stair towers and the central pavilion contain curving wood staircases.

Flooring: Wood.

Site

General Setting and Orientation: Southwest bank of the Mohawk River, on the northeast side of North Mohawk Street, facing the Cohoes Power Canal.

Related Structures: The No. 3 Mill is part of an industrial complex consisting of about eight major mill buildings plus a variety of secondary service structures.

Power Canals 1834-1880

Cohoes Company, Cohoes

(HAER NY–9)

Richard S. Allen

Location: Immediately east of, and generally parallel to, North Mohawk Street, Cohoes, Albany County, New York.
Latitude: 42° 46′ 00″ N. Longitude: 73° 42′ 30″ W.
Date of Erection: 1834–1880.
Designer: Canvass White (1790–1834), C.E., and others following.
Present Owner: Cohoes Industrial Terminal Corporation, with the majority of the shares held by the City of Cohoes.
Present Use: Part of the canal system is being utilized for hydroelectric power. Other parts are used for sewage and drainage, while some areas are completely clogged.
Significance: The canals of the Cohoes Company comprised a typical, major power canal system, providing the power source for the city's mills and factories by supplying water for the water wheels and later for the turbines that drove the machinery in the mills.

HISTORICAL INFORMATION

Physical History

Original Owner: The Cohoes Company was organized in 1826 to utilize the water power potential of the Cohoes Falls on the Mohawk River drawing all the water not already taken for use in the Erie and Champlain canals.

Designer: Canvass White, a prominent civil engineer, canal-builder and the discoverer of hydraulic cement, envisioned Cohoes as a great manufacturing city. It was he who instigated the formation of the Cohoes Company. Backers of the concern included Stephen Van Rensselaer of Albany, Peter Remsen of New York and David Wilkinson (1771–1852), a cotton manufacturer and mechanical genius from Rhode Island. In addition to serving as first president of the concern, White devised the details of the intricate power canal system around which Cohoes was to grow. Unfortunately, ill-health dogged the engineer, and he died before his brainchild became a reality.

Construction of the Cohoes power canal system fell to Canvass' brother Hugh (1798–1870), who directed the building of the first company dam in 1831–1832 and the first canals in 1834.

Original Purpose and Construction: A wooden dam across the Mohawk River above the falls backed up the river. The first power canals completed were "Basin A" at the lower end of the present Harmony Mills, and "Basin B" immediately west of the upper end of Remsen Street.

Next came the Upper Levels, with a fall of 18 feet to bring water to the basins below. These ran on the east side of the old (original) Erie Canal and parallel to it. In the vicinity of the present School Street the water was taken under the canal by means of two wooden trunks four to five feet in diameter. At the lower end (present Remsen Street) the water was let into the basins to the south. In addition, it again

Engineering Information: Prepared by Richard J. Pollak.

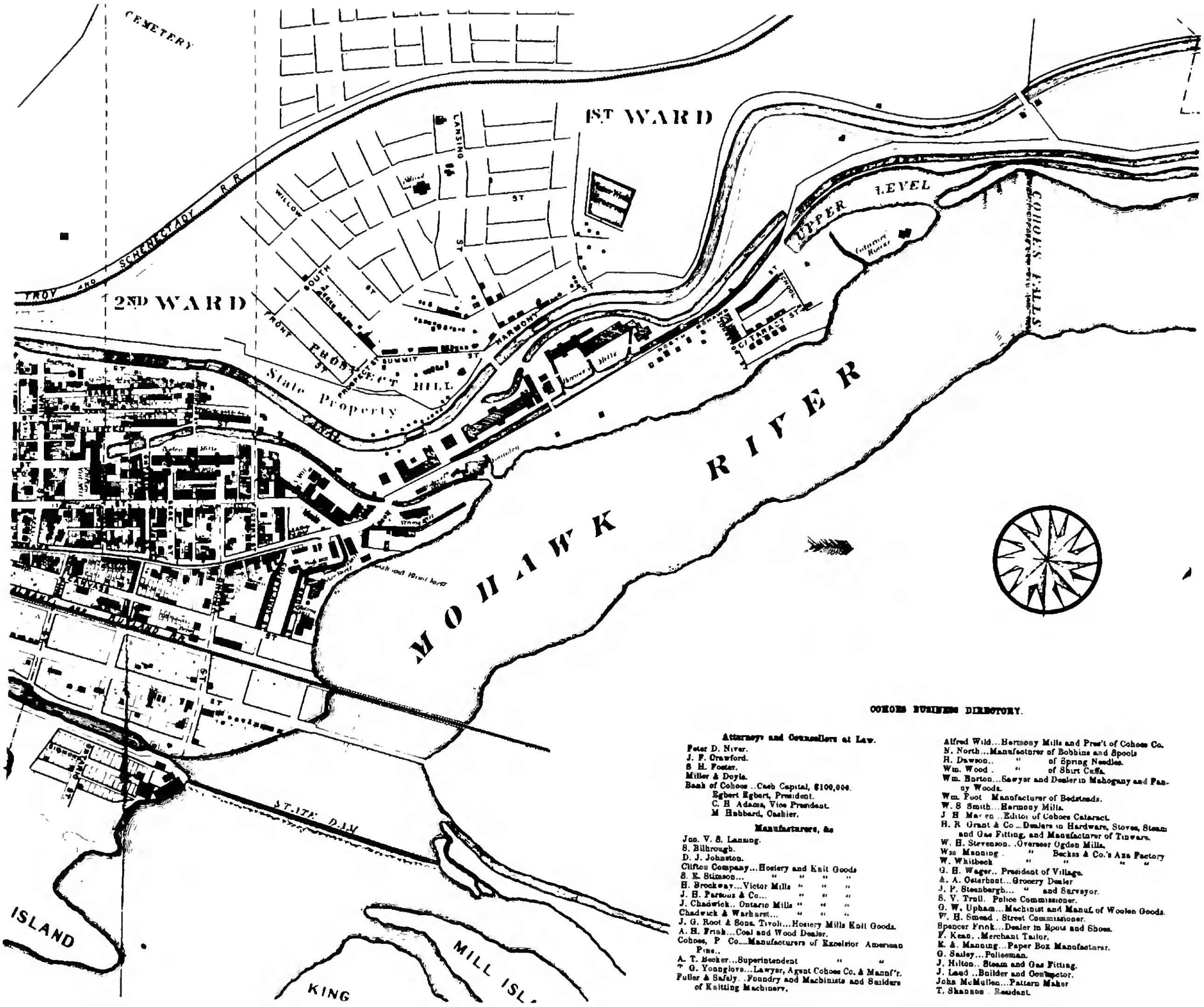


FIGURE 74.—North half of Cohoes, 1856. The Cohoes Company dam is off the map, to the right. (*Beers, 1856, plate 39.*)

tunneled under the canal and back into the Mohawk River to the north. During the last process the water was used to power an early iron foundry (1834–1867) after already having been used by saw mills, grist mills, and a paper mill in the course of its fall.

> [By 1836, the Cohoes power canal system was described as] an independent canal nearly two miles long . . . unconnected with the state [canal] works. The head and fall . . . is 120 feet permitting the use of the water under six successive falls from 18 to 23 feet . . . and may be carried on these levels to almost any part of the company's estate. The minimum supply of water is 1,000 cubic feet a second, competent to drive from 3 to 4 millions of cotton spindles.

Alterations and Additions: An enlarged Erie Canal was planned in 1837 and finally completed in 1843. This involved a number of changes and exchanges between the navigable State canals and the Cohoes Company. Two sections of the old Erie Canal (one to the west of Mohawk Street between the present Harmony Mills, and another west of Remsen Street as far south as White Street) became levels of the Cohoes power canal system.

At first, the role of the Cohoes Company was both to provide almost unlimited power for manufacturing, and to attract potential industries to the town in order to utilize it. Originally, the company engaged in some manufacturing itself, but it gradually became more of a benevolent overseer, leasing lands and providing power only. The passing years saw the phenomenal growth of such industries as the Harmony Mills, one of the nation's largest cotton manufacturers, and Daniel Simmons' Axe Works, whose products were sold world-wide.

Gradually, as both Cohoes and its industries grew, the power canal system was extended and improved. In 1865 a solid stone masonry dam was constructed across the Mohawk River, supplanting the older dam at the head of the canals. Stretching 1,443 feet across the river, it was designed by and built under the supervision of engineer William E. Worthen of New York.

By 1880, the Cohoes power canals were complete as far as they ever would be. Their arrangement was as follows:

Level 1	(Upper Level) Extending from the dam to the rear of the early Harmony Mills. A fall of 18 feet.
Level 2	West of Mohawk Street between the Harmony Nos. 1-2 and No. 3 Mills (original Erie Canal). A fall of 25 feet.
Level 3	From East Remsen Street to just south of Ontario Street. A fall of 23 feet.
Level 4	A short section west of and adjacent to the upper end of Remsen Street. A fall of 20 feet.
Level 5	South of Ontario Street, running east to the Rensselaer & Saratoga (Delaware & Hudson) Railroad tracks. A fall of 20 feet. (No longer in existence, 1969.)
Level 6	South of Courtland Street (a spur of Level 4). (No longer in existence, 1969.)
Level 9	South of Grove Street to the Rensselaer & Saratoga (Delaware & Hudson) Railroad tracks. (No longer in existence, 1969.)

Three other levels (Level 7, east of the Rensselaer & Saratoga Railroad southward; Level 8, between Saratoga Street and the Champlain Canal; and Level 10, an extension of Remsen Street's Level 4) were planned and some work was done, but they were never finished. A 360-foot tunnel, completed in 1876, was excavated from the end of Level 1 to the bank of the Mohawk River. By means of this tunnel, ice and accumulated debris could be jettisoned without stopping the mills below.

The Cohoes Company's officers in later years were the heads of the mills that used the power. They charged nominal rates, the annual rental running to only about $20 per horse power. The exact quantity of power used by each manufacturer was accurately measured and charged for accordingly.

By developing the water power and thus offering inducements for the establishment of industrial enterprises, the Cohoes Company laid the foundations for all of the varied industries that at one time or another made the City of Cohoes their home. Only changes in industry and the use of electric power have brought gradual abandonment of the canals.

Today, four of the levels of the Cohoes Company power canal system still exist, including the two that are parts of the original Erie Canal. The uppermost level is still a hydraulic power canal. Others serve for drainage and sewerage; the two lowest levels, however, are clogged with silt and debris and are close to abandonment. An intricate system of hand and machine-operated guard gates, inlets, and outlets control the remaining portions, much of the machinery being over a hundred years old.

Some of the nation's early hydraulic engineers had a hand in fashioning the Cohoes power canal system, and it is still a monument to their foresight, planning and execution.

Sources of Information

Unpublished

Conversations with William Magee, General Manager, Cohoes Industrial Terminal Corporation.

Records and maps on file at Albany County Clerk's Office, Albany, New York.

Published

Bishop, John Leander. *History of American Manufactures.* Philadelphia: E. Young & Co., 1861.

Child, Hamilton. *Gazetteer and Business Directory of Albany & Schenectady Counties, N.Y. for 1870–71.* Syracuse, 1870.

Howell, George Rogers. *Bi-centennial History of Albany: History of the County of Albany, N.Y. from 1609–1886.* New York: W. W. Munsell & Co., 1886.

Masten, Arthur Haynesworth. *History of Cohoes, New York from its Earliest Settlement to the Present Time.* Albany: Joel Munsell, 1877.

Weise, Arthur James. *City of Troy and its Vicinity.* Troy: Edward Green, 1886.

Maps

Beers, S. N. and D. G. *New Topographical Atlas of the Counties of Albany and Schenectady, New York.* Philadelphia, 1856.

Brevan, John. *Map of Cohoes, Albany County, New York.* 1860.

Gould, Jay. *Map of Cohoes, New York.* c1856.

Sampson, Murdock Company, Inc. *Map of Troy, Watervliet, Cohoes, Waterford & Green Island.* 1889–1935.

Map of Cohoes Company Canal & Erie Canal. 184?. (Drawing. Copy at New York State Library.)

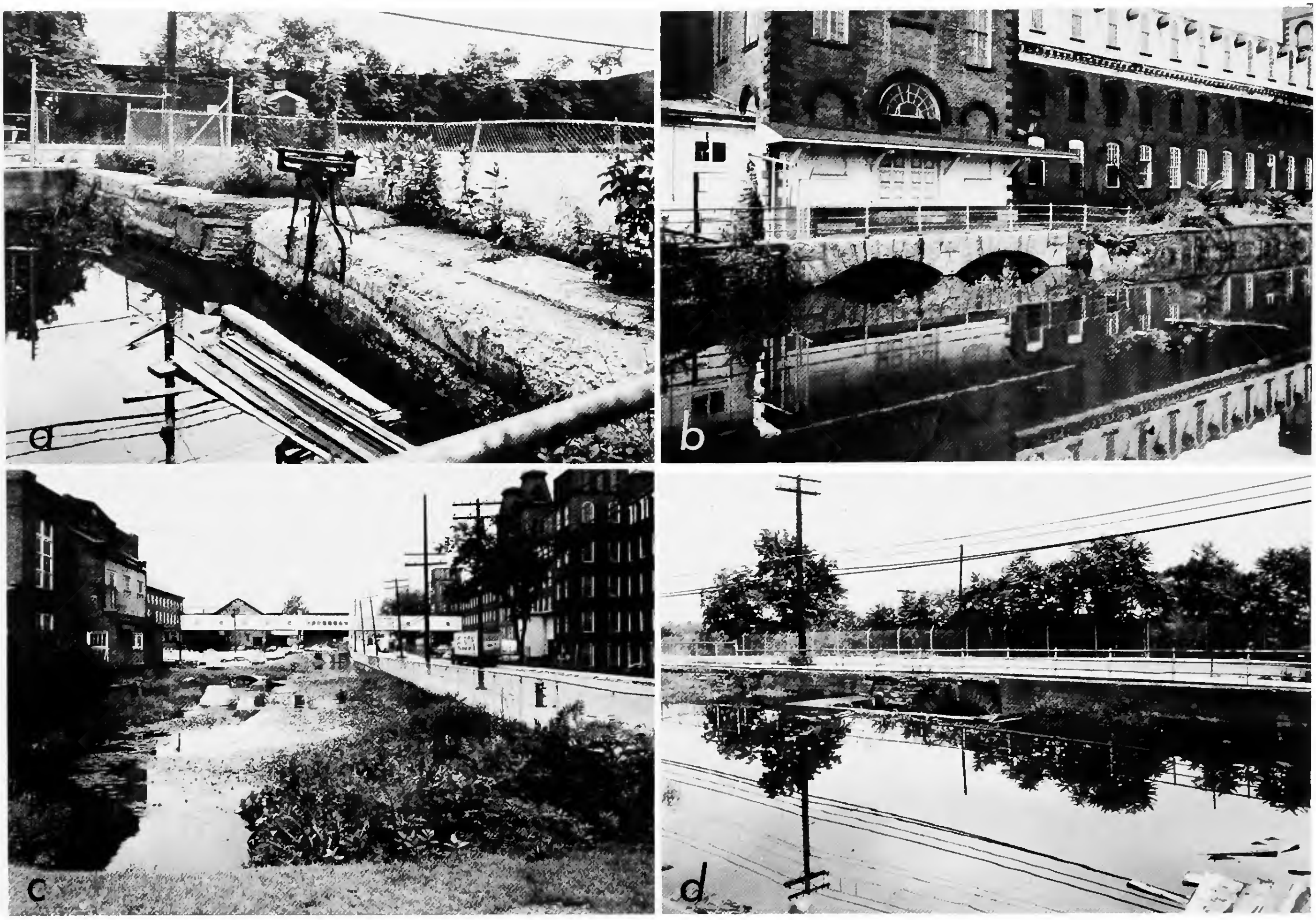


FIGURE 75.—Second level canal: *a,* South end, gate control to let water directly into the third level canal; *b,* arches over intakes at Harmony No. 2 Mill; *c,* looking north between Harmony Nos. 2 and 3 Mills; *d,* south end, spillway into the Mohawk River to prevent overtopping of the berm.

ENGINEERING INFORMATION

General Statement

Structural Character: Typical canals formerly used to feed the turbines that powered the machinery of Cohoes' mills and factories. The system, planned and developed by the Cohoes Company to utilize the energy of the Cohoes Falls on the Mohawk, was similar to the scheme already established at Lowell, Massachusetts; Paterson, New Jersey; and Nashua, New Hampshire.

Condition: The general condition is poor, with most sections drained of water and filled with refuse. The original diversion canal extends south from the head gate house at the dam, and currently serves the Niagara-Mohawk Power Corporation as a headrace.

Physical Description

The earth-banked canals are trapezoidal in section, 4 feet deep, varying in length and width according to the number and size of the mills they were designed to serve. The amount of water drawn by each mill determined the power rates charged. A section of the canal which utilized an abandoned (1840) portion of the original (1824) Erie Canal has been filled in.

Site

Orientation: Generally north and south but directions vary as to mill served.

Setting: Industrial area: mills, factories, and corporation housing.

Head Gate House 1866

Cohoes Company, Cohoes

(HAER NY–9A)

R. Carole Huberman

Location: North end of the power canal abutting the east bank.
Latitude: 42° 47′ 43″ N. Longitude: 73° 42′ 52″ W.
Date of Erection: 1866.
Designers: William Worthen, C.E., and David Van Auken, C.E., architect.
Present Owners and Occupant: Niagara Mohawk Power Corporation.
Present Use: Head gate house for hydroelectric station.
Significance: In addition to its practical function as a gate house controlling the flow of water to the canal, the Head Gate House was conceived romantically as a Romanesque-Revival brick bastion at the head of the power canal, where it is fed by the Mohawk River.

HISTORICAL INFORMATION

Physical History

The inscription on the builder's stone formerly inset on the front of the central tower reads (Figure 76a):

1866
COHOES COMPANY
ALFRED WILD, President
T. G. YOUNGLOVE, Agent
DIRECTORS
ALFRED WILD, WILLIAM T. GARNER,
CHARLES VAN BENTHUYSEN, DAVID J. JOHNSTON,
SAMUEL W. JOHNSON, WILLIAM W. NILES,
TRUMAN G. YOUNGLOVE

STONE DAM ERECTED 1865
HEAD GATES AND GATE HOUSE ERECTED 1866
WM. E. WORTHEN, Engineer
DAVID H. VAN AUKEN, Assistant Engineer
JOHN BRIDGFORD, Contractor
First Dam Erected 1831. Partially
Destroyed by Ice 1839 and Repaired
Same Year.
Second Dam Erected 1839.

Original Purpose and Construction: According to one source, "the cost of the dam and appurtenances [i.e., the head gates and head gate house] was $180,000" (Masten, 1877). David Van Auken, assistant engineer for the head gate house, was the architect for Harmony No. 3 Mill which also began operation in 1866.

Alterations and Additions: The square, crenelated tower on the central part of the Head Gate House has been removed as well as the hipped roofs of the flanking, two-story towers, which now are flat-roofed, as the center tower had been. In 1911, when the entire power canal system was abandoned in favor of hydroelectric power transmission, the stem of the T-shaped building was extended by a slightly higher, one-story brick addition housing the additional gates necessitated by the widened canal (headrace).

Data obtained from secondary sources listed in "Sources of Information" (p. 119) as the building was inaccessible at the time of the initial survey.

FIGURE 76.—Head Gate House: *a*, Principal (east) face, probably shortly after completion in 1866; *b*, view northeast, looking upriver. Head of the upper-level canal is in the foreground. *c*, View southeast. The dam is to the left of the Gate House; the addition of c1911, accommodating additional gates, is in the foreground. (*a: Courtesy of Niagara-Mohawk Power Corporation; b: Boucher; c: Pollak.*)

FIGURE 77.—View north along the second level canal, Harmony No. 2 Mill on left; No. 3 Mill on right.

Sources of Information

UNPUBLISHED

Early photograph of the original front elevation. This print also provides the information incised on the commemorative builder's stone. From Niagara Mohawk Power Corporation.

PUBLISHED

Masten, Arthur Haynesworth. *History of Cohoes, New York, from its Earliest Settlement to the Present Time.* Albany: Joel Munsell, 1877.

Weise, Arthur James. *City of Troy and its Vicinity.* Troy: Edward Green, 1886.

ARCHITECTURAL INFORMATION

General Statement

Architectural Character: A Romanesque-Revival brick structure founded in the water and over the headgates of the canal.

Condition of Fabric: Good.

Description of Exterior

Overall Dimensions: According to Masten (1877: 182), "It is 218 feet long; and the front tower is 31, and the main towers are 43 feet in height."

Plan: Symmetrical T.

Foundations: Stone masonry.

Wall Construction and Finish: Brick running bond with decorative, corbelled arcade at cornices and beltcourse levels.

Structural System: Probably solid brick masonry construction.

Openings: Doors and Doorways: An arched brick doorway in the center of the building with substantial, diagonally panelled, wood double doors.

Windows: Within tall, narrow and shallowly hooded and bracketed brick arches are wood frame 6-over-6 double-hung windows with fanlights.

Ventilators: Slender arched apertures with horizontal louvers and shallow brick hood and bracket detail, on the upper level of the end towers.

Roof: Shape and Covering: The original section of the building, aside from the tower areas, has a low-pitched, slated roof. Originally, the end towers boasted steep roof peaks of slate shingle crowned with ironwork at the ridge. The new section has a flat roof with a raised brick parapet.

Cornice: The brick cornice is delineated and decoratively accented by corbelled arcades which are heavier at the end tower roofs. Originally, there was a central tower with a crenelated termination.

Cohoes: The Historical Background 1811-1918

Samuel Rezneck

The Cohoes Company takes its name from the Cohoes Falls of the Mohawk River, just above its confluence with the Hudson. This was also the point at which the Erie and Champlain canals joined before their descent to the Hudson level and termination at Troy and Albany. The juxtaposition of canal and company is more than a matter of geographical coincidence. The Cohoes Company was, in fact, an early by-product of the Erie Canal improvement, and the fortunes of both were closely linked from the outset.

The very foundation of the Cohoes Company in 1826 was an outgrowth of the Erie Canal. It was the year following the completion of the canal and the inauguration of its use between Buffalo and Albany. Two men of great note were significant as builders of the Erie Canal. One was Canvass White, who along with Benjamin Wright, John B. Jervis, and others, was a pioneer figure in hydraulic engineering in America and whose work on the Erie Canal brought him to this terminal point at the junction of canal and river. The other was Stephen Van Rensselaer, principal landlord and patron of the area, whose vast estate embraced the lands on both sides of the Hudson River, as well as the great water rights on the Mohawk. He was, moreover, a promoter of the canal and chairman of the Canal Commission. To both of these men the value of the water power at the Cohoes Falls was quite apparent, leading to the merger of their interests in this unusual corporation.

The Cohoes Company had, in fact, a predecessor as early as 1811, in the Cohoes Manufacturing Company, which was formed by a group of promoters from Lansingburgh, just across the Hudson River. It acquired a sixty-acre lot of land, part of the Heamstreet farm, together with a water right on the Mohawk. The capital stock was $100,000, a large sum for the time, divided into two thousand shares, and its object was to initiate the manufacture of textiles and iron mongery. Its first and only project was the manufacture of wood screws, which is described in Spafford's *Gazetteer of New York State.* Spafford refers to a William C. Penniman, a self-taught artist, who built the machinery for this little factory. It burned, however, in 1815, and the whole venture languished for a decade. The completion of the Erie and Champlain canals, with their numerous locks within what was to become the settlement of Cohoes, brought considerable activity to the area. The Cohoes Manufacturing Company was revived and a cotton mill was erected, while plans were made for further development of the water power and the eventual establishment of many factories there. There was even a complaint that the canals drew off too much water from the Mohawk.

The Cohoes Manufacturing Company ultimately failed, despite, or perhaps because of, its ambitious plans. Another organization was formed in 1826—the Cohoes Company—inspired largely by Canvass White, who interested Stephen Van Rensselaer, Peter Remsen of New York, and other potential capitalists in the project. On 28 March 1826 the Cohoes Company was incorporated, with Canvass White as president and the son of Stephen Van Rensselaer, Stephen Jr., as vice president. The latter succeeded White as president a few years later. Capital, set at $250,000, doubled a decade later. Van Rensselaer turned over his water rights on the Mohawk to the company for one dollar and other considerations, and it acquired adjoining lands. The plan was to build a dam across the river above the Falls and from there divert water into a canal that would distribute it in measured amounts across the company lands for industrial uses. It was even contemplated to build factories, wharves, and houses and to lease them to various enterprises.

Actual development was delayed, partly because Canvass White was in demand as a hydraulic and canal engineer elsewhere. His brother, Hugh White, took over the direction of the projects, settling in nearby Waterford, where his house now serves as the home of the Waterford Historical Society. In the meantime, the moribund Cohoes Manufacturing Company was liquidated, its rights and land acquired by the Cohoes Company at a receiver's sale in 1829. In 1831 the first wooden dam was built across the Mohawk near the present dam site. At first the company used the Erie Canal to distribute water, but it shortly built its own diversion canal, more than a mile long, which in an enlarged form still serves to supply the hydroelectric station now located below the falls. Other canals were built in later years to distribute water on several levels, each with a head of some 20 feet, suitable for the small waterwheels of the time. These canals still thread their way through the City of Cohoes, sluggish and choked with vegetation and refuse. They have served no purpose for more than a half a century, and indeed are a menace to health and safety. They are to be filled in as part of an extensive urban renewal program which is to convert Cohoes from a rather drab, shadowy reminder of the past into an "All-American model city," as selected by the Federal government.

The industrial development of Cohoes began in 1830, thanks to the activity of the Cohoes Company. New settlers came, among them particularly David Wilkinson and his brother-in-law, Hezekiah Howe, both from Pawtucket, Rhode Island. Wilkinson was a brother-in-law of Samuel Slater, who introduced power cotton-spinning machinery from England. Wilkinson became, in fact, a prime inventor and manufacturer of textile machinery in Rhode Island and New York. Hezekiah Howe, also a mechanic, was the first contractor for the Cohoes Company Canals. The first dam was carried away by ice and high water in a fast-flowing stream in its first year, and despite rebuilding, it remained vulnerable to frequent damage.

Under the paternalistic encouragement of the Cohoes Company, Cohoes acquired an industrial character, developing from what was only a canal town straggling across farmland. Among the early notable arrivals in Cohoes, who gave its industrial development a special character, were Egbert Egberts and his associates: two brothers, Timothy and Joshua Bailey. A storekeeper in nearby Albany, Egberts, becoming interested in the possibility of power knitting, converted the traditional manual knitting frame into a power-driven machine. As practical mechanics, the Bailey brothers accomplished this successfully, and in 1832 they came with Egberts to Cohoes to set up several sets of knitting machines in an existing cotton mill supplied with Cohoes Company water power. Thus, a new industry was born in the United States, and Cohoes became, in due course, a major knitting center with more than a score of mills.

A few years later, Daniel Simmons established a factory for the manufacture of axes and other edge tools in Cohoes. The Simmons axe became nationally famous, and other axe and tool factories were established here as well. Perhaps most important in this decade of the 1830s, which was one of industrial beginnings in Cohoes, was the arrival of Peter Harmony, a Spaniard from New York who, with the support of others, founded the Harmony Manufacturing Company in 1837.

Among the first stockholders were some persons already interested in the Cohoes Company, namely Peter Remsen, Hugh White, and Stephen Van Rensselaer, Jr., thus establishing personal links between the two principal companies in Cohoes, which persisted to the end. Capitalization was initially set at $100,000, later greatly increased as the enterprise grew. In 1837 a brick factory building costing $60,000 was erected, equipped with [water] wheel houses and flumes. Originally it contained 3,000 spindles. As was customary in other new industrial villages, particularly those being developed at the time in New England, the Harmony corporation built several tenements for its workers. In subsequent years these were to grow into a substantial part of Cohoes, located in a section adjoining the expanding Harmony mills. While the corporation no longer exists, and the mill buildings are used for many other purposes, these houses are still occupied and comprise an important part of the housing available for the city's working population.

Despite these industrial beginnings, progress in Cohoes was slow in the early years. In 1839 after a freshet washed away a part of the dam, it was rebuilt more substantially by the company, at a cost of $60,000, of timber filled in with stone and concrete masonry, 1,500 feet long by 9 feet high. In the same period, the Erie Canal was relocated westward and enlarged. The Cohoes Company was allowed to take over the abandoned waterway and to incorporate it into its canal system. By 1848 there were some 4,000 people in Cohoes, which was incorporated as a village. Two decades later, in 1869, it became a city. There was now a weekly newspaper, *The Cohoes*

Advertiser, and a considerable variety of industries was using Cohoes Company water power.

The Cohoes Company was now looked to for still another service to the village. In 1847 it had been asked, and it had agreed to install, water pipes and hydrants in the principal streets and to supply water from the upper-level canal. At a later date the village bought the water pipes and a company reservoir, but it continued to draw water from the company canals.

All was not harmonious, however. Friction between company and village developed, which grew to a climax in the last years of the company's existence, as will be elaborated later. In the early years, there was the complaint that the village was already cut up with roads and canals. The canals, in particular, were a source of inconvenience and discomfort from the outset. There was an early controversy over whether the company or village was obligated to maintain the number of bridges and safety railings required. The company insisted that these were a public obligation. As a result, there was a tendency on both sides to neglect maintenance, and in 1850 a bridge fell into a canal, nearly taking a full omnibus with it. The village authorities sued in court but lost to the company. This incident illustrates the special character of the Cohoes Company as not only a private business, but also as a quasi-public utility with social responsibilities—a concept not yet fully developed a century ago.

In this connection, it is noteworthy that the Cohoes Company owned not only the water rights of the Mohawk, but also much of the land on which Cohoes developed. The company offered for joint use, a water right with the appropriate amount of land on which a mill could be built. As early as 1835 the Cohoes Company printed and publicized a "Map and Proposals . . . for the Sale of their Water Power and Lots at Cohoes."

The unit of water power or "Mill Privilege" was described in detail as comprising 100 square inches of water with a head of twenty feet, i.e., the volume of water flowing through an opening ten inches square, under the pressure due to a head or fall of 20 feet, with adequate water guaranteed. Together with a reserve fund for repairs, the rental was set at two cents per square inch of water and every foot of fall, to be paid annually in perpetuity. Further conditions were set forth in the proposal as to the rights and obligations of each party. All buildings were to be of brick or stone and none was to be used for "any laboratory, powder mill, furnace, or forge nor any chemical or other works whatsoever upon lots bordering or bounded on the East side of Canal and Basin A" which may be "so noxious or dangerous from fire—as to impair, injure, or endanger the life, safety or reasonable comfort of any person . . , or which shall endanger the buildings, property, or works now or hereafter placed upon the grantor's land . ." (Cohoes Company, 1835).

By 1846, an actual indenture between the Cohoes Company and Samuel H. Baldwin, machinist, set the annual rental for 100 square inches of water with a fall at 20 feet at $104 (vs. $40 originally), indicative of the steep rise in the value of the sites. The usual restrictions were repeated including a prohibition against establishing a tavern on the land, "without license from the grantor, nor a public house of entertainment nor any livery stable, nor sell any spirituous liquors of any kind in any shop, store, or other building" (Indenture, 1846). This would appear to have been an unusual degree of social and business regulation in a free enterprise age, reflecting not only the business interests but also the social standards of a puritanical society.

All of this points to a basic question arising out of the role of the Cohoes Company in the evolution of the Cohoes community. It has existed wherever a private, profit-making organization has become such a controlling factor in the life of the community, whether by the ownership of its land or its principal resources. This situation was also present in the case of Lowell, and to a slightly lesser degree, Lawrence, on the Merrimack River in Massachusetts, where Boston capital dominated the growth of these textile cities through the exploitation of the water power site by a similar canal company, even to the extent of having these settlements named after the principal promoters. In more usual form, the problem has arisen as well in company mining towns, where a single company owns everything, including housing and business. The question is, ultimately, whether such an arrangement, however, paternalistic, is conducive to the welfare of the community and its people. At the least, it introduces a private monopolistic influence which limits and dominates, if it does not hurt, the common interest of all the rest.

The division between private and public interest in the case of Cohoes was accentuated after 1850, when the Harmony Manufacturing Company was taken over by a New York firm, Garner and Company, and reorganized as Harmony Mills. The Garners brought in capable management in the persons of Alfred Wild, William E. Thorn, and Robert Johnston and son, David J. Johnston. In the period that followed, especially during the Civil War decade, the Harmony Mills experienced a dramatic expansion, until it comprised six large structures containing 130,000 spindles and 2,700 looms, and employing 2,500 operatives. Here, by the 1870s, was one of the largest cotton factories in the United States, if not in the world. In addition, the Harmony Company owned 900 tenements, most of them built since 1860. There was also a Harmony Hall and a Sunday school as well as a weekday school. Altogether there prevailed the "perfect discipline of a well-trained army corps. An air of excellence and neatness of taste prevades and distinguishes the entire works" (Masten, 1877:000). For thousands of workers and their families the Harmony Mills were their "support, their friend, their constant benefactor, and their own sweet home." These well-meant words of a contemporary observer convey perhaps an unintended note of skepticism and irony.

The condition of Cohoes, however prosperous and growing during the latter nineteenth century, was affected by the fact that the same principals, particularly the Garners, an absentee ownership family in New York City, dominated both the Cohoes Company and the Harmony Mills. There was an interlocking of interests and officers between them. A colossal bronze statue of Thomas Garner was installed in a niche in the main elevation of the ornate Number 3 or "Mastodon" Mill, erected in 1873.

The Cohoes Company too, undertook some major renovation at this time. A solid new stone dam was built across the Mohawk in 1865–1866 with a gate house that controlled the flow of water into a new and enlarged canal. The entire installation was considered the finest of its kind in America. The total available horsepower was estimated at 10,000 with about two-thirds of it in use. The rental was now twenty dollars per horsepower, which was described as "the cheapest in the country." Cohoes had grown into a city of some 15,000 people, and in 1870 David J. Johnston, the superintendent of Harmony Mills, was elected its first mayor. This was at once evidence of public spirit but also of an interlocking interest between city and business. Cohoes was a polyethnic community, its people largely recent immigrants, half of them French Canadians from Quebec.

The 1870s were probably the heyday of Cohoes and the Cohoes Company. Despite the influence of the mills, labor unrest and trouble were almost endemic. It was in this period that Arthur H. Masten (1877) wrote the principal history of the city, which he celebrated enthusiastically in conjunction with the celebration of the Centennial of the Declaration of Independence. He extolled the Cohoes Company as the basis of Cohoes' prosperity by its policy of "developing the water power and offering the inducements for the settlement here of capitalists. . . . It has, moreover, by the construction of creditable works and improvements, by liberal donations of lands for public purposes, and in many other ways contributed to its growth and prosperity." Its facilities, in the form of ten canals, threaded their way through the city. Water was made available in small usable units on six different levels, each with a fall of approximately twenty feet, and it was thereby used repeatedly and economically. A mill power comprising six cubic feet of water per second, rented for $200 annually, at twenty dollars per horsepower. The city's two principal industries were then recovering unequally from the effects of a long and severe depression. Its 17 knitting mills had suffered the greatest suspension and fall of prices, but the large Harmony mills were back at virtually full strength. Its six mills now had 258,054 spindles and 5,650 looms, employing more than 4,100 operatives.

A decade later, in the 1880s, a new power age was ushered in unobtrusively, which was ultimately to have profound effects on the Cohoes Company and the power technology of Cohoes industries, which were linked so closely together. This was electricity, first appearing as a means of improved lighting, and subsequently as a highly efficient form of power transmission. In 1887 the Cohoes Company contracted with the City of Cohoes to supply fifty arc lights in the streets. For this purpose it built and maintained the first electric light plant, presumably powered by water from its own canals. This was, however, only a small beginning. A quarter of a century later, in 1911, came the revolutionary transformation in the means of utilizing the Cohoes Falls, when the Cohoes Company proposed an extensive project of electrification in the form of a hydroelectric plant on its water power site. Dam, gate house, and diverting canal were already in existence. What was needed was an electric generating plant at the base of the falls. Thus, at one stroke, as it were, the system of canals providing water power in small units on six levels for the direct mechanical driving of the mills was to be rendered obsolete. Instead, a total of 30,000 electrical horsepower was to be generated in three hydroelectric units, and the alternating current thus provided could be distributed not only in Cohoes but over a wider area. It could supply light and heat, where required, as well as power. Interestingly, the model for this type of development had been provided as early as 1895, in the construction of the first Niagara hydroelectric plant, on an even larger scale.

This changeover did not occur without considerable controversy. It required, of course, a large investment of capital, but also a renegotiation of power contracts with the participating mills, which would also have to make substantial outlays of capital for wiring, controls, and motors to apply the new power. Moreover, once begun, the venture would have to be carried out promptly and as a whole, since the electric power would be available for use at once. The general negotiations between the Cohoes Company and its lessees occurred during 1911 and produced some controversy and bitterness, which found expression through the press. Of 31 lessees, some 15 refused to sign new agreements. The Cohoes *Evening Dispatch* reported that behind their reluctance was the fact that these mills would now have to pay for all their power. At present, they were drawing more water than they paid for, and the Cohoes Company was not enforcing its rights. This situation would be corrected, and charges made for power actually used.

An article in the *Albany Telegram,* however, presented the opposite side. For many years the company had neglected maintenance, and mills had to shut down periodically for want of water. The present plan was a "Wall Street financial game" to mulct users of millions instead of thousands of dollars. At present, in fact, the same "little clique of men" was in control of the Cohoes Company, the Harmony Mills, the Cohoes Gas Company, and the Cohoes Electric Light Company. The knitting mills were to be the next victims of the Wall Street plan. Moreover, the Garner interests were now in the hands of three daughters, who were married to foreign noblemen, and American funds were thus to go abroad to support them. The mills were to be asked to pay up to four times more for their power. By increasing the power output from an existing 5,500 horsepower to an estimated 25,000, the company income would rise to over a half million dollars per year. In two years such income would repay the cost of the whole investment.

Despite these grievances, progress was not to be stopped. By 1915 the electrification project was executed by Sanderson and Porter of New York as engineers. General Electric Company supplied the generators and other equipment. Three generating units were installed, with a total capacity of 30,000 horsepower. Two more 12,000 horsepower units were added in later years. The power generated was fed at high voltage into a system supplying Troy and Albany, as well as Cohoes.

This modernization of Cohoes power really spelled the doom of the Cohoes Company, as well as of its canal system. In 1918, a newly formed Cohoes Power and Light Company acquired the Cohoes Company together with the associated gas and electric companies. The Cohoes Company had assets of over $6 milion, and the corporate surplus was valued at nearly $4 million. This was a notable showing for an old company that had been rendered obsolete by time and technological progress. In 1927 the Cohoes Power and Light Company was in turn absorbed by the New York Power and Light Company, which in 1950 finally became part of the Niagara Mohawk system, stretching across upper New York state between the great water power sites at each end: Niagara and Cohoes. Thus were united the oldest and the newest power companies in the state, the Cohoes Company dating from 1826.

The provision of hydroelectric power unfortunately did not halt the decline of Cohoes as an industrial city. The Harmony Mills were eventually closed in the 1930s, and the vast structures were emptied of their machinery. The remaining shells have taken on the drab patina of neglect and are partly occupied by small new industries. The many knitting mills too suffered decline, and most of them were eventually closed down. The old canals, useless and clogged with an accumulation of vegetation and refuse, still wind their way through the city, hampering its traffic. Only a newly projected program of urban renewal gives promise of disposing of these relics of a past age. They are to be filled in and turned into parks. In the meantime, they are still there and interfere with the fulfillment of a dream of Cohoes as a "Model All-American city," a title it has taken to itself, which is as yet more hope than reality.

Sources of Information

Unpublished

"Indenture of January 27, 1846 between the Cohoes Company and Samuel H. Baldwin." Manuscript Division, New York State Library, Albany, New York.

File on Cohoes Company in the offices of the Niagara Mohawk Power Corporation at Albany. Contains many items of interest and value.

Deeds and land grants of Cohoes Company, Albany County Clerk's Office, Albany.

Consultation and city tour with Dr. Edward J. Vandercar, Cohoes City Historian, who has also been compiling a newspaper diary of Cohoes happenings.

Published

The City of Cohoes: Its Past and Present History. Albany: Cohoes "Cataract" Book and Job Printing Office, 1873.

Cohoes Company. *Map and Proposals of the Cohoes Company for the Sale of their Water Power and Lots at Cohoes.* New York: Cohoes Company, 1835. [In New York State Library, Albany, New York.]

Cornell, B. R. "The Hydroelectric Development of the Cohoes Company." *General Electric Review,* 1915.

Masten, A. H. *The History of Cohoes.* Albany, 1877.

Spafford, H. G. *A Gazeteer of the State of New York.* 1st edition. Albany: H. C. Southwick, 1813.

Weise, A. J. *The City of Troy and Vicinity.* Troy, 1886.

Gurley Building 1862

W. & L. E. Gurley, Troy

(HAER NY-13)

Samuel Rezneck

Location: 514 Fulton Street, northeast corner of Fulton Street and Fifth Avenue, Troy, Rensselaer County, New York.
Latitude: 42° 43′ 50″ N. Longitude: 73° 40′ 50″ W.
Date of Erection: 1862.
Designer: Unknown.
Present Owner: Teledyne Corporation.
Present Occupant: W. & L. E. Gurley Manufacturing Company.
Present Use: Manufacture of surveying instruments.
Significance: Manufacturing engineering and surveying instruments since the mid-nineteeth century, the Gurley Company made the first all-aluminum transit, for exhibit at the 1876 Philadelphia Exposition. Highly acclaimed by civil engineers, Gurley instruments have been used in the building of major structures. The firm remains an active and important skilled industry in Troy. The building is a typical urban factory of the period, but considerably above average in workmanship and detail. It remains essentially unaltered from its original design.

HISTORICAL INFORMATION

Physical History

Original and Subsequent Owners: Previously owned and operated continuously by the Gurley family and local associates, the W. & L. E. Gurley Company was recently acquired by the Teledyne Corporation of California.

Original Purpose and Construction: The original Gurley Company Building was destroyed in the Great Fire of May 1862. The present building was completed and the firm back in operation by December of the same year.

Alterations and Additions: Sometime after 1889 two cast-iron balconies were attached to the second and third stories on the Fulton Street façade, toward the east end. The display windows at the Fifth and Fulton corner which appear on an early engraving (Figure 78) have been transformed into a diagonal doorway. The original floral finials on the cornice have been removed.

Architectural Information: Prepared by Richard J. Pollak.

Corporate History

W. & L. E. Gurley, Historic Manufacturers of Surveying and Scientific Instruments: In the long history of this unusual industrial concern, dating back to 1845, is embodied a remarkable record of an ambivalent, almost contradictory character. On the one hand there is its continued location on the same site in downtown Troy since its very foundation, the longest on record in Troy's history. It has, indeed, occupied the same four-story building since 1862, which was built hurriedly in less than a year, to

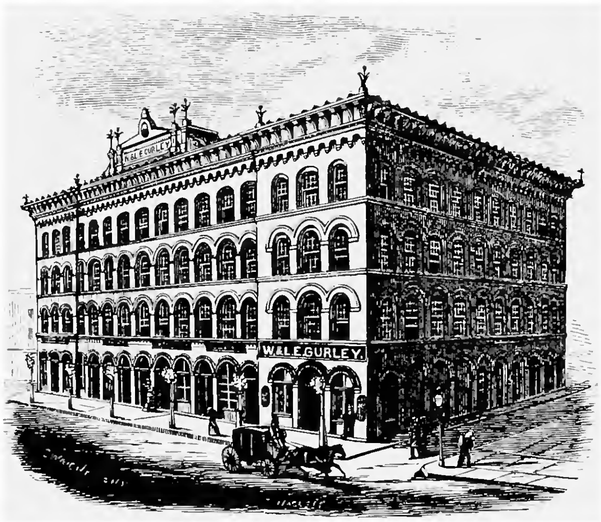


FIGURE 78.—The Gurley Building, c1885. (*Weise, 1886, page 104.*)

replace an older structure destroyed in Troy's greatest fire. Its outer appearance and inner arrangement of rooms and furnishings convey the quaint air and patina of age and tradition. The organization and management of its industrial and business processes still suggest the personal and paternal characteristics of a past age of small-scale, individualized, and family operation.

Their surveying and measuring instruments require great skill to manufacture. Used in many fields, their relatively limited demand and great variety of form would seem to resist any high degree of production mechanization or automation. Nevertheless, and on the other hand, the Gurley business has grown continuously and acquired a progressively advanced character. Its line of products from the original few surveying instruments has broadened to include a wide spectrum of new instruments and devices in such fields as weights and measures, meteorology, and hydraulics. Its technical skills of hand, eye, and tool have persisted and continue to determine the quality

FIGURE 79.—General view of the Gurley Building from the southwest.

of product. It is perhaps noteworthy that when the final and almost inexorable process of modern merger finally reached the Gurley firm, only as recently as 1967, by one of the most dynamic and technologically oriented conglomerates in American industry, the Teledyne Corporation of California, it proved to be a valuable acquisition, however modest in magnitude. Teledyne's other components include underwater exploration for oil, electronic and space mechanisms and devices, and similar sophisticated areas of modern technology. If absorption into a large industrial complex was an inevitable trend, it was almost a compliment to be sought out as suitable by such an advanced and, as it were, fast company.

The roots of the Gurley concern go back to the founding of American and Troy industry in the early nineteenth century. Indeed, the surveying instruments that were its principal products belong to an even earlier age of discovery and exploration through which the American continent was surveyed and plotted and by which the roads, canals, and railroads were planned and constructed. Surveying instruments accompanied the earliest explorers, surveyors, and engineers who laid the basis for the American nation, politically, economically, and socially. Their manufacture goes back to such skilled mechanics and artificers as David and Benjamin Rittenhouse of Philadelphia, whose contributions are recorded in *The Makers of Surveying Instruments in America Since 1700* by Charles E. Smart, a former Gurley president and the creator and curator of its remarkable collection of early surveying instruments.

The origins of the Gurley enterprise, however, are in Connecticut, that early home of the mechanical arts in America, which produced Eli Whitney, Eli Terry, and Samuel Colt, among many others. The Gurleys came from Mansfield, Connecticut, which also was the home of the Hanks family, celebrated as pioneers in the manufacture of bells, surveying instruments, and other metal products. Benjamin Hanks and several sons came to Gibbonsville, across the Hudson River from Troy, as early as 1808, where he established a foundry and shop for these products. This enterprise developed into the Meneely bell works, controlled by Andrew Meneely, an apprentice who married into the Hanks family. His descendants flourished in the bell industry on both sides of the river, operating manufactories both in Troy and Watervliet until quite recent years. Julius Hanks, a son of Benjamin, came to Troy in 1825 where he established a foundry for church bells, clocks, castings, and surveyor's instruments. The site was at the corner of Fulton Street and Fifth Avenue, precisely where Gurley's is now located. Here arose a rather graceful frame building, which even boasted a bust of Benjamin Franklin, the patron of American science, over one of its doorways. It was here also that Oscar Hanks succeeded to his father's business, and where William Gurley, founder of the Gurley enterprise, entered as an apprentice in 1840.

William Gurley's own antecedents were of the same character. His father, Ephraim, as early as 1813, moved to Gibbonsville, now Watervliet, where a new arsenal, established during the War of 1812, gave an impetus to industry. In 1818 Ephraim Gurley settled in Troy and, in partnership with two of the Hanks brothers, established the Troy Air Furnace for castings of various kinds. On Fifth Avenue, near the present Gurley plant, both his sons, William and Lewis E., were born. Ephraim died in 1829, and the boys were raised by their mother. William Gurley attended the Rensselaer Institute, a newly conceived institution founded in 1824 for the "application of science to the common purposes of life." The patron was Stephen Van Rensselaer, the principal landlord in the region, but the innovative head was Amos Eaton, a zealous advocate of and itinerant lecturer on applied science. He was William's teacher, and he recommended Gurley highly for scientific competence upon his gradaution in 1839.

Armed with Eaton's recommendation, William went west to Michigan in 1839, a year of severe depression, but was unable to find engineering employment. Returning to Troy, Gurley entered the Hanks works as an apprentice and in time became foreman of the shop. In 1846 William Gurley formed a partnership with Jonas Phelps, another Hanks apprentice, and as the firm of Phelps and Gurley began the manufacture of "mathematical and philosophical instruments." Some of the early products of this period are in the Gurley museum. In 1851 Gurley's younger brother, Lewis, joined the business following his graduation from Union College in Schenectady. Phelps soon sold out, and the two brothers launched on their long business career together in 1852 by buying out Oscar Hanks and acquiring the Hanks works at their present location. Thus was launched an enterprise that was to expand and become, by the end of the nineteenth century, the largest manufacturer of surveying instruments in the country.

Their instruments went with the engineers of both North and South America, many of them graduates of Rensselaer Polytechnic Institute, to survey the wild western lands and lay out the railroads that were to unite it into a single market and nation. Gurley instruments were, indeed, used all over the world, in Asia, Africa, and Australia, as well as throughout all of Latin America. During the Civil War, the Gurley firm demonstrated its flexibility and prospered by turning its facilities to the manufacture of fuses for shells and even brass fittings for cavalry saddles. Although the factory was totally destroyed in the Great Fire of 1862, it was restored within the year, and its continued use to the present time bears testimony to the solidity of the structure.

Throughout the century there was the continuity of enterprise and management provided by the Gurley brothers. As they prospered, both men found time to devote to numerous civic activities. William Gurley, particularly, participated in the political life of the community, but even more in the patronage and promotion of cultural and educational institutions. William and Lewis were involved in the affairs of the Young Men's Christian Association and the public library that it sponsored. Both shared in the reorganization and modernization of the Emma Willard School, and William was a trustee and vice-president of Rensselaer Polytechnic Institute.

The Gurley enterprise was fortunate to have the life-long services of Edward Arms, a mechanical genius, who became chief engineer of Gurley's. His employment began in 1862, at seventeen years of age, and lasted for seventy-two years until 1934, a not uncommon but unequaled phenomena in this long-lived family enterprise. In 1869, Arms graduated from Rensselaer Polytechnic Institute and subsequently dedicated himself to the improvement of surveying instruments and their manufacture. He was particularly interested in the refinement of the circular dividing engine, so vital in the production of transits and compasses as precise measuring devices. Arms and Theodore Schneider, another Gurley employee, helped Henry A. Rowland in his research at Rensselaer. As a result of this research Rowland was appointed the first professor of physics at the recently established Johns Hopkins University at Baltimore, where he became world famous for his development of the fine dividing engine that ruled the lines on glass defraction gratings used in spectroscopy. Schneider followed Rowland to Johns Hopkins as his mechanical assistant.

Arms' autobiographical account of his life and work at Gurley's describes many other improvements, too numerous to itemize. Among them, however, was the construction of the first light-weight transit, made from aluminum bought in France at $1.30 per ounce. Now in the Gurley museum, it was displayed at the Centennial Exposition in Philadelphia in 1876, across the aisle from Alexander Graham Bell's newly invented telephone. A version of the transit was subsequently offered for sale as a light-weight mountain transit. Arms devised a method for drawing platinum wire to the fine diameters required in the transit telescope, and he was skilled in lens optics as well. At the Columbian Exposition of 1893 in Chicago Gurley's displayed an Arms 11-inch telescope, which won the approval of Alvin Clark, the world's greatest lens maker.

Not only a manufacturer of surveying instruments the Gurley concern entered into related activities. In 1855 it published *A Manual of the Principal Instruments Used in American Engineering and Surveying*. The first of its kind in America, it was an illustrated, instructional account of the instruments and their uses, without any reference to prices. This manual was reissued and sold at a nominal figure year after year, the fifty-second edition as recently as 1951. In 1881 Gurley's published an ephemeris, for use by engineers, which is still issued in an annual edition, as an *Abridgement of the Nautical Almanac*. A *Manual of Gurley Hydraulic Engineering Instruments* was brought out in 1881. In addition, the Gurley concern offered for sale a substantial list of books for engineers as well as a wide variety of engineering supplies, from paper and tracing cloth to pens and pencils. It had become, by the end of the century, a leading manufacturer and supplier of engineering instruments and related materials in the nation.

William Gurley died in 1887 and his brother Lewis a decade later. This brought to an end the first stage of the company's history, one of growth and prosperity. By 1899 Gurley's had been incorporated, although it was still carried on as a family business by Lewis' son, William F. Gurley, and by William's son-in-law, Paul Cook. During these years the company expanded into new fields. In connection with the establishment of the National Bureau of Standards in 1904 Gurley's was pursuaded to engage in the manufacture of weights and measures. The first edition of *Gurley's Handbook of Weights and Measures for the Use of Sealers* appeared in 1906. In 1908 a new department was created under the name of "Department P," for physical and scientific instruments, and a publication was then issued listing *Physical and Scientific Instruments and Mechanical Apparatus.* It was not successful and "Department P" was sold a few years later to a Massachusetts concern.

By the time of World War I, Gurley's line of direct family management had run out, and there was a great need for new outside personnel to carry on the business. In 1919 and 1920 two men were brought in, who became respectively General and Works Managers and successively presidents of the firm during the next generation. They were Charles I. Day, a Columbia-trained engineer, and Charles E. Smart, a graduate of Massachusetts Institute of Technology. They were joined by Lester C. Higbee, a graduate of Rensselaer Polytechnic Institute, who subsequently succeeded Smart as president of Gurley's. Under their combined leadership the methods and machinery of Gurley's were modernized. New lines of products were added and others revived, among

FIGURE 80.—Gurley Building: *a,* The south elevation from the southeast; *b,* entrance detail; *c,* detail of cornice and ornamental parapet; *d,* grill over entrance, southwest corner.

them hydraulic and meteorological instruments, which were used for measuring both wind and water currents, as well as the traditional surveying instruments.

World War II resulted in a great demand for technical instruments of all kinds, and as early as 1942 the United States Navy and Army awarded the firm the "E" pennant, which flew over Gurley's as a symbol of efficiency and excellence in meeting war demands. During the war the largest output of transits in all of its history was recorded. The growth of electronic and space technology in postwar America also provided an impetus to the development of new devices and instruments in these fields.

In time, however, the question of whether the company could operate and grow in the relative isolation of its traditional Troy setting became acute. This was of particular concern as the problem of new management arose and the established line of family and intraplant direction was exhausted. The trend of the time was toward industrial consolidation into large and diversified conglomerates, favored by the advent of computers and other new means of control and coordination. In 1967, a California conglomerate, Teledyne, Inc., acquired the local company and installed its own management in the person of a new president.

New problems arose affecting the continued survival and operation of Gurley's as a separate, autonomous enterprise. Particularly there was a question of complete urban renewal and the consequential removal of the business to a new site in Troy. Negotiations with the city's planning authorities began for a location in a new industrial park established in the outskirts of the city because the old site and buildings stood in the downtown renewal area. Thus Gurley's is engaged at this moment in a crucial process of relocation and renewal, on which could depend its future evolution as a member of a national complex of companies operating in highly sophisticated technological industries, both old and new. Gurley is obviously the oldest of these, and its survival is greatly to be desired, both for its own sake and for the future of Troy. It is perhaps noteworthy that out of Troy's past only two major institutions have persisted and grown, by adaptation to new conditions. These are significantly related to each other: Rensselaer Polytechnic Institute, originating in Troy in 1824, and W. & L. E. Gurley, manufacturer of surveying and other "mathematical and philosophical" instruments, dating from 1845.

Sources of Information

Unpublished

Consultation with and materials obtained from Charles E. Smart and Robert G. Betts, former presidents of W. & L. E. Gurley.

"Edward J. Arms: Autobiographical Sketch." Manuscript, Gurley Company Files, Troy, 1930.

"Charles E. Smart: Autobiography." Manuscript, Gurley Company Files, Troy, 1963.

Published

The Gurley Story. Troy: W. & L. E. Gurley, 1947.

W. & L. E. Gurley. Miscellaneous catalogs and manuals. Published intermittently between 1855 and 1951.

In Memoriam, William Gurley. Troy, 1890.

Smart, Charles E. *The Makers of Surveying Instruments in America Since 1700*. Troy, 1962.

Weise, Arthur James. *City of Troy and Its Vicinity*. Troy: Edward Green, 1886.

———. *Troy's One Hundred Years*. Troy: William H. Young, 1891.

ARCHITECTURAL INFORMATION

General Statement

Structural Character: A typically Victorian commercial expression of Renaissance revival architecture.

Condition of Fabric: Good.

Description of Exterior

Overall Dimensions: 130 feet wide, 90 feet deep on Fifth Avenue, and 118 feet along Union Street (Weise, 1886:15). Aside from its extended depth on one side, the building is 16 window bays by 10. It has 15-foot ceilings.

Shape: U-shaped, four-story building around an open courtyard.

Foundation: Cut stone, light in color, probably limestone.

Wall Construction and Finish: Brick bearing wall pierced by arcaded windows and doorways with cast iron pilaster capitals.

Structural System: Exterior brick bearing walls; interior cast-iron columns approximately 8 inches in diameter, and timber beams.

Stoops and Balconies: Cut stone entrance stoop. Two cantilevered cast-iron balconies on the Fulton Street façade near Union Street.

Chimney: Red brick.

Openings: Doorways and Doors: For such a regular building, the entrances are arranged quite asymmetrically. The principal entrance at the eastern end of the Fulton Street façade is flanked by two windows and topped with a triple, round-arched entablature reading: "ENGINEERS & SURVEYORS INSTRUMENTS." The secondary entrance, at the southwest corner of the building (Fulton and Fifth) has an entryway created by two perpendicular open arches separated by the heavy brick corner pier. Wrought-iron scrollwork gracefully fills the open fanlights. There are simple, double wooden doors with long rectangular glazing recessed in the entry.

Windows: Wooden framed windows are set into the round brick arches on the first, second, and third floors and into segmental arches on the fourth. The first floor windows are plate glass with the fan area, at present, opaqued or filled with air conditioners. On the second, third, and fourth stories, the windows are double hung with 12-over-12 and 9-over-9 glazing, depending on the size of the arch.

Roof: Shape and Covering: Flat pitched, covered with sheet metal (probably tin plate).

Cornice and Eaves: Heavily bracketed sheet metal cornice on Fulton Street and Fifth Avenue faces, and partial-parapet with name and date centrally placed on the Fulton Street façade.

Description of Interior

Floor Plans: Large open space structured by painted, cast-iron columns. The first floor is subdivided into office space, and areas for storage and shipping; the open areas on the other floors are used for the manufacturing activities.

Wall and Ceiling Finish: The walls are painted plaster with a smooth trowel finish. In the office reception area, there is a notable stamped metal ceiling.

Doors and Doorways: Wooden frames and doors with rich Victorian detailing.

Special Cabinetwork: A built-in, cherrywood cabinet, with nineteenth-century classical detailing, serves as an information desk and space divider in the entry office.

Notable Hardware: The door hardware is cast metal, quite elaborate, and in a classical style.

Site and Surroundings

Setting: Located on the northeast corner of Fulton Street and Fifth Avenue, at the edge of the city's business district, the Gurley Building is in a neighborhood of contemporary brownstone rowhouses, some of which were owned by the Gurley family in the nineteenth century.

Outbuildings: The Gurley Company also owns the buildings across Fulton Street and to the east across Union Street. These were probably built no later than the 1860s. The building to the east has a fine, cast-iron front on the first story.

PART THREE

The Record: Transportation

Whipple Cast- and Wrought-Iron Bowstring Truss Bridge 1867

Albany

(HAER NY-4)

Richard S. Allen

Location: Spanning a ravine 250 feet north of Normans Kill and 965 feet west of Delaware Avenue, Normanskill Farm, north of Normansville, within city limits of Albany, Albany County, New York.
Latitude: 42° 38′ 00″ N. Longitude: 73° 48′ 00″ W.

Date of Erection: Fabricated in 1867 (cast into top-chord members) and originally erected at another site; moved and re-erected at Normansville site c1900.

Designer: Squire Whipple, C.E. (1804–1888).

Present Owner: Mark Stevens, Normanskill Farm, Albany, New York.

Present Use: Vehicular bridge, trucks and busses restricted.

Significance: One of only two known surviving "Whipple" bowstring truss bridges, and one of the few remaining composite cast- and wrought-iron bridges, this span was built according to the patented design of Squire Whipple, which was used widely during the second half of the nineteenth century, mainly in New York State. When Whipple's patent of 1841 expired in 1869, the design was copied down to the last detail by a number of builders such as DeGraff, who were glad to avoid royalties.

HISTORICAL INFORMATION

Physical History

Original Builder: Simon DeGraff, after basic pattern of Squire Whipple.

Original Plan and Construction: This bridge is a fine example of Whipple's Patent Iron Arch Truss Bridge, or the Whipple Bowstring Truss, invented in 1841 by Squire Whipple. It was fabricated by Simon DeGraff of Syracuse, New York, whose name with the date 1867, is cast into several iron parts.

Alterations: Beyond the moving of the bridge itself from another site, there are no apparent alterations except the occasional maintenance replacement of the wood deck.

History at Present Location: Normansville, once known as Upper Hollow, is a hamlet located approximately two miles west of downtown Albany, New York. It is situated in a deep ravine formed by the Normans Kill, which once provided water power for saw mills, woolen mills, and a paper factory.

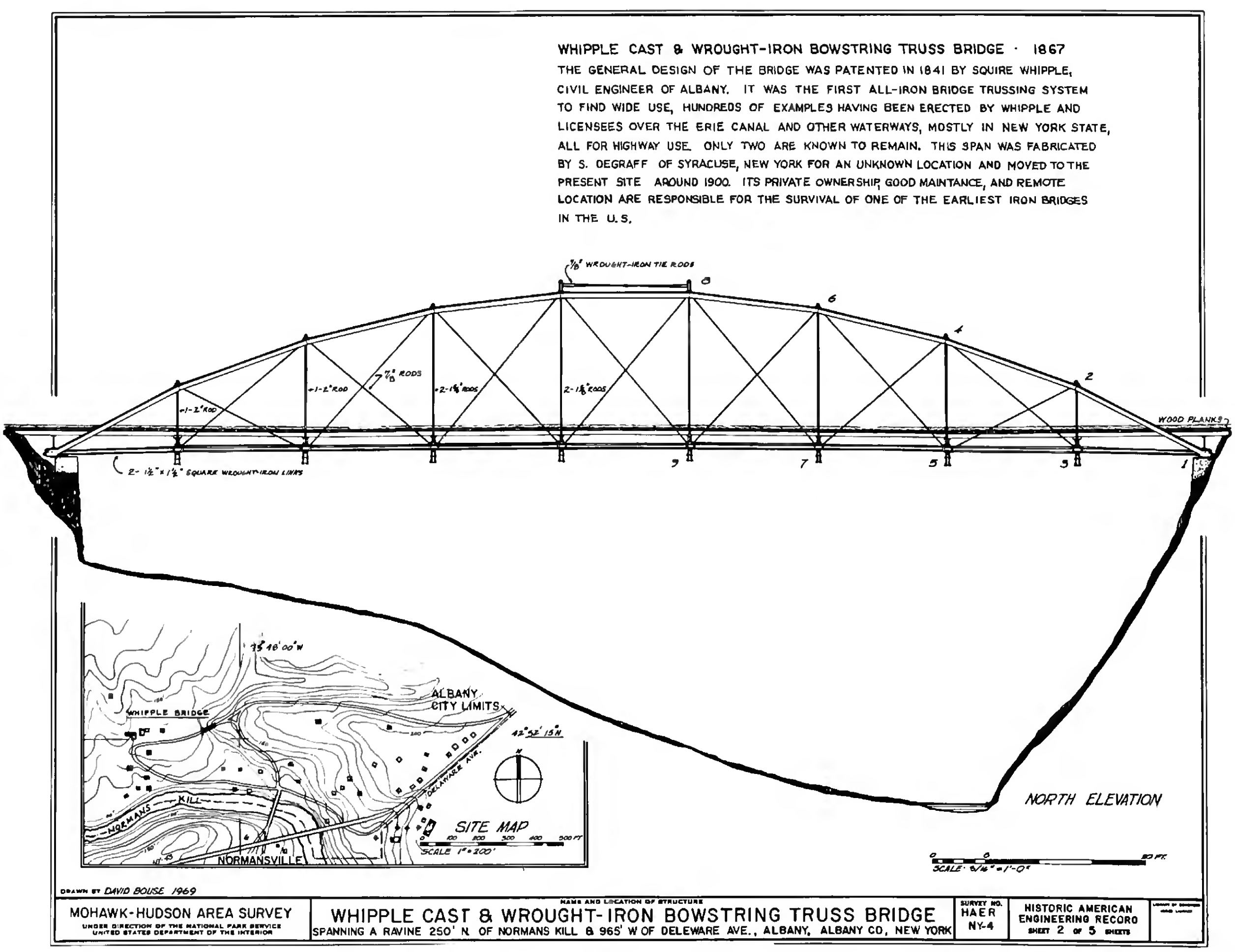
The old Albany & Delaware Turnpike crossed the kill at that point, first with a wooden bridge, and in 1869 by means of an early two-span iron structure built by the Town of Bethlehem.

In 1866 Upper Hollow had seven dwellings, and since nothing is indicated on a map of that year, it is assumed that the present Normanskill Farm was established subsequent to that date. The original access to the farm was by means of the steep road up the bank of the Normans Kill to the west of the village.

Engineering Information: Prepared by Richard J. Pollak; additional data by Robert M. Vogel.

FIGURE 81.—Squire Whipple (1804–1888). (Engineering News, *24 March 1888.*)

FIGURE 82



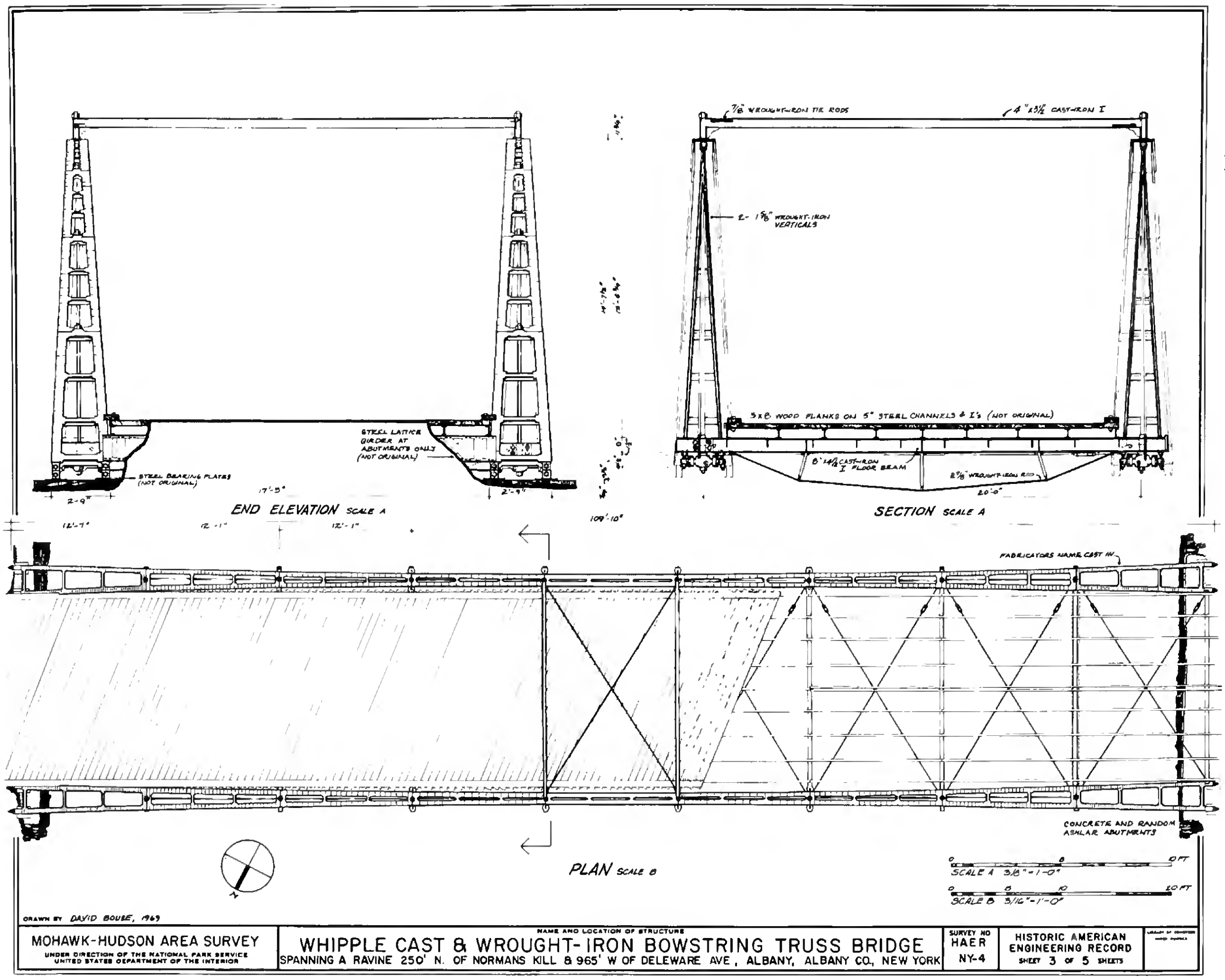


FIGURE 83

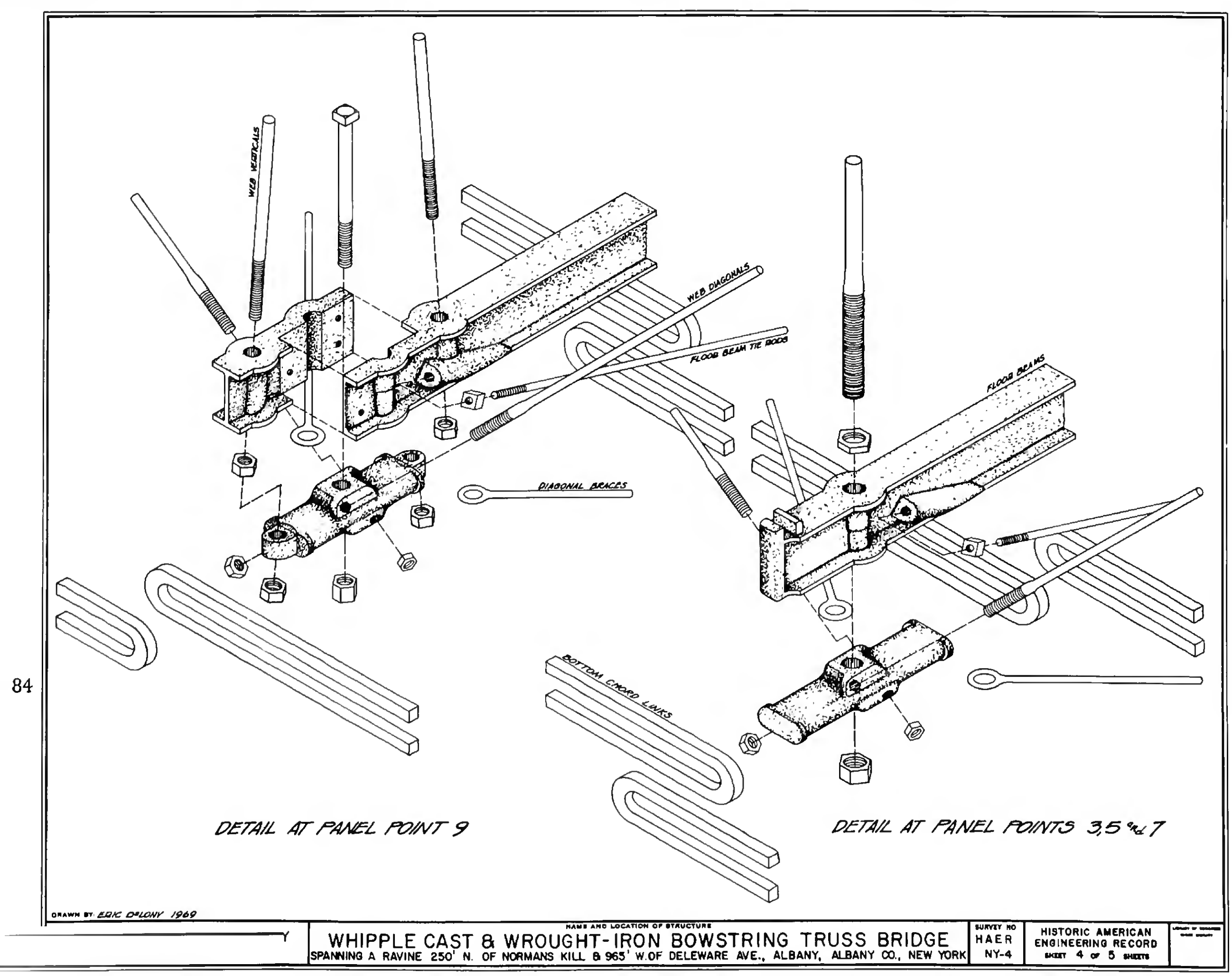


FIGURE 84

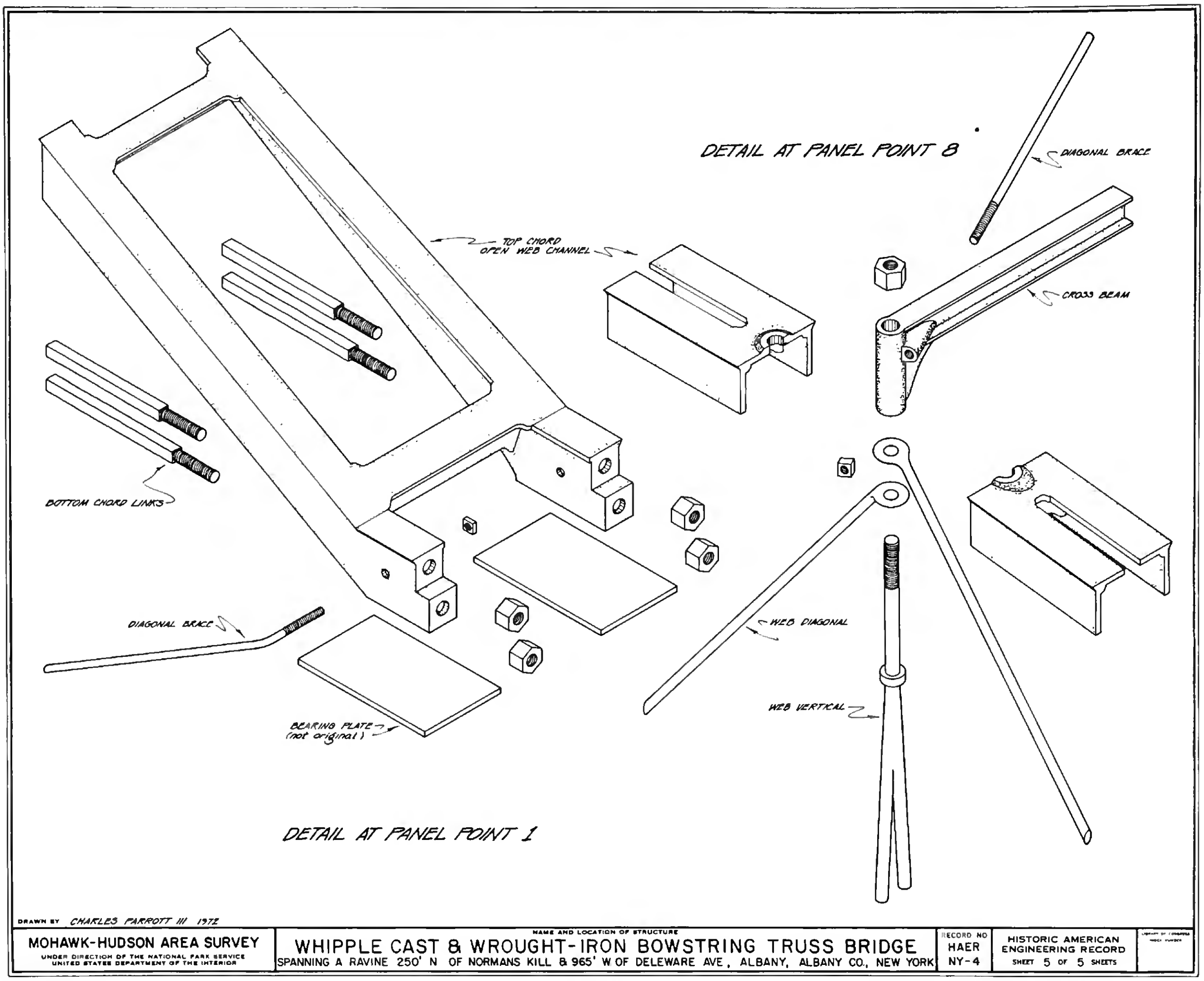


FIGURE 85

In 1899 plans were made to relocate the Albany & Delaware Turnpike (Delaware Avenue) to the north of the original route. It would descend to Normansville by an easier grade along the contours of a hill adjacent to another ravine made by a tiny, unnamed tributary of the Normans Kill. On a map of that year no bridge is shown, and the property was owned by an Amanda M. Lightbody.

After the new, yellow bricked route of Delaware Avenue was constructed, it was obvious that an easier entrance to the Normanskill Farm could be made by bridging the ravine at the eastern edge of the property. Moving and re-erection of small iron truss bridges was common practice by the various New York State-based iron bridge companies of the 1880s. The owners of the farm acquired a 113-foot Whipple Bowstring Iron Truss Bridge that would more than adequately span the ravine. The bridge was a secondhand structure, most likely originally built for a site nearer Syracuse (perhaps over the Erie Canal or one of its branches), and, while still serviceable, superseded by a larger span of greater strength and subsequently disposed of to another town or municipality. It is generally reported to have been brought to Normanskill Farm "from Schoharie." "From Schoharie" could refer to the county of Schoharie, the village of Schoharie, or the valley of Schoharie Creek. The Schoharie area is about 25 miles west of the site. If the bridge originally stood there it was undoubtedly dismantled and moved in sections over

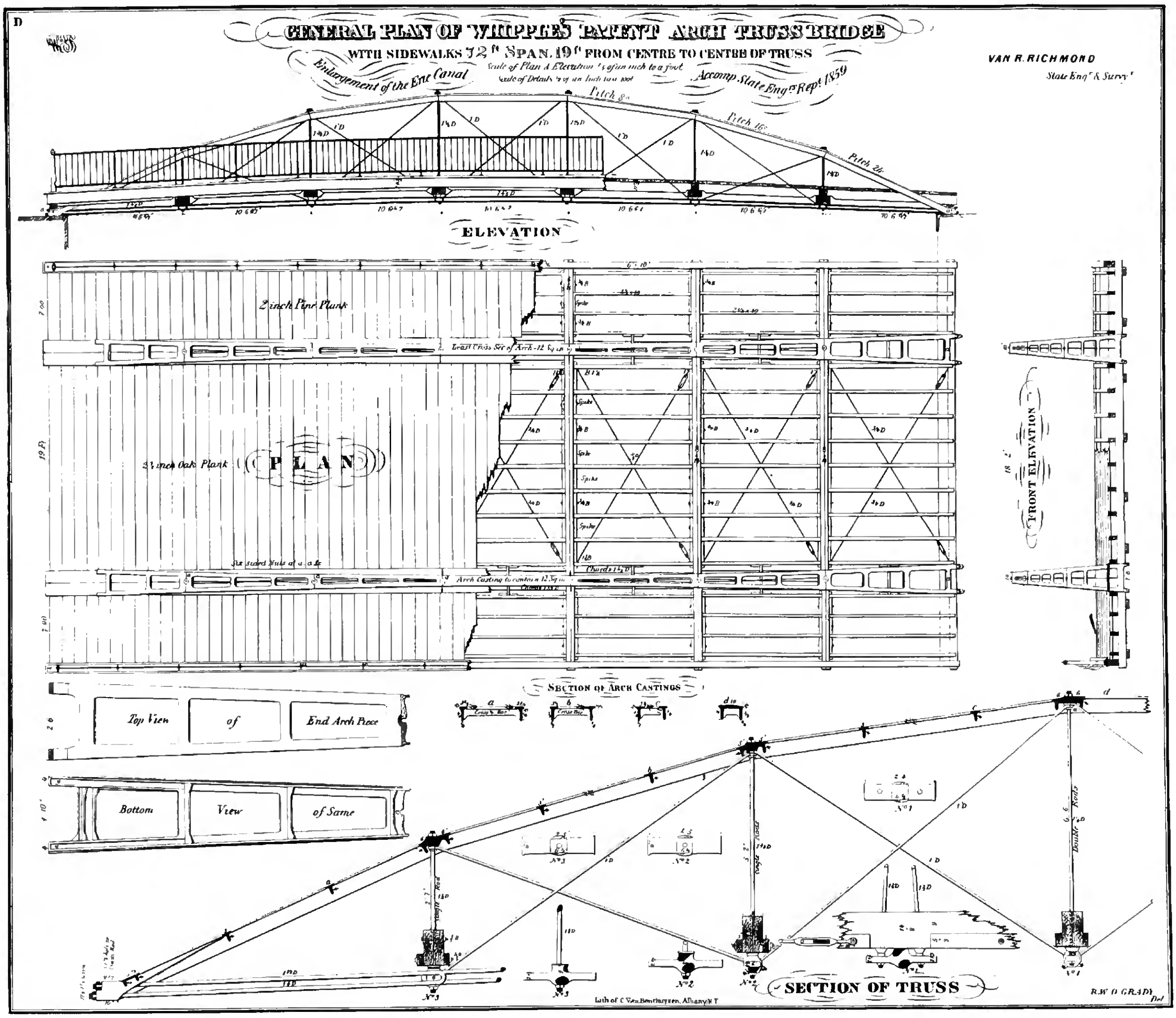


FIGURE 86.—General plan for 72-foot span Whipple Truss Bridge of seven panels. (*State Engineer and Surveyor of the Canals, 1860, plate D.*)

the old route of the Delaware Turnpike to Normansville (possibly its third location), where it was carefully re-erected on suitable stone and concrete abutments previously prepared to receive it. Indeed, one of the happiest features of the bolted and pinned form of bridge construction in use before riveting became common about 1900, was not only the speed of erection, but the ease with which a span could be knocked down, moved in small pieces, and as easily and quickly re-erected on a new site.

Mark W. Stevens has owned the Normanskill Farm for many years, and it appears on some maps and records as the "Stevens Farm."

Bearing only light vehicular traffic, this Whipple Bridge is one of the earliest examples of iron bridge building still in existence.

Biographical Background

Squire Whipple and the Whipple Design: Whipple was a prominent civil engineer who in 1847 published the first work in America describing the theory of stresses in bridge trusses. It was widely distributed

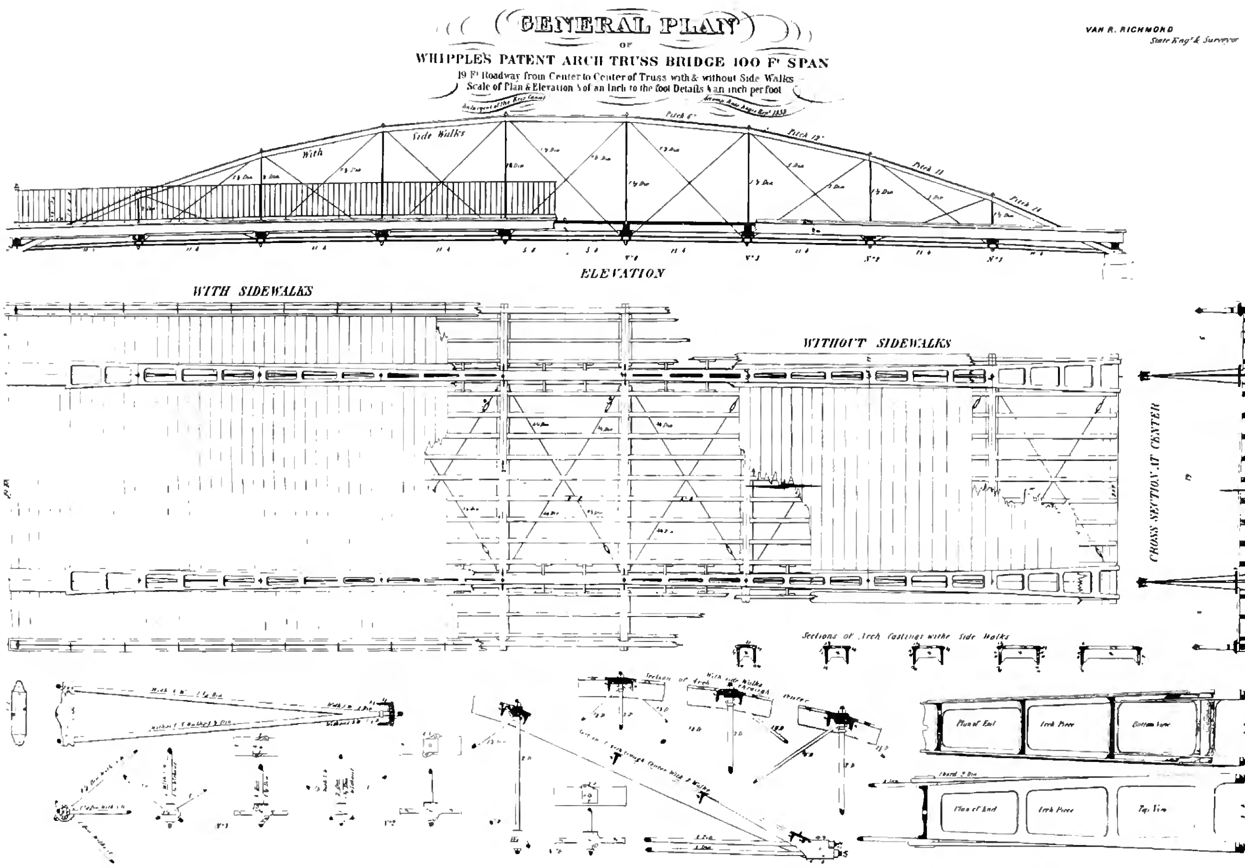


FIGURE 87.—General plan for 100-foot span Whipple Truss Bridge of nine panels. (*State Engineer and Surveyor of the Canals, 1860, plate E.*)

FIGURE 88.—General view of Whipple Truss Bridge from the north.

and reprinted, having a far-reaching effect in establishing scientific bridge design in this country. He has been rightly called "the father of iron bridges in America."

Squire (his given name, not a title) Whipple was born in Hardwick, Massachusetts, and came with his family to live in New York State at thirteen. A farm boy, he was self-educated in an amazing number of subjects, including Greek and astronomy. He studied as well at Fairfield Academy and was graduated from Union College in 1830 after only one year there. His early work experiences included teaching and surveying.

Whipple's early engineering work was with the first American railroads and the New York State canal system. When plans were being readied in 1840 to enlarge the Erie Canal, Whipple realized that hundreds of new bridges would be necessary to span the widened waterway. He managed to save $1,000 with which he constructed his first iron bowstring bridge over the canal at Utica, New York. It was the first of hundreds that in the next thirty years would find acceptance all over the northeastern United States.

The inventor-engineer duly patented the design and details of his bridge in 1841, and thereafter tried in vain to stem the appearance and use of truss spans similar to his own. Other builders managed to incorporate "improvements" and "refinements" just sufficient to contest paying the originator any royalties on his patent. Even the State of New York formally adopted "Whipple's Patent Iron Arch Truss Bridge" as standard for its canals (Figures 86, 87), but decreed that the bridges were to be erected "for the public good," thus evading royalty payments. In a rare outburst of righteous indignation Squire Whipple

FIGURE 89.—Whipple Truss Bridge: *a,* View from the northeast of the north line of trussing; *b,* through view from the east; *c,* general view from the southeast; *d,* through view from the west.

FIGURE 90.—Whipple Truss Bridge: *a*, Detail at northeast corner of bearing and bottom-chord connection; *b*, top-chord details; *c*, underside of deck showing bottom-chord bracing and floor beams; *d*, bottom-chord connections.

penned a wry comment in Latin which roughly translates as: "These little bridges I invented, rats get the pay!"

Despite injustice, Whipple proceeded to write a small book entitled: *A Work on Bridge Building,* which he published himself in 1847. Through it, the obscure New York State inventor has been recognized as the first man ever to analyze correctly and adequately the stresses in a bridge truss. His calculations were simple and precise and even employed short-cut processes that are logical and still useful. Although it took nearly thirty years for the contents of Whipple's book to be appreciated, bridge building itself gradually became accepted as a scientific profession rather than a trade.

From 1850 onward, Squire Whipple lived at 227 State Street in Albany, which is only two miles from the site of the Normanskill Farm bridge. As late as 1869, he continued to invent new types of lift and draw bridges, and built spans similar to that at Normanskill Farm. One bridge of this date over Cayadutta Creek at Fonda, New York, and the Normanskill span are the only known survivors of the type. On his death in 1888, the inventor-engineer was buried in the Albany Rural Cemetery near Menands, New York.

Squire Whipple was issued U.S. Patent 2064 for his Iron Bowstring Truss on 24 April 1841. When this patent expired after fourteen years, it was extended for another fourteen on 26 March 1855. Infringements on the patent, as noted above, were notorious. The patient but frustrated inventor gave up trying to collect royalties long before the patent finally expired. Considering the design within the public domain, or perhaps even ignorant of infringement, many companies and individuals fabricated and erected Whipple-type iron bowstring truss bridges during the 1860–1890 period. Among them was Simon DeGraff of Syracuse, New York.

Simon DeGraff: Simon DeGraff (also in directories as "Harmon" and "Samuel") lived at 35 East Onondaga Street in Syracuse, and apparently maintained a works there as well. First appearing in 1851 listings for Syracuse, he is noted as a "contractor" from 1857 to 1865, and as a "bridge contractor" during 1866–1867.

DeGraff was evidently a small local contractor who gradually came to specialize in bridge work. It is probable that the castings of the Normanskill bridge were cast to his order in a Syracuse foundry, quite likely that of George Draper with whom DeGraff was soon to form a partnership.

By 1869 Simon DeGraff, "Bridge Builder" is listed at a new location, 107 West Onondaga Street. For two years (1869–1870) he is also found as a partner with George Draper in Draper & Co., James St., at the corner of Pearl. This firm advertised: "Iron bridges, iron fence, railing, balconies, stairs, doors, grates, and general forging."

For another year DeGraff appears on his own as a "contractor" once more, and then as a householder still at 107 West Onondaga Street. The last listing for this builder of Whipple truss bridges is 1873.

FIGURE 91.—Whipple Truss Bridge, top-chord end casting with builder's inscription.

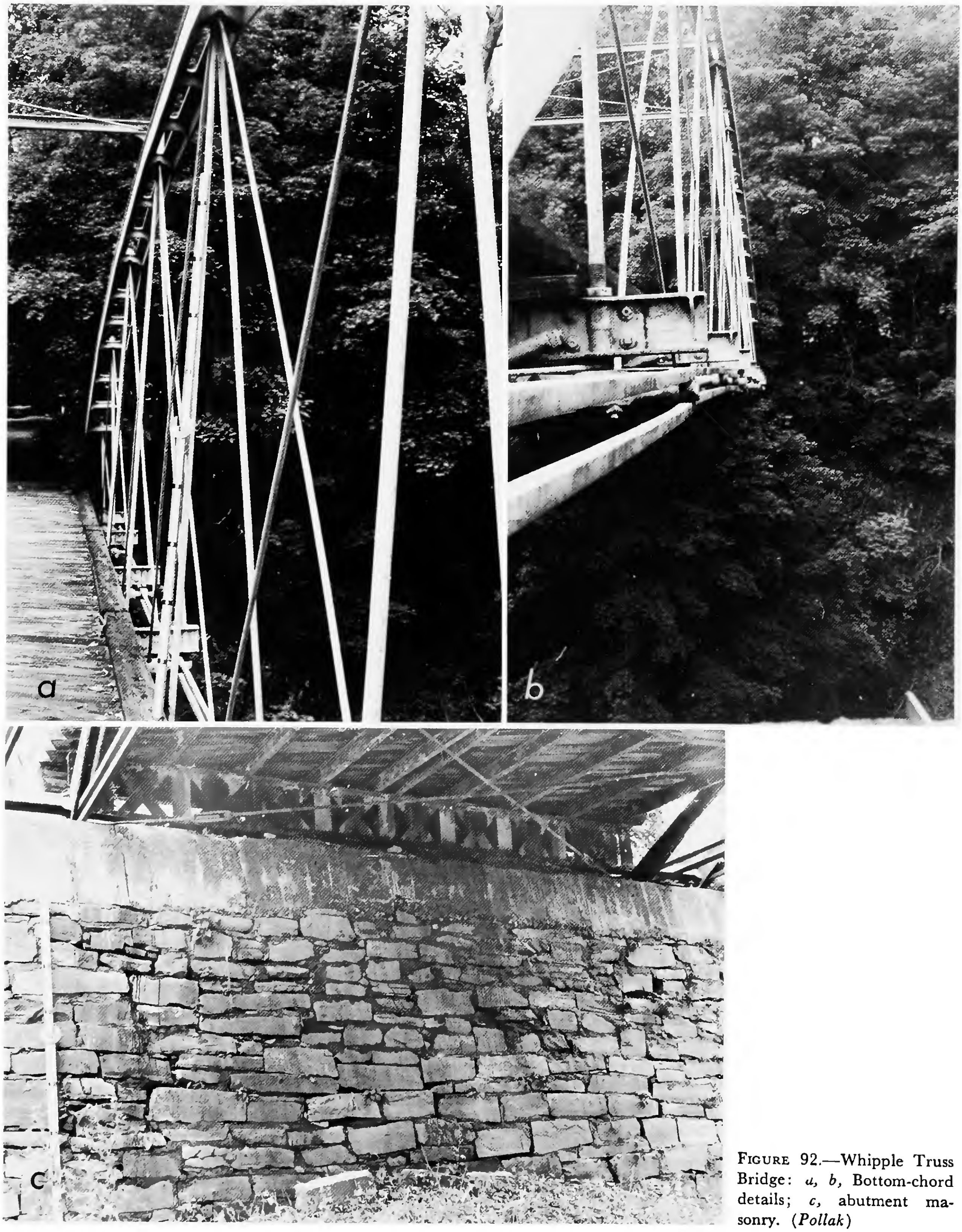
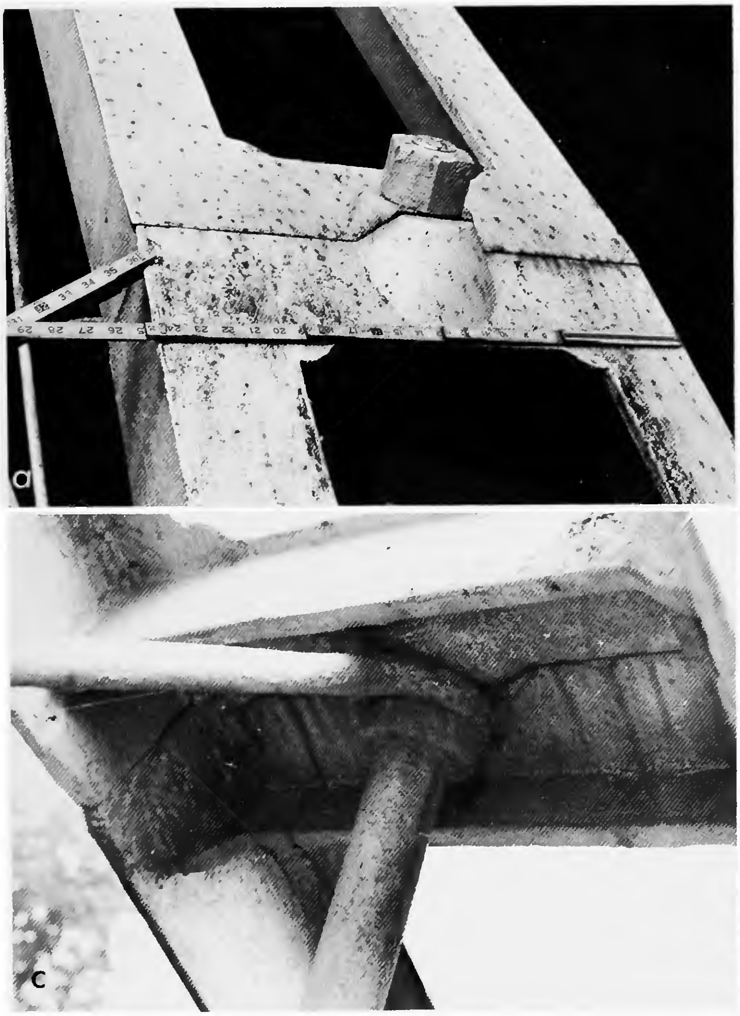


FIGURE 92.—Whipple Truss Bridge: *a*, *b*, Bottom-chord details; *c*, abutment masonry. (*Pollak*)



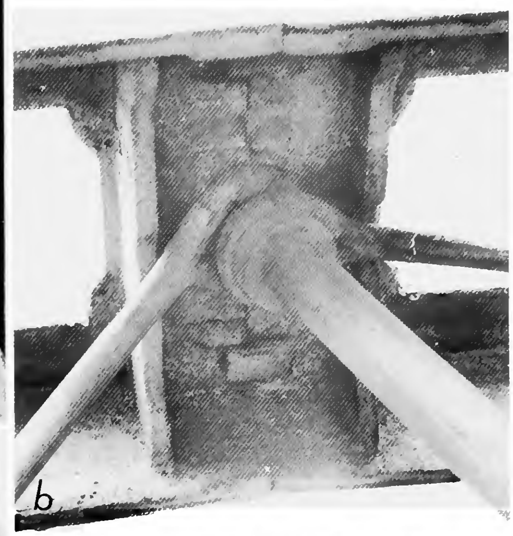


FIGURE 93.—Whipple Truss Bridge: *a-c*, Top-chord details; *d*, bottom-chord detail. (*Pollak*)

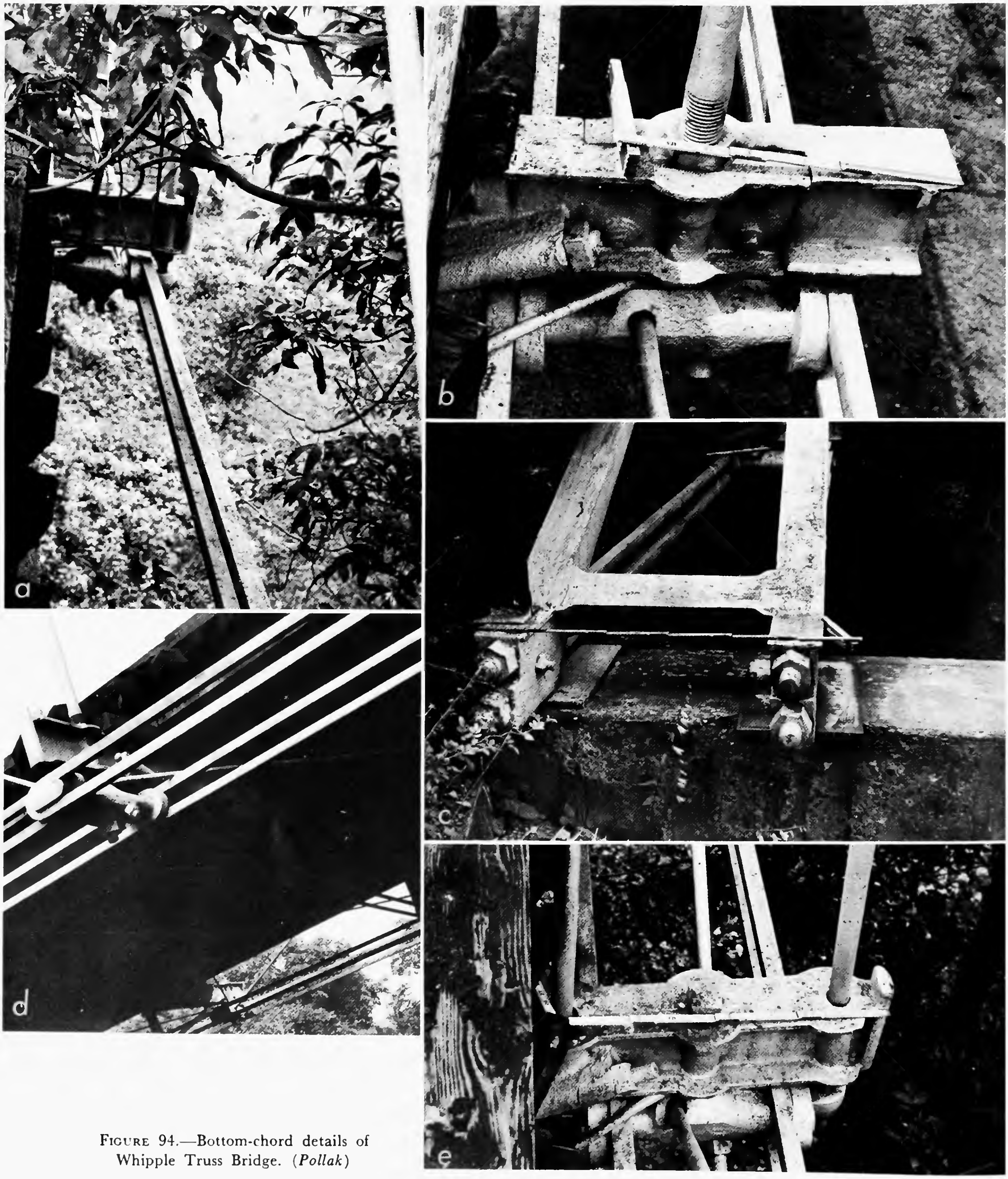


FIGURE 94.—Bottom-chord details of Whipple Truss Bridge. (*Pollak*)

NEW YORK STATE CANALS.

1871.

SPECIFICATION

Of the Manner of Constructing Whipple's Patent Iron Arch Truss Bridge Superstructures,

For ____

____

Each Superstructure to consist of a plank and timber flooring, supported by two or more trusses of wrought and cast iron, and, in cases of bridges with sidewalks, an iron railing three feet high c. the outside of each sidewalk.

The trusses to be composed of cast iron arches and connecting blocks, and wrought iron chords, uprights and diagonals; and the flooring of iron needle beams, pine joists and oak planking, as shown on the plans exhibited at the letting.

The truss arches to consist of straight pieces, diverging and widening horizontally, from a width of about 1-12 the length of the piece, in the middle, to about ¼ the height of the truss (and rather more in short trusses) at the end of the arch, each widening in proportion as it pitches downward from a horizontal position. In trusses from 55 to 75 feet in length, the arch is to contain 7 pieces, meeting at angles of 82 degrees, the ends being beveled 4 degrees, so as to form a joint, with a deflection of 8 degrees from one piece to the next contiguous. In trusses from 75 to 100 feet in length, the arch is to contain 9 pieces, with ends beveled 3 degrees at the joints, giving 6 degrees angle of deflection from piece to piece, or such other angle of deflection as may be directed by the Resident Engineer in charge of the work.

The extremities of the arch are to be formed into feet resting on the abutments with a flat bearing of 11 to 13 inches from heel to toe, and have a firm connection with the ends of the chords by having the endmost links left open at the connection, and after passing through the feet from heel to toe, secured by screw nuts at the toe; in which case, the portion of the rod where the screw thread is cut, is to have at least 3-8 inch greater diameter than the rest of the chord.

The ends of the arch castings at the joints are to be so shaped as to form vertical holes for the uprights to pass through, and afford horizontal bearings for the nuts of the uprights on the upper, and for the eyes of the diagonals on the under side, the holes being so placed that the plane of the arch joint may cut the center of the uprights about two inches below the upper side of the castings.

The depth or width of arch castings (towards the center of the general curvature) is to be not less than 1-18 the length of the pieces respectively, unless a compensating increase be made in the cross sections of the pieces; which cross sections, multiplied by the natural sine of the inclination of the pieces respectively from the vertical, are in all places to give products of not less than one square inch for each 90 square feet of bridge floor supported by the trusses respectively, not including the coping under the trusses and railing; and in trusses supporting less than 10 feet width of flooring each, the cross sections of the arch castings, multiplied as above stated, are to give products of not less than one square inch to every 70 square feet of flooring, and to have not less than half an inch in thickness of iron in any part, and not less than 7-8 inch in thickness within 3 inches of the joints.

No wedging of the arch joints will be allowed. The ends of the pieces must be planed by machinery, or accurately hand-dressed, as may be directed by said Engineer.

Near the outer or upper corner of the joints are to be projections of about 3-4 of an inch in length and depth, and 1½ to 2 inches in width, cast on one piece, and extending into the angles of the contiguous piece, to assist in keeping the ends in place.

Each piece of the arch casting is to have at least 4 cross bars connecting the side portions; the end ones being 5 to 6 inches wide, and of a depth, at the upright hole, not less than 1-5 the width of castings at the point of location; the others at uniform distances between the former, and in section equal to 1-3 that of the longitudinal parts of the castings.

For the forms and proportions of the cross-bars, and for other particulars not here specified, as well as for the better understanding of these specifications generally, reference is had to the drawings, and to instructions and directions of the Engineer in charge of the work.

The connecting blocks are to be of cast iron; the end portions, where the links go on, to be about 2½ inches deep, with a cross section nowhere less than 24 times the cross section multiplied by the diameter of the iron in the chords, and divided by the width of the connecting block. The edges of the blocks to be fitted to the semi-circular ends of the links.

The central portion of the block is to be so enlarged as to admit of the holes for the uprights and diagonals, and not allow of being cut or fractured in that part without an area of section or fracture at least 20 per cent greater than the cross section of the block where it receives the links of the chords.

The lengths of connecting blocks are to be, for those next the ends of the truss, such that the endmost links of the chord may run parallel from their connections with the feet of the arch, and connect on the ends of the block, the next succeeding links being inside of the former, and so on to the middle of the truss, with the two links of each pair parallel, or nearly so, and the blocks diminishing in length successively by about twice the diameter of the iron in the links.

All the iron to be of such kinds, mixtures and qualities as to produce sound and strong castings, equal to the best descriptions of metal used for machinery.

The ends of the chords and the feet of the arches on the abutments are to be covered with a cast iron box to protect them from contact with the earth of the approach.

WROUGHT IRON WORK.

The chords to each arch piece are to be composed of two links of such lengths as to be joined in pairs by the cast iron connecting blocks directly under the arch joints, and connected with the extremities of the arch in the manner before described. The aggregate cross section of the chord to each truss is to contain not less than one square inch for each 120 square feet of bridge flooring (copings not included) sustained by the truss.

The uprights are to be one at each joint of the arch; the middle ones (and more when required) in each truss, to be composed of two rods united into one at the upper end, for that portion which passes through the eyes of the diagonals, the arch, and the nut on the top; with a collar or ring of 7-8 inch square iron welded on just below the eyes of the diagonals, to prevent the latter from sliding down. From 2 to 3 inches below the collar, the two rods diverge at an angle of 10 to 12 degrees, and pass through the connecting blocks outside of the chords. The upper end, or single portion in these uprights, is to be of the same diameter as in the single uprights of the same trusses, and the double portion of 1 5-8 inch iron for sidewalk bridges of spans over 75 feet, and of 1½ inch iron for all other bridges of less than 100 feet span, unless otherwise directed.

Each branch of the double uprights is to have a nut to bear on the upper side of the iron needle beam, and another on the under side of the connecting block, the uprights passing through cast iron thimbles or washers, intervening between the bottom of the needle beam and connecting block, to afford a bearing for the beam.

The rest of the uprights are to be each formed of a single round bar or rod, with a collar and nut, as above described, at the upper end, and passing through the center of the connecting block, to be secured by a nut on the lower end, and to have an adjusting nut to bear on the top of the iron needle beam. The diameters of the single uprights to be not less than 2 inches for spans of 90 to 120 feet, and 1 3-4 inches for spans of 50 to 90 feet for single roadways without sidewalks. For double roadways and bridges with sidewalks, the size of both single and double uprights to be increased, as may be directed by said Engineer.

The diagonals are to be two, crossing each other in each of the quadrilateral panels of the truss, of 1 1-8 inch round iron in all sidewalk bridges of over 75 feet span, and of 1 inch iron for all other bridges, except when otherwise particularly specified. They are to be formed with a strong eye at the upper end for the upright, and bent near the eye, so that it may fit horizontally upon the collar of the upright, or upon the eye of the diagonal, connecting at the same point. Where the diagonals go on to the uprights, the one running downward towards the centre of the truss is to go on last, or above the other; and the bend at the eye is to be close to the outer edge of the collar, or of the other eye upon which it bears.

The lower end of the diagonal is to pass obliquely through the connecting block, with a screw nut at the end for adjustment, the screw being cut at least 8 inches from the end, and to have a diameter ¼ inch larger than the rest of the rod.

The nuts on both uprights and diagonals to be hexagonal, and properly proportioned for the purposes intended.

There shall be a pair of diagonal sway rods in each panel of the bridge; those in the end panels to be 7-8, and in the intermediate panels 3-4 inch round iron, and in bridges of 90 to 120 feet span, there shall be two pairs at each end, of 7-8 inch iron. The sway rods are to be connected with the single uprights of the trusses at the upper side of the connecting blocks by eyes through which the uprights shall pass, and in a similar manner to a horn cast on the upper side of the crotch rod saddles. The sway rods to have turn buckle adjustment near one end, the screwed portion being enlarged ¼ inch.

At the ends of the bridge, the sway rods are to connect by eyes with the screws and nuts uniting the chord with the feet of the arches, or in any other convenient and substantial manner.

The sidewalk railing is to be of wrought iron, except the corner posts, and when not otherwise specified, is to consist of vertical posts of 1 1-8 inch square iron, once in 4 to 5 feet, a bottom rail of 1 inch square iron about 4 inches above the bottom of the posts; a top rail of 1 3-4 inch by ½ inch iron, flatwise on the top of the post, with a strip of 1 inch by ¼ inch on the top of the last; and balusters of 3-4 inch square iron, once in 6 inches, doweled and riveted to and between the top and bottom rails. At the bottom of each post, and crosswise of the railing, is to be a foot piece, 6 to 7 inches long, 2½ inches wide, and half an inch thick, firmly riveted to the bottom of the post, and having two holes, one on each side of the post, and about 3½ to 4 inches from center to center, for bolting down to the wood work with 5-8 inch bolts. On the outside of the railing, the foot plate is to be welded to the lower end of a scroll or oges brace of 3-4 inch square iron, running up, and riveted to the post about midway of its length.

The posts at the ends of the railing, or at the corners of the bridge, are to be of hollow cast iron, 3 to 4 inches in diameter, and of any neat and comely pattern approved by the Engineer.

The wrought iron work is to be made of the best qualities of American rolled iron, for all parts except sidewalk railings, which may be made of good common English bar iron.

NEEDLE BEAMS.

The trusses are to be connected by cross girders (or needle beams) of wrought iron, one at each upright, and resting upon the eyes of the sway rods at the single uprights, and on cast iron thimbles or washers at the double ones. The cross girders to consist of a vertical web plate ¼ of an inch in thickness, with top and bottom flanges each of two angle irons, riveted on with 3-4 inch rivets having 4 inch pitch; the beam to have suitable holes for uprights, and be of such depth, length and form as shall be shown upon the drawings exhibited for letting, or as may be directed by the said Engineer. When required, solid wrought iron beams to be inserted in lieu of vertical web plate beams, and to be so proportioned as to give the requisite cross sections for the variable spans proposed.

FLOORING.

The joists are to be of good pine timber, with a depth equal to about 1-12 of their length between bearings; placed not over 28 inches apart from center to center, nor more than 6 inches from the ends of the plank (or more than 4 inches in case of sidewalk plank), and to have an aggregate thickness in carriage-ways not less than 1 7, and in sidewalks 1-8 the length of plank or width of flooring supported.

When not otherwise specified, the carriage-ways are to be planked with 2½ inch oak, spiked crosswise upon the joists, with 6 inch cut or wrought spikes, having a cross section not less than one inch to each 5 square feet of plank. Sidewalks to be planked with 2 inch pine plank, spiked with 5 inch spike or nails.

Under each arch truss, just above the flooring, is to be a coping of 2 inch pine plank, not less than 3 feet wide, consisting of 2 strings of plank, one on each side of the uprights and diagonals, and fitted about them so as to bring their edges together at the center of the truss, the outer edges coming just over the ends of the floor plank, and being supported by the cross pieces between the joists on either side of the truss.

In bridges without sidewalks, the outer coping to be 15 inches wide, with a facia plank of a proper depth, and 1½ inches in thickness under the coping, placed 2½ inches from the outer edge.

On the outside of sidewalks is to be a stringer, 9 or 10 inches deep and 6 inches thick, with its upper side about ½ inch above the sidewalk plank, and surmounted by a coping 3 by 10 inches, beveled about 2 inches by ½ inch on the upper corners, with grooves 3-8 inch wide and 5-16 deep on the under side, about ½ inch from each edge.

Upon this coping, near the center, the railing is to be secured by two 5-8 bolts to each post, passing through coping and stringer, and through the ends of needle beams when practicable. But when this is not convenient, the stringer may be first bolted firmly to the ends of the beams, and the railing bolted only to the stringer and coping. Bolt heads and nuts are in no case to act against wood without suitable iron washers.

All the coping, facing plank and rail stringers to be of good pine timber, planed on the upper and outer surfaces and edges, and painted with at least two good coats of white lead or zinc paint and linseed oil.

All parts of the iron work which are accessible after the work is put together, are to be painted with two good coats of lampblack and boiled linseed oil, or other paints approved by the Engineer in charge, except the under sides of the arch castings, which may be painted only one good coat. Those parts of the trusses not accessible for painting after being put together, are to be thoroughly painted at least one good coat before putting together.

The preceding specifications are intended to be applicable to all bridges upon the general plans here referred to, whether with two or a greater number of trusses.

In all cases, not otherwise specified, trusses are to be placed 19 feet apart between centers; and the center of sidewalk railing, when used, 6 feet from center of truss.

For a more full and perfect explanation of the form and dimensions of all the work, and of the manner of executing it in all its details, plans and bills of timber will be furnished by the said Engineer, who will also give such directions during the progress of the work as may appear to him necessary to have the same done in every respect complete and perfect, on the plan contemplated in the foregoing specifications; and the said directions shall in every respect be complied with.

FIGURE 95.—Specifications of the Whipple Truss Bridge.
(Horatio Seymour Collection, volume 1, page 40.)

Sources of Information

Unpublished

Horatio Seymour collection of scrapbooks on the New York canals, 1878–1882. Manuscript and History Division, New York State Library, Albany, New York. [Seymour was Chief Engineer and Surveyor of the New York State canals.]

Maps and Records on file at Albany County Clerk's Office, Albany, New York.

United States Patent Office Records, Washington, D.C.

Published

American Society of Civil Engineers. *Transactions*, volume 21 (1889), pages 14–15, 19–20.

Boyd's Syracuse Directory. Syracuse: Sampson and Murdock Co., Inc., 1851–1875.

Engineering News, 24 March 1888. New York.

Howell, George Rodgers. *Bi-Centennial History of Albany: History of the County of Albany, N.Y., from 1609 to 1886*. New York: W. W. Munsell & Co., 1886.

Sayre, Mortimer F., Shortridge Hardesty, and Carl B. Jansen. "Squire Whipple, Class of 1830." *Union Worthies* (Union College, Schenectady), volume 4 (1949).

State Engineer and Surveyor of the Canals. *Engravings of Plans, Profiles & Maps, Illustrating the Standard Models, from which are Built the Important Structures on the New York State Canals, Accompanying the Annual Report of the State Engineer and Surveyor of the Canals for 1859*. Albany, 1860.

Whipple, Squire. *A Work on Bridge Building Consisting of Original Plans and Practical Details for Iron and Wooden Bridges*. Utica: H. H. Curtiss, 1847.

——————. *The Canal Bridge*. . 1852.

ENGINEERING INFORMATION

General Statement

Structural Character: A Whipple bowstring truss vehicular bridge fabricated of cast and wrought iron and originally used at another site.

Condition of Fabric: Excellent. The bridge has been well maintained by its owner.

Description

Overall Dimensions: The span is 109′–10″ in length and 22′–9″ wide.

Shape: Polygonal "bowstring" truss divided into nine panels.

Foundations: The end abutments are of stone and concrete. The stone is laid in random ashlar pattern; the concrete is presumably not reinforced.

In each truss the top chord ("bowstring" or "arch") is formed of nine tangential castings of inverted square U cross-section. The lower chord, at deck level, is formed of two lines of nine wrought-iron open links, made from 1½-inch square-bars. The four center vertical web members are inverted Vs of two ⅝-inch bars, welded together at the top, the threaded lower ends inserted into holes in the floor beams. The four end verticals are single 2-inch rods. Web diagonals are double in each panel, of ⅞-inch rods. The cast floor beams are trussed with two ⅞-inch rods, strutted at the center and approximately the quarter points.

All tensile connections are threaded except for the lower chords, where the links simply bear upon cast-iron joint blocks. The end links, however, are open ended, upset to round section and threaded, and bear against the top-chord ends by nuts to provide a limited adjustment.

Delaware Aqueduct 1848

Delaware & Hudson Canal, Lackawaxen, Pennsylvania, and Minisink Ford, New York

(HAER NY-5)

Robert M. Vogel

Location: Crossing the Delaware River between Lackawaxen, Pike County, Pennsylvania, and Minisink Ford, Highland Township, Sullivan County, New York.
Latitude 41° 28′ 57″ N. Longitude: 74° 59′ 05″ W.
Date of Erection: 1847–1848.
Designer and Builder: John A. Roebling, C.E. (1806–1869).
Present Owner: Lackawaxen Bridge Company (owned by E. H. Huber, Scranton, Pennsylvania).
Present Use: Highway toll bridge crossing the Delaware River approximately twenty miles northwest of Port Jervis, New York.
Significance: The oldest suspension bridge in the United States that retains its original elements and the earliest extant example of Roebling's engineering genius. The Secretary of the U.S. Department of the Interior has designated the Delaware & Hudson Canal a National Historic Landmark and an NHL bronze plaque has been placed on the aqueduct. New York State has also recognized a structure with a roadside historical marker. It has been declared a National Historic Civil Engineering Landmark by the American Society of Civil Engineers.

HISTORICAL INFORMATION

The Delaware & Hudson Canal

The major purpose of towpath canals in nineteenth-century industrial America was to serve as a highway for freight. Unlike the Erie and other canals, the Delaware & Hudson Canal was conceived as an essentially one-way route for a single commodity. As a means of exploiting their great anthracite coal fields in northeastern Pennsylvania, Maurice and William Wurts proposed the construction of a canal as the only feasible way of getting bulk coal to the New York market. The Wurtses obtained charters from the Pennsylvania and New York legislatures to build a canal and improve the navigation of the Lackawaxen River, which almost reached into the Lackawanna coal fields at Honesdale. The canal would extend from the mouth of the Lackawaxen, where it joined with the Delaware, to the Hudson River, down which the coal could be readily transported to the city.

In the spring of 1823 the Delaware & Hudson Canal Company contracted with Benjamin Wright, chief engineer of the Erie Canal, to survey and locate a suitable route. Wright was instructed to select a line from tidewater on the Hudson at Rondout (near Kingston), up the valleys of the Rondout, Neversink, Delaware, and Lackawaxen rivers to the coal fields. The total distance was 108

Abstracted from Robert M. Vogel, "Roebling's Delaware & Hudson Canal Aqueducts" (number 10 in Smithsonian Studies in History and Technology, *Washington: Smithsonian Institution, 1971), 45 pages, 57 figures.*

FIGURE 96.—John A. Roebling (1806–1869). (*Courtesy of Division of Mechanical and Civil Engineering, National Museum of History and Technology, Smithsonian Institution.*)

miles with a lockage of 1,086 feet. Construction began in 1825, the year of the Erie's opening, Wright acting as chief engineer with the later renowned John B. Jervis as assistant. The entire canal was opened for business in October 1829. It reached its operational peak in 1872 when 2.9 million tons were moved. From that time, competition from an expanding railway network rapidly rendered the canal obsolete, with tonnage gradually declining until final cessation and abandonment in 1898.[7]

[7] The best account of the history of the D & H Canal is Wakefield's extremely detailed, beautifully illustrated, and thoroughly enjoyable *Coal Boats to Tidewater* (1965).

When the canal opened it was shallow—four feet in depth—with a waterline width of 28 feet (soon increased to 32 feet) and a bottom width of 20 feet. The first boats held 20 tons of coal. With a supply assured, the use of anthracite for heating, iron smelting, and steam generation expanded rapidly engendering more business for the mines and canal. Even with the introduction of 30-ton boats, by 1841 the demand for coal had so increased that the canal's limit had been about reached.

The Delaware Aqueduct was built as an integral element in an almost continuous program to increase the canal's capacity. The need for periodic enlarge-

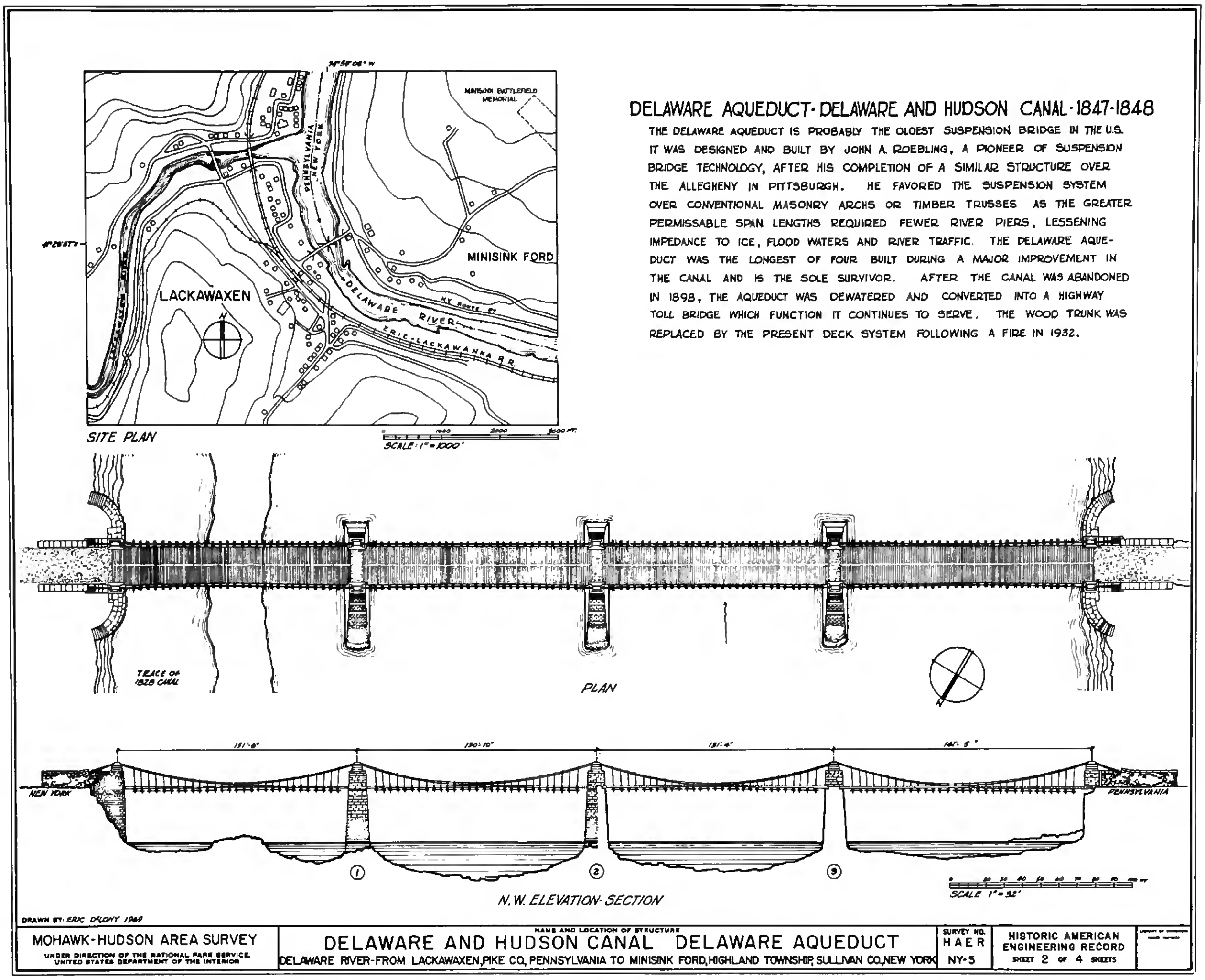
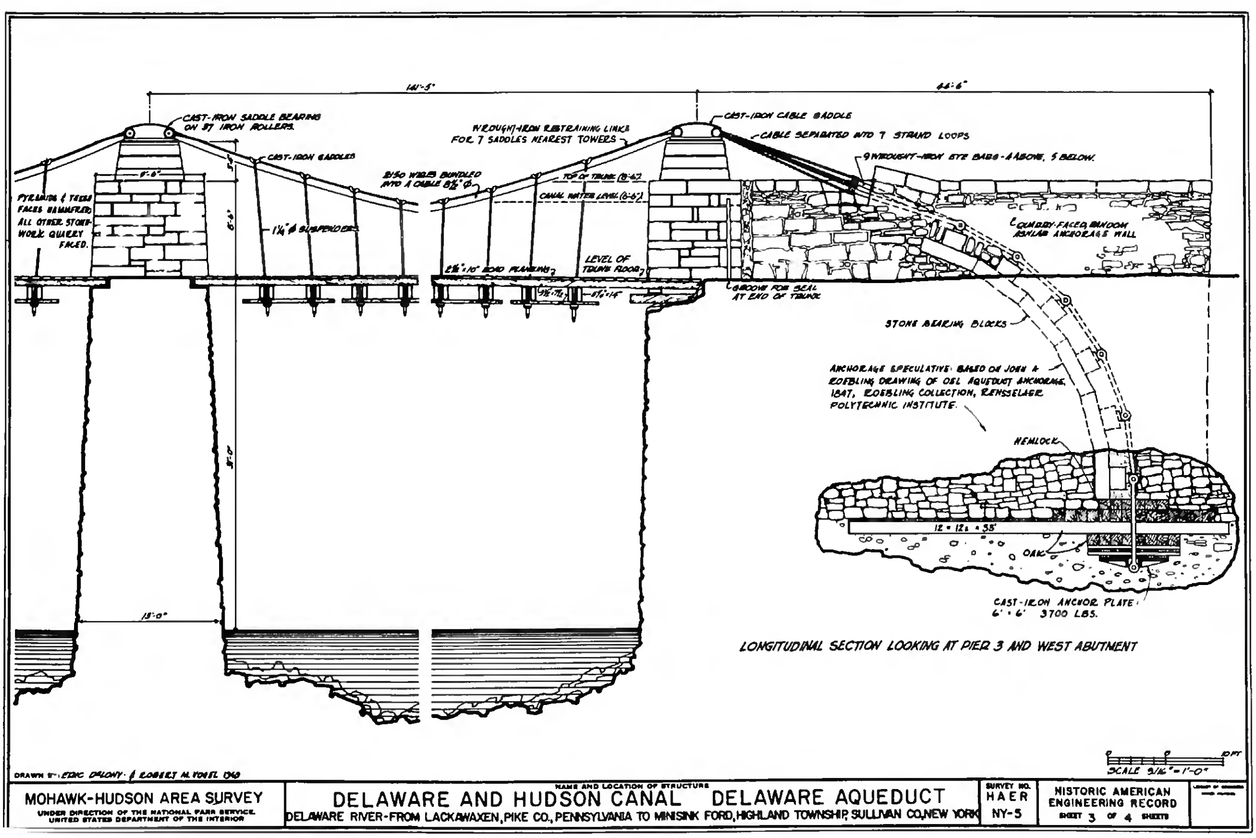


FIGURE 97

FIGURE 98



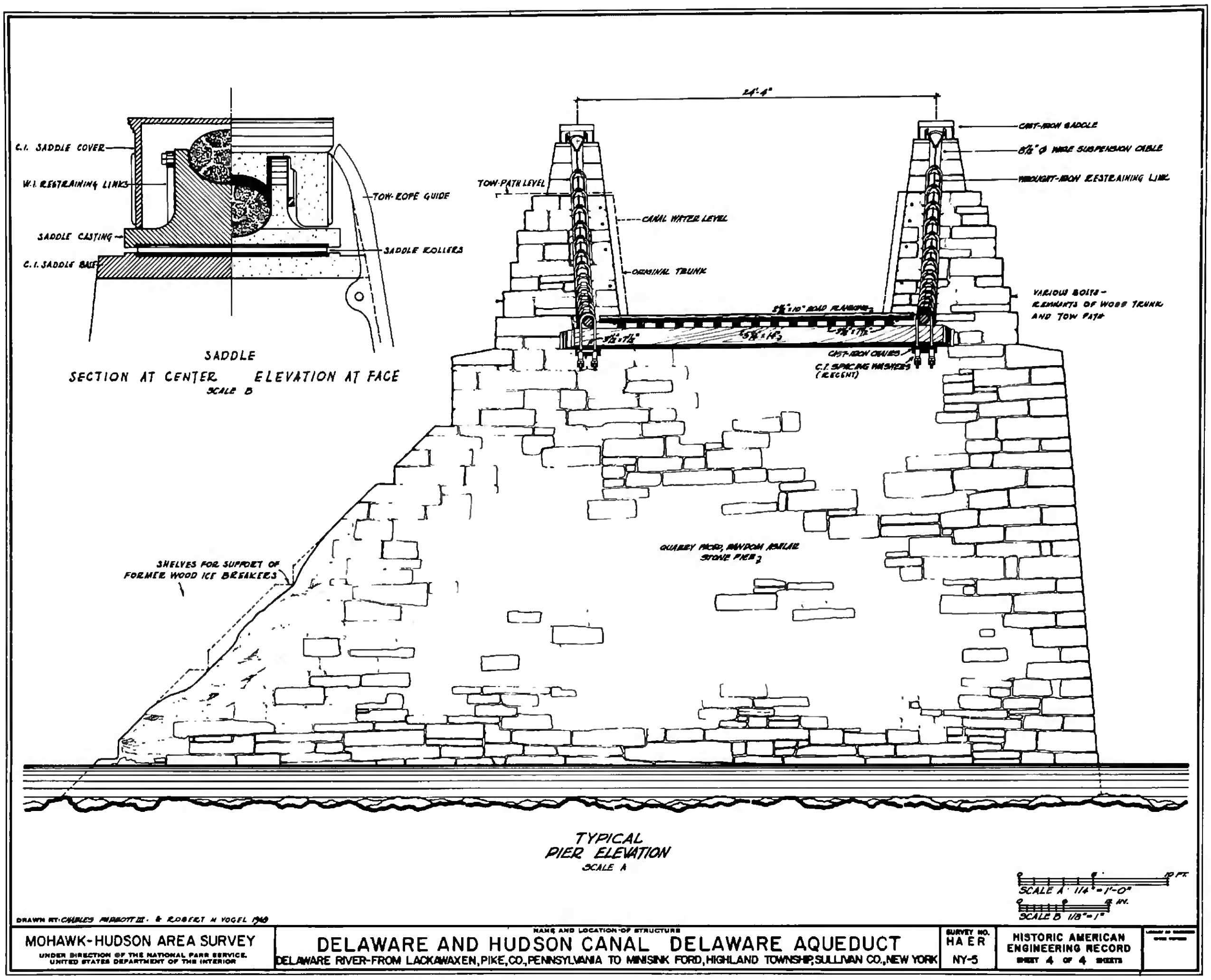


FIGURE 99

ments had been assumed almost from the outset, since the modest capital initially available and the uncertainty of later needs dictated many expediencies and compromises in the first works.

With the profits from the first decade's operations, it was possible to begin enlarging the canal. The first enlargement, begun in 1842 and finished in 1844, accommodated 40-ton boats (originally capacity had been 30 tons), and in 1845 the canal was deepened to 5½ feet to pass boats of 50-tons capacity. The most ambitious enlargement plan, authorized by the Delaware & Hudson directors in 1846, was to increase both the canal's capacity and the speed of passage in order to compete economically with the Erie Railroad, which by then had progressed into the Delaware Valley and toward the coal regions. This involved deepening the canal to 6 feet and widening it to accommodate 98-ton boats, thus approximately quintupling the canal's original capacity, an indication of the growing importance of both anthracite and the canal in the coal industry. The principal consequence of the widening was the necessity for rebuilding all locks and aqueducts.

The most significant improvement to the canal's operation, however, was to be a material reduction in the passage time by removal of the worst bottleneck in the system: the slack water crossing of the Delaware between Lackawaxen, Pennsylvania, and Minisink Ford, New York, just above the mouth of the Lackawaxen. As capital originally had been inadequate to build an aqueduct across the Delaware, a still pool had been formed by damming the river,

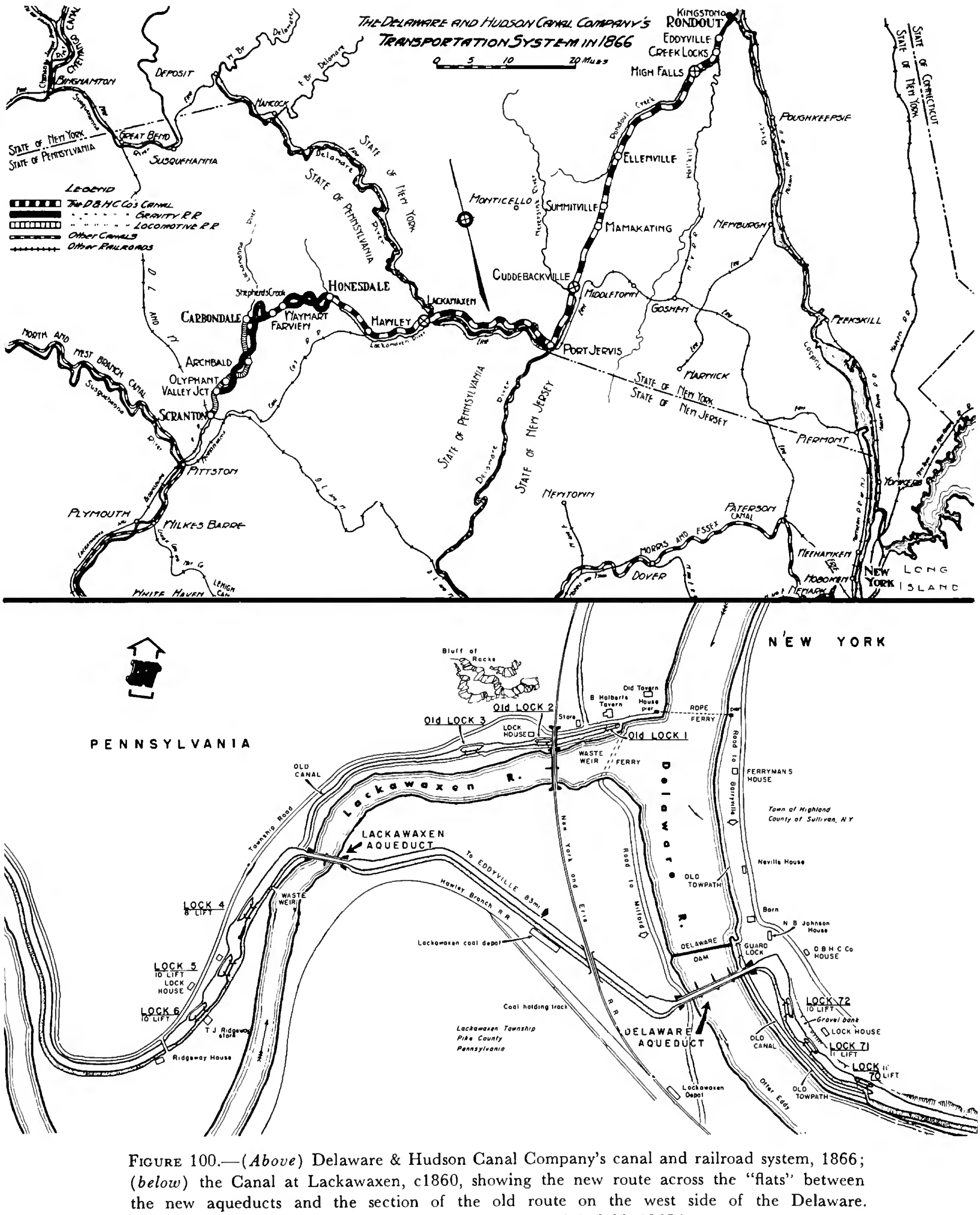
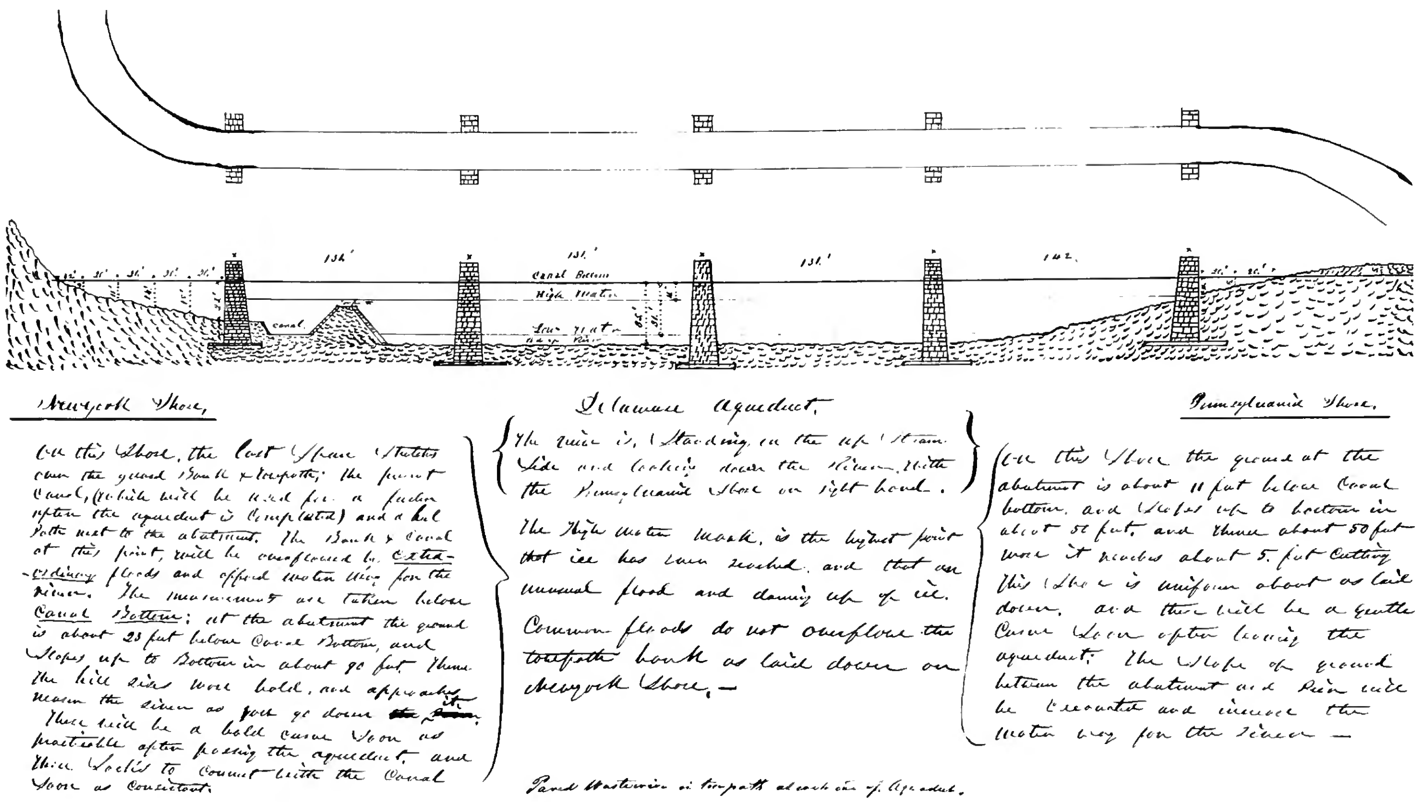


FIGURE 100.—(*Above*) Delaware & Hudson Canal Company's canal and railroad system, 1866; (*below*) the Canal at Lackawaxen, c1860, showing the new route across the "flats" between the new aqueducts and the section of the old route on the west side of the Delaware. (*above: Delaware & Hudson Company, 1925; below: Wakefield, 1965.*)



New York Shore,
On this shore, the last span stretches over the guard Bank & towpath; the present Canal, (which will be used for a feeder after the aqueduct is completed) and a foot path next to the abutment. The Bank & Canal at this point, will be overflowed by *extraordinary* floods, and afford water way for the river. The measurements are taken below *Canal Bottom;* at the abutment the ground is about 23 feet below Canal Bottom, and slopes up to Bottom in about 90 feet. Then the hill rises more bold, and approches nearer the river as you go down it. There will be a bold curve soon as practicable after passing the aqueduct, and three locks to connect with the Canal soon as consistant.

Delaware Aqueduct,
The viewer is standing on the up stream side and looking down the River, with the Pennsylvania shore on right hand.
The high water mark, is the highest point that ice has ever reached, and that an unusual flood and damming up of ice. Common floods do not overflow the towpath bank as laid down on New York shore.
Paved Wasteweir in towpath at each end of Aqueduct.

Pennsylvania Shore,
On this shore the ground at the abutment is about 11 feet below Canal bottom, and slopes up to bottom in about 50 feet, and thence about 50 feet more it reaches about 5 feet cutting. This shore is uniform about as laid down, and there will be a gentle curve soon after leaving the aqueduct; the slope of ground between the abutment and pier will be excavated and increase the water way for the river—

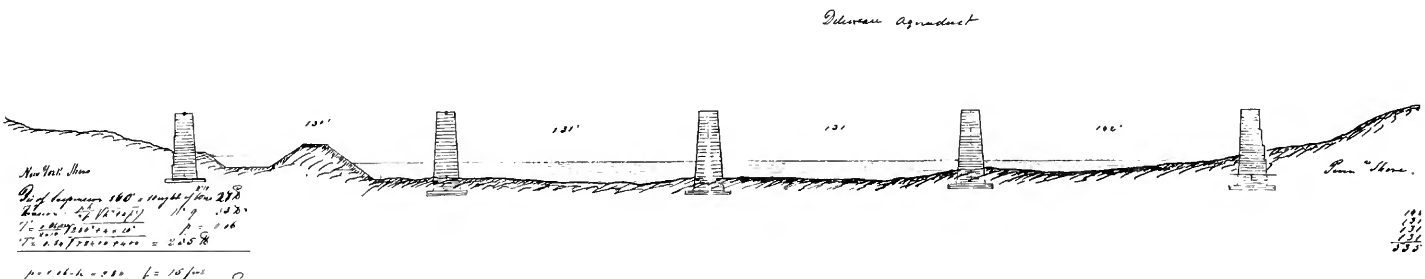


FIGURE 101.—Cross-sections of the ground and masonry at the Delaware Aqueduct site: (*above*) R. F. Lord's rough sketch of 27 February 1847 to Roebling; (*below*) Roebling's refined drawing. (*Courtesy of Rensselaer Polytechnic Institute*).

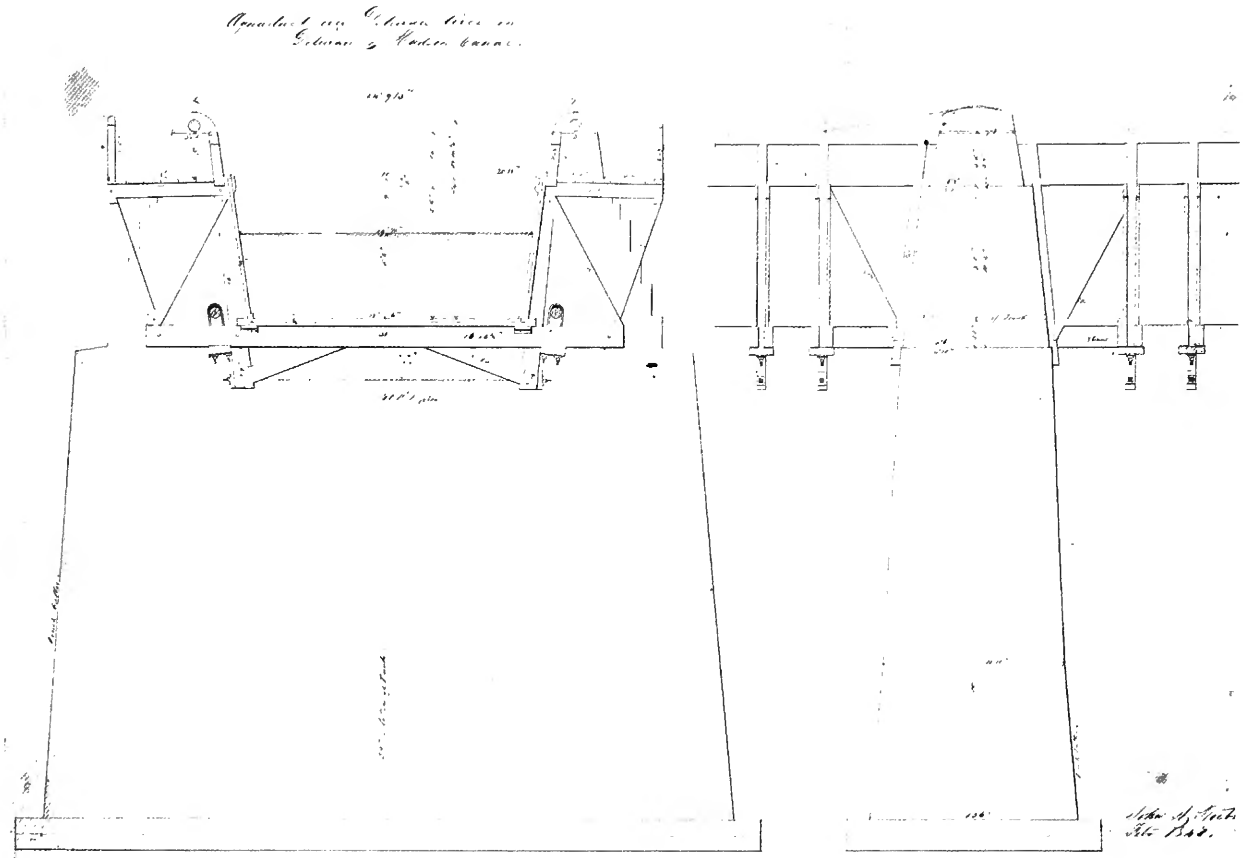
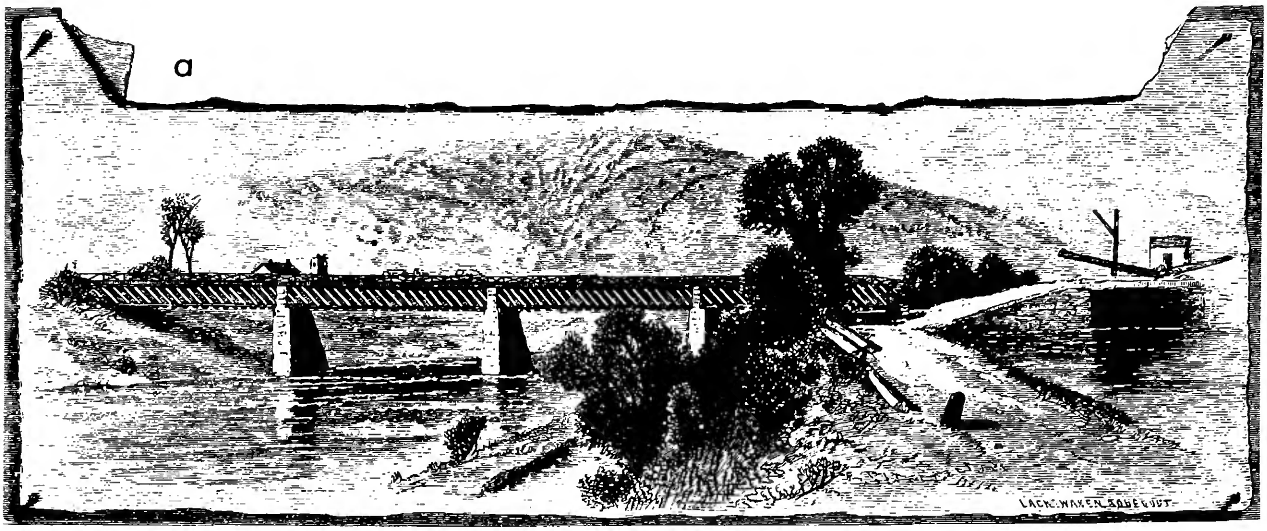


FIGURE 102.—The Delaware Aqueduct superstructure, February 1847. By the time of construction, Roebling had abandoned the floor-beam trussing shown, and had adopted saddle covers rectangular in cross-section (Figure 99). Otherwise the drawing reflects the aqueduct as built, following the Allegheny Aqueduct design. (*Courtesy of Rensselaer Polytechnic Institute.*)

into which the boats were locked down on each bank. They then crossed either by momentum or hand haulage along a ferry rope strung between the banks, the mules being carried over separately on a small rope ferry. Under ideal conditions the crossing was slow and a serious operational snag. At worst, during high water in spring and fall, the passage was impossible and canal operations came to a halt for days at a time. A further hazard was conflict with the considerable traffic of timber rafts on the river. The raftsmen, forced to traverse the low canal dam either by shooting it on the flowage over the crest or passing through a sluiceway, in general were understandably hostile to the canal interests and engaged the company in constant physical and legal harassment. An aqueduct had, in fact, been projected from the canal's beginning. The need now being pressing and the capital available, it was included in the enlargement plan.

Construction of the Delaware Aqueduct

R. F. Lord, chief engineer of the canal, in planning the enlargement of the canal relocated the route at Lackawaxen, establishing the aqueduct over the Delaware not at the rope ferry site above the mouth of the Lackawaxen River, but just below. This necessitated, in addition, construction of a second new aqueduct, over the Lackawaxen (Figure 100*b*). Every D & H Canal scholar and author has speculated on Lord's reasons for planning the new route in that



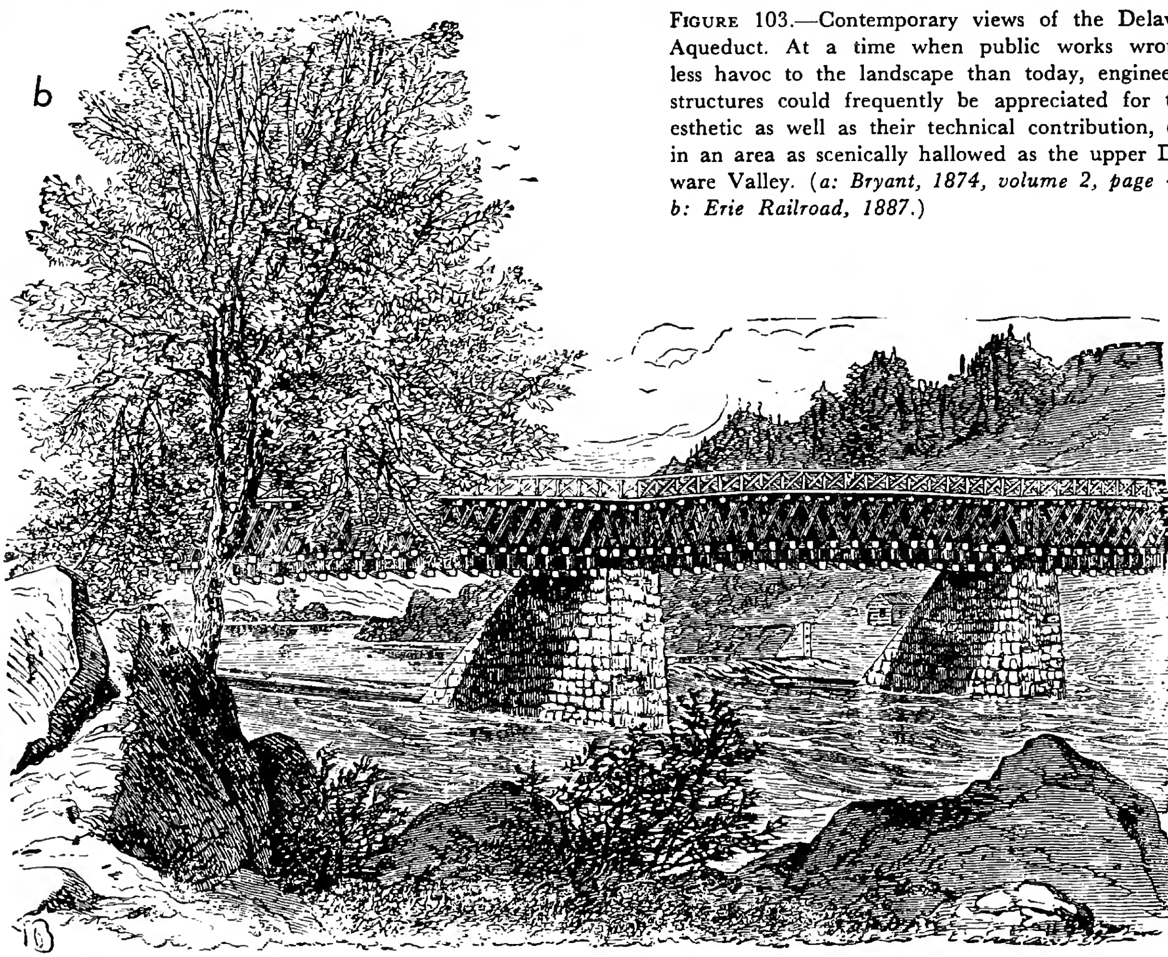


Figure 103.—Contemporary views of the Delaware Aqueduct. At a time when public works wrought less havoc to the landscape than today, engineering structures could frequently be appreciated for their esthetic as well as their technical contribution, even in an area as scenically hallowed as the upper Delaware Valley. (*a: Bryant, 1874, volume 2, page 474; b: Erie Railroad, 1887.*)

seemingly extravagant way. There were obvious disadvantages to the scheme, notably the added cost of the second aqueduct and the fact that the piers of the Delaware Aqueduct would be subject to the collective flow and battering of ice from both rivers. Two reasons are most commonly assumed for the re-routing: political consideration, and river bed and bank conditions unfavorable to the upstream location. The first, in the case of a private company under the scrutiny of its stockholders, seems unlikely, and there is nothing in the topography of the site lending much support to the second. More reasonable is a recent hypothesis proposed by Manville B. Wakefield, author of the definitive D & H Canal history, that if the aqueduct *had* been built at the ferry, practically opposite the Lackawaxen's mouth, the piers would have been in constant jeopardy from the great ice flows that annually came down the Lackawaxen, grinding across the Delaware to the eastern shore with great force.

Another likelihood, however, is suggested by the site conditions. Had the ferry location been selected, the aqueduct would have been right in the slack water pool, with several consequences. First, there would have been less vertical clearance under the aqueduct for the rafts, probably an insufficient amount at spring high water when much of the rafting was done. Worse, the cofferdams used in building the aqueduct piers would have to have been considerably higher and heavier, and the entire problem of pier construction would have been a good deal more difficult in the deeper water of the dammed pool, probably to a degree more than offsetting the added cost of the Lackawaxen aqueduct. There is also the probability that in the twenty years the Delaware had been stilled above the dam, quantities of silt had been deposited in the pool so that there would have been that much more material to excavate before reaching a solid footing. Finally, the river, in addition to being deeper, was, on the evidence of contemporary photographs, apparently somewhat wider above the dam, which would have necessitated a longer structure.

In February 1846, the canal directors authorized the two aqueducts at Lackawaxen, and by late December that year two proposals had been received. One was for a conventional trussed timber structure on masonry piers, in six spans. The other, submitted by John A. Roebling, C.E., of Saxonburg, Pennsylvania, was for a wire-cable suspension aqueduct

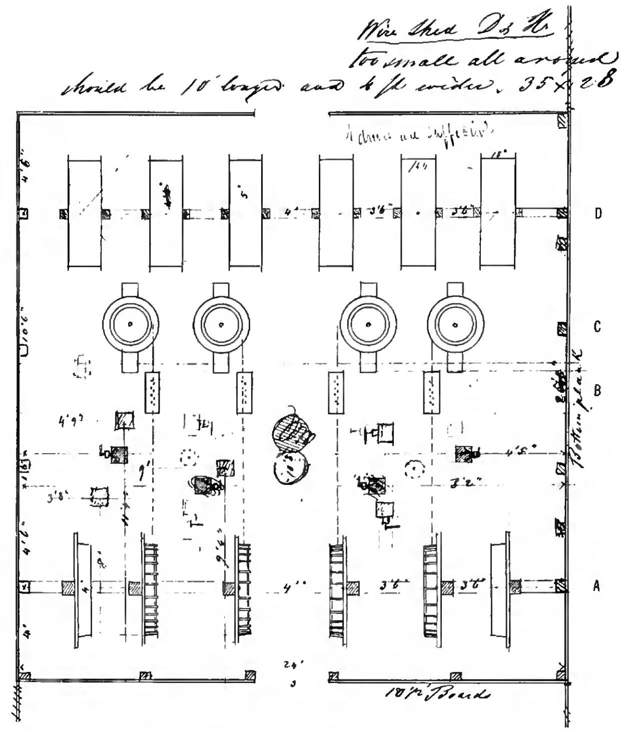


FIGURE 104.—Roebling's sketch plan for the wire shed at Lackawaxen. The coils of cable wire as received were placed on the front reels (A). The wire was drawn through the pins in the straightening blocks (B) by being wound upon the drawing drums (C), and finally reeled on the back drums (D). The reels were taken to the bridge site for cable making. The wire also was given an initial coating of protective oil in the shed. (*Courtesy of Rensselaer Polytechnic Institute.*)

of four spans. The management inclined toward the latter scheme as it not only was cheaper, but more important, the longer spans meant two less river piers, and thus reduced impedance to flood water and ice, as well as greater horizontal clearance for the river traffic. Another major advantage, not generally recognized by D & H historians, was that suspension spans, unlike either truss or masonry-arch spans, could be erected without falsework in the river, a matter of some significance at a site so subject to flooding and ice jams. The cables were laid up in place, without support. When they were complete and the suspenders attached, the timber cross frames of the trunk were hoisted into position from barges anchored below, following which the rest of the suspended structure was easily laid down. The freedom from falsework continues to be one of the suspension bridge's chief advantages.

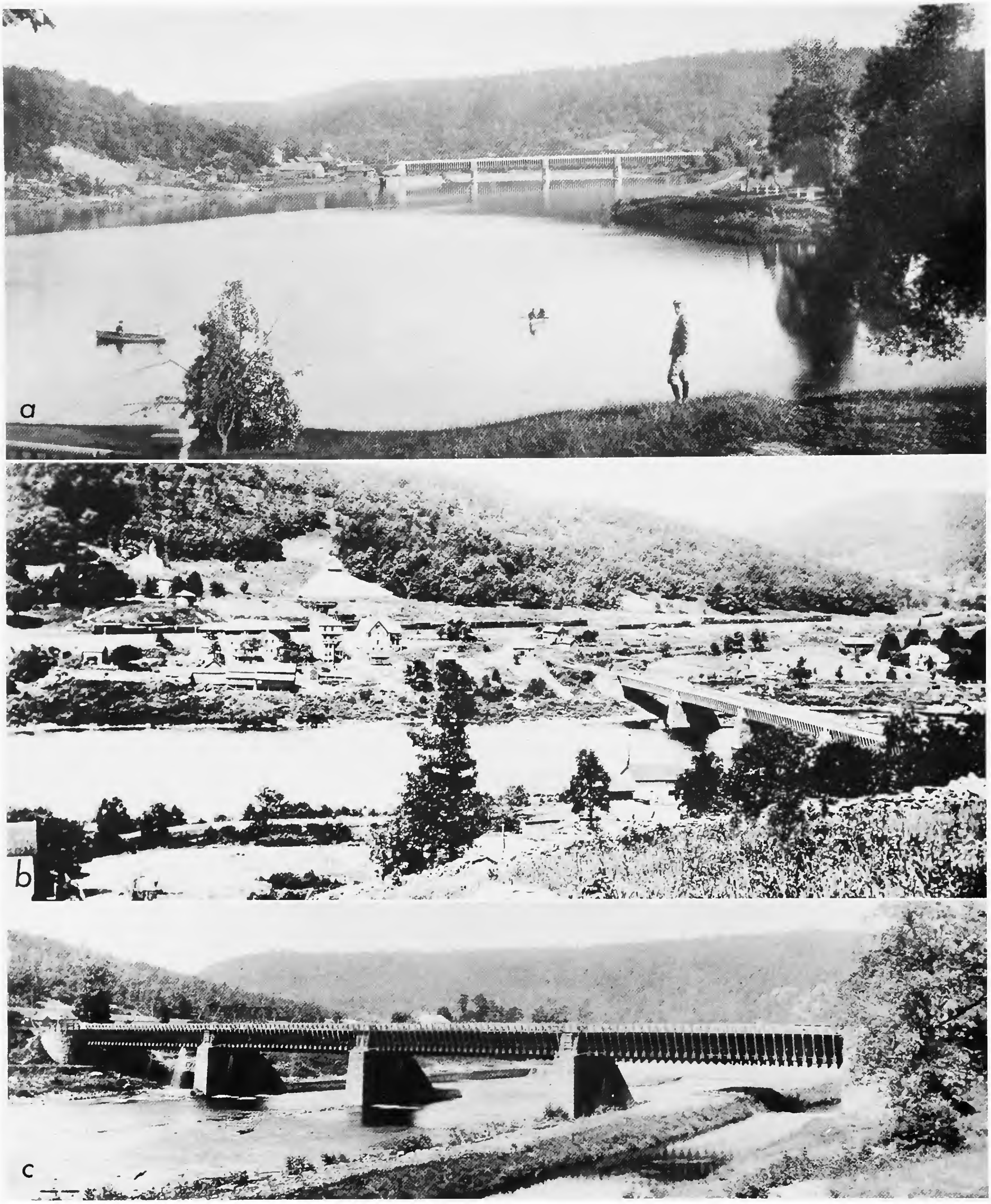


FIGURE 105.—*a,* Delaware Aqueduct from above the mouth of the Lackawaxen, shortly before suspension of canal operations. The Delaware & Hudson Canal dam, retained after construction of the aqueduct to provide water for the section of the canal to the east, is just in front of the aqueduct piers. *b-c,* Downstream side of the Delaware Aqueduct before abandonment. Except for the canal's absence, Lackawaxen, Pennsylvania, seen across the river, has changed little over the years. In *c* may be seen the Erie Railway's truss bridge over the Lackawaxen, the remains of the 1828 canal, and the canal company's dam across the Delaware. (*a: Courtesy of Delaware & Hudson Railway Company; b: courtesy of Jim Shaughnessy; c: courtesy of Delaware & Hudson Canal Historical Society, Ghear Collection.*)

Roebling's plan was tentatively accepted on 6 January 1847. On the 19th Lord arrived in Pittsburgh for a four-day visit to inspect a similar aqueduct built by Roebling in 1844–1845 to carry the Pennsylvania Canal over the Allegheny. This aqueduct was the first bridge of any kind built by Roebling, who until then had done general civil engineering—mostly railroad surveys—and manufactured wire ropes for haulage on the inclined planes of the Pennsylvania state and other canal systems. The aqueduct replaced, and was erected on the piers of, an earlier timber structure of seven spans that had been damaged by ice.

Lord was impressed with both the aqueduct and Roebling's Smithfield Street suspension bridge over the Monongahela, also in Pittsburgh, built in 1845–1846, and concluded that Roebling's abilities were far ahead of their time. Aside from Lord's report and the natural advantages of a suspension aqueduct, a further factor no doubt influencing the D & H's selection of Roebling to build the aqueducts was their confidence in him resulting from the long and satisfactory use of Roebling wire ropes on the inclined planes of the company's gravity railroad at the west end of the canal.

FIGURE 106.—One of the last boats through the canal crossing the Lackawaxen Aqueduct, about 1898, moving unloaded toward Honesdale. (*Courtesy of Delaware & Hudson Railway Company.*)

FIGURE 107.—Neversink Aqueduct at Cuddebackville, New York, which had the longest single span of the Delaware & Hudson Canal suspension aqueducts. (*Courtesy of Division of Mechanical and Civil Engineering, National Museum of History and Technology, Smithsonian Institution.*)

FIGURE 108.—After standing derelict for nearly twenty years following abandonment of the canal, fire destroyed the wooden trunk of Roebling's Delaware & Hudson aqueduct at High Falls, New York, c1916. The cables and suspenders were left in a state not unlike that during original construction, just before the first of the trunk frames had been hoisted into place. (*Courtesy of Delaware & Hudson Canal Historical Society, Ghear Collection.*)

The contract for both final design and construction of the Delaware and Lackawaxen aqueducts was given to Roebling, for a combined price of $60,400: $41,750 for the Delaware Aqueduct and $18,650 for the Lackawaxen. Roebling claimed a clear profit of $8,600. While almost 15 percent of his actual cost, it is hardly excessive when we realize that his contracting profit included his engineering fee as well. Possibly because of their remote location, these structures cost considerably more, relatively, than the Pittsburgh aqueduct: $82 and $78 per foot vs $48.

Roebling's construction contract covered only the superstructure or suspended spans, "including all iron, timber and wire work, the company to do all masonry and cement." His presentation and estimating drawings apparently were based only on general site information, for shortly after his return from Pittsburgh Lord sent Roebling detailed data on the bank and riverbed conditions for preparing the working drawings (Figures 101*a, b*). With these in hand, Lord's crews in March 1847, despite the dual handicaps of weather and probably river ice, commenced the foundation work and the laying of the pier and abutment masonry. Although the canal company was primarily responsible for that portion of the work, continual coordination with Roebling (during most of this period at home) was necessary concerning setting of the great iron anchor plates in the abutments. These huge castings resisted the pull of the chains of eyebar links that rose up through the masonry mass ultimately to restrain the main cables.

Roebling presumably visited the site periodically, but much of the consultation was conducted through correspondence. In late March, Lord advised him that "we are proposing to get the abutments for Delaware Aqueduct in a state of forwardness so that the anchors may be put down soon after 1st of July; and have the piers all done so that you can have a chance to commence the superstructure in the fall and pursue it during the winter." The substructure work on the Lackawaxen span lagged somewhat behind, Lord anticipating that the last of the four anchor plates there could not be placed until well into the winter, "probably by building a roof over it [the abutment foundation] so that we can use a fire, hot water &c." That excavation and masonry work could be carried on in that period, at that season, in that notoriously cruel climate is something of a miracle, and a sure reflection of the company's eagerness to capitalize on the improvement.

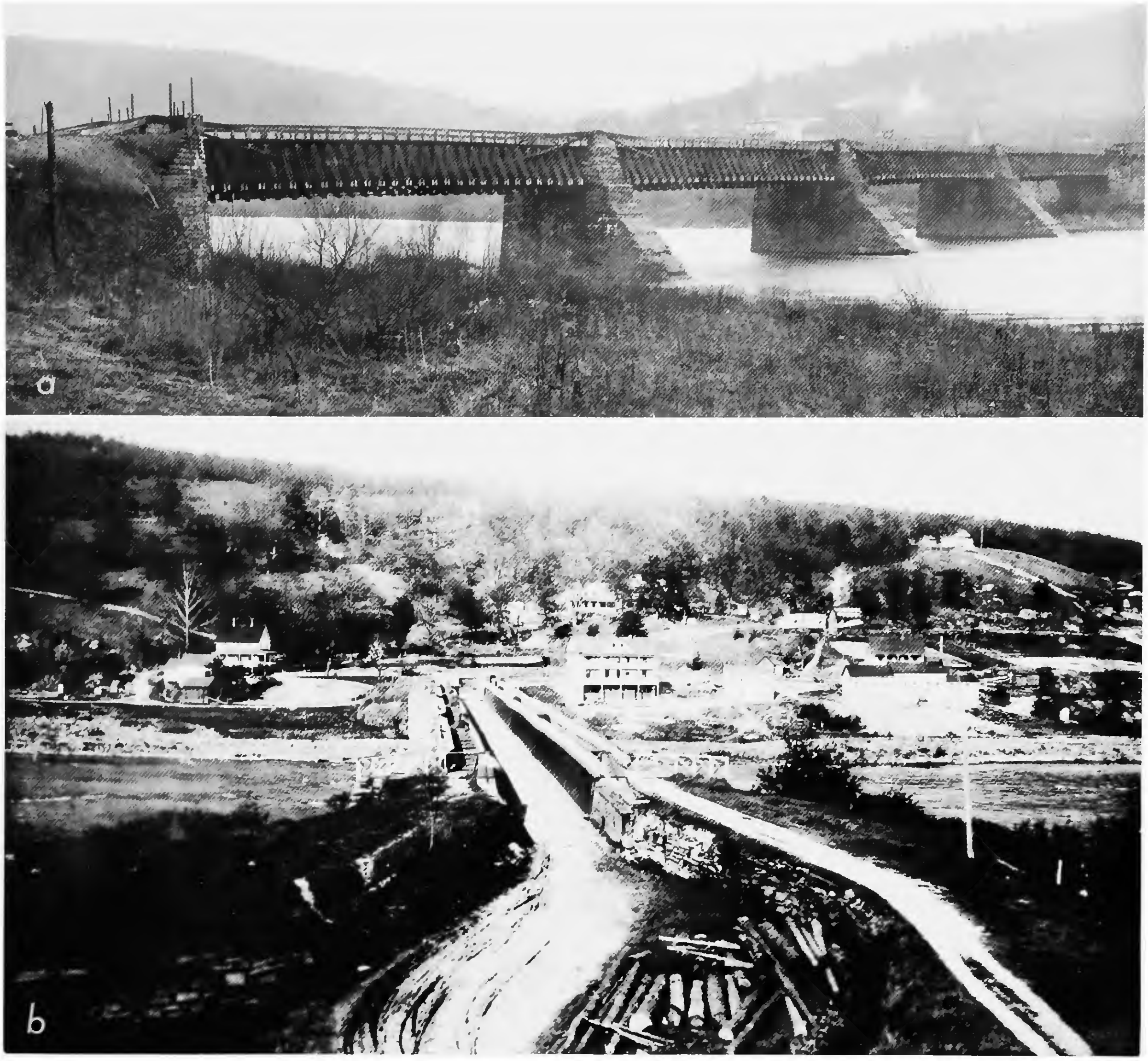


FIGURE 109.—*a,* Early twentieth-century view of the Delaware Aqueduct from New York; *b,* the Delaware Aqueduct and Minisink Ford, New York, shortly after the canal's abandonment in late 1898. Except for removing the berm wall on the outside of the curve at Lackawaxen to provide road access, nothing has yet been done to alter the structure for toll-bridge service. (*Courtesy of Delaware & Hudson Railway Company.*)

Roebling took up his work at Lackawaxen in the summer or fall of 1847, working on both aqueducts simultaneously throughout 1848, completing them by year's end in time for the opening of the 1849 canal season on 26 April. They were, needless to say, an unqualified success structurally and operationally. The Lackawaxen Aqueduct, about half a mile west of the Delaware, was almost identical but had only two spans, each of slightly less than 115 feet, with a single river pier.

Decline and Recent History

The 1847–1850 enlargement of the canal was spectacularly successful. In the D & H annual report for

1849 the management noted that "the two Wire-Suspension Aqueducts over the Delaware and Lackawaxen Rivers, are a part of the new work brought into use last year, and proved to be all that was expected or can be desired of such structures, and a great facility to the navigation." With a slight additional deepening and widening, the canal by 1852 was able to pass 130-ton capacity boats, which had the coincident advantage of being large enough to be river-worthy. They could thus make the down-Hudson trip to New York directly, eliminating the expensive trans-shipment of the coal to sloops at Rondout, the boats being hauled up and down the river by tugs.

Chief Engineer Lord estimated that in the first year following the construction of the Delaware and Lackawaxen aqueducts, nine days stoppage of boating due to high water had been avoided and total passage time was reduced by a full day. Consequently, the company was able to reduce rates by half, bringing the transportation cost down to about fifty cents per ton. On this basis the canal was able to compete successfully with the railroads for bulk coal haulage well into the 1870s. From the peak year of 1872, however, the competitive situation deteriorated rapidly for the canal. While the canal had reached its maximum practical capacity, the technology of the railroad was in a state of flourishing and seemingly unlimited advance. In the last decades of the century, locomotive weights doubled, with corresponding increases in car capacity and train lengths, and decreases in rates.

The Delaware & Hudson Company management had the wisdom to march with, rather than against, this trend, and although the canal was operated almost to the century's end, it was under rapidly declining conditions as the company expanded its own rail network, commenced decades earlier. In 1898 the last boat moved over the waterway, and the following year the physical plant of the system was liquidated.

Of the four suspension aqueducts that Roebling designed as part of the major enlargement operation, only the Delaware had any apparent adaptive usefulness. The spans over the Lackawaxen, Neversink, and Rondout all were simply abandoned and eventually demolished. Abutments and remains of anchor chains are evident at all three sites.

The Delaware Aqueduct, however, being in a strategic location well away from any road-crossing of the river, was purchased privately and converted into a highway bridge. From the evidence of photographs the process of adaptation was simplicity itself: the towpaths were sawn off, a low railing was run along the downstream side of the trunk floor to provide a separated pedestrian walk, a toll house was built at the New York end, and some grading was done at each end for accommodation to the existing roads.

The first private owner was Charles Spruks, a Scranton lumber dealer, who specialized in the heavy timbers used as supports in the area's coal mines. His principal timber lands being in Sullivan County, New York, he purchased the aqueduct primarily to afford a simple means of getting the logs across the

FIGURE 110.—Delaware Aqueduct: *a,* View from Lackawaxen, c1910. The towpaths have been removed in the alteration but not the tow-rope rail. During the canal period, the upstream faces of the piers were protected by pointed wooden ice-breakers. Renewed as needed, they prevented the type of deterioration of the masonry that has occurred since. The pier faces were shelved to support the ice-breaker framing. *b,* Interior of the trunk after conversion to a toll bridge, c1900. (*Courtesy of Delaware & Hudson Railway Company.*)

FIGURE 111.—The Delaware Aqueduct Suspender System: *a-d,* All ironwork in the present suspender system is original. Unlike the plan adopted by Roebling for his Niagara and other later bridges where wire-rope suspenders were hung from clamps bolted tightly around the unwrapped main cables, on the Delaware & Hudson aqueducts he first wrapped the cables for their entire length between the tower saddles and hung the doubled-rod suspenders from small cast-iron saddles that simply sat on the cables. The scheme had the advantage of avoiding the many joints where the wrapping was interrupted at the suspender clamps, a problem in the later system (and today).

It was necessary, however, to prevent the saddles near the towers, where the cable slope was greatest, from sliding downhill by a series of restraining links engaging the saddles in a series. Adhesion was adequate to hold the saddles in place near the center of the cable span.

The long iron bushings between the suspender nuts and the bearing castings are recent, placed to compensate for the reduced thickness of the present deck system. (*Vogel*)

Delaware to the railhead in Lackawaxen. The collecting of tolls from common-road traffic was actually a side line (pers. com., Edward H. Huber, Scranton).

In about 1929 the bridge was purchased by the Federal Bridge Company of Washington, D.C., a toll-bridge holding company, which operated it under the style Lackawaxen Bridge Company, incorporated 10 January 1930. In late 1930 plans were announced by Colonel P. K. Schuyler, Federal's president, to rebuild the floor system for "highway traffic of the heaviest class." It may have been at that time, or in about 1832, after a fire that destroyed the woodwork of the west (Pennsylvania) span and part of the one adjacent, that virtually all of the original timber was removed—trunk, floor beams, and all. The simple floor system of today was substituted, consisting of transverse floor beams hung from the suspenders, longitudinal stringers, and plain transverse plank decking.

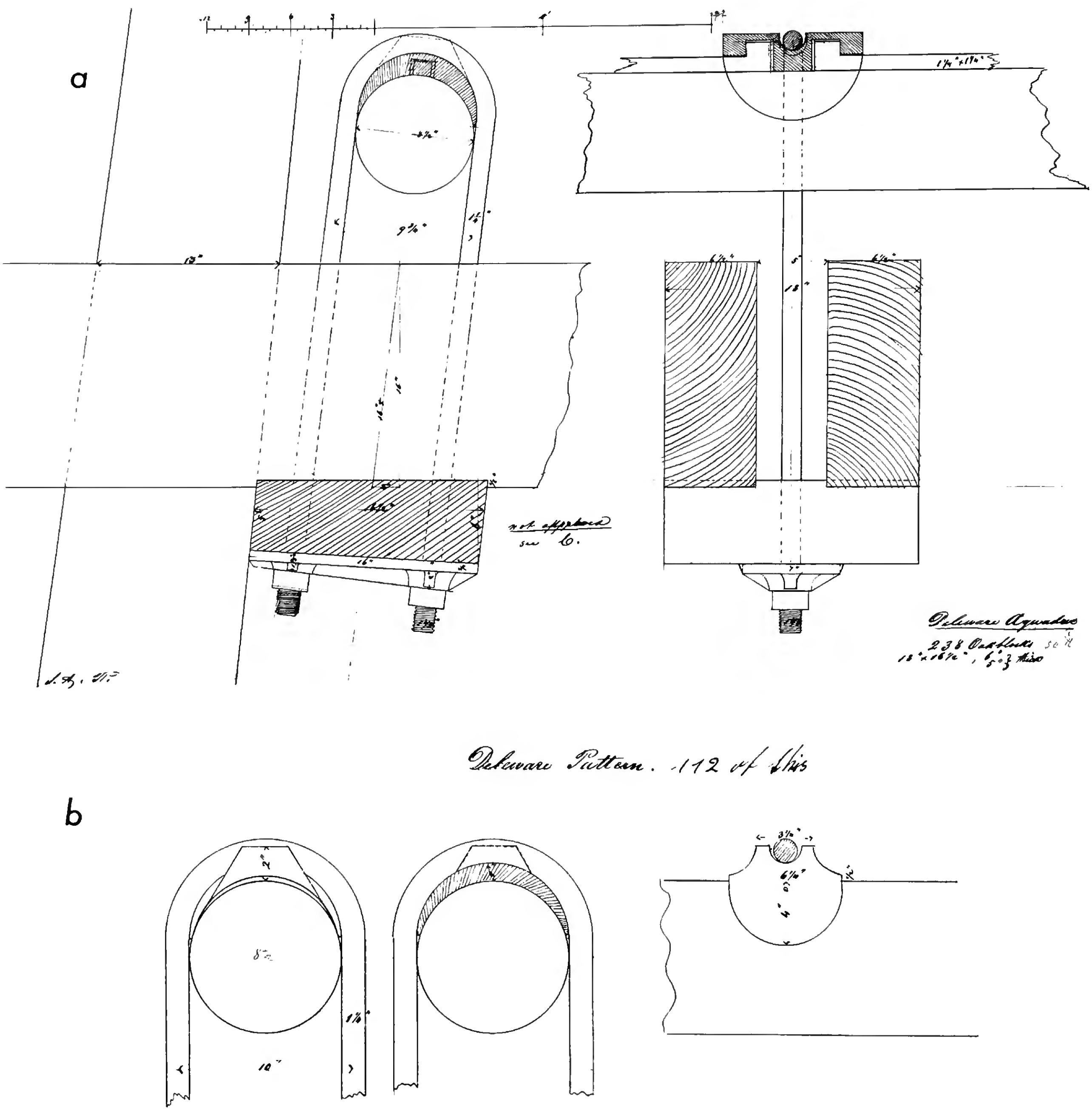


FIGURE 112.—Roebling's pattern drawings for the (*a*) restrained and (*b*) unrestrained suspender saddles. (*Courtesy of Rensselaer Polytechnic Institute.*)

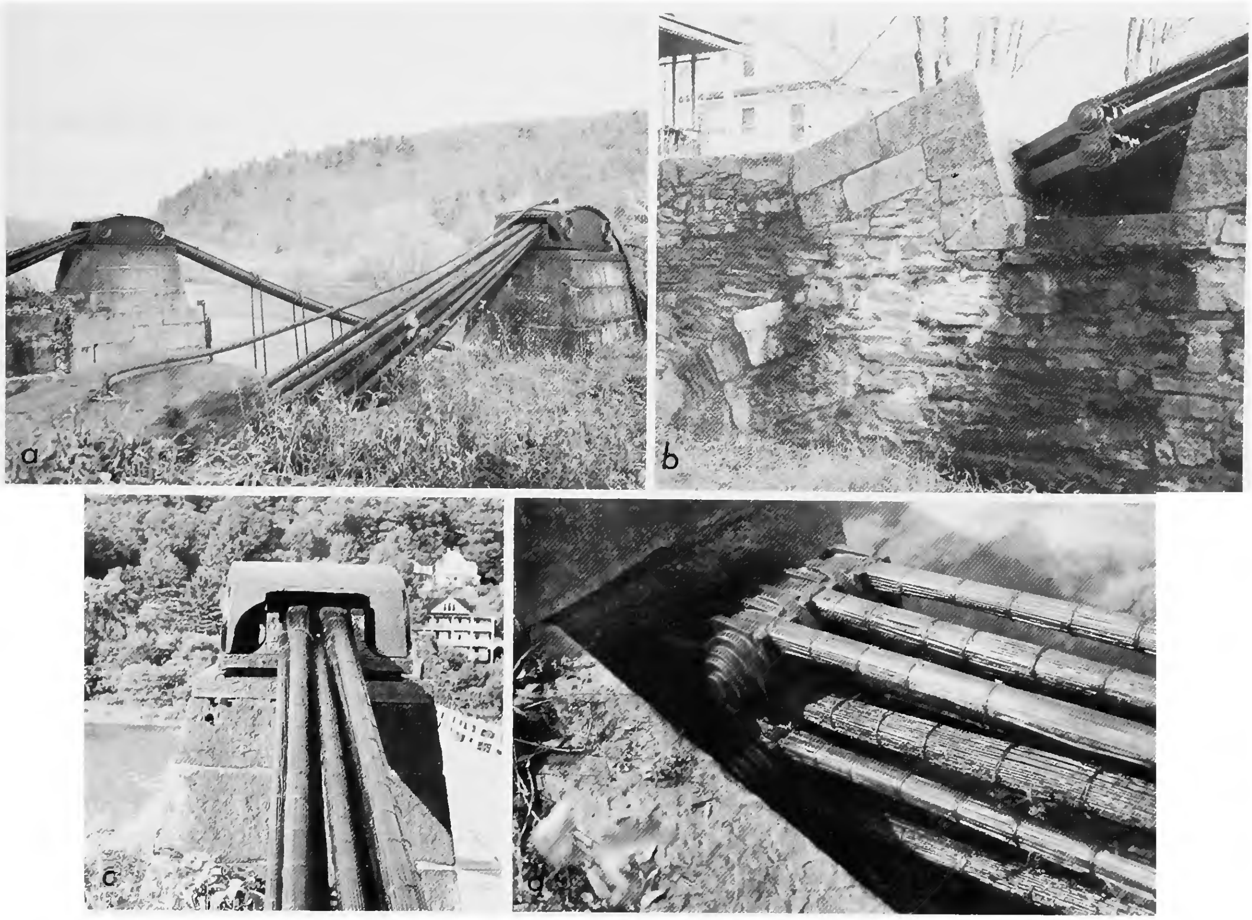


FIGURE 113.—Delaware Aqueduct Anchorages, Cable Connections, and Saddles: *a,* The Pennsylvania towers and saddles. Surprising survivals are the guides that prevented snagging of the canalboat tow ropes as they passed over: the iron bar just above the back-span strand loops and the casting bolted to the tower corner on the river face. *b,* New York south anchorage, showing projection of the stone blocks supporting the knuckles of the curving anchor chain; *c* and *d,* saddle, strand loops, and attachment of loops to anchor chains, Pennsylvania north anchorage. (*Vogel*)

The Lackawaxen Bridge Company was purchased in March 1942 by E. H. Huber of Scranton, who presently maintains the operation. A toll of 25 cents for cars and 5 cents for pedestrians is charged, all passage free when the collector goes home at night. The fabric is generally in good condition. The masonry, except for an understandable minor deterioration of the upstream pier faces from river ice, is quite unimpaired. The floor system is good, the planking being periodically replaced, and the cables, despite unwinding of the outer wrapping in a few areas, are kept painted and appear as adequate as when made. The posted allowable load of six tons is almost ludicrous in view of the fact that *each span* originally contained about 500 tons of water plus the additional dead load of the trunk and towpaths. True, it was an evenly-distributed, nonmoving, non-impact load, but there can be little doubt that the cable system today is not working very hard.

The Aqueduct's Historical Status

There is good reason to believe that the Delaware Aqueduct is the oldest suspension bridge in the United States today. There are, however, two other possible contenders for this distinction: The famed Essex-Merrimack Bridge designed by James Finley and

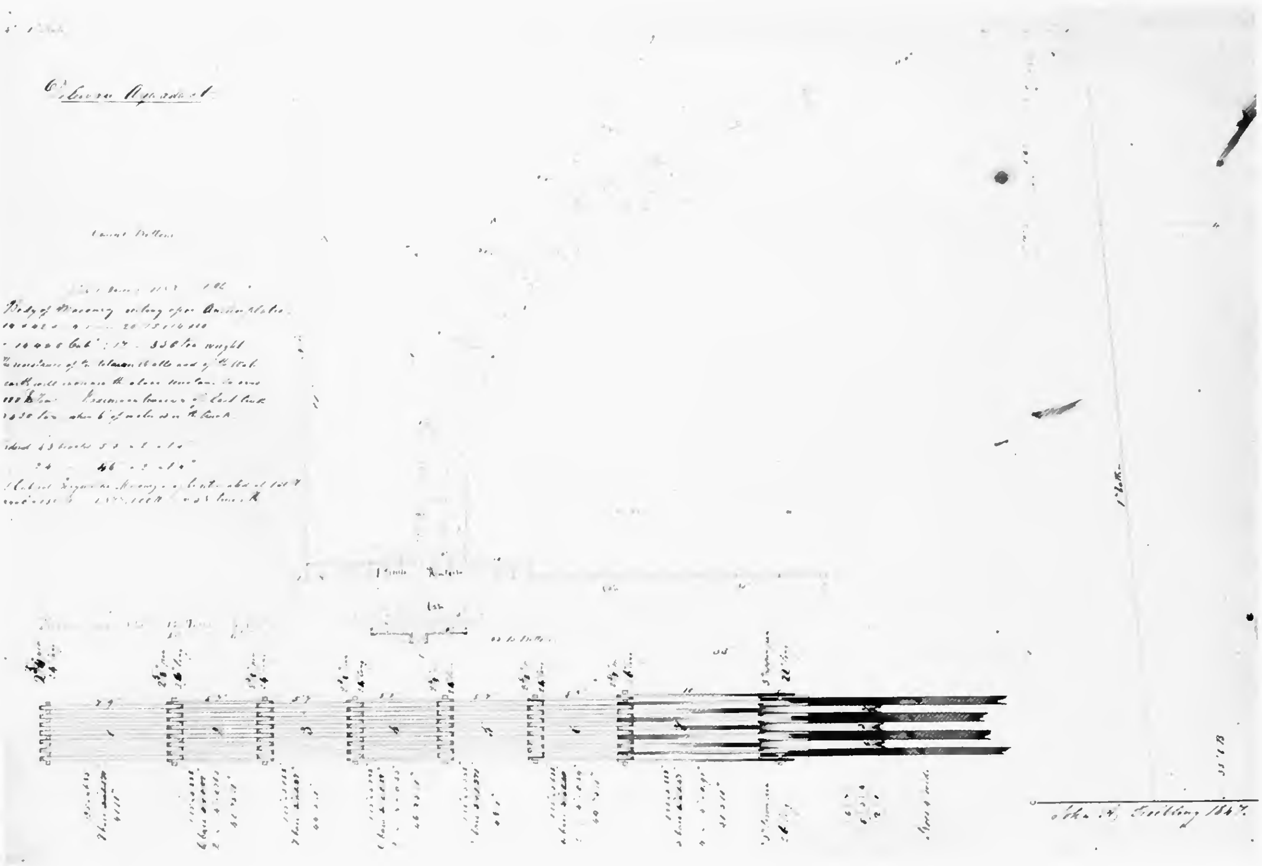


FIGURE 114.—Roebling's drawing of the eyebar anchor chains.
(*Courtesy of Rensselaer Polytechnic Institute.*)

FIGURE 115.—The Delaware Aqueduct and Lackawaxen, looking southwest.
(Helicopter aerial, April 1971) (*Jack E. Boucher for* HAER.)

FIGURE 116.—Looking downstream at Pennsylvania shore. (*David Plowden*)

erected in 1810 over the Merrimack River at Newburyport, Massachusetts; and the "Wire Bridge" over the Carrabasset River at New Portland in central Maine. While the Finley bridge at first appears the oldest, its entire superstructure was replaced in 1913. The new one only loosely resembles the original form with the pier masonry below deck level the only remaining original fabric.

Although the "Wire Bridge" has undergone a certain amount of rebuilding, the majority of the tower framing, the main cables and their anchorage hardware—the prime elements of a suspension bridge—are entirely original. According to local tradition, the bridge was built in 1842. This date could be valid, as Charles Ellet's wire bridge over the Schuylkill River in Fairmount Park, Philadelphia, the first wire suspension bridge of consequence in America, was built in 1841–1842; and there is no technical reason why the Maine bridge could not have been constructed at that time. If it was, then it would rightfully supersede the Delaware Aqueduct as the oldest standing suspension bridge in the United States.

The 1842 date is doubtful, however, considering the lack of historical authority and the former presence of two similar suspension bridges in the immediate area, one built in Kingfield in 1852–1853 and the other in Strong in 1856. Since the cables of the Kingfield span were not of wire as in the other two, but of chain, a more familiar and less novel material, it is reasonable to assume that it was erected first. The New Portland bridge, in that case, must have been built *after* 1852, invalidating its traditional date of 1842. Taken altogether it seems reasonable to consider the Delaware Aqueduct America's earliest standing suspension bridge.

Its future seems reasonably secure. Although it is in a remote area, between the Poconos and the Catskills, it remains the only crossing of the Delaware for ten miles upstream and four down. Vacation and local traffic make it an economic, if not wildly profitable, venture for its owner, well worth adequate maintenance.

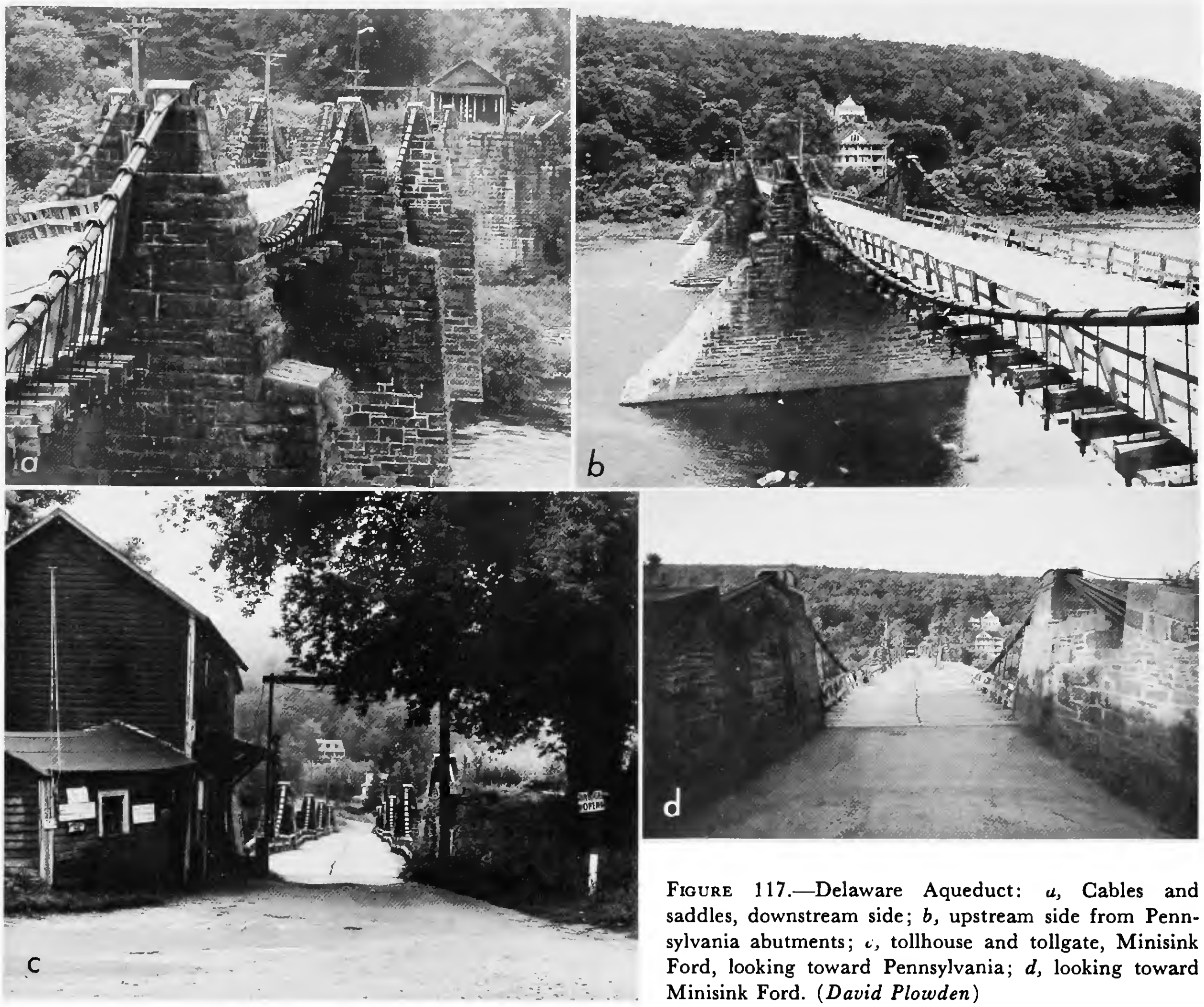


FIGURE 117.—Delaware Aqueduct: *a*, Cables and saddles, downstream side; *b*, upstream side from Pennsylvania abutments; *c*, tollhouse and tollgate, Minisink Ford, looking toward Pennsylvania; *d*, looking toward Minisink Ford. (*David Plowden*)

Sources of Information

PUBLISHED

[*Annual Report of the*] *Delaware & Hudson Canal Company for 1849*. New York.

Bryant, William Cullen. *Picturesque America*. Volume 2. New York, 1874.

Delaware & Hudson Company. *A Century of Progress: History of the Delaware & Hudson Company*. Albany, 1925.

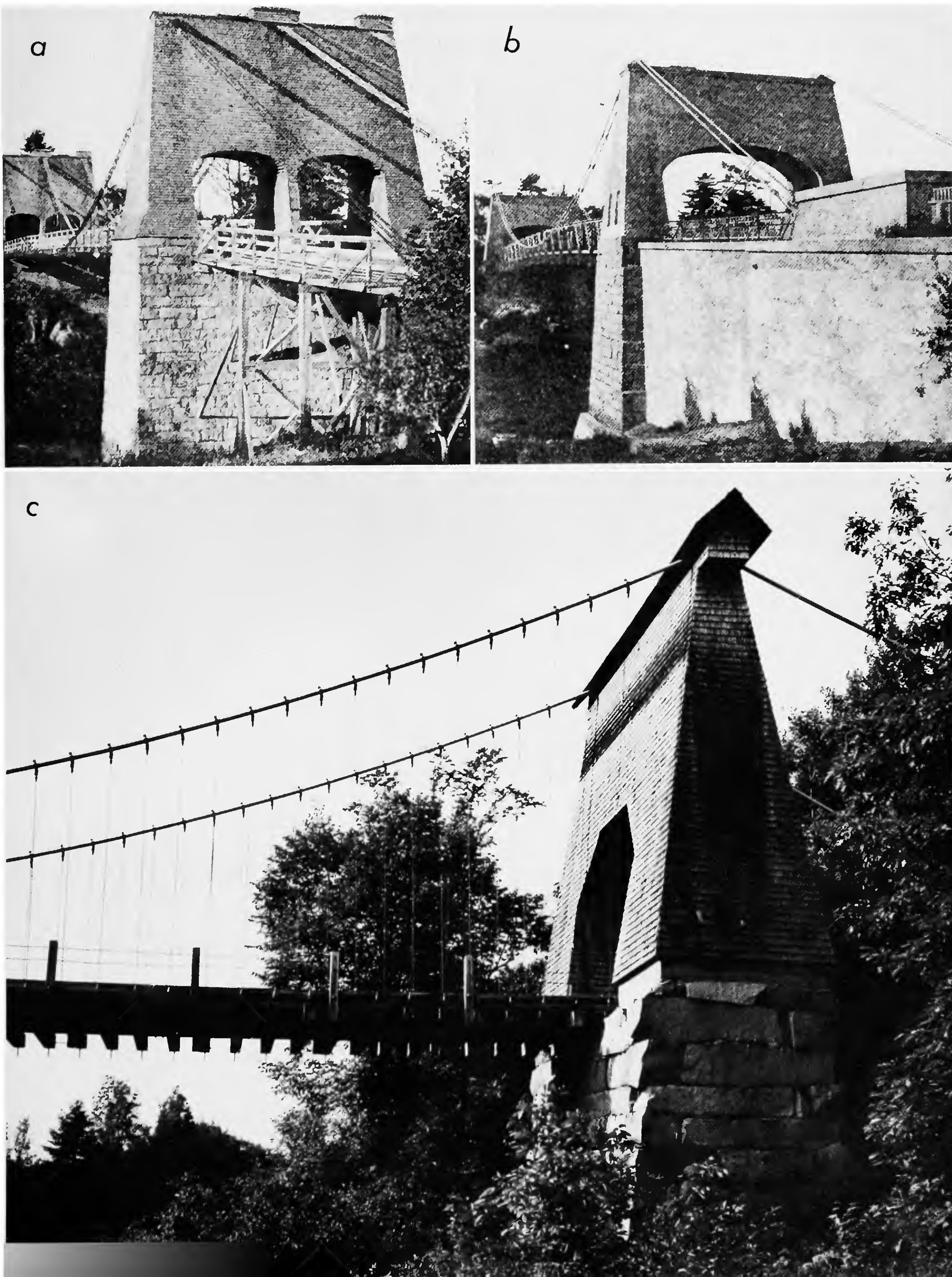
Erie Railroad. *Erie Route*. N.P., 1887.

Wakefield, Manville B. *Coal Boats to Tidewater—The Story of the Delaware & Hudson Canal*. South Fallsburg, New York: Steingart Associates, 1965.

ENGINEERING INFORMATION

The aqueducts were designed, like the locks, to pass only a single boat, but nevertheless had a path on each side. The design closely followed that used by Roebling at Pittsburgh with a heavy wood trunk or flume holding between 6 and 6½ feet of water, 19 feet wide at the water line. The trunk sides were built up of two thicknesses of 2½-inch untreated white-pine plank, laid tight on opposite diagonals and caulked up to the water line, in effect forming a rigid, solid lattice truss, but without functional top

FIGURE 118.—Essex-Merimack Bridge near Newburyport, Massachusetts: *a*, 1810. *b*, 1913. In the 1913 "rebuilding" of the 1810 structure, the entire superstructure was replaced with a loose replica, leaving of the original fabric only the pier masonry below deck level. *c*, The "Wire Bridge," New Portland, Maine. While having undergone some rebuiding, the bridge is original in its principal elements, a rare survival of an early suspension structure. (*a, b:* Engineering News, *25 September 1913, page 585; c: David Plowden.*)



and bottom chords (Figure 110*b*). The stiffness of these great trusses was such that they were capable of sustaining their own dead weight, leaving the cables to carry only the water load. The floor was also of double plank, carried by transverse double floor beams, in turn hung from the suspenders as in a conventional suspension bridge. The 8-foot tow and foot paths, on opposite sides, were bracketed out from the trunk sides, level with its top.

All was supported by the continuous main cables, one on each side of the trunk. At the bottom of their dip the cables were slightly above floor level, rising to be carried at each pier and the abutments over cast-iron saddles atop squat stone towers that stood about 4 feet above the trunk top. The suspenders were (and are) plain 1¼-inch-round wrought-iron rods, doubled over the cables into stirrup form, the bottom ends threaded for the floor-beam nuts. They bear upon the cables on small cast-iron saddles, those nearest the towers where the cable slope is greatest being prevented from sliding downhill by wrought-iron restraining links or stays (Figures 111, 112).

Roebling's technique of anchoring the suspension cables at their ends and resist the great stress imposed by them on the anchorage system was in general based upon European practice, but with two significant improvements. The principal of these was the solid encasement of the iron anchor chains in cement grout to exclude air and moisture and thus prevent rusting (Figure 114). European engineers traditionally left open galleries around the chains and anchor plates to *permit* air circulation and, more importantly, inspection and painting.

The other departure was placement of a solid timber grillage between the anchor plates and the superincumbent masonry mass, to act as a slight cushion between them and evenly distribute the stress between the two unyielding surfaces (Figure 114). Roebling patented the system after applying it on two earlier structures in Pittsburgh (U.S. Patent No. 4710, 26 August 1846). The timber, well below the water table, was not susceptible to rot.

The radial thrust of the chains, as they change angle from vertical at the anchor plates to the backspan angle, is borne by a series of stone blocks set into the abutment side walls. The projection of these is seen in Figure 113*b*.

Equal stress in all the anchor chain links in a section was obtained by drilling their eyes simultaneously, in a pile, to insure equal length.

Roebling had developed at Pittsburgh a method for fabricating and anchoring the cables of major suspension bridges (U.S. Patent No. 4945, 26 Jan. 1847: "Apparatus for Passing Suspension Wires for Bridges Across Rivers, &c."). It was used by him in every bridge he built (except the one at Smithfield Street) as well as by most of his successors to the present day. The 2,150 iron wires forming each of the Delaware Aqueduct's 8½-inch cables were individually laid up in place. Each cable is composed of seven strands, formed by carrying the wires across from anchorage to anchorage, over the saddles, in a bight of two wires at a time carried by a traveling sheave, so that at each anchorage a loop was formed which passed over a cast-iron strand shoe, pinned to the anchor bars, anchoring the strand. The strands are thus actually skeins formed of a single, continuous wire, spliced at the ends. Between the towers the seven strands were compacted into a single cylindrical form, virtually solid, then varnished and served with a continuous wrapping of iron wire for protection from the weather. However, where they splay out between the abutment towers and the anchor bars, the strand loops are exposed to view, clearly showing their formation as they join the strand shoes (Figure 113). Although photographs of the aqueducts in use show wood guards over these sections, the loops would still have been subject to a certain amount of condensation and other moisture. The exposure to the weather of so much area of such small-diameter unwrapped strands is in odd discord with Roebling's consistent advocacy of solid, single cables, the wires within protected overall by the envelopment of a close wrapping. It was, in fact, on this very point that he inveighed most critically against Charles Ellet, a contemporary and sometimes rival suspension bridge builder, and other members of his school. Ellet favored, rather, cables composed of many small, separate wire bundles, because, he claimed, with the solid, wrapped cable it was impossible to so lay the individual wires that each carried its proportional share of the total load. Unwilling to encase any wires in masonry because of the difficulty in achieving the positive airtight seal needed to prevent corrosion, and aware that the stress on these backspan sections was less than on those carrying the suspenders, Roebling seems to have been satisfied to depend for weather protection upon the varnish and oil coating of the individual wires and on a heavy coating of the completed loops.

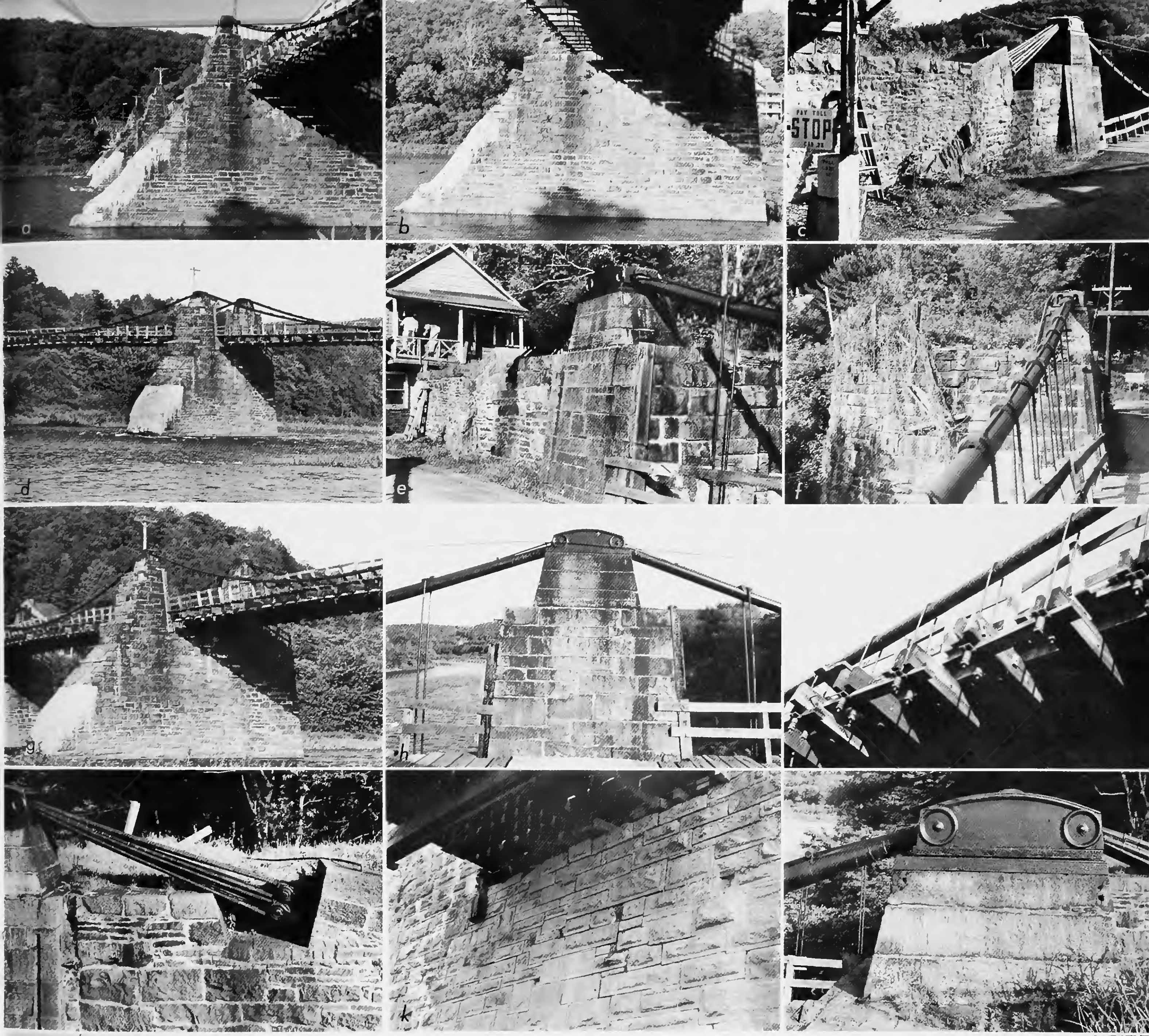


Figure 119.—Additional views of Delaware Aqueduct: *a*, Looking toward New York; *b*, pier face; *c*, New York south anchorage; *d*, New York pier (No. 3); *e*, New York south anchorage and tollhouse; *f*, New York north anchorage face; *g*, New York Pier (No. 3); *h*, south tower and saddle, Pennsylvania pier (No. 1); *i*, deck and suspender details; *j*, anchor bars and cable-strand loops; *k*, date stone, face of Pennsylvania abutment; *l*, north tower and saddle, New York anchorage; *m*, Pennsylvania pier (No. 1); *n*, top view of anchor bars and cable-strand shoes and loops; *o*, south tower and saddle, Pennsylvania pier (No. 1). (*Vogel*)

Another of Roebling's principal reasons for favoring the solid wire cable was that it added considerably to the overall stiffness of the suspended structure in its resistance to the dangerous oscillations caused by gusting winds under certain conditions. Here again, this effect would have been of no consequence in the aqueducts' short, unloaded backspans between the end towers and anchorages, where there were no suspenders.

The anchor bars were carried down through the anchorage masonry, terminating in 6-foot-square cast-iron anchor plates upon which the masonry bears, its dead weight resisting the pull of the cables. Roebling calculated the ultimate strength of the pair of cables at 3,870 tons and the stress on them (and thus on the anchors) from the loaded trunk at 770 tons.

The difference in the four span lengths of the aqueduct has been a matter of occasional speculation. The three spans closest to the New York shore are all so close to 131 feet that the present differences are obviously the result only of construction discrepancies and the shiftings of age and long service. The original design did indeed call for equal lengths of 131′0″. But what of the odd 142-foot length of the first Pennsylvania span? That too, is specified, as early as 27 February 1847, in Lord's rough sketch (Figure 101*a*), which is the earliest mention found of the aqueduct's relationship to the site. The correspondence between them does not make it clear whether Roebling or Lord made the basic determination of the span lengths. Undoubtedly they conferred during the Pittsburgh visit and perhaps reached a joint conclusion. That does not, however, answer the initial question. Although Lord obviously had far greater knowledge of the site conditions, his sketch shows a relatively level river bed, with no particular circumstances on the Pennsylvania side that would have led to a span variation there. In a presumably later refined sectional drawing of the river and masonry (Figure 101*b*), however, Roebling clearly *does* show a slight rise in the surface of the river bottom at the first Pennsylvania pier, and it was probably to take advantage of the shallower water at that point that the pier was placed there. Had the adjacent abutment been located further out into the stream to make that span also 131 feet, it would have projected so far beyond the bank as to form an impediment to the flow of river and ice during high water. The span lengths (in feet: inches), from the Pennsylvania to the New York sides, are:

Original design	*Shown by Roebling as built*	*As measured August 1969*
142:0	141:9	141:5
131:0	131:0	131:4
131:0	131:0	130:10
131:0	131:0	131:6
535:0	535:2	535:1

Schoharie Creek Aqueduct 1841

Erie Canal (Enlarged), Fort Hunter

(HAER NY-6)

R. Carole Huberman

Location: Crossing Schoharie Creek 0.4 miles southeast of its confluence with the Mohawk River, Fort Hunter, Montgomery County, New York.
Latitude: 42° 56′ 00″ N. Longitude: 74° 17′ 00″ W.
Date of Erection: 1841.
Present Owner: Division for Historic Preservation, New York State Office of Parks and Recreation.
Present Use: The aqueduct, now abandoned and only partially intact, is to be structurally stabilized and made accessible to the pubilc as a historic monument, part of a state park commemorating the Erie Canal installations at Fort Hunter.
Significance: One of the major aqueducts of the enlarged Erie Canal, the aqueduct replaced the difficult slackwater crossing of Schoharie Creek.

HISTORICAL INFORMATION

Physical History

Dates of Construction: Begun 1839; completed 1841; put into service 1845.

Original and Subsequent Owner: New York State continuously.

Designer: John B. Jervis, C.E., was responsible for at least part of the basic aqueduct design. At the time of the canal's first enlargement he proposed a plan, ultimately adopted, of stone arches for the towing path and a timber trunk for the boat channel, its height above the river being insufficient for the rise of masonry arches. (Whitford, 1906, I:800).

Builder: Incised on a stone in the tow path parapet: "BUILDER: OTIS EDDY 1841."

Historical Information: Based on material assembled by Robert M. Vogel. Engineering Information: Prepared by Richard J. Pollak.

Original Purpose and Construction: Before 1845, when the Erie Canal Aqueduct No. 5 was put into service, crossing the Schoharie Creek was a difficult and dreaded operation. The canal boats had to traverse the stream behind a dam using ropes and windlasses. Several dams were built at different times, but all proved inadequate especially when the waters were turbulent. The Schoharie Creek Aqueduct, part of the enlargement program initiated in 1836, was located slightly downstream from the slackwater crossing, between Locks No. 30 and No. 31, the realignment carrying the canal right through the center of Fort Hunter.

Alterations and Enlargements: In 1855, a new timber trunk was built for the aqueduct costing $32,899.68; it was again replaced in 1873 for $44,070.12 (Whitford, 1906, I:962, 967). All but the nine arches at the southwest end were demolished c1915 to reduce impedance of flow, when the canal was abandoned upon completion of the New York State Barge Canal.

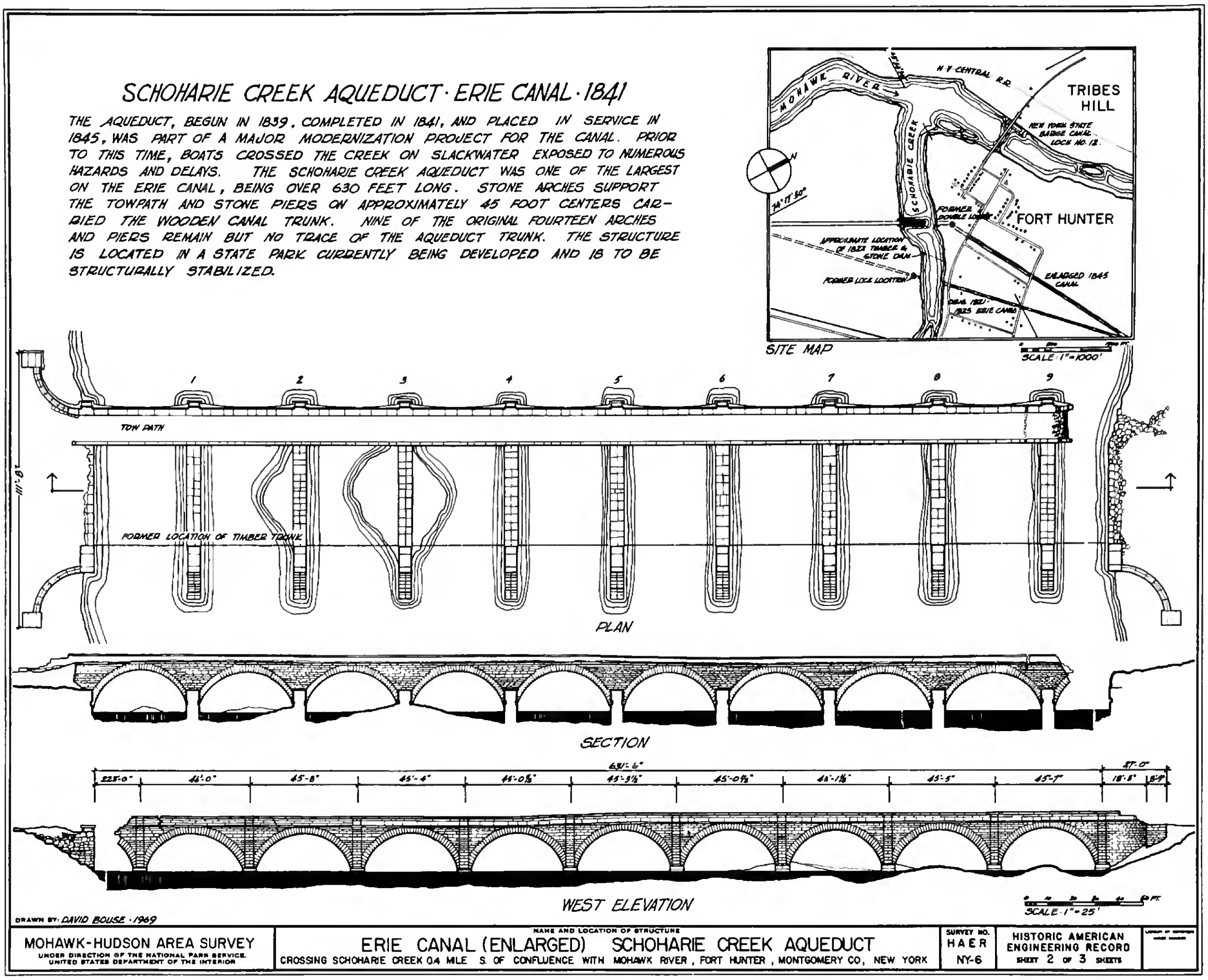


FIGURE 120

Other Erie Canal Structures at Fort Hunter

Yankee Hill Lock No. 28: Builder's inscription:

LOCK No. 28
Archt. C. Powell Rest. Engr.
William Coleman & Co. Contractors
1841

Empire Lock No. 29: Built in 1841, it stands adjacent to the remains of Empire Lock No. 20, part of DeWitt Clinton's Big Ditch of 1822. Its 8-foot lift replaced the old 4-foot lock. Improvements were recorded in 1885.

Sources of Information

Unpublished

Gayer, Albert E. A comprehensive collection of visual material on the Erie Canal Eastern Division structures. Schenectady, New York. [Mr. Gayer is founder and director of the Canal Society of New York State.]

Hutchinson, Holmes. "Map of the Erie Canal," Volume 9 (6 September 1834). Manuscript and History Section, New York State Library, Albany, New York.

New York State Department of Transportation Archives. Book 11 [original title: Aqueducts, volume 1], 1893. State Campus, Albany, New York.

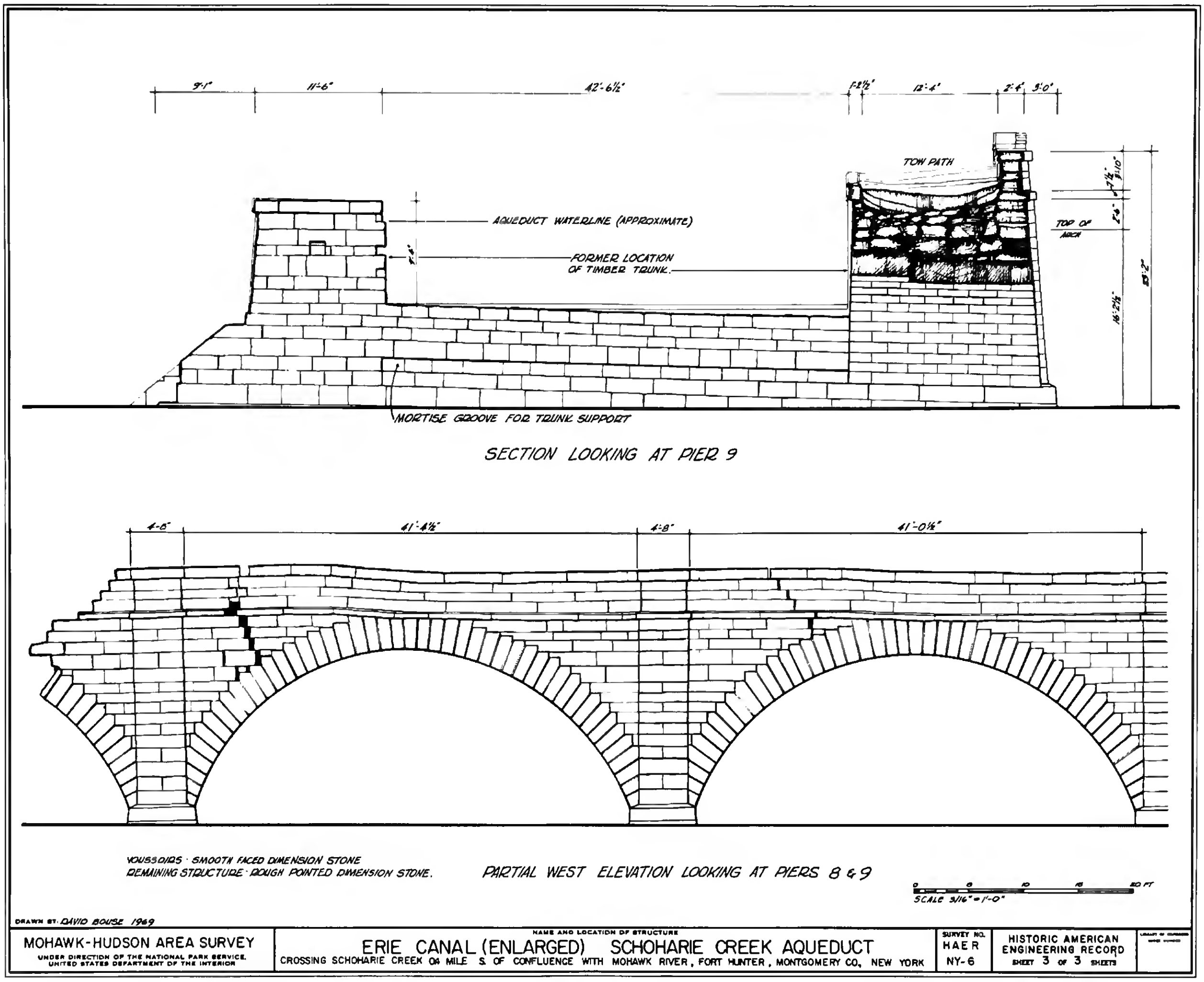


FIGURE 121

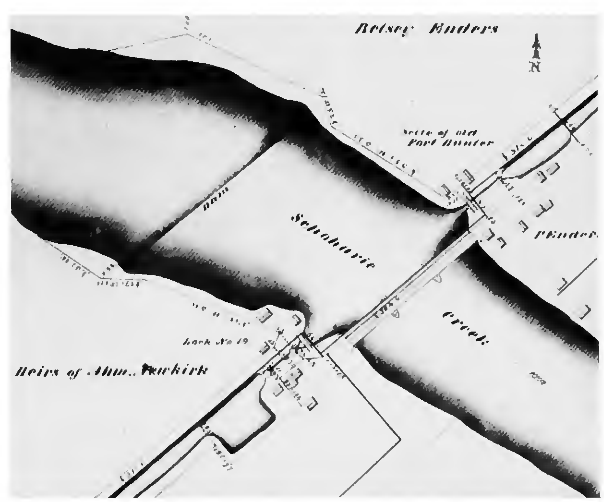


FIGURE 122.—Hutchinson's map of the canal crossing of Schoharie Creek, 1834. The dam pooled the Creek above, providing sufficient depth for the canal boats to cross directly in the water of the Creek. The towpath was bracketed out from the downstream side of the timber highway bridge adjacent to the crossing (see Figure 124). (*Hutchinson, 1834, volume 9, plate 39.*)

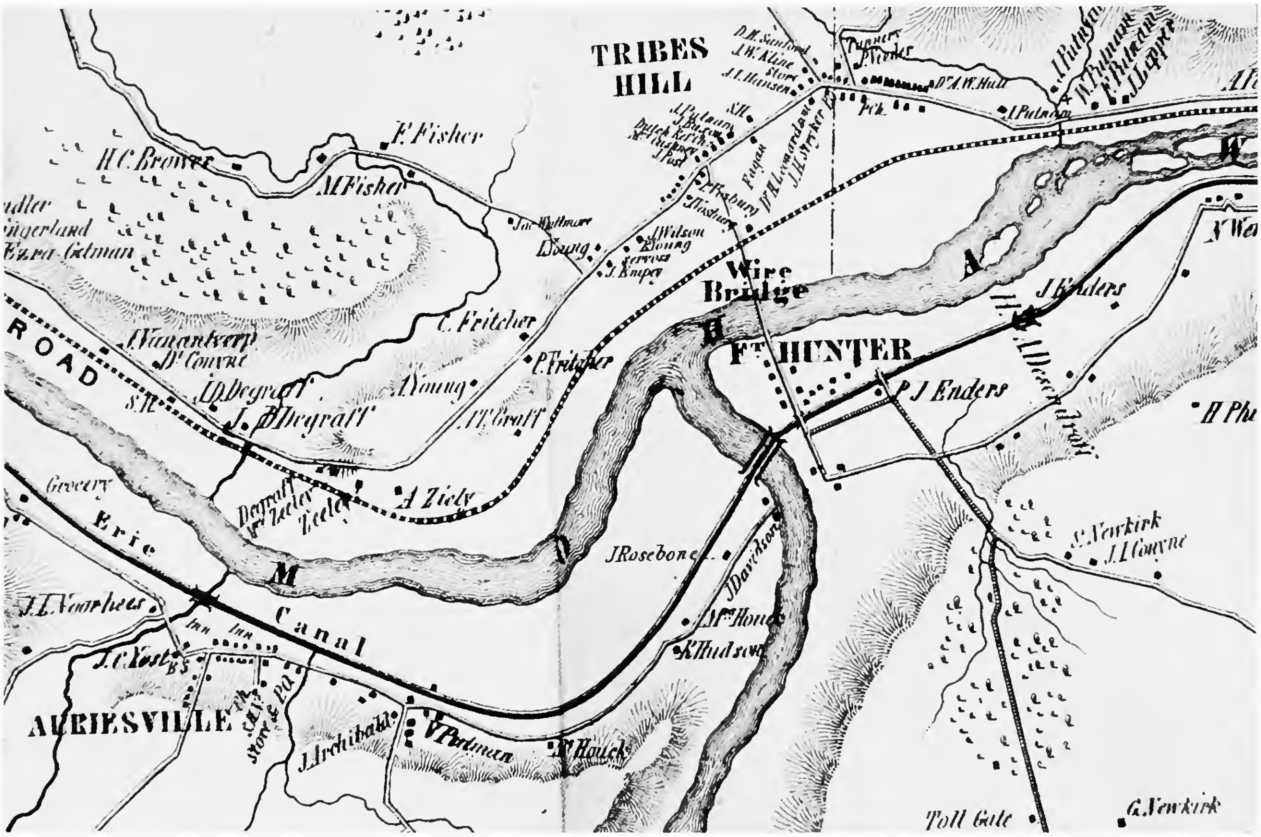


FIGURE 123.—Fort Hunter area, 1853, showing re-routed enlarged Erie Canal, now crossing Schoharie Creek by means of the aqueduct. The timber-tower wire suspension bridge over the Mohawk at Tribes Hill, built 1854, was itself a structure of considerable scale and eminence. (*Geil and Hunter, 1853, detail.*)

Published

Canal Society of New York State. *Bottoming Out: Useful and Interesting Notes Collected for Members of the Canal Society of New York State.* Volumes 18–19. Syracuse, 1962.

Geil, Samuel, and R. J. Hunter. *Map of Montgomery County, New York.* Philadelphia: Peter A. Griner and Robert P. Smith, 1853.• [Original at New York State Library, Albany, New York.]

New York State Engineer and Surveyor. *Annual Report on the Canals of New York State for 1863.* Albany, 1864.

Shaw, Ronald E. *Erie Water West: A History of the Erie Canal 1792–1854.* Lexington: University of Kentucky Press, 1966.

Sheehan, Edward J. *A Prospectus for a New York State Canal Town Museum at Fort Hunter, New York.* Fonda, New York, 1955. [Mimeographed pamphlet in MS collection, New York State Library, Albany, New York.]

Veeder, David. *The Original Erie Canal at Fort Hunter.* Fort Hunter: Fort Hunter Canal Society, 1968.

Whitford, Noble E. *History of the Canal System of the State of New York.* Volumes 1, 2. Albany: Brandow Printing Company, 1906. [Supplement to the annual report of the New York State Engineer and Surveyor.]

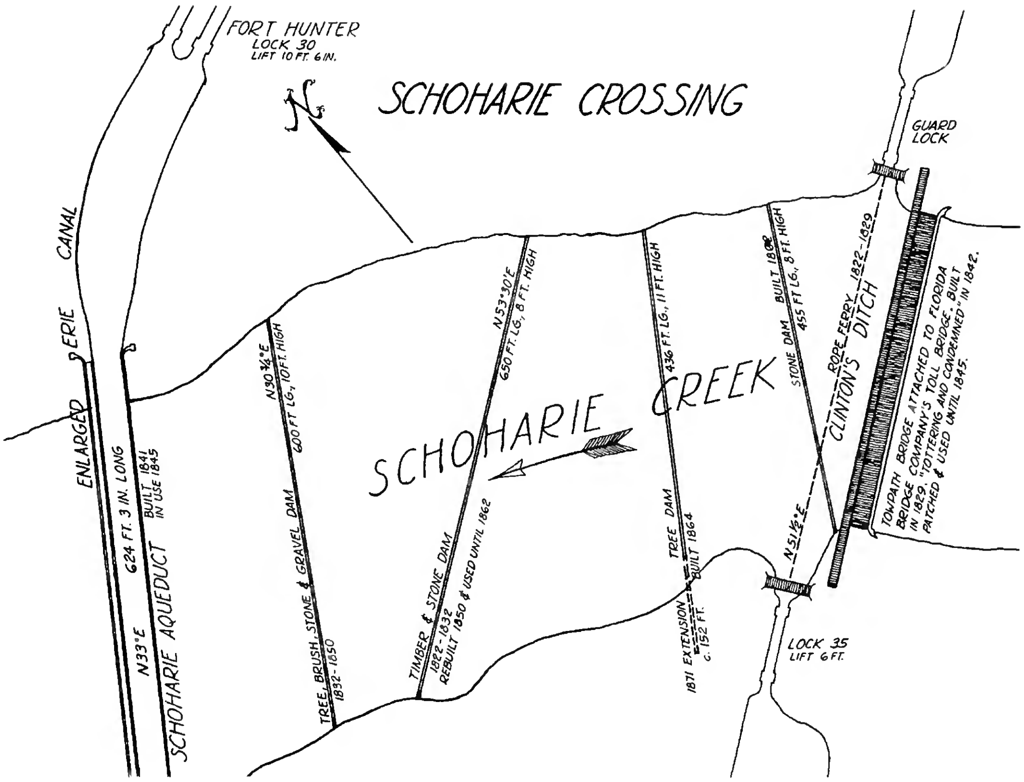


FIGURE 124.—Composite map of the crossing site by Daniel J. Mordell, showing all canal-related structures. (*Canal Society of New York State, 1962, volumes 18–19.*)

ENGINEERING INFORMATION

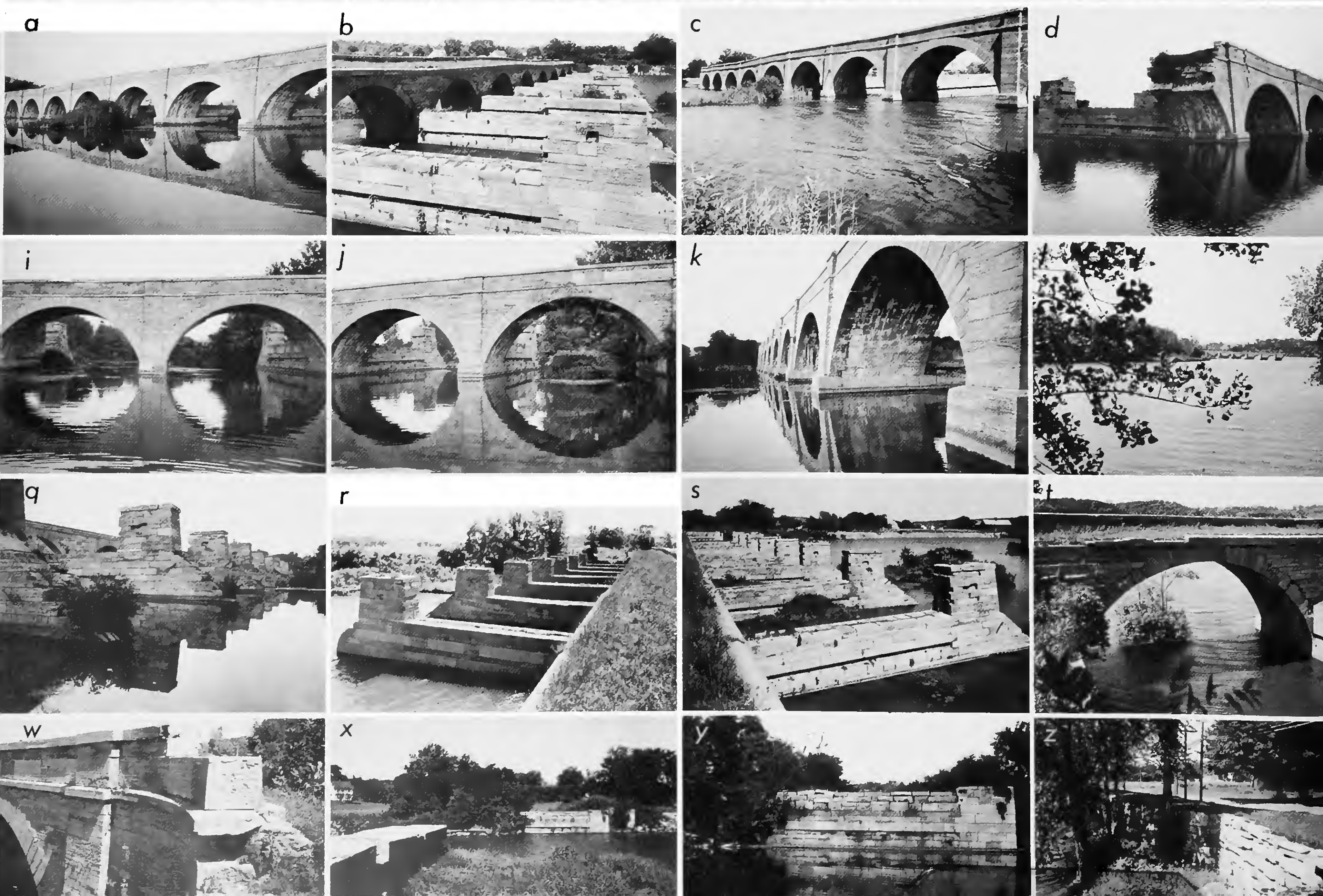
General Statement

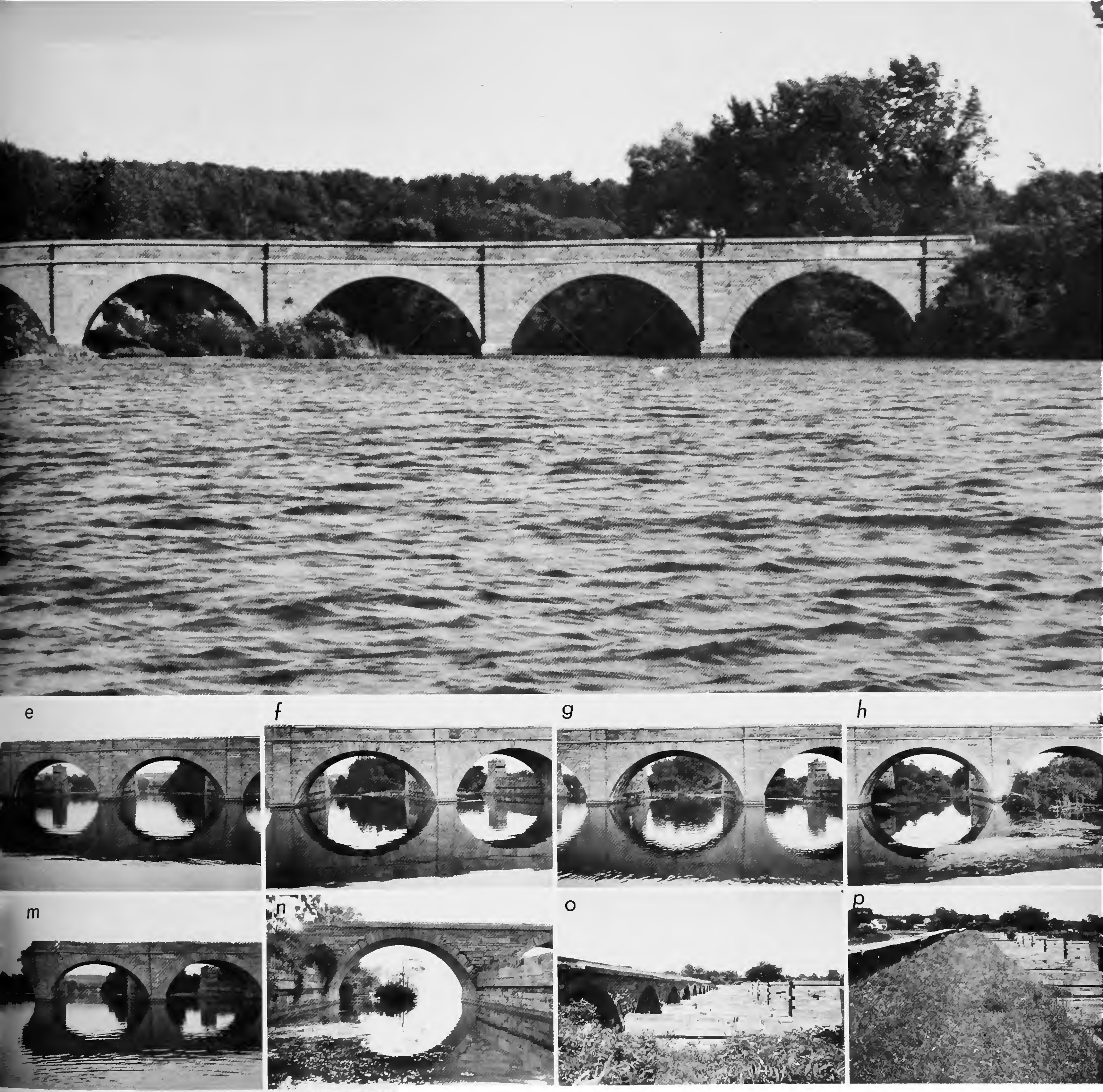
Structural Character: Extensive physical remains of an 1841 Roman-arch aqueduct built as part of the enlargement of the Erie Canal.

Condition of Fabric: Good to poor. Nine of the original arches remain (on the southwest end); the others were demolished c1915 to reduce impedance to creek flow. There has been considerable subsidence and cracking in the two end arches due to lack of counter thrust from the demolished adjacent arches. All piers have settled heavily toward the towpath side from the eccentric loading resulting from absence of the weight of water on the trunk side.

Detailed Description

Overall Dimensions: 415 feet (original length: 631 feet or 624 feet 3 inches (Whitford, 1906, II:


a
b
c
d
i
j
k
q
r
s
t
w
x
y
z



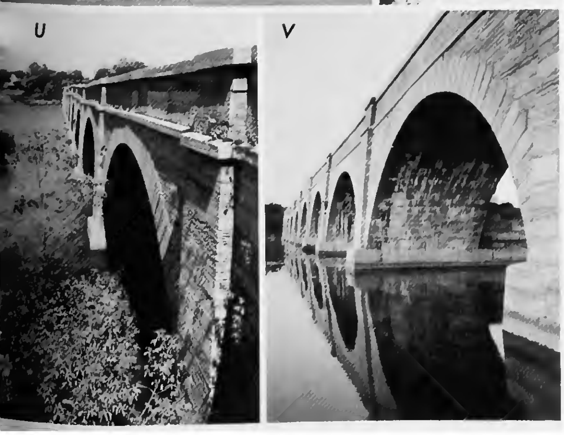


FIGURE 125.—Schoharie Creek Aqueduct: *a*, Towpath side, looking east; *b*, view along trunk piers, looking north; *c*, looking east; *d*, southward view of broken end; *e*, arches 9, 8, and 7; *f*, arches 7 and 6; *g*, arches 7 (partial), 6, and 5; *h*, arches 4 and 3; *i*, arches 3 and 2; *j*, arches 2 and 1 from southwest end; *k*, looking northeast; *l*, looking west; *m*, end pier and arch (opening of the joints is due to the absence of counter thrust from the missing arches); *n*, looking northwest through arch 1; *o*, looking northeast along trunk piers; *p*, looking northeast along towpath; *q*, looking north; *r*, looking southeast; *s*, looking east; *t*, looking north through arch 1; *u-v*, looking northeast; *w*, parapet and wingwall, west corner, looking east; *x*, looking northeast along towpath; *y*, abutment, northeast bank, looking northeast; *z*, riverwall, northeast side of river, looking north.

NEW-YORK STATE CANALS.

1854.

AQUEDUCT SPECIFICATIONS.

GENERAL DESCRIPTION.

The aqueducts to be composed of abutments with wing walls, and piers of substantial stone masonry, on which a trunk of timber and plank for the prism of the canal, and a towing path bridge is to be placed. The trunk of the aqueduct, when not otherwise directed, to be 50 feet wide and 7 feet deep, and the towing path to be 12 feet wide in the clear. The whole, except where rock occurs, to rest on a foundation of timber and plank; and when required by the Resident Engineer in charge of the work, bearing piles shall be driven to support and protect the foundation.

1st. SPECIFICATION. The foundation pit shall be excavated in such form and dimensions, and the earth from the same shall be deposited as may be required by said Engineer; and the bottom made smooth and even, to give a firm and uniform support to the foundation. If the material shall be removed 200 feet from the place excavated, and be deposited in a necessary bank, it shall be estimated both as excavation and embankment.

2d. SPECIFICATION. If the ground on which it is to be placed be such as to require bearing piles, the same shall be driven and secured to the foundation timbers, as the said Engineer shall direct. The foundation shall be composed of hemlock timber, from 10 to 12 inches thick, and not less than 12 inches in width, covered with hemlock plank, from 2 to 3 inches thick, as shall be required; the plank shall be well treenailed to the timbers with treenails 7 inches long for 2-inch plank, and 8 inches long for 3-inch plank; at each end of each plank, and at every three feet intermediate, there shall be two treenails for plank of ordinary width, and a corresponding increase in number for those of greater width. If rock be found in the foundation, then the timber and plank shall be wholly, or in part dispensed with, or varied in dimensions, as may be directed by said Engineer. In cases where it may be required by said Engineer, the foundation shall extend between and cover the spaces between the abutments and the piers. A course of sheet piling, from four to six feet long, shall be put down along the upper and lower sides of the foundation, and at such other parts as the said Engineer may direct. The manner of putting them down, shall be by excavating a ditch to the depth of the sheet piling, and placing the pile plank edge to edge, and spiking the head to the foundation timber, so as to render the work close and substantial. Except when otherwise directed, a lining course of inch boards shall be put over the plank, so as to break joints with them, and be secured by nails. Where the gravel or other earth is liable to be washed by floods, so as to fill or obstruct the channel for the passage of water under the aqueduct, a breast or dam of suitable masonry shall be carried up at the head or upper side of foundation, in such manner as may be directed by said Engineer; the fall over said dam or breast shall be protected by a second course of planking, either level or inclined, as may be directed: and if said Engineer shall direct, other erections of a similar character shall be made at points further up the stream, in all cases to be well guarded against injury from floods. The spaces between foundation timbers, and each side of sheet piling, and above breast wall shall be filled with fine clean gravel, well puddled in, or with concrete, as said Engineer shall direct.

3d. MASONRY. The front face of the abutments and side faces of the piers to be carried plumb in aqueducts of ordinary height and exposure; but those over large streams shall be battered, and have such recesses as the said Engineer may direct. The ends of the piers shall be battered from one-twelfth to one-ninth their rise; and in cases where it may be directed by said Engineer, the upper ends of the piers shall have a suitable slope from the foundation for ice breakers, which shall be coped with stone at least one foot in thickness, and have a length equal to the thickness of the pier, and if required shall be well secured with iron bolts in such manner as shall be directed. The wing walls shall have a batter on the face of one-twelfth the height. Suitable pilasters shall, if directed, be carried up on the face of the wing walls. A buttress shall be formed at the exterior end, projecting one foot in the front, and in the rear from one to four feet beyond the wing wall, as may be directed by said Engineer; there shall also be a buttress in the rear, near the centre of the wing, which shall be four feet thick, and project from four to six feet back from the wing. The rear of the abutment and wings between the centre buttress, shall have a batter of one to six. That part of the abutments covered by the trunk shall be five feet thick at the bottom of the canal, and that part which is carried to or near the top bank level, shall be four and a half feet thick on the top, and increase in thickness towards the foundation by the batter above mentioned, and also by an offset of one foot on the rear, at every six feet down from the level of the canal bottom.

The wings to be four feet thick on the top, and increase downwards by the batter, and at the bottom level of the canal by an offset of one foot on the rear, and a similar offset at every six feet down, corresponding with the offsets in the abutments. The piers shall be from four to six feet thick. The top finishing of all the masonry shall be a coping of cut stone, not less than nine inches deep. That part of the abutments and piers under the trunk, shall have a course of coping alternately crossing the wall, and meeting in the centre, from each side of the walls. The spaces between the floor timbers shall, when required, be filled with rubble masonry. The remainder of the abutments and wings shall be coped with stone, that shall extend across the wall, and project forward to three inches over the face, and be not less than three feet wide in the direction of the wall. A recess for the toe of the braces shall be cut when directed by the said Engineer.

The masonry to be formed of sound, well shaped and durable stone, and laid in courses not less than twelve inches thick. The face stone shall be dressed to one-fourth of an inch joint on the beds, for the whole breadth of bed, and on the ends twelve inches, twelve inches back from the face.

2

The stretchers shall have a breadth of bed equal to the thickness or depth of the course, and in no case less than 18 inches; and the breadth from the front to the rear of the headers shall be in no case less than ⅔ the thickness of the wall. One-fourth of the wall in front and rear of each course shall be occupied with headers, arranged on both sides to give the greatest stability to the work. In the larger aqueducts, one-third of the headers, or at least one-twelfth of the stone in each course, shall extend through the piers at each end. The ends of the piers shall be formed of one stone that shall fill the course, and be at least three feet long; and the next course of two stones, that shall make the width of the pier, and be at least four feet long; the ends to be composed of such alternate courses to the top. The same or larger sized stone shall be used in the courses of the abutments, at upper side of aqueduct. The upper courses of the coping to the breast and ice-breakers, shall be carefully beveled or rounded off as shall be directed. Where ice-breakers are to be constructed, this kind of work will not be required below the top of the same.

The backing and interior wall shall be composed of large and well shaped stone, and in no case to be less than 6 inches thick, and three feet area of bed, and laid to form a good bond. The lower beds shall be dressed level and even, and all high projecting points hammered off from the top beds, so as to give the succeeding stone a firm bearing. In all cases the beds shall be properly prepared by leveling up before the next stone is laid; but no leveler shall be placed under a stone by raising it from its bed.

All the stone shall be well bedded in mortar, made of the best quality of hydraulic lime, and clean, sharp sand, and in such proportions, not more than two parts of sand to one of lime, as the said Engineer shall direct; and the vertical joints grouted with similar materials, and subject to the same directions; each course, as far as laid, shall be grouted fully before another is commenced, and spalls shall be filled in all the spaces after the grout is in. The masonry to be carried up in regular courses, and the work during its progress, shall, at no time, have more than two unfinished courses. The stone shall be kept wet and free from all dirt: no dressing shall be done upon a stone after it is laid. No cement shall be used until after it has been approved by the Engineer. Where rock-dressed masonry is required, a draft about one inch wide around the edge of each face stone shall be cut, and the rock projection shall not exceed three inches. When rock-dressed masonry is not required, the front of the wall shall be dressed to a smooth and even surface.

4th. TRUNK. The trunk shall be composed of white oak, or white pine string timbers, of such dimensions, and placed at such distances apart as may be directed by the aforesaid Engineer.

The two outside stringers shall be placed so as to embrace the side post tenons, and give them a firm support. The side posts shall be white pine or white oak timber, 8 by 11½ inches at the top, and 8 by 18 at the bottom shoulder, and placed 3 feet from centre to centre. The corner or end posts shall be white oak, and extend down three feet into the masonry, to give firmness to the corner of trunk. A white pine plate, 10 by 16 inches, shall be framed on the top of posts.

The bottom of the trunk, and the ends of the floor timbers in the abutments, to be covered with a course of two-inch white pine plank, of a good quality, to make water-tight joints, free from shakes and unsound knots; the plank to be well treenailed to the foundation timbers, with treenails 6 inches long, of suitable size to fill an aperture one inch in diameter. The sides shall be planked with three-inch white pine plank, of suitable quality, and grooved and tongued as may be directed, and secured to side posts with treenails 7 inches long, of suitable size to fill an aperture one inch in diameter. The sides and bottom of the trunk, if required, are to be braced from recesses to be cut in the masonry, in such manner as shall be directed.

When required to increase the water way of the stream in which the aqueduct is located, the sides of the trunk to such extent as may be directed, shall be constructed with posts and girths, and be planked vertically. Each side, for a length equal to the spaces between the piers, or the abutments and the piers, shall have two posts, one of which shall rest on a pivot and socket, and its upper end shall be secured by a collar and clamp: it shall have at least three girths and a roller or sheeve; shall be so secured to the under side of the lower girth as to roll on a circular rail plate of bar iron, which is to be let down level with, and secured to the floor: and the whole is to be so constructed as to furnish a practicable and easy movement to the side, when it shall be necessary to open the space by moving the side of the trunk around in line with the piers. Suitable recesses shall be formed in the corners of the piers nearest the trunk, to receive hollow quoins of wood and toe posts, the former of which are to be secured in their places by tenons, and screw bolts, firmly anchored in the walls.

When required to secure the floor of the trunk in case of opening the sides, recesses 8 inches deep and 10 inches wide shall be formed on the upper side of the floor timbers, over the centre of the piers and abutments, to receive a timber 8 by 10 inches square, which shall be secured in its place by bolts passing through and terminating at the top of the same, once in every 10 feet. The bolts shall be one inch square, and extend at least 3 feet into the masonry, and be firmly secured with an anchor, or by being driven with fox wedges, and be leveled as shall be directed. The top of each bolt shall have a screw, and the timber shall be held in its place by a nut and washer, so let in as to be even with the top.

TOWING PATH BRIDGE. To be 12 feet wide, and supported by white pine stringers, of such number, width and depth as said Engineer shall require, according to the span. A floor of white oak or red beech timber, 3 inches thick, to be laid on the stringers, and well treenailed to the same. A timber of hard wood, to be 6 by 8 inches, placed upon the inside end of the floor to guide the towline, and securely fastened to the front stringer. A suitable railing to be placed on the rear of the bridge, of such form and dimensions, and built of such material as the said Engineer shall direct. The railing to be planed and well painted.

The tie rods, screw-bolts and suspension-rods, with their appropriate straps, anchors, washers and nuts, shall be of first quality American wrought iron.

5th. For a more full and perfect explanation of the form, and dimensions of materials and parts, and of the manner of constructing the aqueducts in all their details, plans, with bills of timber and iron, will be furnished by the said Engineer; who will also give such directions, from time to time, during the progress of the work, as may appear to him necessary and proper, in order to make the work, in every respect, complete and perfect, on the plan contemplated in the above specifications. And the said plans, bills of timber and iron, and directions, shall, in every respect, be complied with.

FIGURE 126.—Aqueduct Specifications, 1854. (*Courtesy of Division of Mechanical and Civil Engineering, National Museum of History and Technology, Smithsonian Institution.*)

960); or 627 feet (New York State Engineer and Surveyor, 1864) by 82 feet.

Number of Arches: 9 (originally 14).

Sub- and Superstructure: Random ashlar masonry of light gray limestone. No trunk material remains.

Structural System: Stone arches supporting towpath. Span: ±39 feet; 45 feet on center; stone piers supporting the wooden trunk of the canal.

Site

Orientation: Northeast to southwest.

Setting: Pleasant rural site which is presently (1969) being developed as a state historic site to include proximate Erie Canal structures. [Now (1973) fully developed.—ed.]

Upper Mohawk River Aqueduct (Rexford Aqueduct) 1842

Erie Canal (Enlarged), Rexford

(HAER NY-12)

R. Carole Huberman

Location: Originally spanning Mohawk River adjacent to New York Highway 146 (Ball Town Road) between Rexford, Saratoga County and Niskayuna, Schenectady County, New York.
Latitude: 42° 47′ 44.5″ N. Longitude: 73° 53′ 00″ W.
Date of Erection: 1842.
Present Owner: State of New York.
Present Use: Historic site.
Significance: Remains of one of the two aqueducts built to carry the enlarged Erie Canal over the Mohawk River.

HISTORICAL INFORMATION

Physical History

Original and Subsequent Owners: New York State continuously.

Original Purpose and Construction: One of the major aqueducts of the enlarged Erie Canal, the Upper Mohawk River Aqueduct, replaced the original aqueduct at Rexford, near Alexander's Mills. It was one of two crossings of the river; the other, the Lower Mohawk River Aqueduct, was at Fonda's Ferry (Crescent). This double crossing, approved in 1821, was devised by Canvass White, C.E., to avoid a section of steep, rocky terrain on the river's south bank. Both replacement aqueducts were completed in 1842.

Alterations: Continuing in operation until the new State Barge Canal system opened in 1916, a major portion of the aqueduct was removed in 1918; nothing remains of the Crescent Aqueduct. All the stones removed from the Rexford Aqueduct are available for use if it ever is to be restored.

Engineering Information: Prepared by Richard J. Pollak.

Sources of Information

Unpublished

Hutchinson, Holmes. "Map of the Erie Canal," volume 10 (6 September 1834). Manuscript and History Section, New York State Library, Albany, New York.

Published

New York State Historic Trust. *Historic Sites of New York State* [pamphlet]. Albany, n.d. [c1968].

Papp, John. *Erie Canal Days: A Pictorial Essay.* Schenectady, 1967.

Shaw, Ronald E. *Erie Water West: A History of the Erie Canal 1792–1854.* Lexington: University of Kentucky Press, 1966.

Whitford, Noble E. *History of the Canal System of the State of New York.* Volumes 1, 2. Albany: Brandow Printing Company, 1906. [Supplement to the annual report of the New York State Engineer and Surveyor.]

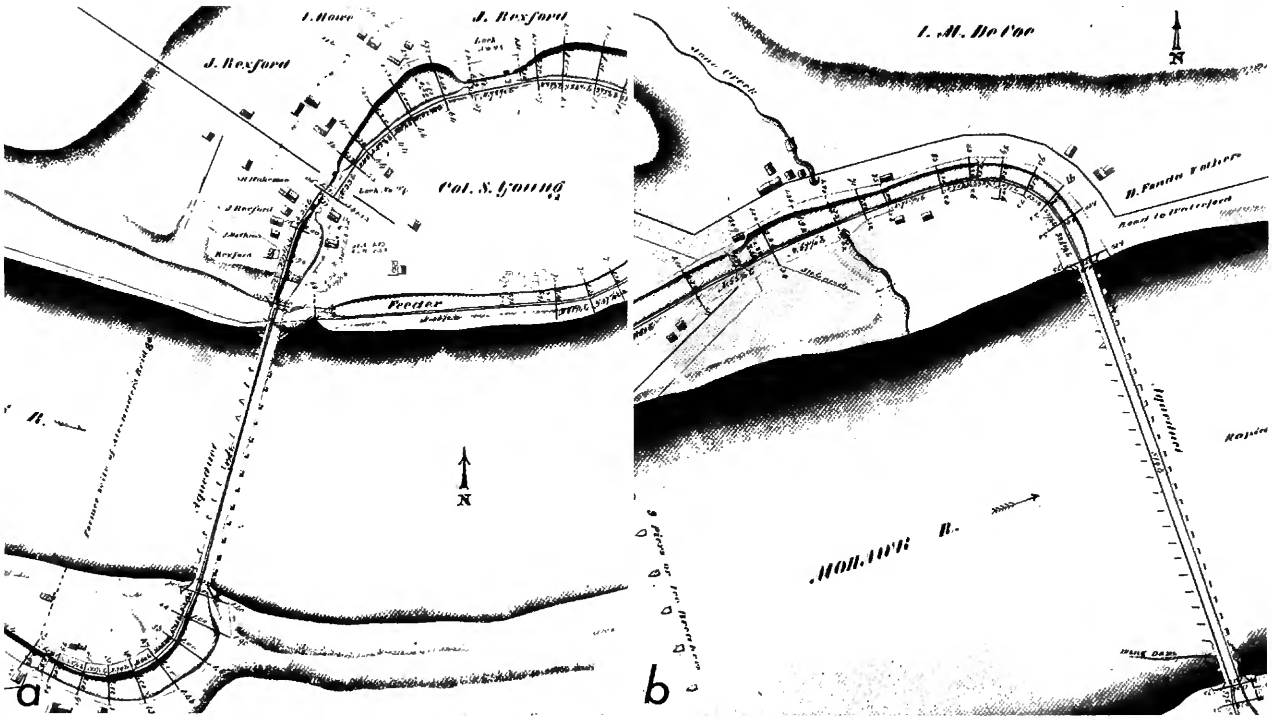


FIGURE 127.—Hutchinson's maps: *a,* Rexford Aqueduct area; *b,* companion Lower Mohawk River Aqueduct at Crescent, of which no traces remain. (*Hutchinson, 1834, volume 10: a: plate 21; b: plate 37.*)

ENGINEERING INFORMATION

General Statement

Structural Character: The remaining abutments, piers, and arches of an Erie Canal aqueduct; the end-sections not removed during the building of the present State Barge Canal which involved the canalization of the Mohawk in this area.

Condition of Fabric: Good.

Detailed Description

Overall Dimensions: Approximately 160 feet by 86 feet on south side (structure not measured).

Number of Bays: Two arches and three piers remain on each side (originally 13 arches and 14 piers).

Sub- and Superstructure: Random ashlar masonry, probably limestone.

Structural System: Masonry arches spanning approximately 45 feet to support towpath; masonry piers approximately 45 feet wide to support original timber canal trunk.

Site

Orientation: North (east) to south (west); approximately 10°NNE.

Setting: The aqueduct remains exist on either side of the river in a semi-rural area.

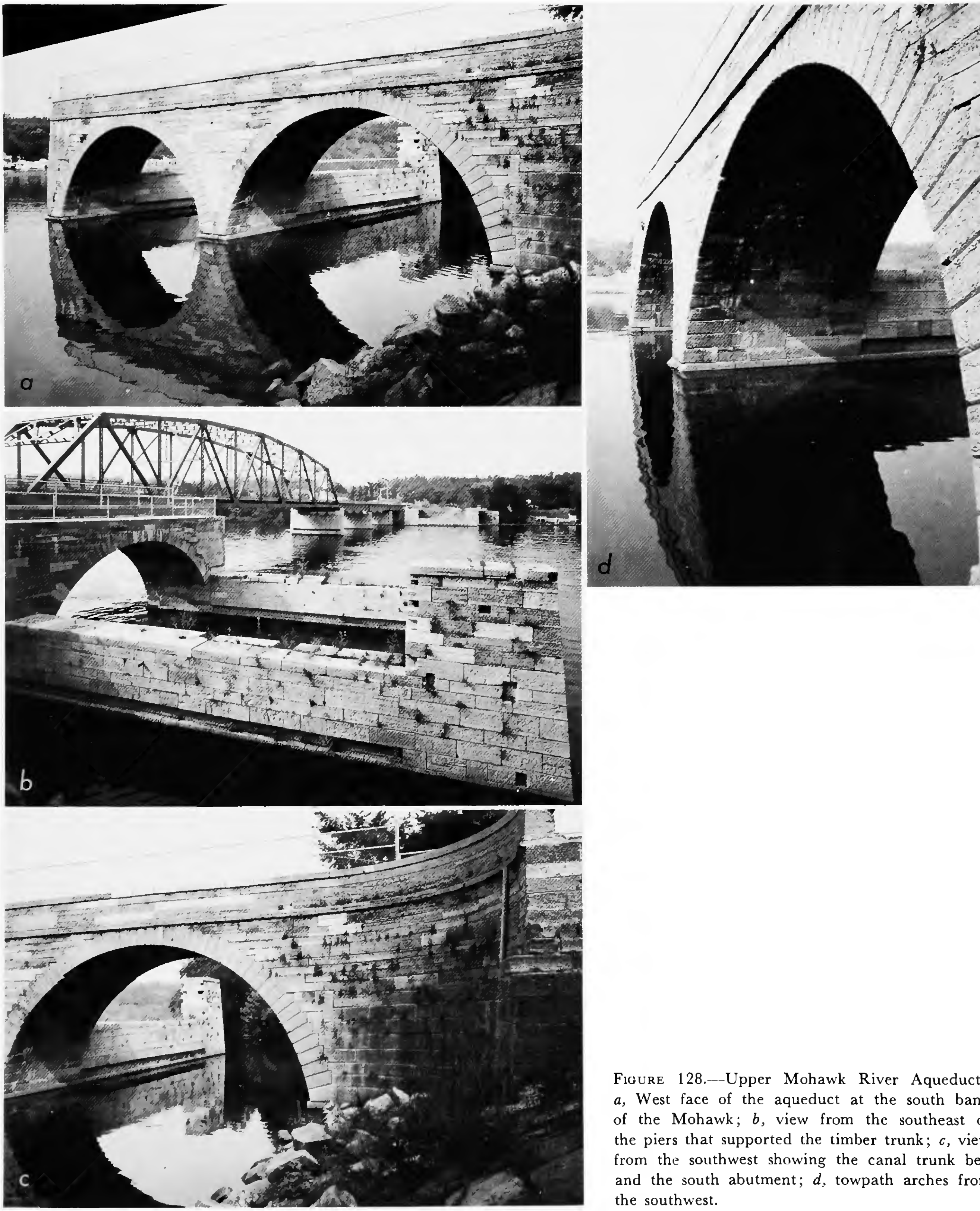


FIGURE 128.—Upper Mohawk River Aqueduct: *a*, West face of the aqueduct at the south bank of the Mohawk; *b*, view from the southeast of the piers that supported the timber trunk; *c*, view from the southwest showing the canal trunk bed and the south abutment; *d*, towpath arches from the southwest.

Lock 18 (Double Lock) 1837-1842

Erie Canal (Enlarged), Cohoes

(HAER NY-11)

Diana S. Waite

Location: West of 252 North Mohawk Street, East of Reservoir Street, between Manor Avenue and Church Street, Cohoes, Albany County, New York.
Latitude: 42° 46′ 50″ N. Longitude 73° 42′ 43″ W.
Date of Erection: 1837–1842.
Present Owner: Estate of Henry Bourgeois and the City of Cohoes.
Present Use: Dry and abandoned.
Significance: Lock 18 of the enlarged Erie Canal was part of a scheme to reduce the number of locks between Albany and Schenectady, thus making transportation easier and speedier on what was one of the most difficult stretches of the canal. Promoters of the enlarged Erie Canal, which was designed by some of the outstanding engineers of the day, believed that by doubling the locks on the canal, and by increasing the size of the locks and the canal bed itself, the economy of New York State would be improved and the chances of competition from railways lessened. Although the lock now contains no water, it remains a fine specimen of canal-era masonry work.

HISTORICAL INFORMATION

Physical History

Dates of Construction: Enlargement of this section of the canal was under contract in 1836 (NY, *Annual . . Commissioners,* No. 73). The contractors' first payment for the work is dated 27 June 1837 indicating that work was under way by that time (NY, *Annual . . . Canals,* No. 6). Masonry work on the lock was completed in 1841 (NY, *Report . . . Canals,* No. 173). Water was first admitted to the lock on 20 April 1842; regular traffic used the lock the following day (NY, *Annual . . . Commissioners,* No. 25).

Engineers: Holmes Hutchinson (1794–1865), a civil engineer, completed rough surveys and estimates for the enlarged canal by June 1834. His plans for the locks on the enlarged canal were adopted. He served as an engineer on the Erie Canal from 1819 to 1835, and as Chief Engineer from 1835 to 1841. He was involved in the engineering of many other canals in New York, Connecticut, Rhode Island, Massachusetts, and Vermont, and also was a director of two New York railroad companies.

John Bloomfield Jervis (1795–1885) was appointed Chief Engineer of the Eastern Division of the Erie Canal from Albany to the Rome summit, in 1835, and prepared in that year a report and estimate of the proposed enlargement work. He also served as engineer for various other New York canals, water works, and for several railroad companies.

William Jarvis McAlpine (1812–1890) was a student of Jervis, whom he succeeded as Chief Engineer of the Eastern Division. He was the resident engineer of this section from 1838 to 1846. McAlpine was the engineer most directly involved with the actual con-

Engineering Information: Prepared by Richard J. Pollak.

struction of the locks. A contemporary source reported that

> the works on all this section [from the Lower Aqueduct to Albany] have been planned by and carried forward under the immediate direction of Mr. McAlpine, the resident engineer, of whose capacity and great efficiency we can speak in terms scarcely too strong and emphatic. (*Albany Argus,* 22 April 1842).

McAlpine also designed water works in Albany and Chicago, served as a railroad commissioner and as State Engineer and Surveyor of New York, and was an engineer for several railroads and bridges.

One James T. Smith was paid $42.52 on 26 June 1837 for "hollow quoin patterns" for use on the Eastern Division (NY, *Annual . . Canals,* No. 6). Smith is not listed in the Albany, Cohoes, or Troy directories of this period.

Original and Subsequent Owners: Lock 18 was constructed on land owned by Isaac D. F. Lansing (NY, Assembly Doc., 1835, No. 143). On 15 June 1838 Abraham Lansing appeared before appraisers concerning his claim for damages caused by the construction of the canal on his property, which is indicated on an attached map as including the site of Lock 18 (Albany County Book 66, page 180). This property was acquired by the State and transferred to the City of Cohoes, after the canal was no longer used, about 1916. The city still owns the western portion of the lock. The city in transactions in 1943 and 1945 granted the eastern portion of the lock to Albina M. Bourgeois (Albany County Book 1332, page 381; Book 1374, page 425). Mrs. Bourgeois deeded the property to her son Henry in 1953 (Albany County Book 1375, page 7). The property is now held by the Estate of Henry Bourgeois.

Contractors: Merriam, Carr & Co., and Barker & Smith. The material for the new locks from Cohoes to Albany was "generally of the Amsterdam stone" (*Albany Argus,* 22 April 1842).

Original Plan and Construction: The necessity of enlarging the Erie Canal was apparent as early as March 1825, seven months before completion of the original canal. The Canal Commissioners noted the need for double locks and the possibility of constructing a second canal parallel to the first. But it was not until sometime in 1833 that official preparations in the form of preliminary surveys were undertaken to enlarge the canal. On 29 January 1834, the Canal Commissioners submitted a special report to the legislature concerning the enlargement of the canal in which the Commissioners recommended that the locks be doubled (i.e., that a second lock be constructed beside the original lock). Holmes Hutchinson drew up the surveys, maps, plans, and profiles submitted with the report and recommended the following for Locks 33, 34, 35, and 36, which at that time were the northernmost locks located in Cohoes and the last before the Lower Mohawk Aqueduct:

> These four locks are situated above the Cohoes Falls, adjoining the land of Issac D. F. Lansing; the road and river so near, on the east side, that the new locks must be placed on the west side of the canal; the additional width to the canal will take the yard in front of Mr. Lansing's brick dwelling-house, and this new line, so near the building will materially injure Mr. Lansing's property.
>
> The excavation will be principally rock, with clay on the surface; the pound reaches between the locks are small, and I would recommend that the upper lock be placed twelve rods to the north, to give greater distance between the locks.
>
> The canal should be excavated wider opposite the Cohoes Falls, to give the necessary width to pass boats, the excavation would be slate rock, and the work must be done when there is no navigation (NY, *Annual . Commissioners,* No. 88, pp. 20–21).

In response to this report, the legislature on 6 May 1834 passed "An Act to Provide for the Improvement of the Canals of This State" (NY, *Laws 1834*), in which the Canal Commissioners were "authorized and required to construct a second set of lift locks, of such dimensions as they shall deem proper, on the Erie Canal from Albany to Syracuse. . ."

Hutchinson prepared further surveys, estimates, and maps for the double locks, which were completed in June 1834. On 13 June 1834 the Canal Commissioners "met at Albany, and proceeded through the line, examined the locations recommended by the engineer at the several locks, and the appropriations necessary to be made for them" (NY, No. 143, p. 2). Hutchinson had evidently changed the proposed location of Locks 33, 34, 35, and 36, for he now reported that

> the new locks should be placed on the south side. The excavation will be clay and gravel, and all the foundations slate rock. The land is owned by Isaac D. F. Lansing, and the new location takes his brick dwelling-house, two wood-houses, two wells, his garden, fruit trees and shrubbery, and the western part passes through an old orchard and pasture. (No. 143, p. 45).

Hutchinson's plans for double locks were used in their construction. Included in his report of 31 January 1835, were the following specifications for the new locks:

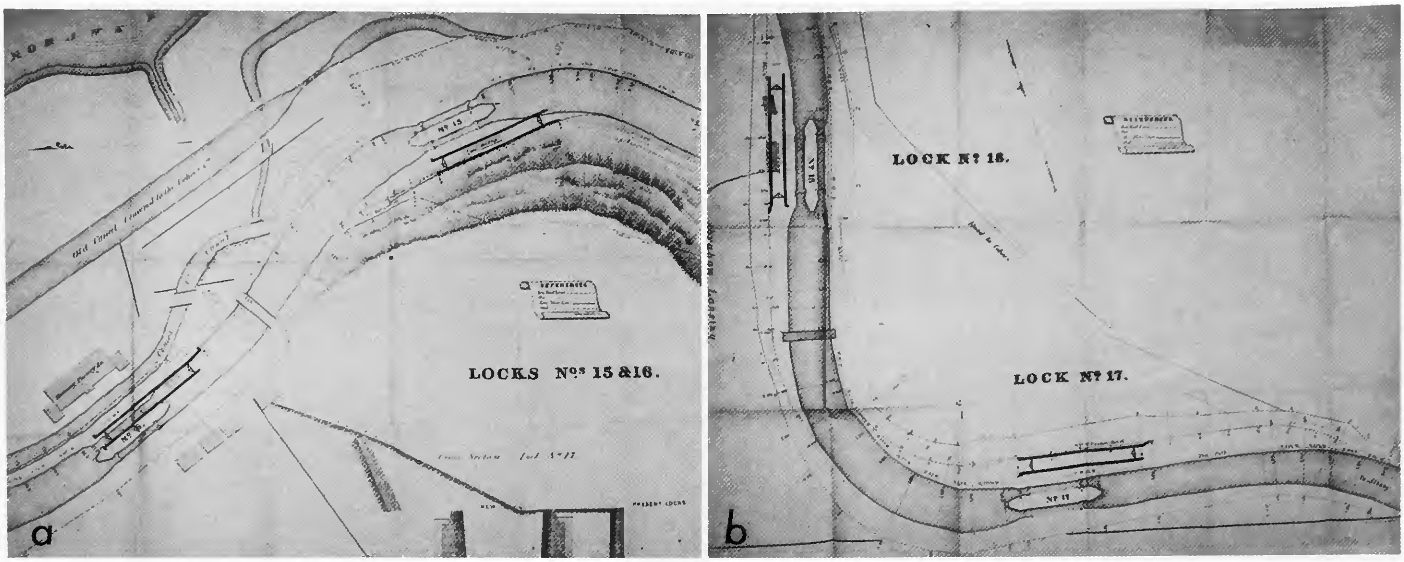


FIGURE 129.—Plans of Locks: *a,* Nos. 15 and 16; *b,* Nos. 17 and 18. Plans show proposed enlarged locks (never built). The Harmony Company's No. 1 Mill is shown in *a,* below a section of the original Erie Canal that became part of the Cohoes power canal system following realignment of the Canal during enlargement. (*New York,* State . . 1853.)

The following description will show that the new locks are to be made much more perfect than the old; the stone are to be of better quality, and the defects in the first constructed masonary, that are now visible after ten years use, will be to a great extent avoided.

FOR FOUNDATION

The foundation when not on rock or piles, after the pit is escated [sic.] and prepared, to be laid of square timber, 10 inches in thickness, placed so near each other as not to allow a space of more than 4 inches between the timbers.

When piles are used, there shall be four rows under each lock wall, the centres three feet apart, and a row in the centre of the lock with the requisite quantity at the lower mitre sill, and on these piles, the foundation timbers shall be well secured on each row across the lock, by 24 inch treenails.

All the foundation timbers to be 34 feet long, counterhewed on the upper surface, and firmly bedded, and to have a level surface for planking.

The surface to be covered with 2½ inch hemlock plank, well laid and secured, and in all cases a lining of two inch pine plank, to be laid on the inside of the lock walls. There are to be two rows of sheet piling, when not in rock, extending across the lock, of at least four feet long.

On slate rock, the foundation timbers shall be of hard wood, and shall extend four inches under each lock wall; under the mitre sill to be 10 inches in thickness, and at the other parts of the lock, 8 inches in thickness, laid in grout or cement. In all cases, the timbers under the mitre sills, to be of hard wood.

SUPERSTRUCTURE

1. The locks to be made 138 feet long, 100 feet between the gates, and 15 feet wide; and the walls for an 8 feet lift, to be 6½ feet thick, except the buttresses. There are to be buttresses in the rear of the middle of each lock wall, and an enlargement opposite each recess, and at the ends of the lock; and in general, there is to be a space of 26 feet between the chambers of the new and old locks.

2. The lock walls shall be constructed of compact quarry, grey limestone, perfectly sound and free from seams, flaws, or other defects, and shall be laid in courses.

3. The face stone shall be laid in courses of not less than 10 inches nor more than 24 inches thick; shall be of the same thickness through the whole course. And each stone in every course shall break joints of at least one foot with the stone on which it rests; and every quoin shall measure at least three feet in length of the wall, and shall alternately be a header and a stretcher.

4. The front stone shall be cut true and even on the face, sides and ends, and of a uniform thickness between opposite surfaces.—The lower course shall be two feet wide on the top, and bevelled inward so as to increase the lower bed one foot in width, except at the quoins and recesses. The next course shall be three feet wide, and shall break joints at least one foot on the stone back of the face stone. In the second course, there shall be a header of 2½ feet in length on the wall, and extending back into the wall at least five feet, at least one in every twelve feet in the length of the wall. The front of the wall shall be made of such alternate courses to the coping.

5. The backing shall be laid in courses corresponding with the front, with similar headers in the first and

FIGURE 130.—Lock 18: *a,* East face of lock structure; *b,* foot of wall at southeast corner of Lock; *c,* east lock chamber, looking south; *d,* east chamber, looking northeast; *e,* north (upper) face of lock, showing filling ports; *f,* north face.

alternate course, and placed intermediate the headers from the front. Each stone, including the headers, shall be hammered to regular forms and sides, and shall form good close joints with the contiguous stone, and break joints at least six inches with the stone on which they rest; all the stone shall have beds of at least two feet wide, but opposite the front headers, they shall be of a width to fill the space.

6. The coping shall be at least fifteen inches thick, four and a half feet wide on the upper surface, with a bevel on the back side, extending the lower bed to five feet; each stone to be at least as long as wide, and cut true and even on all their sides, and well secured by clamps and bolts.

7. The front stone, and eighteen inches of the rear of the wall, shall be laid in hydraudlic [sic.] cement; and the centre of the wall shall be faithfully grouted, as often as once in every course. Each stone to be laid in cement, shall be fitted to its bed and position, then raised by machinery, the cement placed, and the stone re-laid in the place previously prepared; and the front stone, and all stone weighing 200 pounds shall be brought, and moved on the lock walls by cranes.

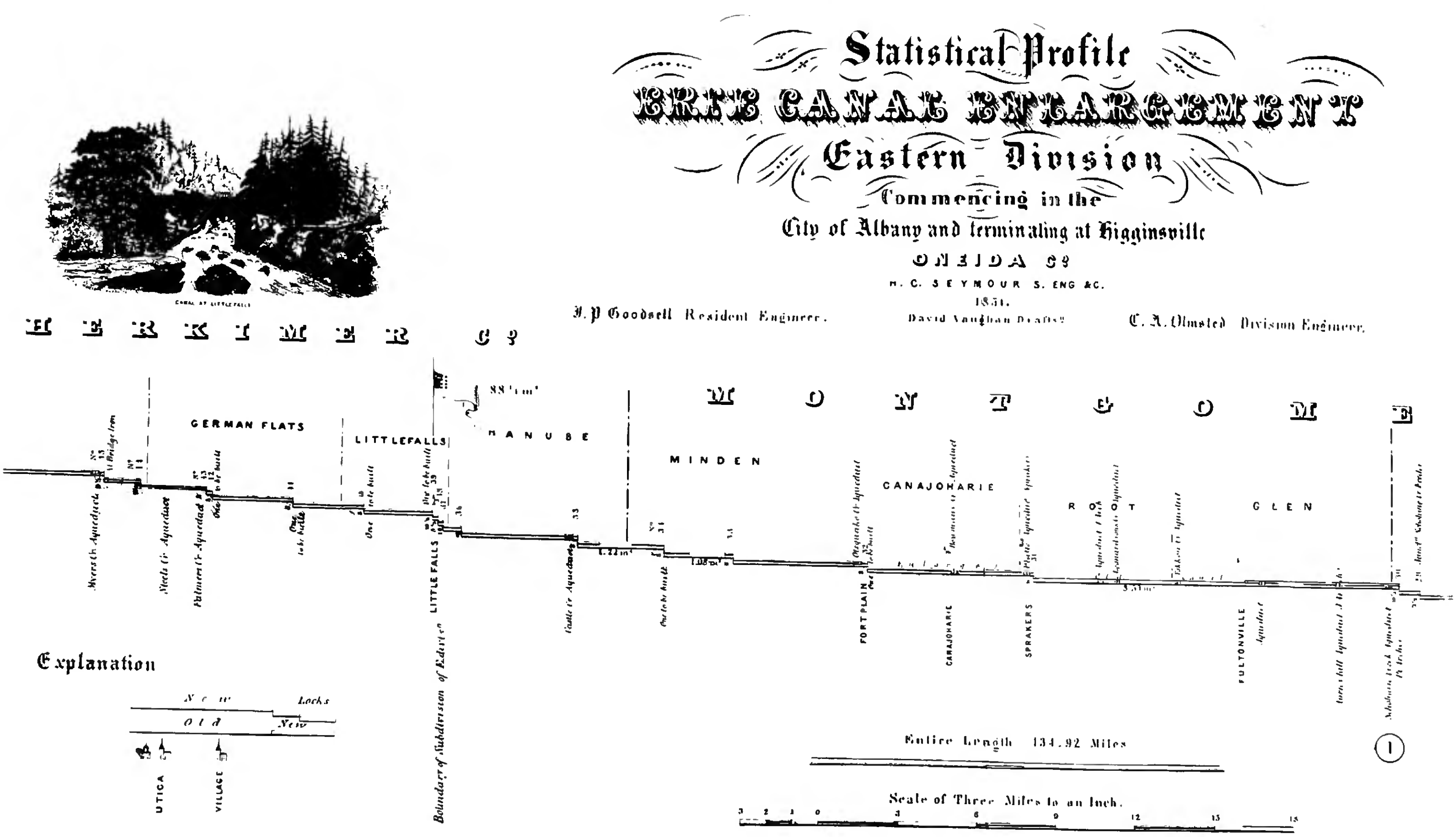
8. The cement to be obtained from Madison or Onondaga, of the best quality, and to be mixed with equal parts of pure, coarse, washed sand, for the grout and mortar.

9. The lock gates to be made of the best white oak timber, and good, merchantable, seasoned white pine plank, and all the iron work to be of approved size and quality.

Masonry, constructed according to the preceding specifications, it is believed, will be reasonably permanent. And although the expense will be greater than any locks heretofore constructed in this State, the increased costs will be fully repaid by their durability (NY, No. 143, pp. 38–39).

On 11 May 1835 the legislative passed "An Act in Relation to the Erie Canal" (NY, *Laws 1835*) in which the Canal Commissioners were "hereby authorized and directed to enlarge and improve the Erie Canal, and construct a double set of lift locks therein, as soon as the canal board may be of the opinion that

FIGURE 131.—Erie Canal: (1) Schoharie Creek Aqueduct; (2) Upper Mohawk River (Rexford) Aqueduct; (3) Lower Mohawk River (Crescent) Aqueduct; (4) Lock 18 ("Double Lock"); (5) junction of the Erie and Champlain canals. (*New York,* State . . . 1850.)



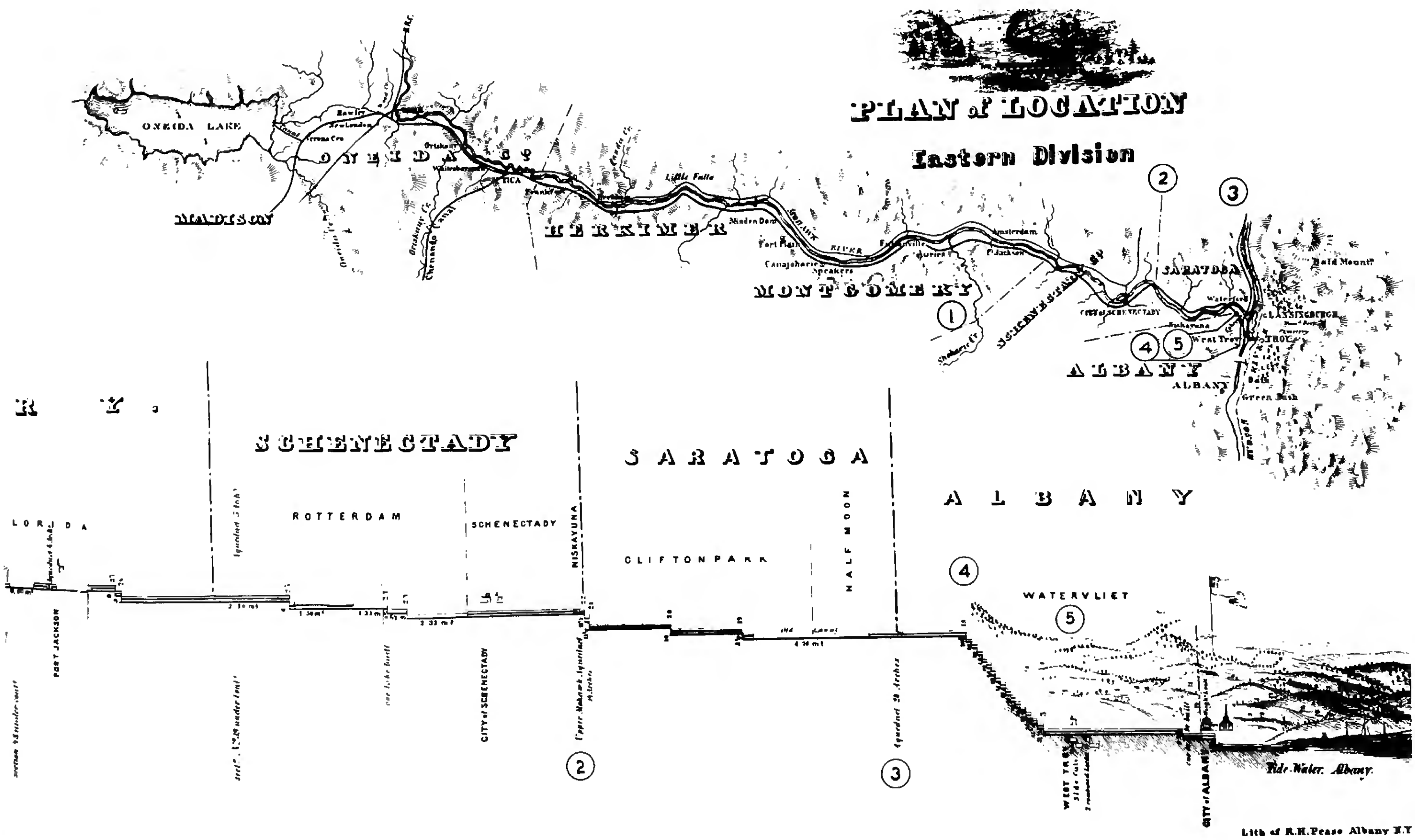
the public interest requires such improvement" (NY, *Laws 1835,* pp. 313–314). The cost of these locks, including their construction and maintenance, was to be paid from the Erie and Champlain canals fund, not from ordinary repair and maintenance funds of the Erie Canal.

On 30 June 1835 the Canal Board met and adopted the following resolution:

> *Resolved,* That the doubling of the locks, and the works connected therewith, ought to be commenced without delay, and prosecuted with all reasonable dilligence [sic.], beginning with that portion of the Canal between the village of Syracuse and the city of Albany (NY, *Report . . . Board,* No. 98, p. 2).

In addition, more surveys were to begin immediately. Acordingly, John B. Jervis prepared a report and estimate on the enlargement from Albany to Fultonville, which he submitted on 17 October 1835. Acting on the instructions of the Commissioners, Jervis included two estimates, one for a canal 6 feet deep and 60 feet wide at the top water line and another for a canal 7 feet deep and 70 feet wide. Jervis recommended that the canal be of the latter proportions and that the locks each be 16 feet wide and 110 feet long between quoins. In October the Canal Board approved the 7 x 70-foot dimensions for the enlargement and a few months later decided that the locks should be 110 feet long between quoins and 18 feet wide.

In the same report Jervis advocated abandoning the parts of the old route of the canal at a point below the junction of the Erie and Champlain canals above Watervliet to the head of the four locks above the Cohoes Falls (i.e., to old Lock 33) and constructing instead a new line. Concerning the four locks specifically, Jervis wrote:



The 4 locks are located so near each other as to allow shorter pound reaches than at other locks and such as to render the navigation extremely inconvenient and embarrassing. To widen the old line and lay the new locks along side of the old ones, I consider entirely out of the question, and a new line indispensable for these locks; which has accordingly been laid, and the estimate made on the same. (*NY, Documents* Board, No. 99A, pp. 4–5).

In the early spring of 1836, the line was once again surveyed, and in June, maps of the line between Albany and Schenectady were submitted to the Canal Board. Members of the Board examined the schemes for this area in the field and adopted one which called for a new line 4 miles and 28 chains long, beginning at a point 1½ miles above West Troy and joining the old line above the four locks. The Board explained its decision on the new line thus:

The locks are so located as to give convenient pound reaches between them, the lifts of the locks are so arranged as to reduce their number from nineteen to sixteen, without making the lift of either of them over ten feet. This plan will add to the convenience of the navigation, save on annual expense of lock-tending and repairs, and enable the work to be done without the chance of interruption to, or from the navigation (NY, *Annual . Commissioners,* No. 73, p. 16).

At some time during 1835 or 1836 the locks were renumbered. Previously they had been numbered beginning with the westernmost lock of the Eastern Division and ending with Lock 53 at Albany. Under the revised system, locks were numbered from east to west with Lock 1 located in Albany and the northermost lock in Cohoes being Lock 18.

Work generally on the new line was put under contract in 1836, evidently during the last half of the year, after the location of the new line had been determined.

The first payment for work on Lock 18 was not made, however, until 27 June 1837. Contractor Barker & Smith was paid $5,100 between 27 June and 18 November 1837 for work on Lock 18. Between 6 January and 31 August 1938 the firm was paid $4,697.63 for Lock 18. On 20 August 1838, Merriam, Carr & Co. received a payment of $3,000 for work on Locks 17 and 18.

On 18 April 1838 the legislature passed "An Act to Provide for the More Speedy Enlargement of the Erie Canal" (NY, *Laws 1838*), which authorized a four-million dollar loan to finance the enlargement work. The Canal Commissioners encountered difficulties in obtaining some of the funds authorized in this loan, however, and that situation impeded work by the contractors in 1839. The Commissioners reported that

a large amount of work has been done on the enlargement during the past season [1839], but not as much as was contemplated at the date of the last annual report. . . . Generally the contractors were not pressed to a vigorous prosecution of their work . .

[But] A heavy amount of work has been done on the first 14 miles from Albany . . . .

A lock of wood has been constructed at the Cohoes [Falls] for temporary use, while the enbankment [sic.] for the enlargement is making opposite, which is to cover the site of the present lock. The lock of wood is completed, and will be ready for use in the spring; but the present lock for which it is a substitute, should not be taken up, until after the new lock has been satisfactorily tested (NY, *Annual Commissioners,* No. 60, pp. 46–48).

In 1839 Barker & Smith received a final payment of $974.23 for "Lock 18, and additional allowance." Merriam, Carr & Co. received $31,200 for Locks 17 and 18.

Between April and December 1840 the Commissioners reported that "the construction of the work has been advanced more rapidly than in any previous season," due in part to the lowered cost of materials and labor as well as to favorable weather (NY, *Annual . . . Commissioners,* No. 72, p. 19). Work on Section 10, in which Lock 18 was located, was not as far advanced as on other parts of the new line. The contractors were busy on Section 10 with "a heavy side hill excavation and enbankment [sic.]," and work on Lock 18 was described as being "in a forward state" (six other locks on the line had been completed except for the gates) (*Ibid.*). The Commissioners hoped that

with the proper energy on the part of the contractors, all the work on this line can be completed next season [1841], in time to admit the water, and test its permanency, before the close of navigation so that it can be safely brought into use in the spring of 1842. (NY, *Annual . Commissioners,* No. 72, p. 22).

Merriam, Carr & Co. received another payment of $14,500 for work during 1840 on Locks 17 and 18.

The accounts for expenditures during 1841 when much of the work on Lock 18, as well as on Lock 17, was done, were not, unfortunately, published. However, a report published in 1842 stated that Merriam, Carr & Co. had been paid $146,221 for all their work to date on Locks 17 and 18. Since that firm had received $48,700 through 1840, it could be assumed that the firm received $97,521 for work during 1841 on the two locks. The firm received $1,550 for work in 1842.

During 1841 contracts were let for paddle and valve gates for Lock 18. The masonry work on all locks under contract between Albany and the Lower Aqueduct was completed by 25 January 1842, although the work on the rest of Section 10 was behind schedule.

Evidently the line was tested at some time before 30 November 1841, when navigation was closed for that year; for in the following spring, on 20 April, water was let into the canal. A special party including the Canal Board, the comptroller, the contractors, and resident members of the legislature, traveled on that day from the Lower Aqueduct to Albany on board two boats, the *Enlargement* and the *G. W. Little*. In celebration of the occasion, the boats bore American flags, and a brass band was aboard, as well as a six-pounder which fired salutes along the route. The party left the aqueduct at noon and arrived at Albany between five and six p.m., having traveled over 11 miles of the enlarged canal and through 18 locks. It was expected that the new line would reduce the travel time between Albany and Schenectady by five or six hours. A contemporary source noted that the new locks

> will vie with any work of the kind in America, the capaciousness, and for solidarity and beauty of masonry. . Notwithstanding their greatly increased size, they are worked with surprising ease and rapidity, the average time of locking in and out for each boat being only one minute and twenty seconds.
>
> But the difficulties of a part of the route were truly formidable. At the Cohoes [Falls], in attaining the elevation, the new route passing above the factories, the side hill was cut off 126 feet above the bottom of the canal, so that we now look upward on one side to that altitude, while on the other is an enbankment [sic.] from 30 to 60 feet in height. This proved to be the most difficult portion of the route, the hill being of hardpan formation, and requiring continued blasting, and the enbankment [sic.] requiring in its unfinished state, the greatest skill and care to prevent its yielding to the pressure. (*Albany Argus,* 22 April 1842).

In 1843 an additional payment of $9,051.41 was made to Merriam, Carr & Co. for Locks 17 and 18. A locktender's house was not immediately constructed. A grocery store and barn, dating from before 1834, were located just west of Lock 18.

Alterations and Additions: The gates of the lock have been removed. The portion of the lock owned by the City of Cohoes is being filled in because of alleged danger to children. The Bourgeois portion, according to the owners, will be preserved in its present state.

Sources of Information

Maps

Hutchinson, Holmes. "Map of the Erie Canal." Volume 10 (6 September 1834). Manuscript and History Section, New York State Library, Albany, New York.

Statistical Profile, Erie Canal Enlargement, Eastern Division, Commencing in the City of Albany and Terminating at Higginsville. Albany: R. H. Pease, 1851.

Unpublished

Albany County. *Deeds.* Books 66, 1332, 1374, 1375. County Clerk's Office.

Published

New York. *Annual Report of the Canal Commissioners.* Assembly Documents No. 16 (13 Jan. 1844), No. 24 (25 Jan. 1842), No. 25 (22 Jan. 1843), No. 60 (28 Jan. 1840), No. 65 (20 Jan. 1836), No. 72 (27 Jan. 1841, No. 73 (25 Jan. 1837), No. 85 (24 Jan. 1835); No. 86 (22 Jan. 1839), No. 88 (29 Jan. 1834), No. 159 (10 Mar. 1838).

———. *Annual Report of the Comptroller.* Assembly Document No. 16 (1839).

———. *Annual Report of the Comptroller, Relative to the Expenditures on the Canals.* Assembly Document No. 6 (3 Jan. 1838), No. 51 (21 Jan. 1841), No. 56 (10 Feb. 1843), No. 105 (2 Mar. 1844), No. 131 (31 Jan. 1840).

———. *Documents Accompanying the Report of the Canal Board.* Assembly Document No. 99 (26 Jan. 1836).

———. *Laws, 1834.* Chapter 312: "An Act to Provide for the Improvement of the Canals of This State." 6 May 1834.

———. *Laws, 1835.* Chapter 274: "An Act in Relation to the Erie Canal." 11 May 1835.

———. *Laws, 1838.* Chapter 269, "An Act to Provide for the More Speedy Enlargement of the Erie Canal." 18 April 1838.

———. *Report of the Canal Board.* Assembly Document No. 98 (26 Jan. 1836).

———. *Report of the Canal Board in Answer to Resolutions of the Assembly Respecting the Canal Debts and Revenues, and the Enlargement of the Erie Canal, &c.* Assembly Document No. 306 (1840).

———. *Report of the Canal Commissioners, in Relation to Contracts on the Canals.* Assembly Document No. 173 (1842).

———. *State Engineer's Report for 1853.* Albany, 1854.

Masten, Arthur H. *The History of Cohoes, New York, from Its Earliest Settlement to the Present Time.* Albany: Joel Munsell, 1877.

"Opening of the Enlarged Canal." *Albany Argus,* 22 April 1842.

Shaw, Ronald E. *Erie Water West: A History of the Erie Canal 1792–1854.* Lexington: University of Kentucky Press, 1966.

Whitford, Noble. *History of the Canal System of the State of New York.* Albany: Brandow Printing Company, 1906. [Supplement to the annual report of the New York State Engineer and Surveyor.]

ENGINEERING INFORMATION

General Statement

Structural Character: Locally known as the "Double Lock," Lock 18 is part of the enlarged Erie Canal system of 1840. The masonry lock chambers, which is all that remains, are rapidly being filled with refuse and earth.

Condition of Fabric: Good to fair.

Description

Shape: Long rectangle.

Foundation: Cut stone laid random, probably limestone.

Wall Construction: Cut limestone. The blocks are approximately 3 feet long, 2 feet deep, and 1½ feet wide.

Note: The lock gates were of wood, but no traces of the gates or their hardware survive.

Site

General Setting: Suburban residential.

Orientation: North to south.

Waterford Locks 1826

Champlain Canal, Waterford

(HAER NY-14)

R. Carole Huberman

Location: Immediately north of Lock No. 2 of the New York State Barge Canal, 0.1 mile south of U.S. Route 4, Waterford, Saratoga County, New York.
Latitude: 42° 47′ 38″ N. Longitude: 73° 41′ 00″ W.
Date of Construction: 1824–1826.
Engineer: Erie Canal engineering staff, under John B. Jervis, et al.
Present Owner: State of New York.
Present Use: Spillway for surplus water, New York State Barge Canal.
Significance: The Champlain Canal was built to link Lake Champlain with the Erie Canal and with tidewater via the Hudson River. The canal is now part of the New York State Barge Canal system, the most extensive in the United States. When the Barge Canal was built, c1911–1915, most of the original alignment of the Erie and Champlain canals was abandoned, although followed generally. The Champlain portion of the Barge Canal, which accommodates tug and barge traffic, for much of its route at the lower end is the canalized Hudson River.

HISTORICAL INFORMATION

History of the Champlain Canal and the Waterford Locks

Construction of the Champlain Canal was first considered in 1792 when the Inland Navigation Company was chartered for the purpose of creating a waterway between Lake Champlain and the Hudson River. Although the company spent $100,000 on the project, no canal was built. The British civil engineer, Sir Marc Isambard Brunel (1769–1849, father of Isambard Kingdom Brunel) is known to have been associated with the Champlain Canal plans while he was working in America 1793 to 1799 (Beamish, 1862).

In 1816 the Canal Law and the plans for the Erie Canal included recommendations and specifications, as well, for the Champlain Canal, or Northern Canal.

Engineering Information: Prepared by Richard J. Pollak.

A group of commissioners including Stephen Van Rensselaer, DeWitt Clinton, Myron Holley, Samuel Young, and Joseph Ellicott were appointed "to consider, devise, and adopt plans to effect means of communication between the navigable waters of the Hudson River and Lake Erie, and the said navigable waters and Lake Champlain" (Whitford, 1906, I: 410). Throughout the discussions and legislative activity of 1816–1817, the canals were treated together as one issue; the route of the Champlain Canal would appease the constituents of the northeastern part of the state who might otherwise object to Erie Canal expenditures.

The advantages of connecting Lake Champlain with the Hudson River were summarized by the commissioners in an 1817 report to the State Assembly.

> The Champlain Canal would save vast sums in the price of transportation; it would open new and increasing sources

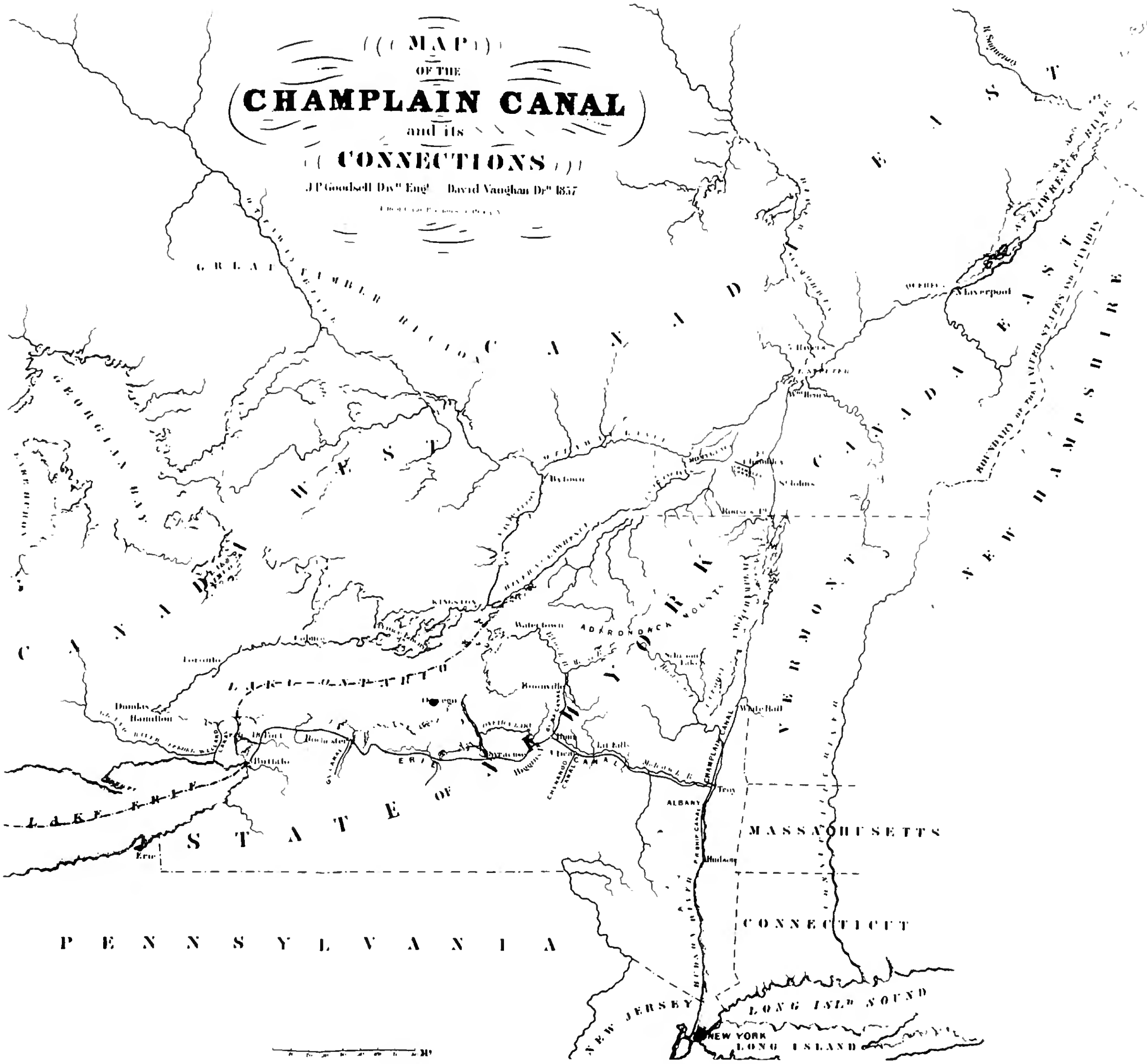


FIGURE 132.—Champlain Canal (New York State Engineer and Surveyor, 1856, *following page 72.*)

of wealth; it would divert from the province of Lower Canada, and turn to the south, the profits of the trade of Lake Champlain; and, by imparting activity and enterprize [sic.] to agriculture, commercial and mechanical pursuits, it would add to our industry and resources, and thereby augment the substantial wealth and prosperity of the State (*Assembly Journal,* 1817, p. 589, in Whitford, 1906, I:411).

Work began in 1817 at the northern end of the canal, near Whitehall at the lower end of the lake, concurrently with the start of work on the Erie Canal. Construction progressed southward and by 1822 was completed to Waterford, the lower terminal, where the canal entered the Hudson by means of a lateral cut with three locks. A low dam across the Hudson provided a still pool into which the boats were locked. Whitford (1906, I:416–417) described the facility:

The works consisted of a dam and a sloop lock. The masonry of the lock was completed in 1822, but a section of the dam had been left open in order to discharge the water of the river while the other works were being constructed. While the contractors were closing this gap, a heavy freshet occurred which undermined and carried away about one hundred and twenty feet of the unfinished dam. The high water continued so long that it was impossible to do any further work that season. In the spring of 1823 this breach was repaired, but during the season another one occurred in the old portion of the dam. In the following spring this breach became enlarged by the action of heavy freshets and the commissioners were in a quandry as to what they should do. Finally an agreement was made with certain responsible individuals that they should repair the dam at their own expense and risk. If the dam, as repaired, should withstand the fall, winter and spring floods and at the subsiding water in the spring should remain entire and undamaged, the contractors were to receive the sum of $25,750, otherwise nothing. The dam was repaired upon these conditions and in the spring of 1825 it had withstood the test so well that it was accepted by the commissioners.

The locks were finally placed in service by 1826.

Below the lateral cut, the Champlain Canal continued southward in a slightly westerly direction crossing the Mohawk River on slackwater near its mouth, below Cohoes Falls, and formed a sharply acute angle in its junction with the Erie Canal at Juncta, due west of the Lower Sprout of the Mohawk River.

Alterations and Additions

1842. Another lock on the main canal was built at Waterford.

1845. New gates were constructed on the guard locks.

1852. Lock No. 7 at Waterford was rebuilt, probably enlarged to accommodate tow boats.

1854. A contract was let to rebuild the three single locks on the Waterford side cut, and by

1856. Three new combined locks were completed on the north side of the old side cut.

1862. A weighlock built at Waterford was a significant improvement to the canal system.

A weighlock had been needed at Waterford as up to [1861] the only one available for weighing boats on the Champlain Canal was at West Troy on the Erie Canal. The Waterford side-cut had served as a convenient shunpike to any boats that were not

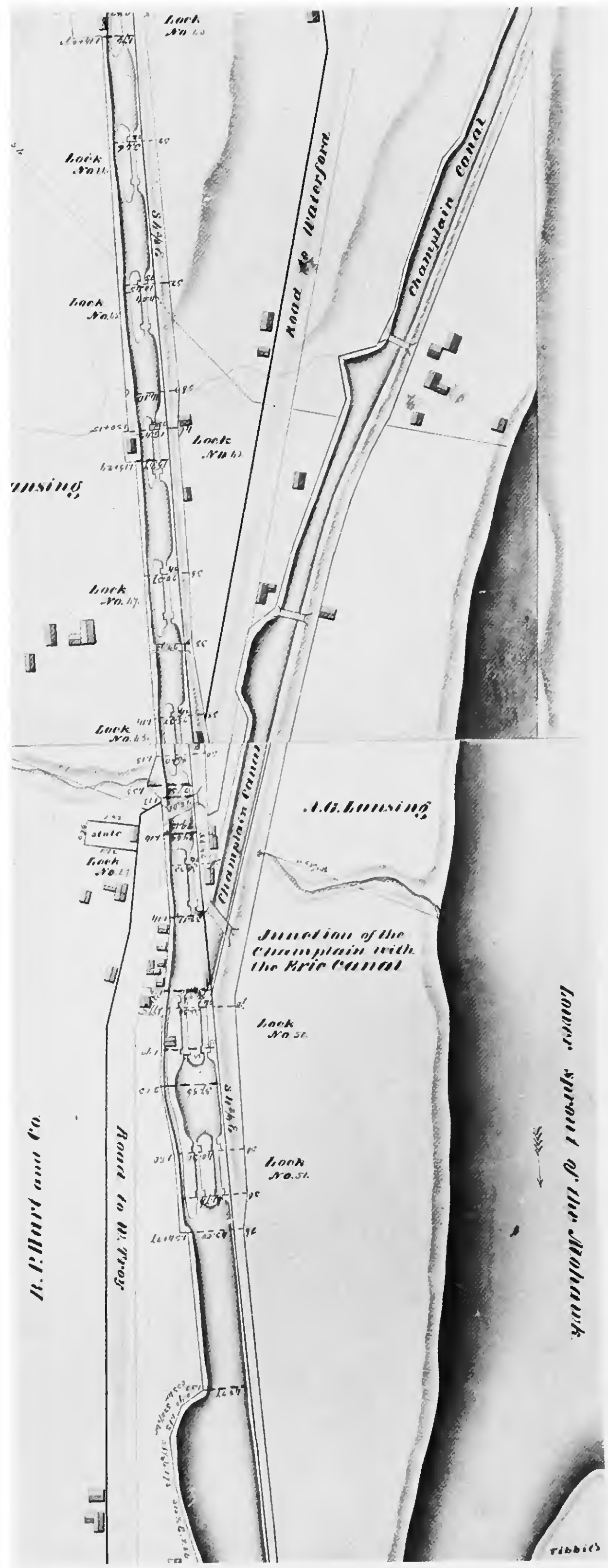


FIGURE 133.—Hutchinson's map of the Champlain-Erie Canal junction at Juncta, south of Cohoes. (*Hutchinson, 1834, plate 43, right half.*)

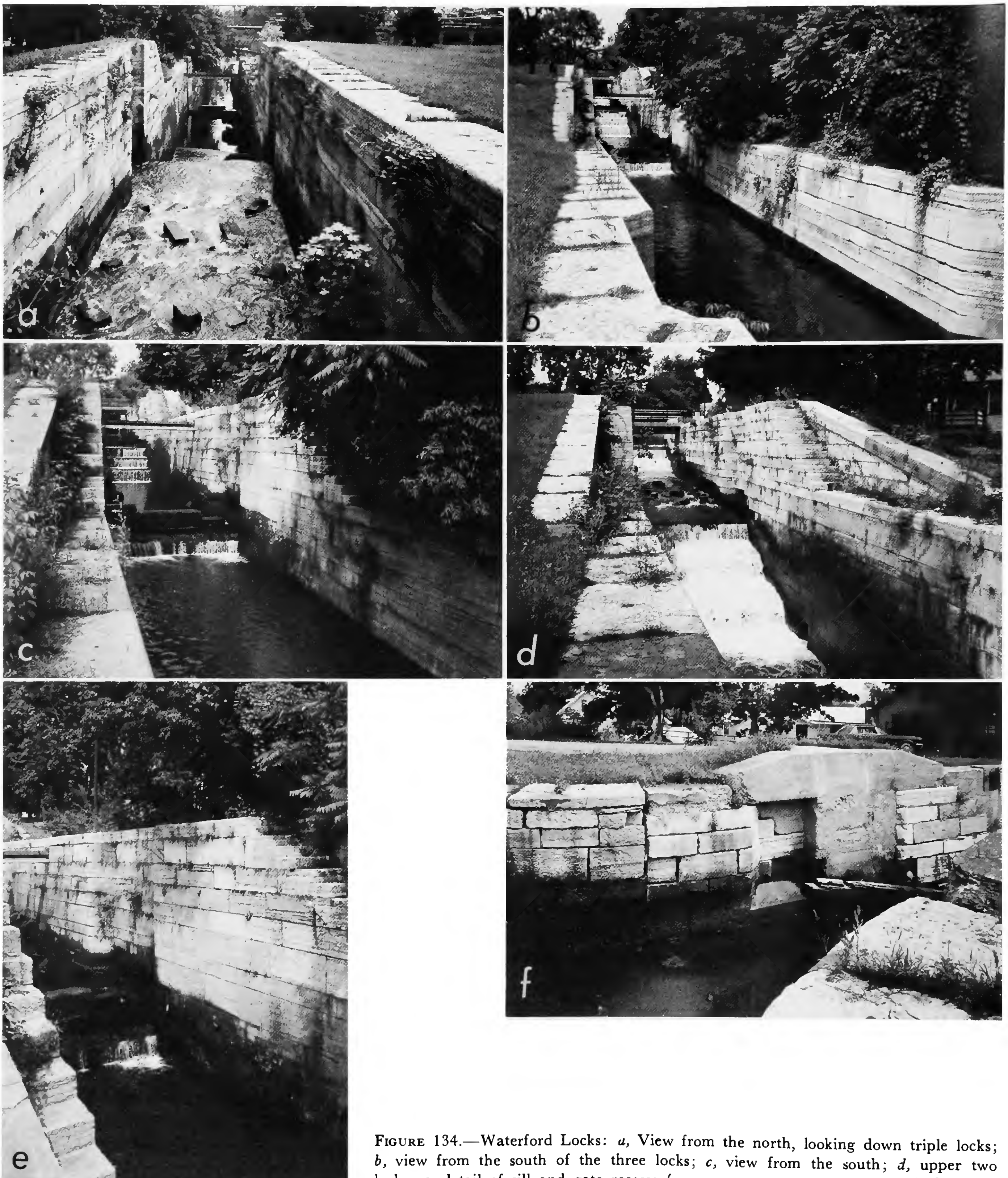


FIGURE 134.—Waterford Locks: *a,* View from the north, looking down triple locks; *b,* view from the south of the three locks; *c,* view from the south; *d,* upper two locks; *e,* detail of sill and gate recess; *f,* masonry at upper entrance to locks.

bound for the Erie Canal, and consequently the State had been defrauded of a large percentage of its just tolls (Whitford, 1906, I:430). It cost $22,115.70 and relieved the congestion at the West Troy weighlock.

1889. Waterford weighlock was enlarged.

1903. By means of a referendum, the Champlain Canal became part of the New York State Barge Canal system. Work began on the Barge Canal two years later and the Waterford Locks eventually became a spillway for its surplus water.

Sources of Information

Maps

Geddes, James. *Map and Profile of the Champlain Canal as Made from Lake Champlain to the Hudson River and Surveyed Thence to the Tide at Waterford.* James Geddes, Engineer, 1820. [Library of Congress, Geography and Map Division, Alexandria, Virginia.]

Mahon, S. *Map of the Grand Erie Canal, with the Stage Roads from Albany to Buffaloe, and the Distances Between Each Place, Drawn and Engraved for the Tourist.* S. Mahon, 1830. [Library of Congress, Geography and Map Division, Alexandria, Virginia.]

Hutchinson, Holmes. "Map of the Erie Canal." Volume 10 (1834). Manuscript and History Section, New York State Library, Albany, New York.

New York State Engineer and Surveyor. "Map of the Champlain Canal and its Connections." *Annual Report for Year 1856.* Albany, 1857.

State of New York Department of Public Works. *Champlain Canal, Waterford to Stillwater, March 1, 1916.* Sheet 1 of 2. [Library of Congress, Geography and Map Division, Alexandria, Virginia.]

Beamish, Richard. *Memoir of the Life of Sir Marc Isambard Brunel, Civil Engineer.* Second edition. London: Longman, 1862.

Shaw, Ronald E. *Erie Water West: A History of the Erie Canal 1792–1854.* Lexington: University of Kentucky Press, 1966.

Whitford, Nobel E. *History of the Canal System of New York.* 2 volumes. Albany: Brandow Printing Company, 1906. [Supplement to the annual report of the New York State Engineer and Surveyor.]

ARCHITECTURAL INFORMATION

Condition of Fabric: The masonry walls and floors are in good condition; the wood lock gates and the hardware do not remain.

Overall Dimensions: Approximately 15 feet by 150 feet in three levels.

Construction: Limestone. "At the northern termination of the canal some limestone excavation would be necessary . . , but the material would be very useful in the construction of locks, nine of which were considered necessary between the Hudson and Lake Champlain" (Whitford, 1906, I:412). Stone stairways, 3 feet wide with 10-inch treads and 12-inch risers serve the different lock levels.

Site: Neatly and pleasantly landscaped as typical of all State Barge Canal property.

Hawk Street Viaduct 1890

City of Albany

(HAER NY-10)

Samuel Rezneck

Location: Hawk Street, one block north of State Capitol, Albany, Albany County, New York. Latitude: 42° 39′ 00″ N. Longitude: 73° 45′ 30″ W.
Date of Erection: 1889–1890.
Designer: Elnathan Sweet, C.E. (1837–1903).
Present Owner: City of Albany.
Present Use: Pedestrian bridge [from 1968].
Significance: First appearance of a cantilever arch bridge.

HISTORICAL INFORMATION

Physical History

The Hawk Street Viaduct, originally called the Hawk Street Bridge, was closed to vehicular traffic in January 1968. A monument of another age, it has been condemned as unsafe, and only pedestrians now cross over this rusted, dilapidated structure. The City of Albany plans neither to repair nor to rebuild it. There is a proposal, however, to build a new viaduct across the same ravine a block farther west at Swan Street. [The viaduct was dismantled by the city in July 1970.—ed.]

According to the commemorative plaques attached to the bridge, it was built in 1889–1890 by the Hilton Bridge Construction Company of Albany, when Edward A. Maher was Mayor. The bridge was rebuilt in 1925 under the leadership of William S. Hackett, Mayor; Lester W. Herzog, Commissioner of Public Works; and James G. Brennan, City Engineer. Davis and Post were the consulting engineers and the Boston Bridge Works, Inc., was the contractor who did the actual repairs.

Engineering Information: Prepared by Richard J. Pollak; additional data by Robert M. Vogel.

By 1949, however, extensive deterioration of the bridge made it necessary to reduce its allowable carrying load from ten to three tons. In 1958, the city appropriated $250,000 for reconstruction, but the plan was abandoned as impractical because of the bridge's condition. Neither plans for the bridge nor records of its maintenance exist in the Albany City records. In its dimensions alone, the bridge is inadequate for the demands of modern traffic.

Despite its almost obscure record, the Hawk Street Viaduct is significant in the physical and social history of Albany. Spanning the ravine between Capitol Hill and Arbor Hill, it connected the fine residential section that had grown up around the government buildings, with working class neighborhoods. A canal at one time ran through the ravine, but it has been filled in and displaced by Sheridan Avenue.

In the late nineteenth century, the Hawk Street Viaduct provided a solution to both a social and an engineering problem. It was necessary to establish direct access and communications between the separate camps of the city, but neither the city nor state governments worked rapidly toward a solution. All through the 1880s the state legislature rejected a bill authorizing a viaduct across the ravine, which, by

FIGURE 135.—Hilton letterhead, 1890s. E. Sweet, the firm's president, apparently also was its principal engineering force. The technical role of George P. Hilton, listed here as engineer, is unknown. (*Warshaw Collection, National Museum of History and Technology, Smithsonian Institution.*)

that time, was at least an engineering and a financial possibility. Two successive mayors, city councils, and corporation counsels also opposed this logical civic improvement idea. The legislature finally approved the project in 1888, thanks to the efforts of Maurice Cranwell, the "father of the bridge," who facilitated the "poor man's short cut to town." The City of Albany at that time appropriated $125,000, but only $107,000 of it was used and the construction costs actually were only $90,000.

As a significant engineering achievement, the construction of the Hawk Street Viaduct in 1889–1890 heralded the use of the cantilever arch. It was regarded as "a genuine architectural wonder," and was much admired and copied in Europe and America, in spite of the fact that it was a dry-land structure and lacked the romance and boldness of bridges across water. Other major cantilever arches were erected over the Seine and Viaur in France, and the Elbe Canal at Mölln, Germany, as well as on railways in Alaska and Costa Rica (Tyrrell, 1911: 325–326).

A contemporary writer described the viaduct as "a daring experiment in bridge construction." At its highest point it is 79 feet above the street below. A power plant on Sheridan Avenue barely rises to the level of the roadway. Undoubtedly, this elevated feature has been an invitation to the would-be suicide, and a considerable number are reported over the years to have leaped to their death from the railing to the pavement below.

The original structural novelty of the viaduct has long since been eclipsed, and its abandoned, dilapidated appearance adds a note of sadness to the general disarray of central Albany as the city undergoes reconstruction and renewal. The vast South Mall and its gigantic buildings rising slowly on Capitol Hill on one side of the Hawk Street Viaduct is matched by the leveled surface that covers much of Arbor Hill on the other side. As these areas are rebuilt, the need for a new bridge linking them across the Sheridan Avenue ravine will become more urgent. It is expected that in due course a new and more modern viaduct will rise across Swan Street, a block west of the viaduct. Indeed, there may be need of another bridge across the ravine at a point closer to downtown Albany east of Hawk Street. All of this points to the growing importance and utility of a crossing at this strategic site, which has been evident since the last century.

Figure 136.—Hawk Street Viaduct: *a,* Underside of the viaduct, looking north; *b,* detail of anchor arm underside and face of north abutment; *c,* the viaduct from the southeast, looking toward the city center; *d,* builder's plate and center pin, east face; *e,* view south along the roadway; *f,* balustrade newell detail.

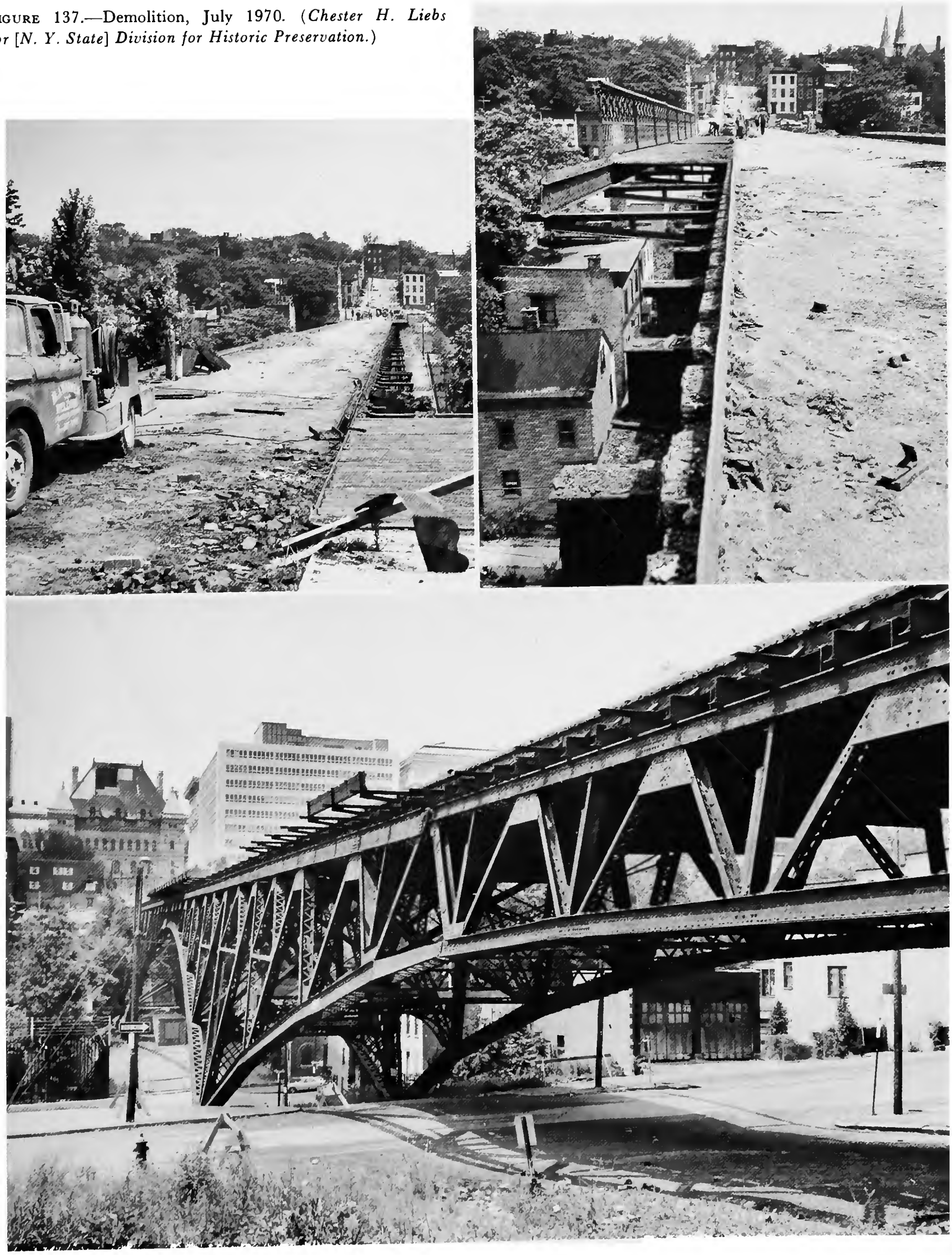


FIGURE 137.—Demolition, July 1970. (*Chester H. Liebs for [N. Y. State] Division for Historic Preservation.*)

Biographical Background

Elnathan Sweet: Designer and engineer of the bridge, Sweet was also president of the Hilton Bridge Construction Company, the bridge's builders. His contribution was significant both professionally and technically. In many respects the Hawk Street Viaduct was the most important engineering project in his long and diversified career. Born in Cheshire, Massachusetts, in the Berkshire Mountains, Sweet received a degree in civil engineering from Union College, Schenectady, in 1859. It was the age of railroad building, and he traveled westward to participate in some of its more ambitious undertakings. He was particularly involved with the construction of the Rock Island and Northern Pacific railroads. In 1875 he came to Albany where Governor Samuel J. Tilden engaged him to help clean up the scandalous activities of the contractors on the state canals. Sweet was subsequently elected State Engineer of New York and served until 1887.

Returning to private engineering practice, he became president of Hilton. In the Hawk Street Viaduct design he introduced some novel features, most importantly the combination of the arch and the cantilever in one structure.

Sources of Information

Unpublished

Consultations with the City Engineer and City Planner of Albany.

File on "Albany Bridges" in the Albany Room of the Albany Public Library.

Published

Hislop, Codman. *Albany: Dutch, English, and American.* Albany, 1936.

Parsons, Brinckerhoff, Hogan, and MacDonald, Consulting Engineers to Albany. *Know Albany Survey.* Albany.

Reynolds, Cuyler. *Albany Chronicles.* Albany, 1906.

Tyrrell, Henry Grattan. *A History of Bridge Engineering.* Chicago: (By the author) G. B. Williams Co., Printers, 1911.

ARCHITECTURAL INFORMATION

General Statement

Structural Character: Steel three-hinged arched-cantilever span.

Condition of Fabric: Poor. Closed to automobile traffic.

Description

Overall Dimensions: 1,000 feet total length; 79 feet from street level to highest point.

Foundations: Light gray cut granite.

Structural System: The viaduct's principal element is the center three-hinged, two-rib arch, spanning 360 feet. Springing "backward" from each end of the arch is a 114-foot cantilver "half-arch" that balances much of the load on the central arch. Sixty-six-foot end spans extend beyond the cantilevers to the abutments. The total length of the bridge with its approaches, from Clinton Avenue to Elk Street, is 1,000 feet.

The hinges in the arch permit its elements to adjust freely to changing temperature and traffic loadings. The hinges are composed of large iron pins, 12 inches in diameter. One pair of pins is at the top center of the arch, while the other pairs are at each of the springing points where the arch bears on underground piers of concrete. It thus combines stability and mobility. Eight-hundred tons of iron and open-hearth steel were used in the structure, which originally was paved with creosoted yellow pine blocks.

Special Decorative Details: Cast- and wrought-iron railings.

Green Island Shops 1872

Rensselaer & Saratoga Railroad, Green Island

(HAER NY–15)

Richard S. Allen

Location: West side of Delaware & Hudson Railroad tracks; 500 feet north of Tibbitts Avenue, Green Island, Albany County, New York.
Latitude: 42° 45′ 00″ N. Longitude: 73° 41′ 00″ W.
Dates of Erection: 1871–1872.
Designer: Unknown.
Present Owners: John J. Ryan & Sons, Inc., owner of buildings; Delaware & Hudson Railway Company, owner of land.
Present Occupant: John J. Ryan & Sons, Inc., waste materials dealers.
Present Use: Warehouse.
Significance: An early railroad shop building of typical heavy timber and brick construction.

HISTORICAL INFORMATION

Physical History

Green Island is located at the confluence of the Mohawk and Hudson rivers due west of the City of Troy. It was connected both to Troy and to more islands at the north of Waterford by bridges constructed in 1835 by the Rensselaer & Saratoga Railroad. LeGrand B. Cannon, who owned much of Green Island, was active in the management of the R&S. In December 1868, the railroad purchased more than 21 acres of the north central portion of the island from Cannon as a site for extensive locomotive repair and car-building and repair shops. The R&S shop site, however, should not be confused with the site of the Eaton, Gilbert & Company (later Gilbert Car Manufacturing Company) works on Green Island. That plant stood at George and Clinton Streets, six blocks to the south. Gilbert & Company, which operated on Green Island from 1852 to 1893, was an early and well-known builder of coaches, railroad cars, omnibuses, street cars, and Civil War gun carriages.

Begun in 1871, according to the builder's stone on the south face of the main building, the R&S shops were completed the following year. By that time the company had been leased in perpetuity to the Delaware & Hudson Canal Company. (All R&S properties have subsequently been operated by the D&H, although the R&S charter extends to 1 January 2500).

The Delaware & Hudson soon launched an ambitious expansion program, only slightly curtailed by the Panic of 1873. Heavy repairs and rebuilding of steam locomotives were carried on there, with this type of work for the railroad's tri-state system being equally divided among shops at Green Island, Oneonta, New York, and Carbondale, Pennsylvania.

For forty years the Green Island Shops were a hive of activity, engaged in heavy industrial work. The majority of D&H locomotives were in work

---

Architectural Information: Prepared by Richard J. Pollak; additional data by Robert M. Vogel.

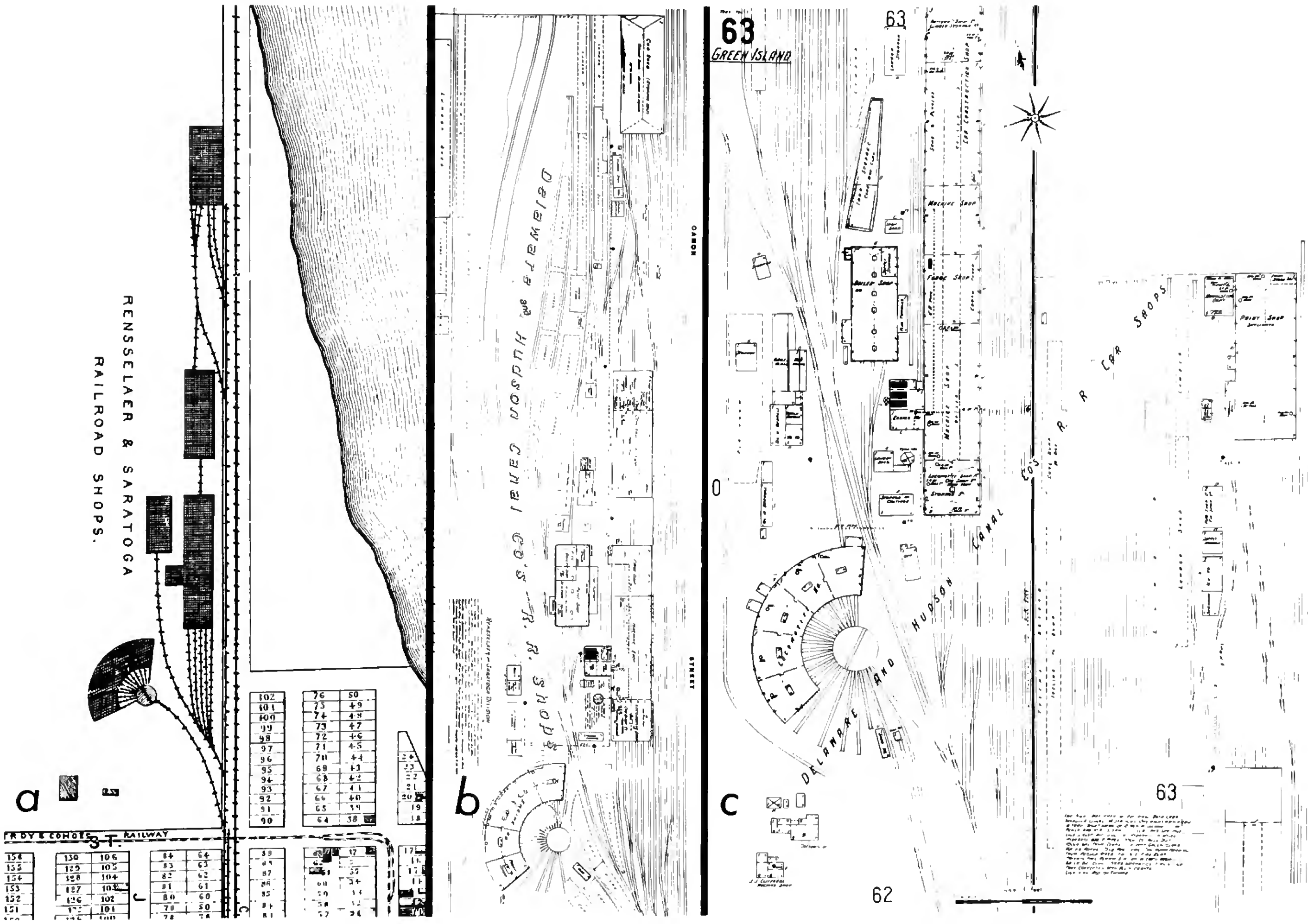


FIGURE 138.—Rensselaer and Saratoga Railroad Shops: *a*, Earliest known representation of the Shops, 1873. *b*, By 1885 various auxiliary buildings had appeared but the principal shop structures were unchanged. *c*, By 1903 the locomotive and car shops had been joined, forming a single structure 750 feet long. The presently surviving building constitutes only the original locomotive, machine and forge shops, everything to the north having been razed. (*a: Young and Blake, 1873; b: Sanborn Map and Publishing Co., 1885, volume 2, plate 55; c, Sanborn Map Co., 1903, volume 1, plate 63.*)

there at one time or another, the jobs ranging from simple repairs or paint to major overhaul and redesign.

Locomotive work was discontinued in 1912, when all D&H locomotive building and repair was concentrated in new shops at nearby Colonie, New York. The Green Island plant continued in operation, however, into the late 1930s, devoted to the building of the D&H's wooden freight cars, as well as repair and light work on other freight equipment.

Portions of the property were sold for industrial and private use in 1940. Since that period, the remaining buildings have stood idle or have been used for storage purposes.

The shops, as indicated on the Sanborn insurance map of 1875, consisted of three separate brick buildings extending northward along the Rensselaer & Saratoga's Troy to Waterford line.

First was the main machine shop, with office at the center on the east side. The large (32 feet to the eaves) southern section housed the five-bay locomotive shop on the first floor. The second story was used for wood work and pattern storage. The central section (18 feet to the eaves) was devoted to machinery, with the blacksmith shop at the north end.

Immediately west of this building were a 50-foot, brick-enclosed water tank of 51,819-gallon capacity, a stone cistern, a boiler room with two boilers totaling 175 horsepower and a 110 horsepower engine, capped by a 120-foot chimney, and various sheds.

Southwest of the main building was a turntable, serving an eight-stall roundhouse, built in the form of a segment of concentric circles, with a single sloped roof.

To the northwest stood the paint shop, which was 20 feet to the eaves and contained as well the boiler shop and storage for hardware. Other nearby buildings included a two-story sand shed; a combined oil, varnish, and waste room; and a large frame, circular privy.

The next principal building was the car shops, located next to an old roundhouse north along the track side. A one-story section used for sawing and planing came first, and then a two-story erecting shop, with sawing and turning on the second floor and storage in the loft under the roof. This section apparently was similar in character to the existing locomotive shop.

A third one-story building 230 feet long stood approximately 450 feet further north. This was the car storehouse. Adjacent to this on the east were various lumber sheds, storage for castings, and a coal pile.

The shops were heated by stoves mounted on brick and iron bases and burning wood shavings and coal. Light was furnished by kerosene lamps. A work force of 75 to 125 men worked six days a week, with three night watchmen and one Sunday watchman.

According to the data on the Sanborn map, the three-story, five-bay locomotive shop/machine-forge shop, which is still standing, was originally separate. It is now connected with the one-story section of the former car shop. The connection was made between 1885 and 1903. Adjacent are the wooden roundhouse, brick water-tower base, boiler room, etc. The paint shop of 1872 burned on 23 January 1904 and its site is occupied today by a more recent structure used for storage.

Sources of Information

Published

Delaware & Hudson Railway Co. *A Century of Progress: A History of the Delaware and Hudson Company 1823–1923.* Albany: J. B. Lyon Co., Printers, 1925.

———. *Inspection of Lines.* 1928.

Howell, George Rodgers, editor. *Bi-centennial History of Albany: History of the County of Albany, N.Y., 1609–1886.* New York: W. W. Munsell & Co., 1886.

Shaughnessy, Jim. *Delaware & Hudson—The History of an Important Railroad Whose Antecedent Was a Canal Network to Transport Coal.* Berkeley, California: Howell-North Books, 1967.

Weise, Arthur James. *City of Troy and its Vicinity.* Troy: E. Green, 1886.

———. *Troy's One Hundred Years 1789–1889.* Troy: W. H. Young, 1891.

Maps

Sampson, Murdock & Co., *Map(s) of Troy, also West Troy and Green Island.* 1889–1935.

Sanborn, D. A. *Insurance Maps of the City of Troy, N.Y. Including West Troy and Green Island.* New York, 1875.

Sanborn Map and Publishing Co. *Troy, Including West Troy and Green Island, N.Y.* New York, 1885.

Sanborn Map Co. *Insurance Maps of Troy, Rensselaer County, Including Green Island and Watervliet, Albany County, N.Y.* New York, 1903.

———. *Troy, N.Y. 1955.* New York, 1955.

Young, William H. and Blake. *Map of the City of Troy, New York.* Troy, 1873.

Additional records and maps on file at Albany County Clerk's Office, Albany, N.Y.

ARCHITECTURAL INFORMATION

General Statement

Architectural Character: The R&S Shops are representative of railroad repair facilities of the period, designed for work on both locomotives and railroad cars. The single surviving shop building is of brick and heavy-timber construction throughout. The principal block, on the south, is multistoried, the high ground story for accommodating the locomotives in work and the upper stories for light work on the

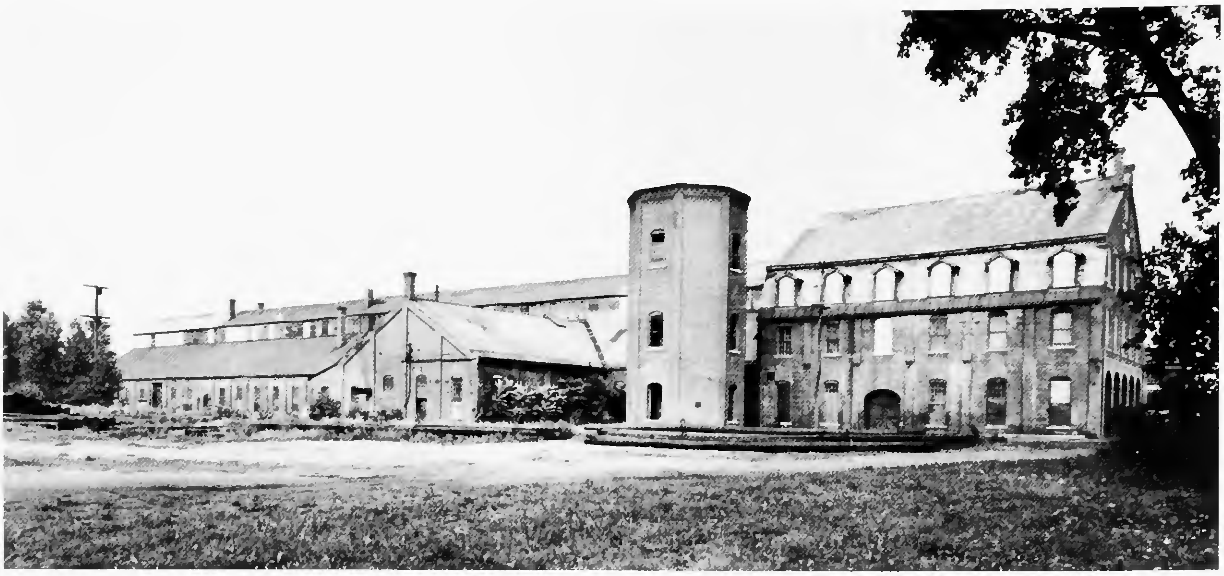


FIGURE 139.—View of the Green Island Shops from the southwest showing the boiler-engine house ell and the water tower base.

FIGURE 140.—Green Island Shops: *a*, Brick water tower base; *b*, joining of machine and locomotive shops and north face of water tower base; *c*, window in water tower base, showing diaphragm walls that supported tank floor; *d*, interior of the north section. (*a-c: Boucher; d: John Courtney Fisher for* [*N.Y. State*] *Division for Historic Preservation.*)

wooden cabs and other small components. The single-story shop to the north housed the larger machine tools, the forge, and the other heavy metal-working operations that required foundation on grade.

A single-story brick ell with pitched roof and a one-bay lean-to addition on its north side joins the north section of the building perpendicularly on its west face, just north of the brick watertower base. This was the boiler and engine house, and is original construction.

Condition of Fabric: Good.

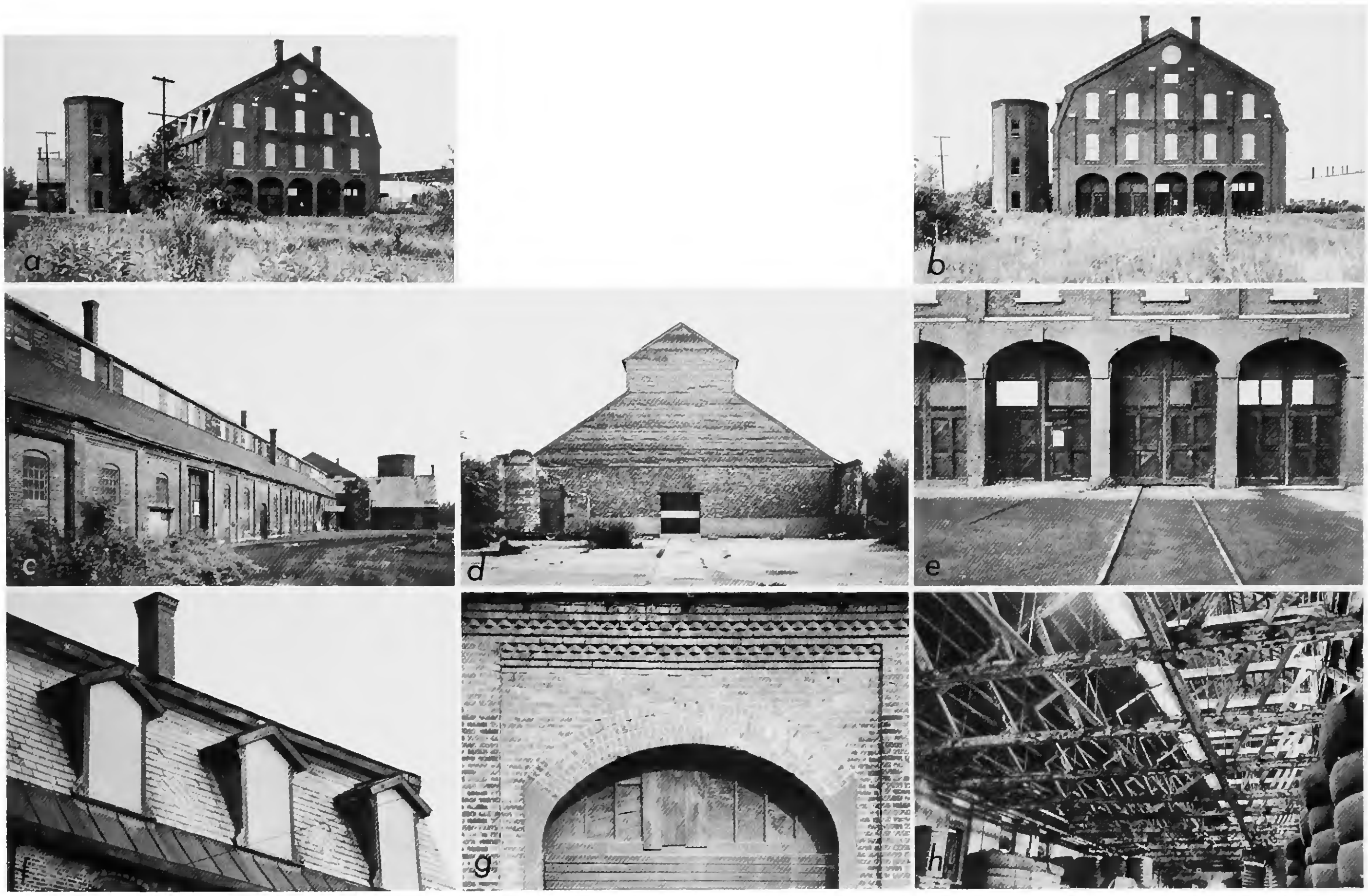


FIGURE 141.—Green Island Shops: *a,* Southwest view. The plan of the locomotive shop is typical of locomotive construction and repair shops, to about 1890, in which a series of short parallel tracks held one locomotive each. They remained stationary while in work, all parts being manhandled or rigged into and off of the engines. In later plans, the locomotives were moved about on a few long, longitudinal tracks by massive traveling cranes, which also handled the heavier components. *b,* South elevation of the locomotive shop and water tower base; *c,* west side of the machine shop and north face of the boiler-engine house; *d,* north end of the building with wall remains of the connector between the car and forge shops; *e,* detail of the locomotive doors, south face; *f,* dormer details; *g,* detail of head, materials door, west face, showing iron castings from which the arches spring; *h,* interior of the north section. (*a-g: Boucher; h: Chester H. Liebs for* [*N.Y. State*] *Division for Historic Preservation.*)

Description of Exterior

Overall Dimensions: The rectangular building is approximately 80 feet by 400 feet. The south portion, about 80 feet long, is five bays wide by six; the north portion, about 320 feet long, is three bays by twenty-nine.

Foundation: Cut stone, probably limestone.

Wall Construction, Finish, and Color: Red brick bearing wall construction. The interior is painted, the exterior unfinished.

Structural System: The heavy-timber roof trusses of the north section bear on the brick exterior walls and wood interior posts. There are wrought-iron rods in the roof trussing. Purlins and roof sheathing are wood. In the south part, the timber framing is supported by cast-iron columns and the exterior walls, enlarged into piers at the bearing points.

Chimneys: Two brick chimneys at south front; miscellaneous brick chimneys on north portion.

Openings: Doors and Doorways: On the south face are five wooden panelled double locomotive doors.

Windows: The windows on the south face are boarded over. On the west side, they are wood, double hung with 12-over-12 sash. All openings are segmentally arched.

Roof: Shape, Covering: The north section has a gabled roof with full-length, high, glazed monitor and slate and asphalt shingles. The south portion has a slated double-pitch roof best described as gambrel with shallow dormers in the steep-pitched lower section.

Cornice, Eaves: Brick cornice; sheet metal eaves.

Description of Interior

Floor Plans: All three floors and the loft of the south section as well as the first floor of the north section are large open spaces interrupted only by columns.

Stairways: In the south part there are wooden stairs in a straight, single run from floor to floor.

Flooring: The first floor is concrete; the upper three floors of the south end are wood.

Site

General Setting: The building is situated on a north-south axis in a completely flat, moderately industrial area. Adjacent to it on the east is a large, modern Ford assembly plant.

Outbuilding: A three-story, octagonal brick base for a water tower stands just west of the south front. The tank itself no longer remains.

☆ U.S. GOVERNMENT PRINTING OFFICE: 1973 O—497-570