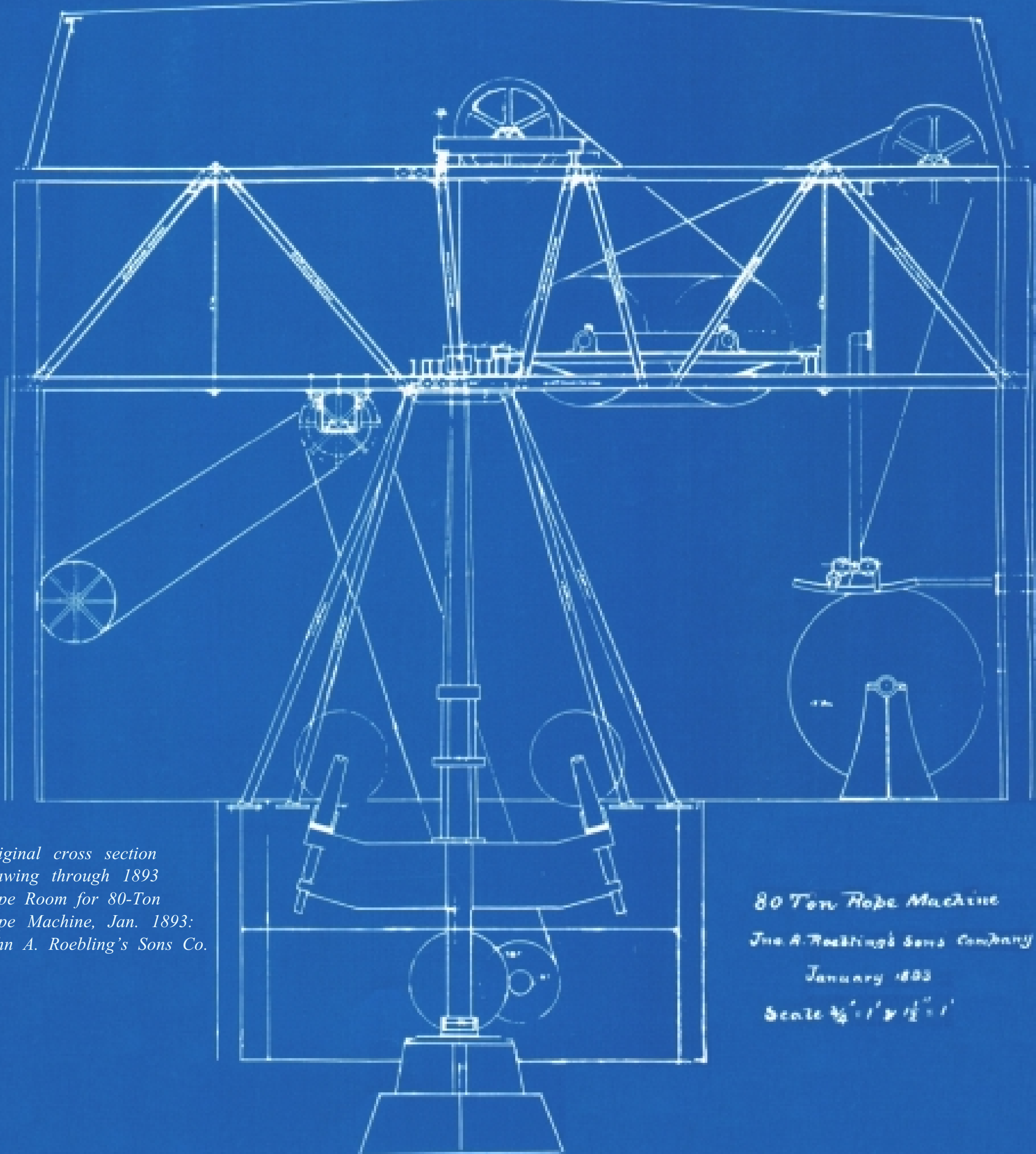
GREATER TRENTON SECTION

ROEBLING 80-TON WIRE ROPE MACHINE

(Circa 1893)



Original cross section drawing through 1893 Rope Room for 80-Ton Rope Machine, Jan. 1893: John A. Roebling's Sons Co.

The American Society of Mechanical Engineers

93rd National Historic Mechanical Engineering Landmark

October 21, 1989

The Roebling 80-Ton Wire Rope Machine

The American Society of Mechanical Engineers has designated as a Landmark, the Roebling 80-Ton Wire Rope Machine not only for its individual engineering merit, but also as a symbol of the achievements of the Roebling family and their company.

It is indeed fortunate that the planning of the Trenton Roebling Community Development Corporation and DKM Properties Corporation for the redevelopment of the John A. Roebling's Sons Company historic industrial complex has included preservation of the Roebling 80-Ton Wire Rope machine as a centerpiece of their efforts. Otherwise this only remaining Roebling machine would be lost to posterity.

The Roebling Legacy

The Roebling family and the wire rope company they created achieved international recognition for the design and construction of our nation's greatest suspension bridges. John Augustus Roebling was a brilliant engineer and entrepreneur who established his firm in Trenton in 1849. His three equally brilliant and industrious sons, Washington, Ferdinand, and Charles, built the company into a major manufacturing business that designed and produced wire rope and related products for a world market.

The Roebling legacy is embodied today not only in the Cincinnati, Brooklyn, Williamsburg, Manhattan. Bear Mountain, George Washington, and Golden Gate Bridges, but also in two manufacturing plants, in Trenton and in Roebling, New Jersey. Constantly anticipating technological change, the Roebling's wire rope products contributed to the development of shipping, railroading, elevators, telegraphs, electricity, mining, cable cars, construction, tramways, and airplanes.

The Founder: John A. Roebling

John A. Roebling, who immigrated to America from Germany in 1831, had studied bridge engineering at the Berlin Polytechnic Institute. After trying his hand at farming in Saxonburg, near Pittsburgh, Pennsylvania, John worked as an assistant engineer building a canal across the Allegheny Mountains in western Pennsylvania. In the mid-1830's, canal boats were hauled over the mountains on inclined railways with hemp hawsers, which rapidly wore out.

Having seen wire used in cables in his native country, Roebling experimented with twisting wires by hand and developed a wire rope to replace the hemp hawsers. Its immediate success brought orders for more wire rope, which he continued to make on a rope walk on his farm for a number of years.

Recognizing the potential of the wire rope manufacturing business and the need to be near transportation and eastern markets, Roebling established a manufacturing plant along the Delaware & Raritan Canal in the Chambersburg section of Trenton in 1849. During the 1850's and 60's, he designed and built suspension bridges utilizing his wire rope and cable technology over the Niagara River at Niagara Falls, over the Allegheny River at Pittsburgh, and over the Ohio River at Cincinnati.

Roebling then turned his attention to the design of the crowning achievement of his career, the Brooklyn Bridge over the East River between New York and Brooklyn. In 1869 while surveying for the bridge location, his foot was crushed by a ferryboat in a tragic accident which resulted in his death ten days later from lockjaw. This left the construction of the bridge to his son and assistant Washington Augustus Roebling, who had studied engineering at Rensselaer Polytechnic Institute.

The Roebling Brothers

Washington Roebling (1837- 1926) spent the next decade and a half completing the Brooklyn Bridge. With his health nearly shattered at the end of this endeavor, he spent most of the rest of his life in semi-retirement in Trenton. In 1921, at the age of 84, he assumed the presidency of the Roebling Company, which he held until his death in 1926.

His brothers, Ferdinand Wilhelm Roebling (1842-1917) and Charles Gustavus Roebling (1849-1918), took over their father's business and built it into a company employmg 10,000 people at its peak. Despite his afflictions, Washington played a key role in making business decisions, but he was not involved in the day-to-day affairs until after the death of his brothers and nephew, Karl, who was president in 1921.

Ferdinand, known as F.W., oversaw the financial, marketing, and sales portions of the business. Charles oversaw the production portion of the business, and like his father, personally supervised the design and construction of the buildings and machinery required to meet the ever burgeoning demand for wire rope.

John A. Roebling's Sons Company

In the early 1870's, the brothers took over the company from Charles Swan, their father's loyal manager. At the time it had 85 male employees, ten of which were children under sixteen. In the next decade the company produced wire and wire rope for bridges, shipping, and the recently developed technologies of the elevator and the telegraph. In the 1880's the brothers established the Electric Wire Division to produce galvanized and copper strands for municipal electrification and the many growing uses of electric power and communications.

By the 1890's, the cable car business had ushered in "a prosperous period of rope making," as Washington noted in his memoirs. The demand for ever longer cable car ropes led Charles to design and build the 80-Ton Rope Machine to produce 30,000-foot-long ropes. Between 1904 and 1914 JARSCO produced enormous quantities of wire rope for the tramways and digging operations needed to build the Panama Canal.

The turn of the century brought the Roeblings back into the bridge business, with the Williamsburg and Manhattan Bridges, while demand for electrical wire continued to soar. Having built their Chambersburg plant to its capacity, in 1902 the brothers constructed a new plant for the Electrical Wire Division one mile south along the canal in Trenton.

When the company needed to separate its supply of rod for wire from the vagaries of foreign sources, it built a huge plant, with blast furnaces and rod mills, along the Delaware River in Kinkora, ten miles south of Trenton. In the absence of housing for its workers, JARSCO built an entire town, with nearly 800 houses, shopping, a school, a hotel, and recreational facilities. As time progressed, the town came to be known as Roebling, New Jersey.

With the advent of the First World War, the company became a major producer of submarine netting used in the English Channel, as well as fine wires for airplane rigging and controls. By the end of the War, both Charles and Ferdinand had died. Their nearly fifty years of efforts in the family business had transformed JARSCO from a local firm with less than 100 employees in 1870 to over 8,000 employees during the First World War. The annual sales of JARSCO products had likewise soared from $250,000 to over $47,000,000 in 1918.

In the 1920's and 30's, with Washington and then the third generation of Roeblings in control, JARSCO manufactured and installed the main cables and suspender ropes and cables for the Bear Mountain Bridge and their greatest bridges, the George Washington (opened 1932) and the Golden Gate (1937). During the early 1940's JARSCO again became a major supplier of wire rope products for the war effort.

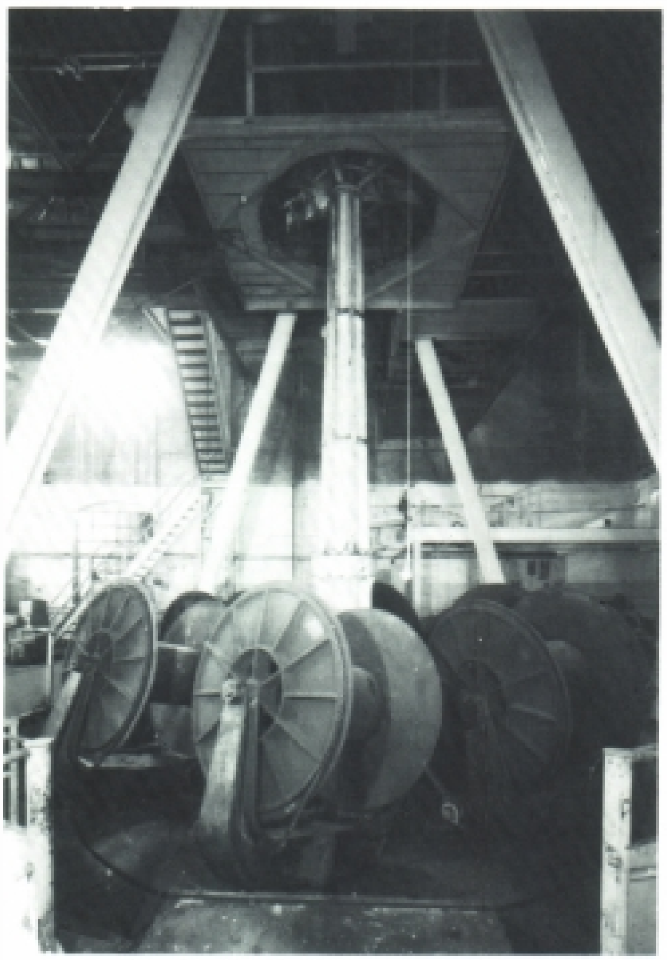
In 1952 the Roeblings sold JARSCO to the Colorado Fuel and Iron Company (CF&I), with headquarters in Pueblo, Colorado. CFI ran the Roebling plants until the early 1970's when foreign suppliers with lower labor costs made the domestic production of wire rope uncompetitive.

The Roebling Development of Wire Rope Machinery

From his earliest attempts at manufacturing wire rope, John Roebling had to design and develop the necessary machinery. He received his first patent in 1842 for a method of spinning wire rope which maintained uniform tension on all the strands, one of the key aspects of producing a quality rope.

John meticulously drew cross sections, plans, and details of wire rope machines, their components and drive mechanisms, and the buildings to house them. His earliest surviving drawings are for a "Twist Carriage" he designed in 1848 for the first wire rope walk in Trenton. These and dozens of his other machine drawings in the Roebling Collection at Rensselaer Polytechnic Institute illustrate his prodigious output in the 1850's and 60's despite his bridge building and management activities.

By 1855 Roebling had developed a design for a vertical rope spinning machine that became a prototype for the company's future vertical machines. The "7 x 19 Rope Machine" he designed by November 1855 spun six 19-wire strands around a core strand to produce "fine rope" for flexible applications. Nearly all the later vertical machines designed either by him or by his son Charles followed the same basic design. In 1885 Charles designed and built a 30-ton rope machine. Because of its size, he had to overcome friction problems at the base with a pressurized lubrication system.



Spindle and strand reels on 80-Ton Rope Machine, 1987:Jet Lowe, Historic American Engineering Record, for TRCDC.

Charles G. Roebling, c. 1905:
Trentoniana Collection, Trenton Public Library.

Charles G. Roebling

Charles Gustavus Roebling was born on Dec. 9, 1849 in Trenton, only two months after John Roebling had moved his family from Saxonburg, Pa., to the property where he was building his new rope factory. Charles was the third son, after Washington and Ferdinand.

Charles attended public school in Trenton and private school on Staten Island. He followed Washington to Rensselaer Polytechnic Institute, where he graduated as a civil engineer in 1871. Like his two older brothers, Charles had inherited 30% of the Roebling Company from his father following his tragic death in 1869. A fourth brother, Edmund, who was involved in the business for only a short time, inherited the other 10%.

Upon graduation, Charles immediately returned to Trenton to assume the manufacturing reins from Charles Swan, his father's longtime manager. During the next five decades Charles devoted his life to running the engineering and manufacturing departments of the company. In the late 1870's he assumed the presidency of the company, which he held for the rest of his life.

During his tenure, Charles supervised all the construction and outfitting for manufacturing the company's wire rope and related products. He expanded the company's original location in Chambersburg to over twenty-five acres, built two new plants in Trenton, and the huge plant in Roebling, N.J., ten miles south of Trenton.

In 1905 Charles personally supervised the design and constuction of the village at Roebling for the company's employees and then families. While disclaiming suggestions that he was building an "ideal" town, Charles designed the buildngs, street layout, and landscaping with exceptional care. The town included an assembly hall, a school, a fire house, a boy scout lodge, an inn, athletic fields, a bakery and other shops, all of which the company built or contributed to.

Besides his work at the mill, Charles built the Oil City, Pa., suspension bridge, and supervised the installation of the main cables for the Williamsburg Bridge in (1903).

Charles was an accomplished pianist, and he amassed a large collection of orchids in his home conservatory, including several species which he personally developed. For most of his life he lived in a large house at 330 West State Street in Trenton, within a block of Washington's and Ferdinand's houses. At the time of his death in 1918, he was reputed to be the wealthiest of the Roebling brothers.

Charles' son Washington perished on the Titanic in 1912, and two other children died in infancy. His grandson by one of his two surviving daughters, Charles Roebling Tyson, became president of the company in the 1940's, the position his grandfather held for over 40 years.

The 80-Ton Rope Machine

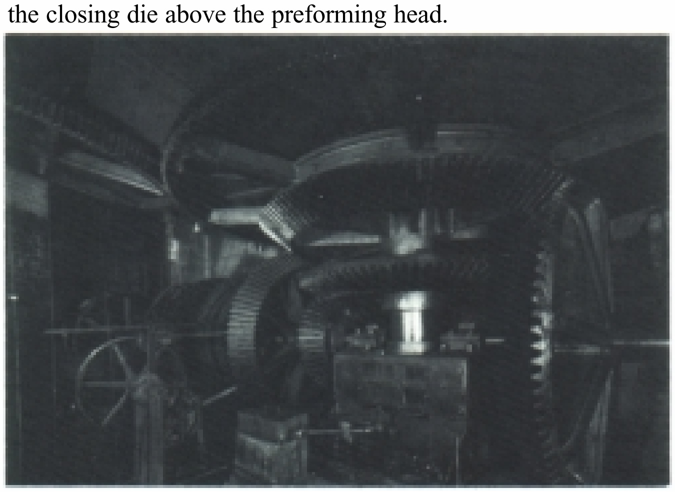
By the early 1890's. cable cars had become a popular means of street transportation in many cities. As usual, the Roeblings had moved quickly to produce wire rope for this new market. Ferdinand's marketing and sales efforts were so successful that for a while the company captured all of the business. The increase in orders outstripped the capacity of the new rope shop that Charles had built in the mid 1880's.

The cable car companies needed exceptionally long ropes with as few splices as possible. In 1893 Charles designed a vertical machine to lay up to 30,000 feet of 1.5 inch rope. It was called the 80-Ton Rope Machine because 80 tons was the total weight of the strand that could be mounted on the machine for one spinning. To house this mammoth, he built a square building on the end of his 1880s rope shop. Because of the machine's size. Charles had to design the machine and the building as an integral unit (see cover illustration). He gave the building a Mansard roof to match the 1885 section of the rope shop which housed the 30-Ton machine. Both of these "rope rooms" are extant today within a larger rope shop that the company built in the 1930's.

As in the earlier vertical machines, six spools of wire or strand are mounted on yokes which are arranged in a circle on a horizontal frame called a spider. The reels were kept tight on the carriages by means of a hemp rope which could be adjusted for greater or lesser tension by a rachet. The spider weighed 10½ tons, while the loaded reels weighed just over 10 tons each.

The spider is mounted on a long vertical shaft, or spindle, which is hollow to accommodate the core strand, which comes up from below. The yokes turned in the opposite direction from the spindle as they rotated around it. This prevented the twist in the strands that would otherwise progressively accumulate from the revolution of the spindle.

At the top of the spindle the strands passed through a pre-forming head which gave them a slight helix or kink. This enabled them to be layed tightly together around the core strand within the closing die above the preforming head.



Drive mechanism in underground pit on 80-Ton Rope Machine, 1987: Jet Lowe, Historic Amercian Engineering Record, for TRCDC.

The finished rope passed over a sheave, or wheel, above the spindle and then passes several times around a pair of pullout drums or wheels. It is the turning of the pullout drums that actually pulled the rope off the spools and through the closing apparatus. The drums were eight feet in diameter and were originally powered by leather belts.

The rope passed over another sheave and down to the floor level where it was wound around a shop spool for handling within the plant. A "fleeting device" moved the rope back and forth across the width of the spool. After cutting to the required lengths and installing special fittings such as end sockets, the finished rope was spun onto shipping reels.

The 80-ton machine is 49 feet tall above the floor, and 64 feet in overall height. The spider, or platform, which supports the strand reels is 20 feet in diameter. The strand reels are 70 inches in diameter, while the take-up reel is ten feet in diameter.

In a 27 feet wide pit that reaches 15 feet below the floor level, there is a series of bevel gears and pinions which turned the spindle and the spools. The primary power for the machine was originally transferred through leather belts to a drum which turned a 5½ inch horizontal shaft. This shaft turned a bevel gear nearly seven feet wide and a pinion 3½ feet wide. The gears could be adjusted to vary the turning of the spools relative to the turning of the spindle, this enabled the machine to produce ropes of different lays, the "lay" being the length that one strand requires to make one turn around the rope. Different applications require different lays. Elevators, for example, require flexible rope with a relatively short lay, while cable cars require ropes of longer lay. John Roebling had developed these various capacities on his earliest vertical machines in the 1850's.

Although the Roebling tradition was to manufacture machine components on site, they jobbed out certain parts to specialty manufacturers. The molded gearing was made by Robert Poole & Son Co. of Baltimore, the spindle and carriages were made by the Bush Hill Iron Works in Philadelphia, the spider was made by the Southwark Foundry and Machine Company in Philadelphia, and the pullout drums and frame were made by the Walker Manufacturing Co. in Cleveland, Ohio.

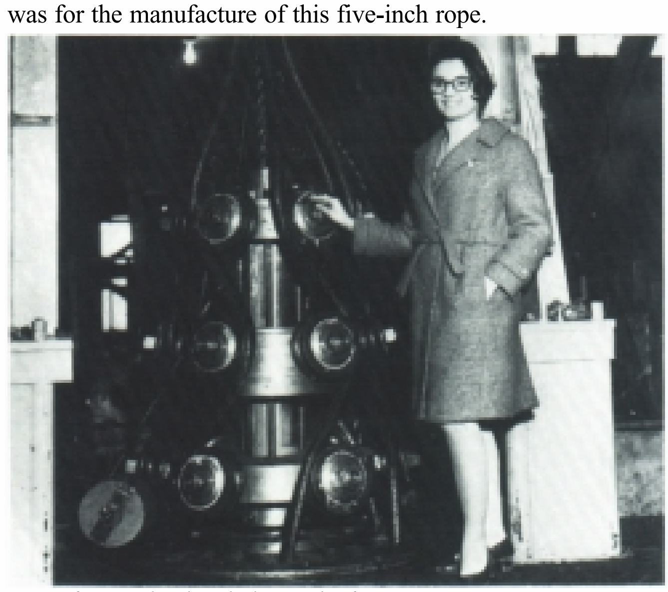
(See page 4 for diagram)

Five-Inch Diameter Wire Rope

After the decline of the cable car business, the company used the machine to produce wire ropes for a variety of purposes. In 1968, the company modified the machine to manufacture its last product: five-inch wire rope, the largest ever made at that time.

The rope operated the boom crane and bucket on a "4250-W" dragline machine made by Bucyrus-Erie for a surface mining and land reclamation operation in southern Ohio. Billed as the world's largest land machine, it was 410 feet long and could hoist material to a height of 18 stories. The bucket had a capacity of 220 cubic yards, or 325 tons of material.

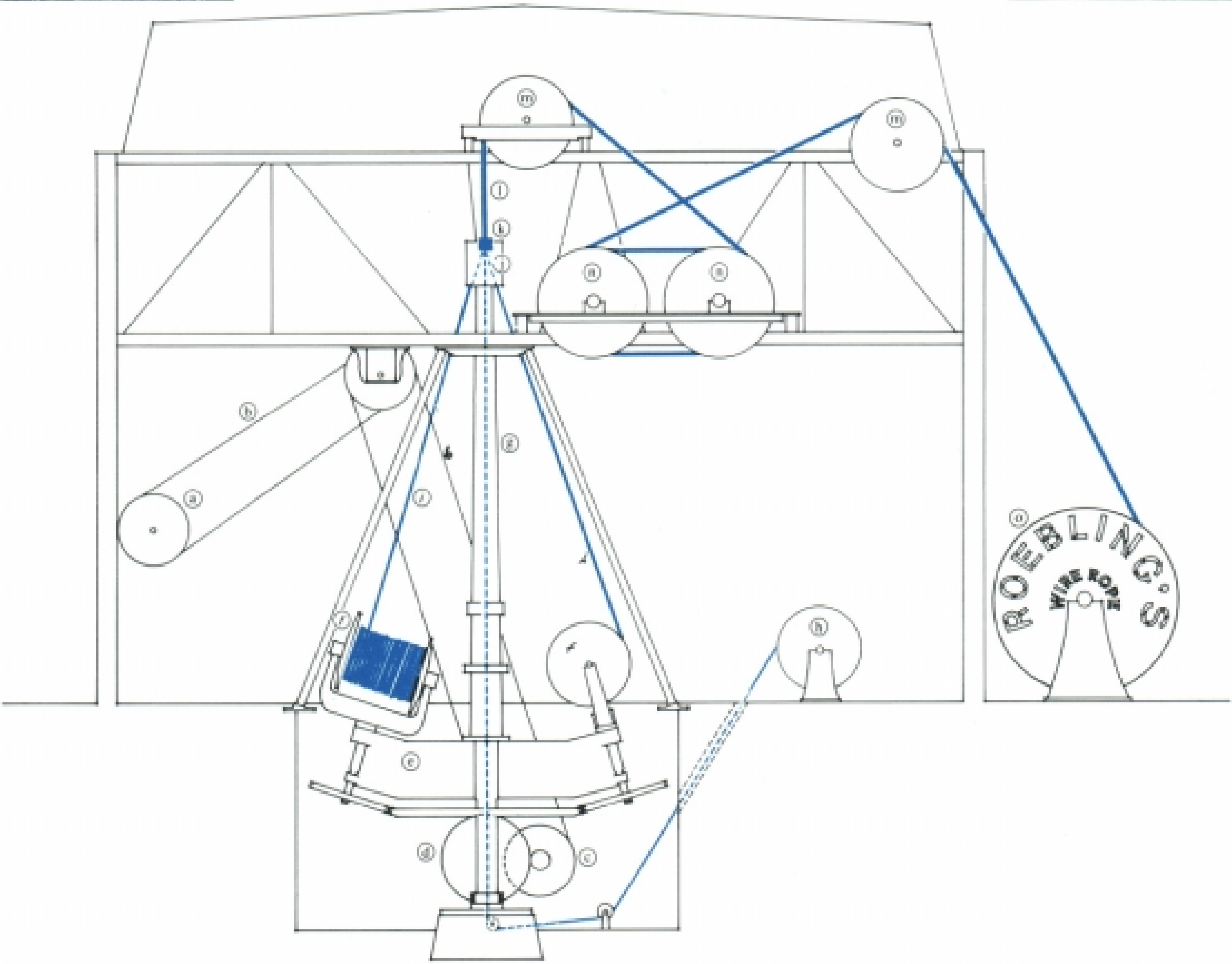
The company set up the machine to make 1300-foot lengths of five-inch wire rope. At 46 pounds per foot, each length weighed 59,800 pounds. The five-inch rope had a breaking strength of 1,080 tons. The company manufactured this rope for five years, and then leased the machine to the American Steel & Wire Company (AS&W), a Division of U.S. Steel which occupied the site across the former canal from the Roebling works. The basic configuration of the machine today exists as it was for the manufacture of this five-inch rope.



Preforming head and closing die for 5"wire rope on 80-Ton Wire Rope Machine, 1 968: John A. Roebling's Sons Co. Division of Colorado Fuel & Iron Company.

The Brooklyn Bridge. Showing the use of wire rope.

Section of 2¾," wire rope, taken from the Golden Gate Bridge when replaced in 1976.



Schematic drawing showing operation of 80-Ton Rope Machine, 1989: Y.S. Huang for TRCDC.

Roebling 80-Ton Wire Rope Machine

a) Main drive pulley
b) Leather drive belts
c) Pulley supplying power to lower drive
d) Gears driving spindle and strand reels
e) Spider supporting strand reels
f) Strand reels (6)
g) Spindle (with hollow center for core strand)

h) Core strand reel
i) Strand
j) Preforming head—forms helix in strand
k) Closing die—"lays" strands together into rope
1) Finished rope

m) Transfer sheaves
n) Powered pull-out drums with grooves for pulling strand off reels and through closing die.
o) Take-up reel (1968 adaptation)

Acknowledgements: The Greater Trenton Section of the American Society of Mechanical Engineers is most grateful to the Trenton Roebling Community Development Corporation (TRCDC), to DKM Properties Corporation, and to the Delaware Valley Junior League for their assistance with the ceremony arrangements; to Richard Brackin, Chairman of the ASME Greater Trenton Section History and Heritage Committee for supervising this project from the nomination of the machine through the preparation of the brochure and ceremony; to Clifford W. Zink, TRCDC Executive Director, for writing this brochure and supplying the photographs, to Yun Sheng Huang for drawing the schematic cross section of the 80-Ton Rope Machine; and to Ken Leyden/PHP Typography, *Philadelphia,* for Design and Typography.

Trenton Roebling Community Development Corporation (TRCDC)

Community residents, local business persons, and elected officials formed TRCDC in 1985 to plan and promote the preservation and redevelopment of the John A. Roebling's Company and the American Steel & Wire Company historic industrial sites.

With support from the City, Mercer County, the State, N.J. foundations, and private contributions, TRCDC in 1987 produced a mixed-use Redevelopment Plan. The plan calls for converting the largely vacant 45 acre site into housing, offices, light industry, retailing, and cultural facilities. Following documentation by the Historic American Engineering Record in the summer of 1987, TRCDC nominated the site to the National Register of Historic Places as the Trenton Historic Industrial District.

To promote understanding of the historical significance of the Roebling and AS&W complexes, TRCDC has: published a reproduction of an 1898 watercolor painting of the Roebling Works from the collection of the N.J. State Museum; and researched and written a history of the Roebling Company. TRCDC is working to create in the former Roebling machine shop **"The Invention Factory:"** an interactive museum/learning center which will present the history of the companies and the people responsible for Trenton's great industrial heritage in an interactive learning environment.

DKM Properties Corporation

Founded in 1984, DKM has grown into one of central N.J.'s largest private development corporations. DKM has been particularly active in the revitalization of New Brunswick and Trenton. DKM has owned approximately one half of the Roebling site, including the 80-Ton Rope Machine, since 1984, and has acquired the American Steel & Wire site. Recognizing the historical and architectural significance of the site, DKM has proposed a Phase I redevelopment which will convert vacant historic buildings to offices and retailing, with the 80-Ton Rope Machine as a special exhibit.

Landmark Ceremony Planning Committee

1) ASME National Headquarters, Carron Garvin-Donahue;
2) ASME Greater Trenton Chapter, Richard Brackin P.E., Chariman, History and Heritage Committee, Lou Gallagher P.E., Alfred Colabella P.E., Gerry Koo P.E., Mike Mazzarella, Dr. Philip Wolf, Jim Miller;
3) Trenton Roebling Community Development Corporation, Clifford Zink, Executive Director, Nancy Beer, Vice Chairperson;
4) DKM Properties Corporation, Patrick Henry, Grace Alexander, Kurt Hubert;
5) Delaware Valley Junior League, Rachel Herr.

ASME History and Heritage Committee

To implement and achieve public service goals, the ASME formed the History and Heritage Committee in 1971, comprised of mechanical engineers, historians of technology and the Curator of Mechanical and Civil Engineering at the Smithsonian Institution. Its purpose is to recognize and record mechanical engineering achievements of outstanding significance.

Each of these designated landmarks of a local, national, or world wide scope represents a progressive step in the evolution of mechanical engineering. The ASME History and Heritage program illuminates our technological heritage and serves to encourage the preservation of historically important artifacts. It provides an annotated roster for engineers, students, educators, historians, and travelers.

For further information, contact the Public Information Department of the American Society of Mechanical Engineers, 345 East 47th St., New York, N.Y. 10017, 212-705-7740.

History of the Greater Trenton Section of the ASME

The Greater Trenton Section of ASME includes Mercer and Burlington Counties in New Jersey and Bucks County in Pennsylvania. Prior to 1948, the ASME membership in these counties were included as part of the Philadelphia Section. During 1948 the Trenton sub-section was chartered, mainly under the influence of a group of ASME engineers from the DeLaval Steam Turbine Company, with about 400 members.

From that time, the Section evolved as follows:

1) In 1956, the Trenton ASME group became independent of the Philadelphia section and was chartered as the Trenton Section with a total membership of approximately 600 members.

2) As of 1976 the ASME-Bucks County Group was formed as a sub-section under the Trenton Section.

3) During 1982, The ASME-Bucks County Group was brought back into the main section, which was named the Greater Trenton Section of ASME, with approximately 800 from the counties.

4) In 1988, the Greater Trenton Section undertook the designation of the Roebling 80-Ton Wire Rope Machine as a National Mechanical Engineering Landmark.

With few exceptions, the Section has eight monthly dinner meetings each year with programs (speakers and plant tours) that are aimed at the professional development of our members. In the past ten years, the Section has also been active in supporting the ASME Student Sections at Trenton State College and Princeton University.

Resources: *John A. Roebling's Sons Company, Blue Center, (company periodical), Trentoniana Collection, Trenton Public Library.*

John A. Roebling's Sons Company, Division of Colorado Fuel and Iron Company, CF&I Steel Manufacturers Biggest Wire Rope Ever Made, Press Release, February 13, 1968.

Mumford, John Kimberly, "Outspinning the Spider: The Story of Wire and Wire Rope," Robert L. Stillson Co., New York, 1921

Roebling, John A. and the John A. Roebling's Sons Company, Rope Machine Drawings, Roebling Collection, Special Archives. Rensselaer Polytechnic Institute.

Sayenga, Donald, "Roebling and Ellet," American Canal and Transportation Center, York, Pa., 1983.

Schuyler, Hamilton, "The Roebling's: A Century of Engineers, Bridge Builders, and Industrialists," Princeton: Princeton University Press, 1931.

Zink, Clifford, and Hartman, Dorothy, "Spanning the Industrial Century: The History of the John A. Roebling's Sons Company, Trenton New Jersey," manuscript, 1989, (to be published by TRCDC in 1990).