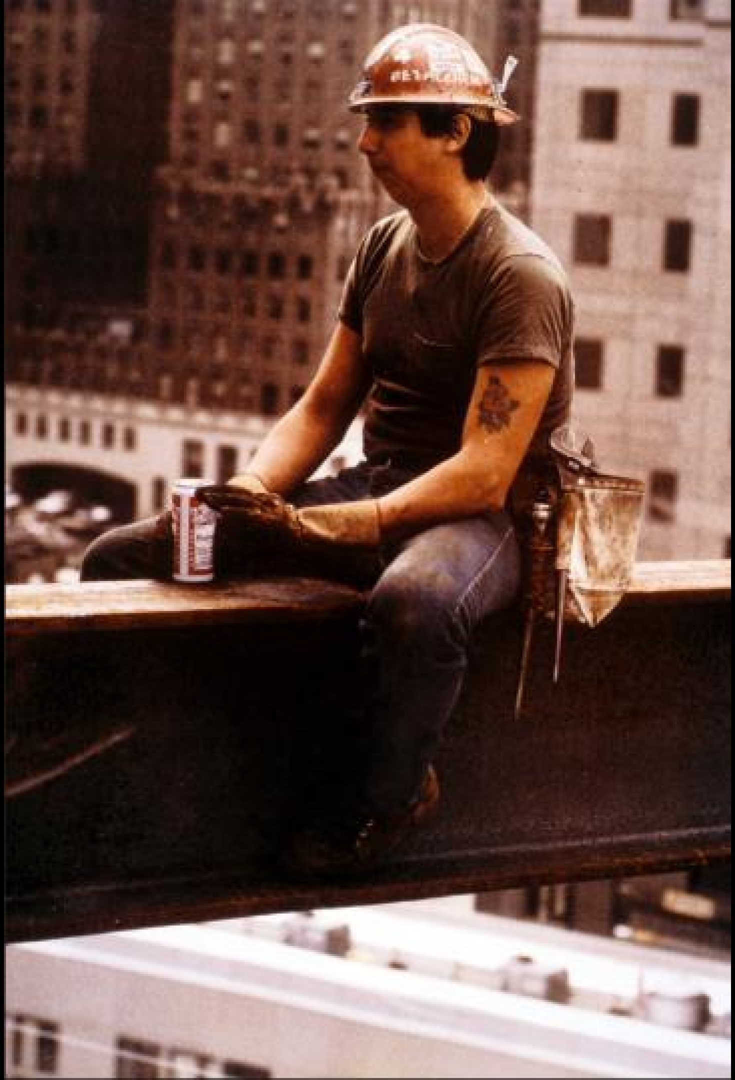
From Iron to Steel
~ technique to technology~

Part One: Material advances
and to the Invention and uses of Framing





Pig Iron

~noun

1. Iron tapped from a blast furnace and cast into pigs in preparation for conversion into steel, cast iron or wrought iron.
2. Iron in the chemical state in which it exists when tapped from the blast furnace without alloying or refinement

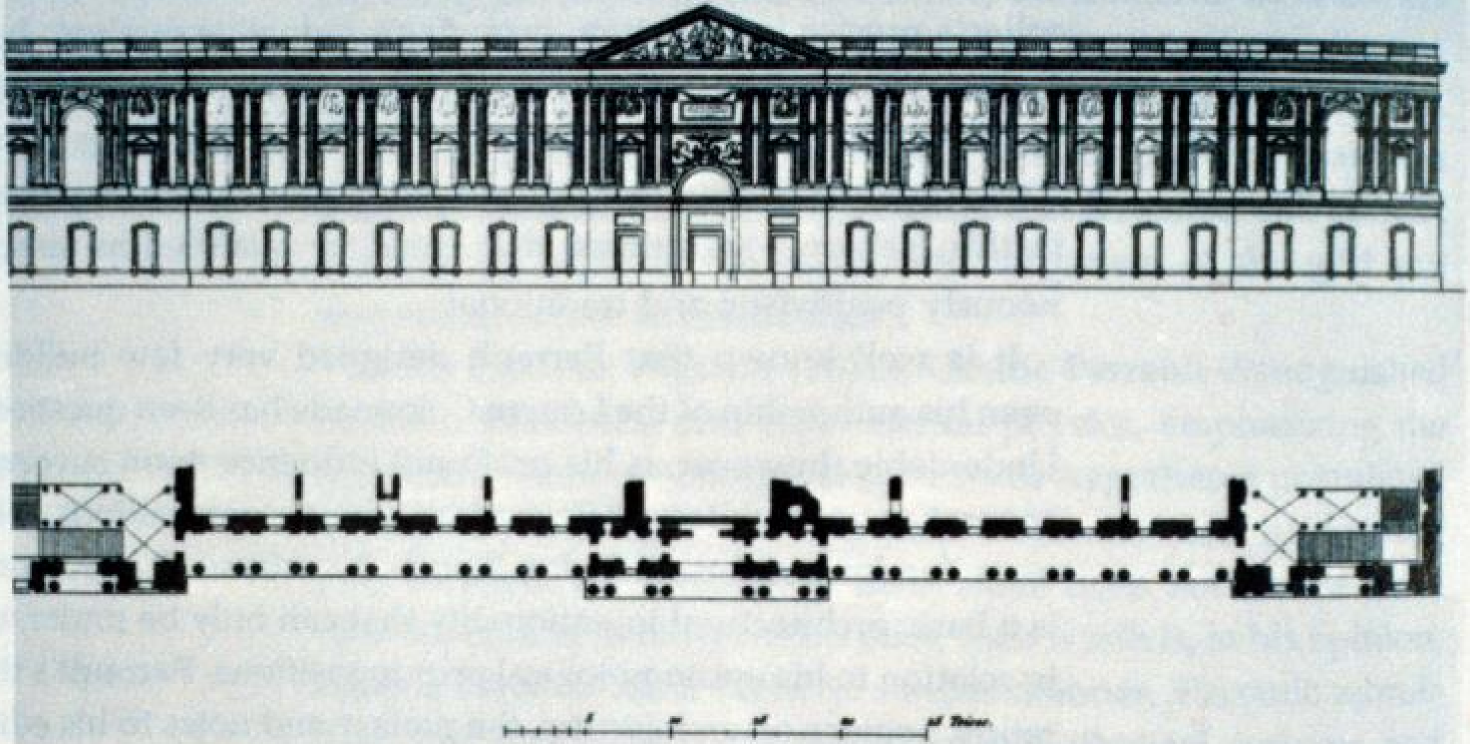
[Origin: 1655-65]

Wrought iron
~ noun
A form of iron, almost entirely free of carbon and having a fibrous structure including a uniformly distributed slag content that is readily forged and welded

Inherently better at resisting corrosion

Cast iron
~noun
An alloy of iron containing so much carbon that it is brittle and so cannot be wrought but must be shaped by casting – meaning heating to a much higher temperature so it can liquefy

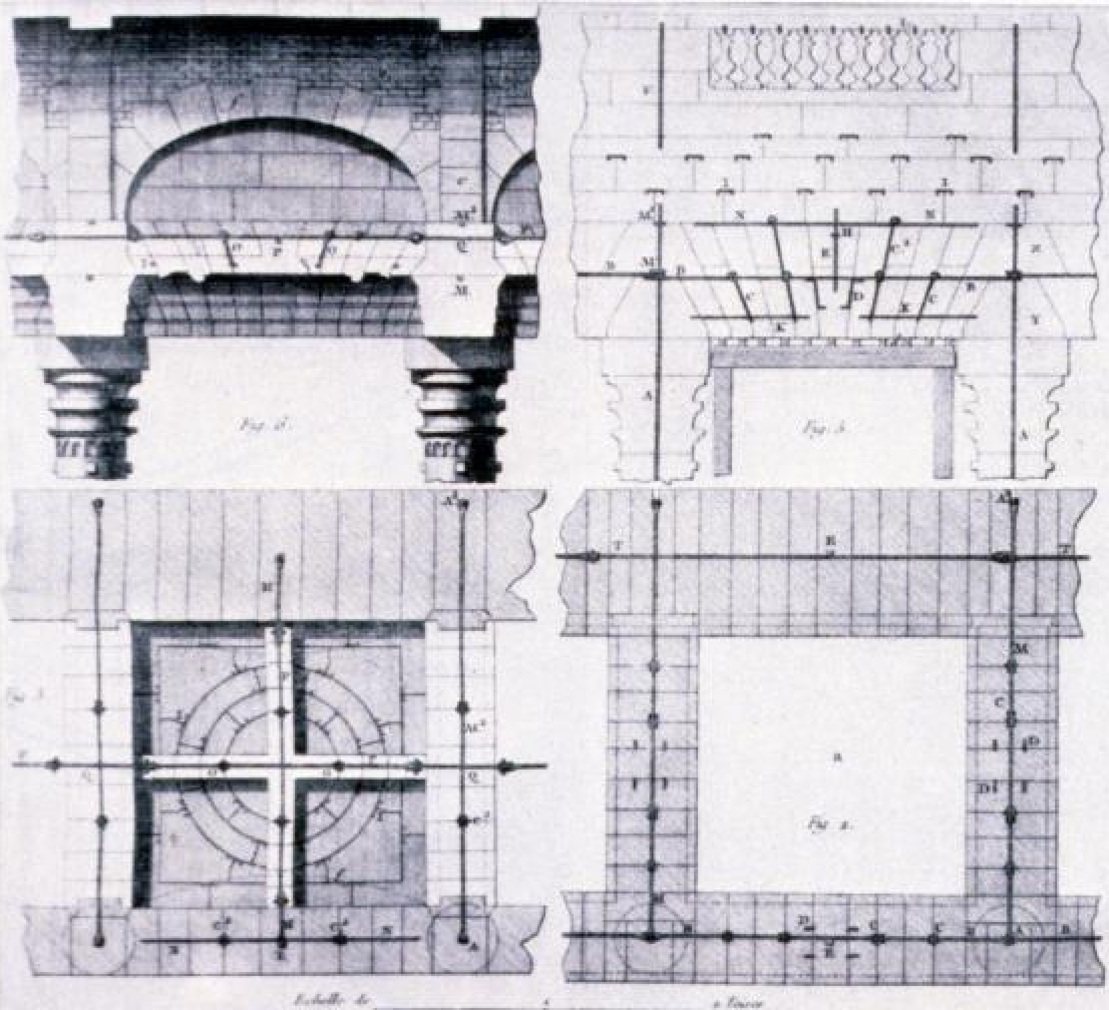
Claude Perrault
East Façade of the Louvre Museum
Paris, France
1680



Perrault's design for the eastern facade of the Louvre with its controversial paired columns, from Quatremère de Quincy's *Histoire de la Vie et des Ouvrages des Plus Célèbres Architectes* (1830).

Place de la Concorde
Anges-Jacques Gabriel
Paris, France
1755

The obelisk was
stolen from the
Temple at Luxor



Construction des Platebandes de la Place de Louis XV. a Paris.

Church of Ste. Genevieve
(Pantheon)
Paris, France
Jacques-Germain Soufflot
Jean-Baptiste Rondelet
1789

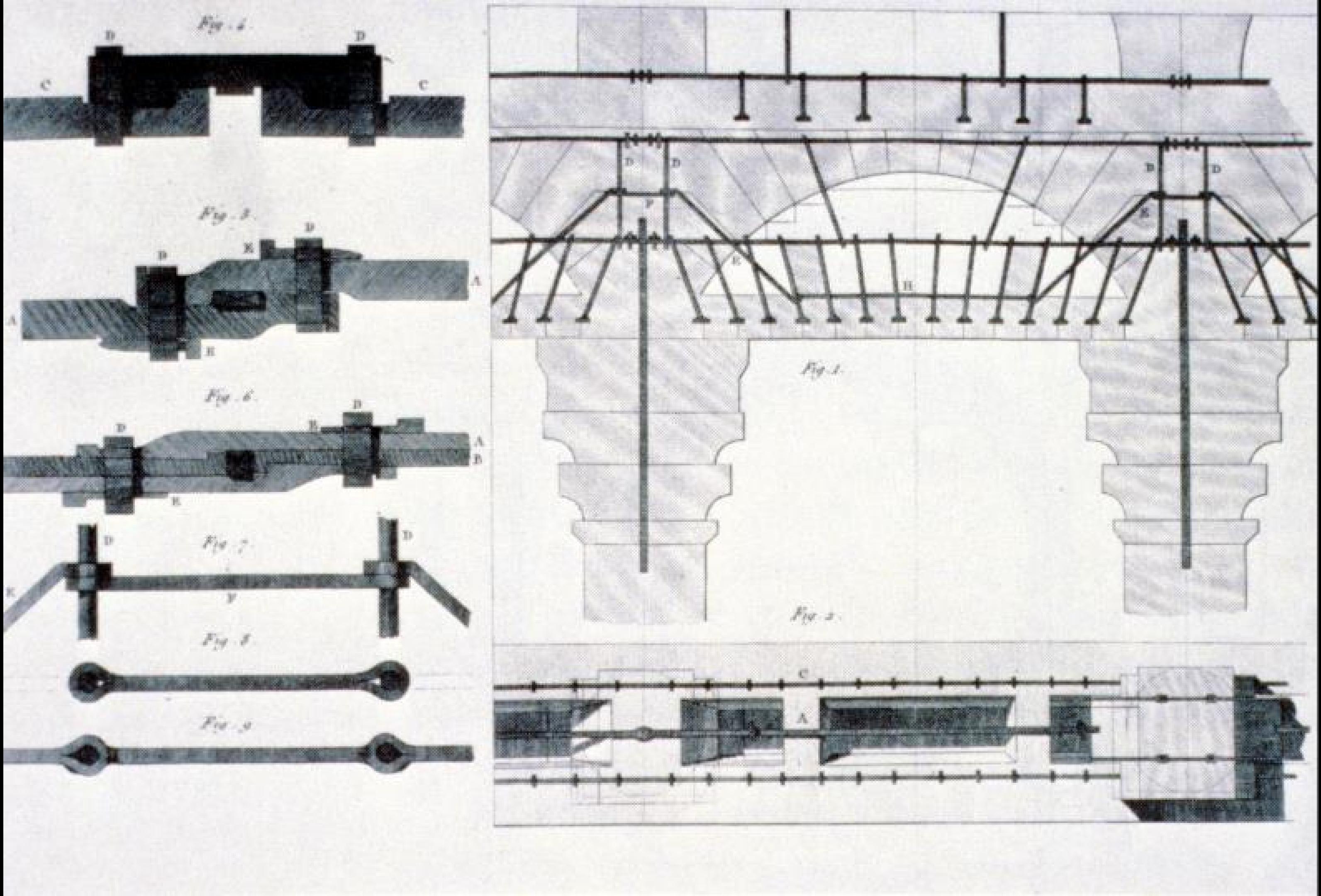


Fig. 4
Fig. 5
Fig. 6
Fig. 7
Fig. 8
Fig. 9
Fig. 1
Fig. 2

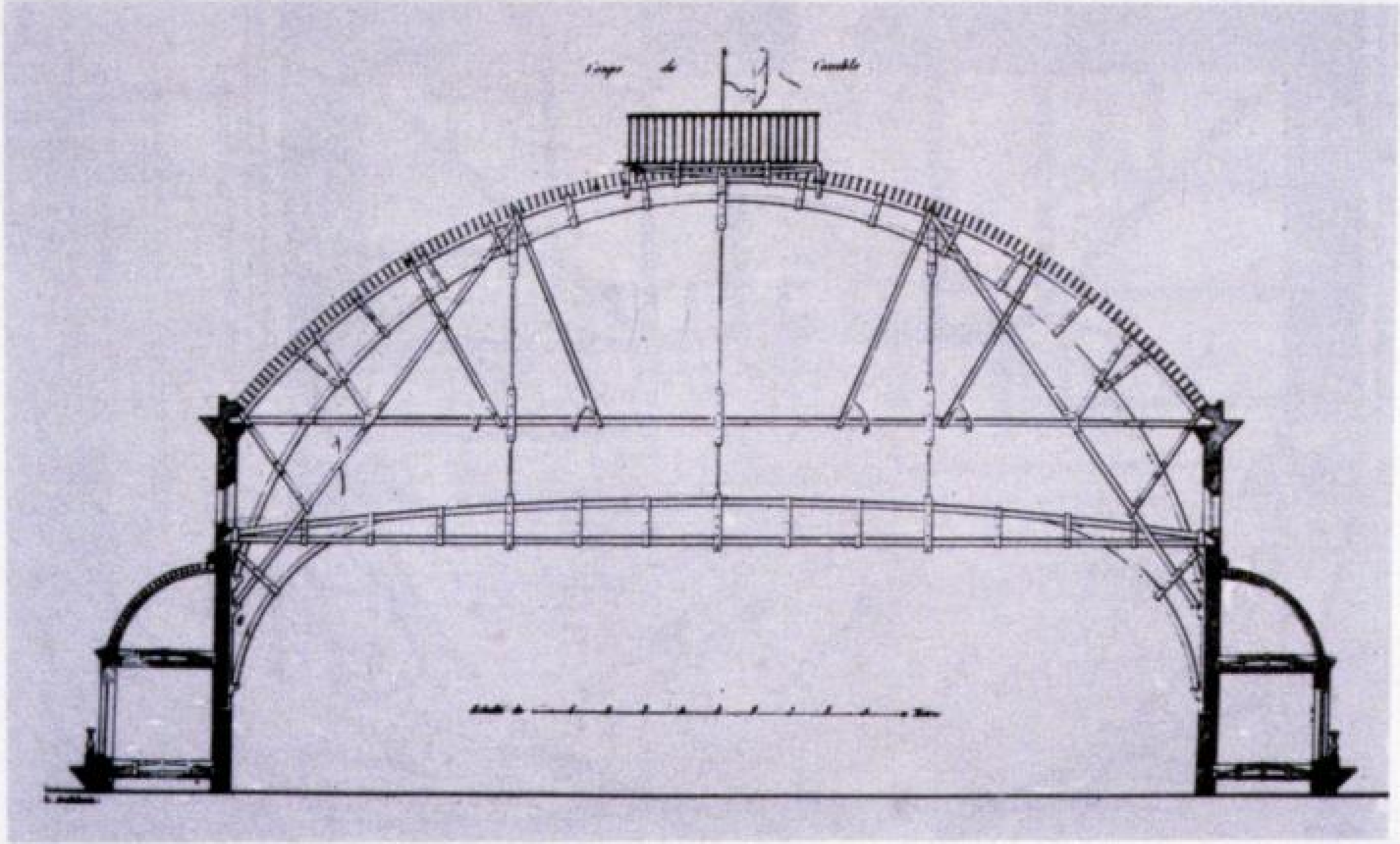
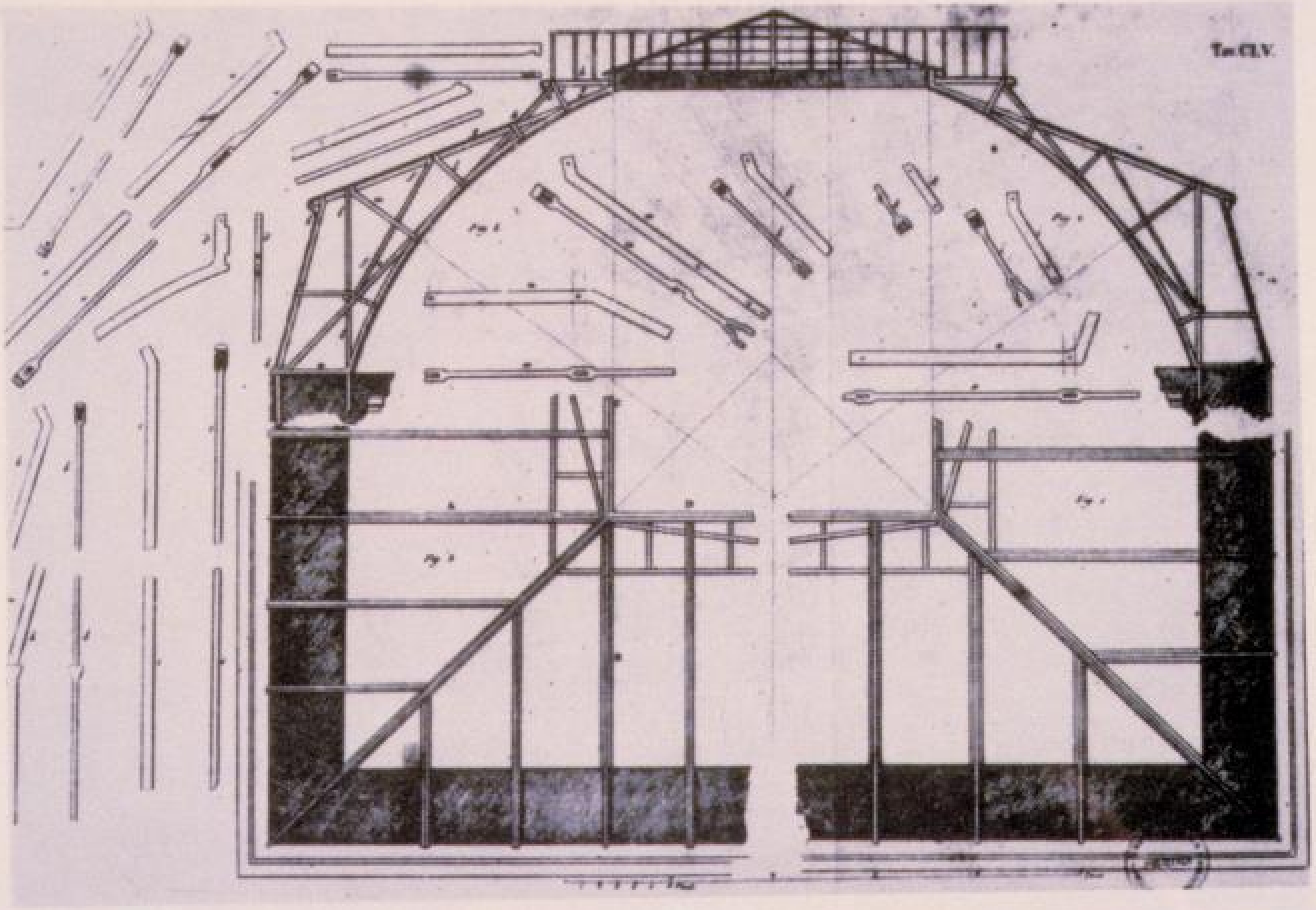


Plate 5. Victor Louis. Théâtre Français, Paris, 1786 (Rondelet, *L'Art de bâtir*, pl. 154)

Plate 6. Auguste Rénard. Iron roof over the Salon adjoining the Grande Galerie, Louvre, Paris, 1789 (Rondelet, *L'Art de bâtir*, p. 155)



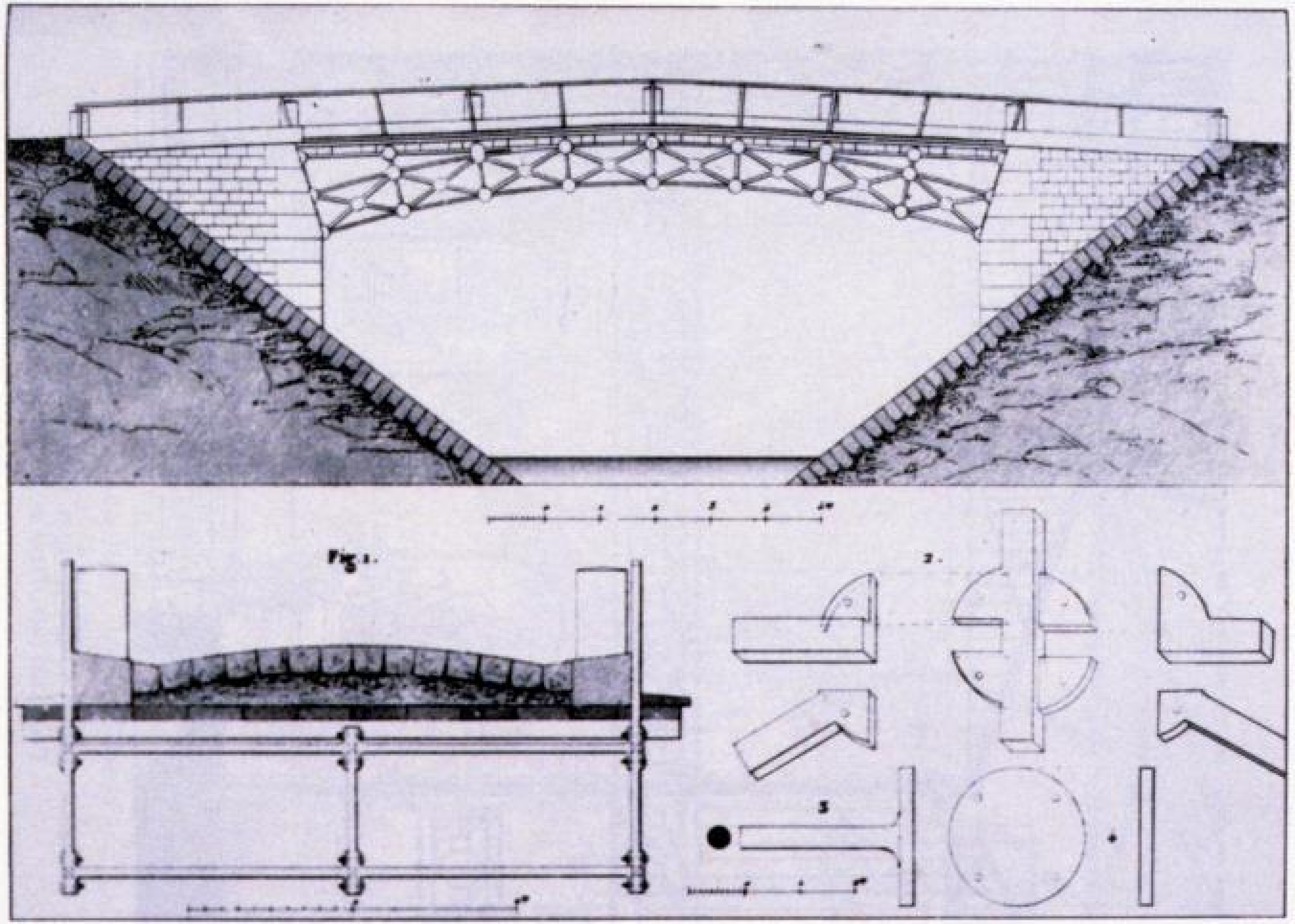


Plate 9. Louis Bruyère. Pont sur la Crou, near Saint-Denis, 1808 (Thiollet, 1832, p. 32)

Pont des Arts
Louis-Alexandre de Cessart and Jacques Dillon
Paris, France
1804
Original 9 arch bridge rebuilt
1984 with 7 arches

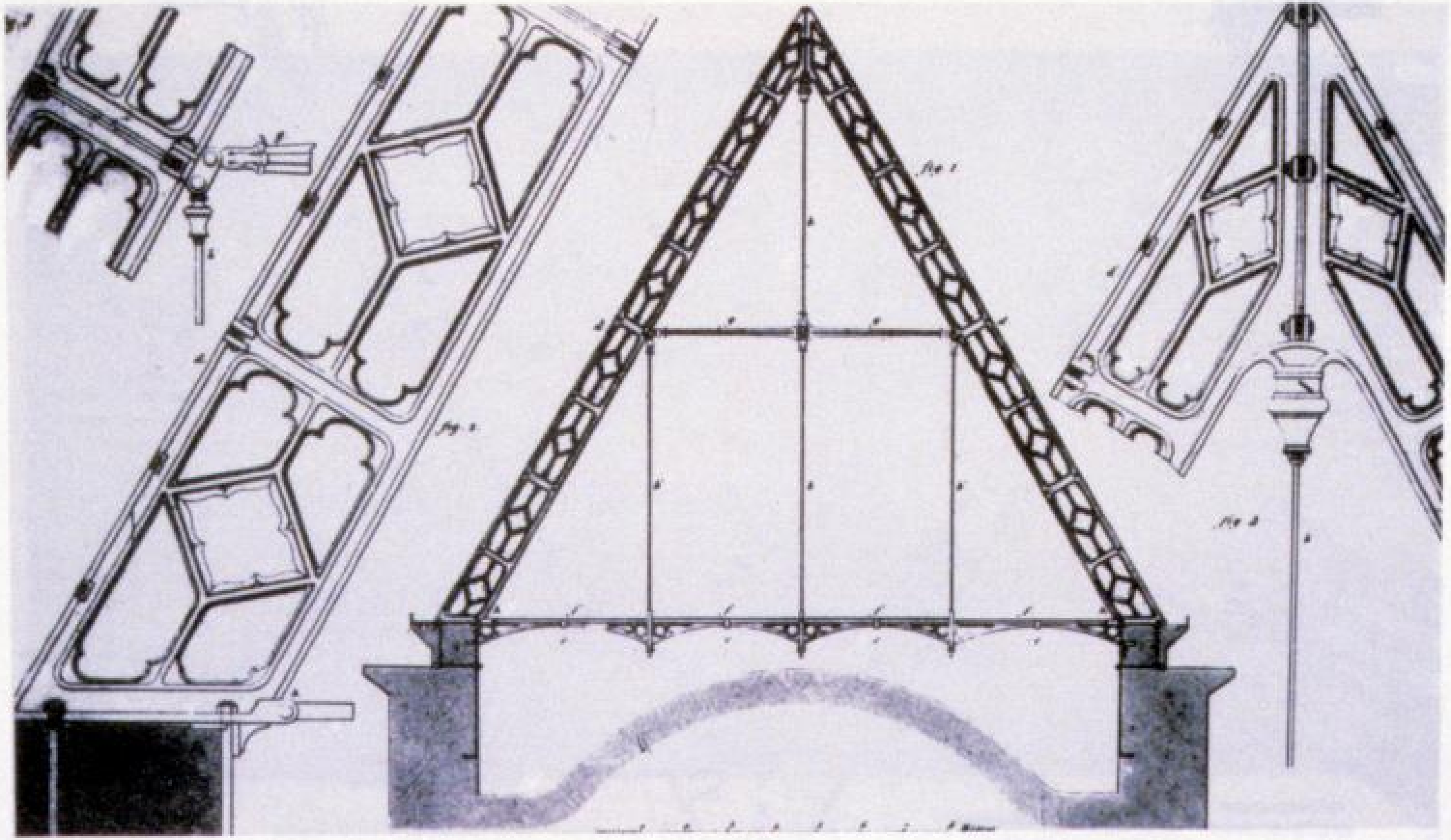
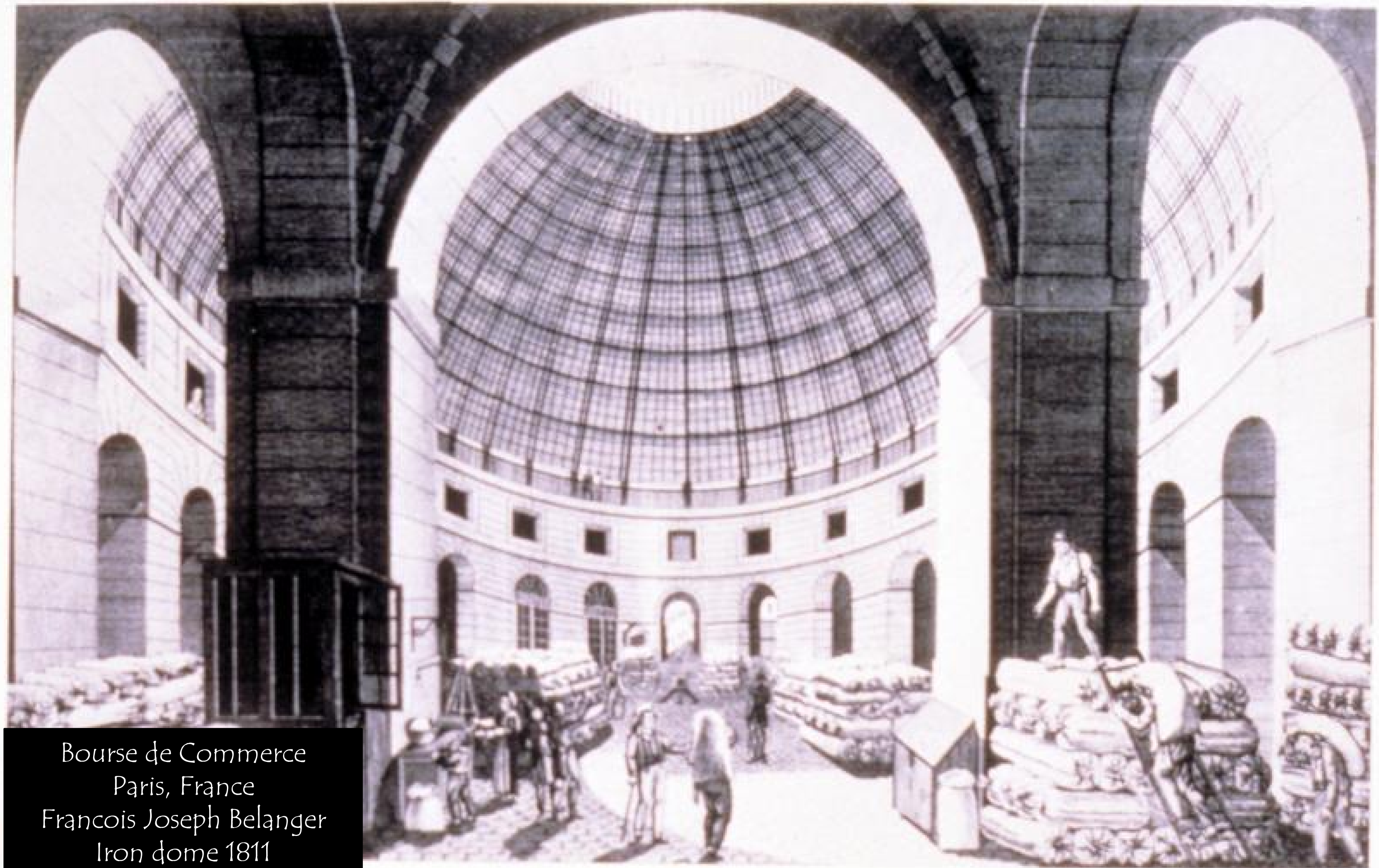


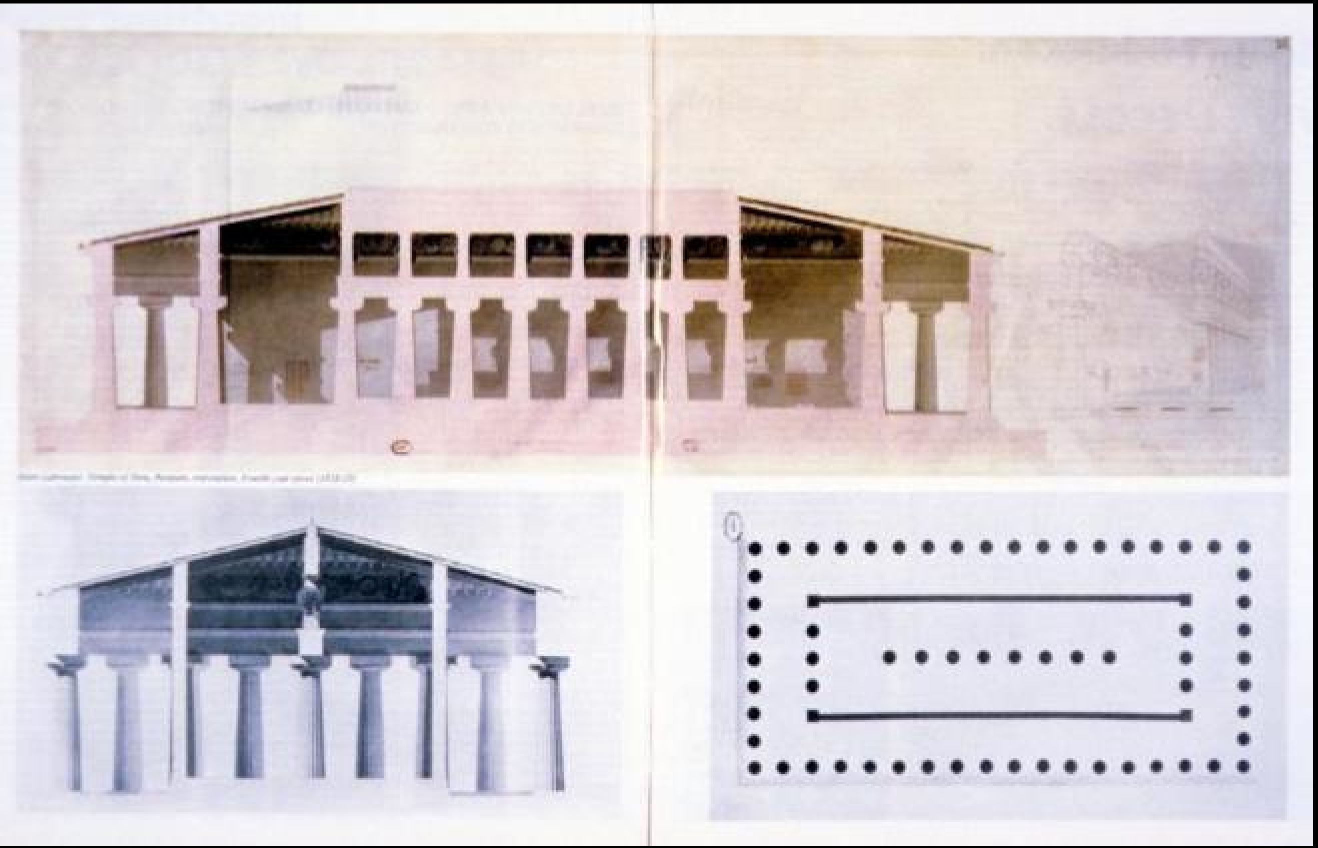
Plate 35. Leturc. Project for the roof of Chartres Cathedral, 1836 (Eck, *Traité de construction,* pl. 28)

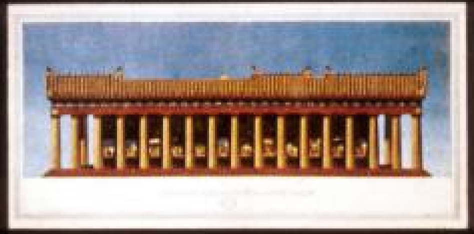


Bourse de Commerce
Paris, France
Francois Joseph Belanger
Iron dome 1811

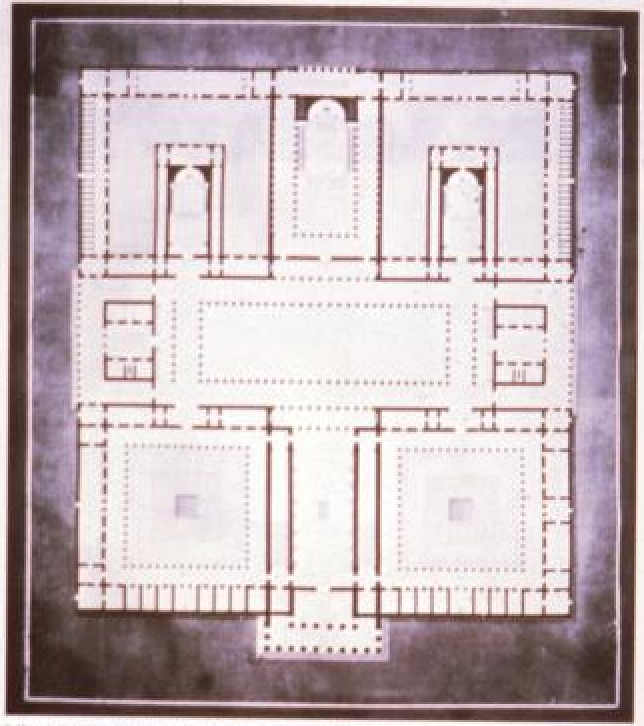

Renovation/Restoration
Tadao Ando

Henri Labrouste
Ecole des Beaux Arts
1801 to 1895
Structural Rationalism



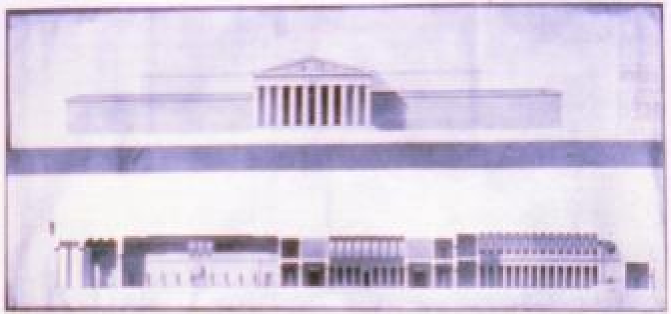


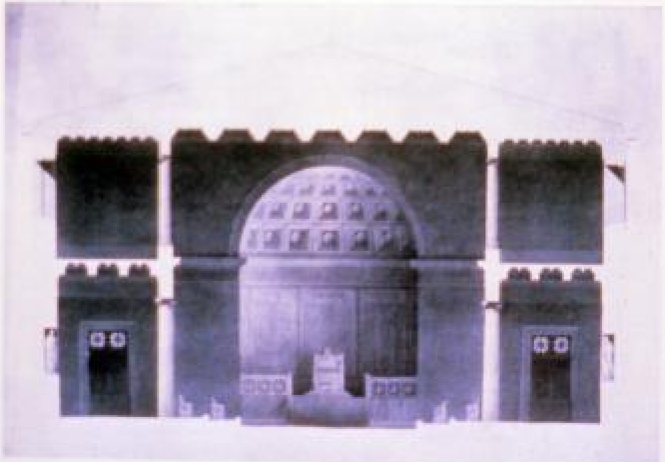
ΜΦΣ
ΕΝ



3 Henri Labrouste, plan of the Tribunal de Cassation, 1er Grand Prix, 1824

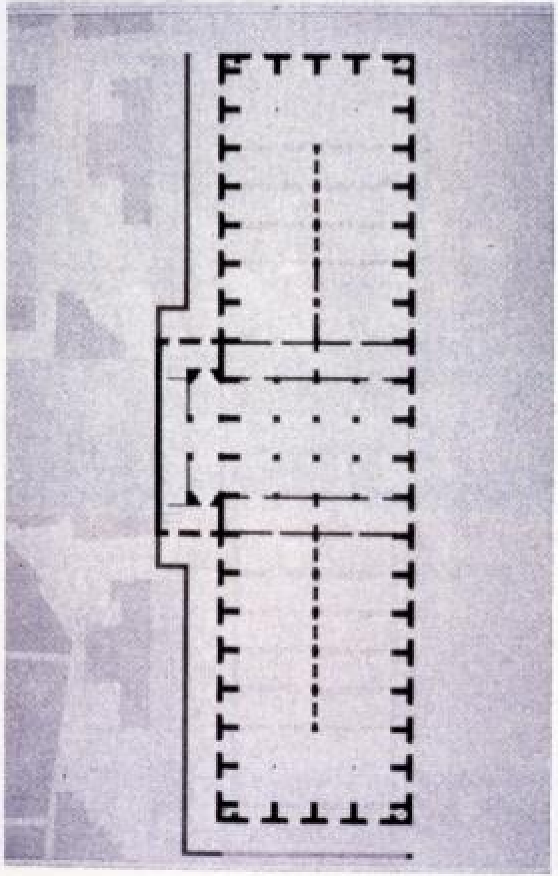
3 Henri Labrouste, plan du Tribunal de Cassation, 1er Grand Prix, 1824.

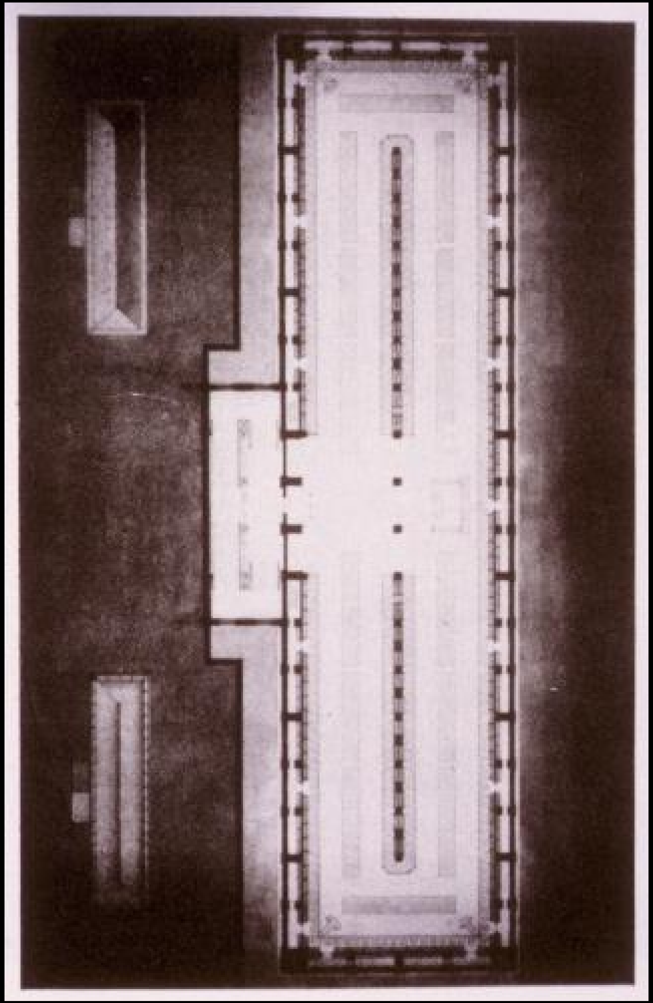


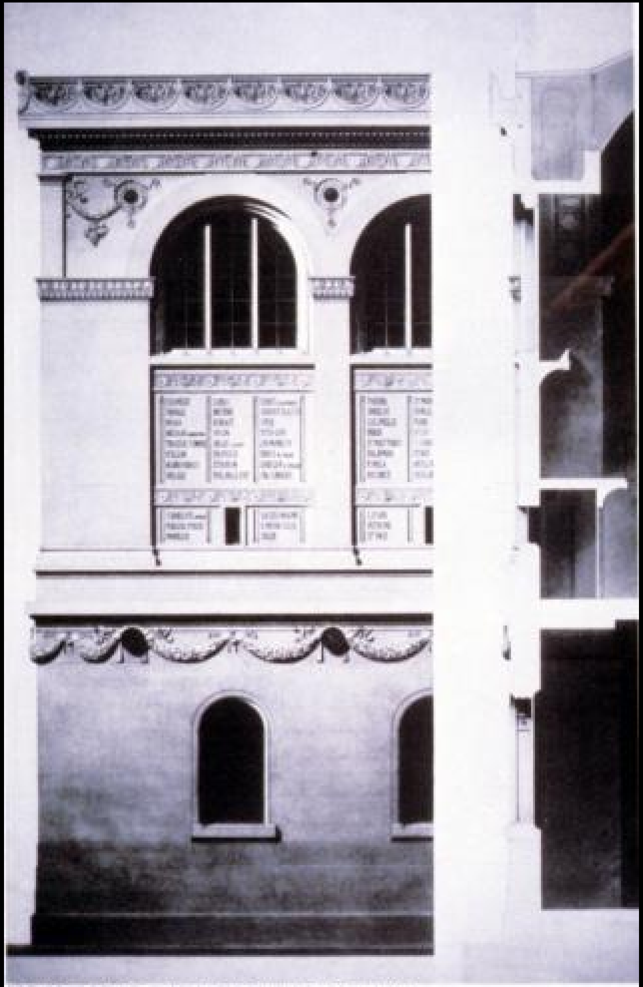


Biblioteque Sainte-Genevieve
Paris, France
Henri Labrouste
1838-1851

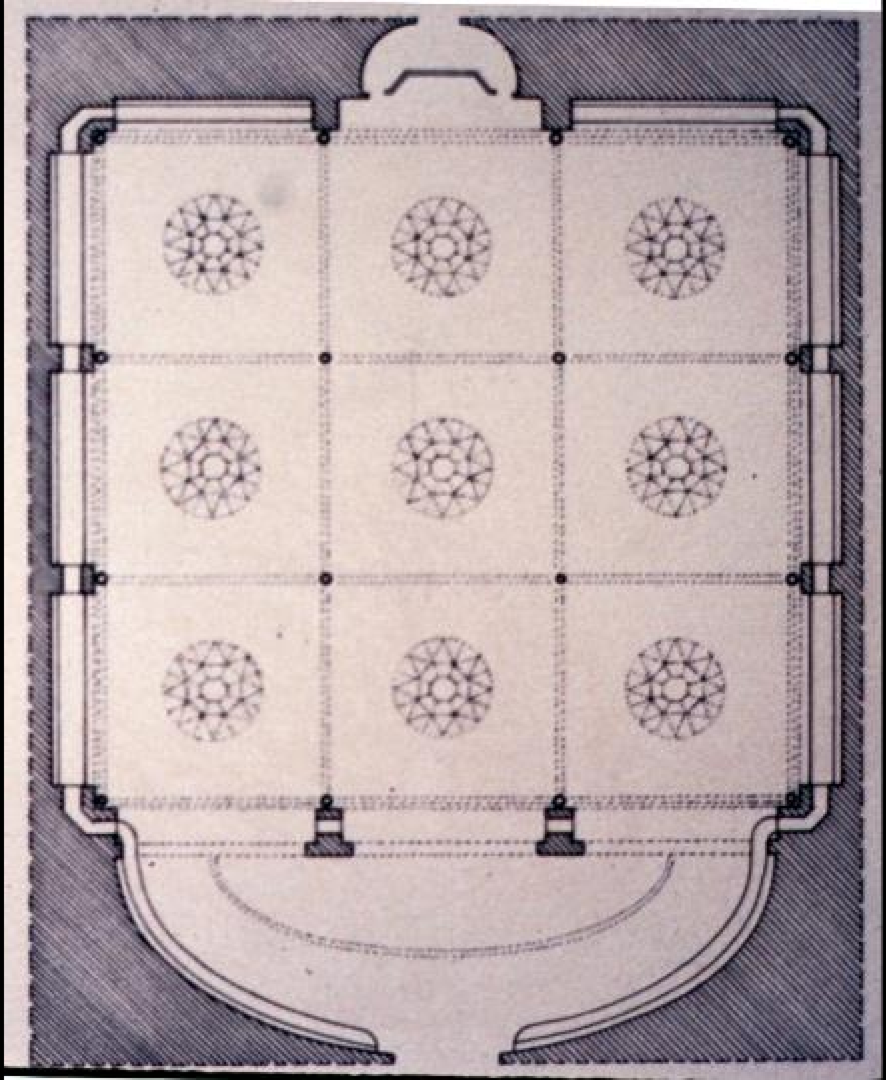
Henri Labrouste's Bibliothèque Sainte-Geneviève, Paris, 1838-50



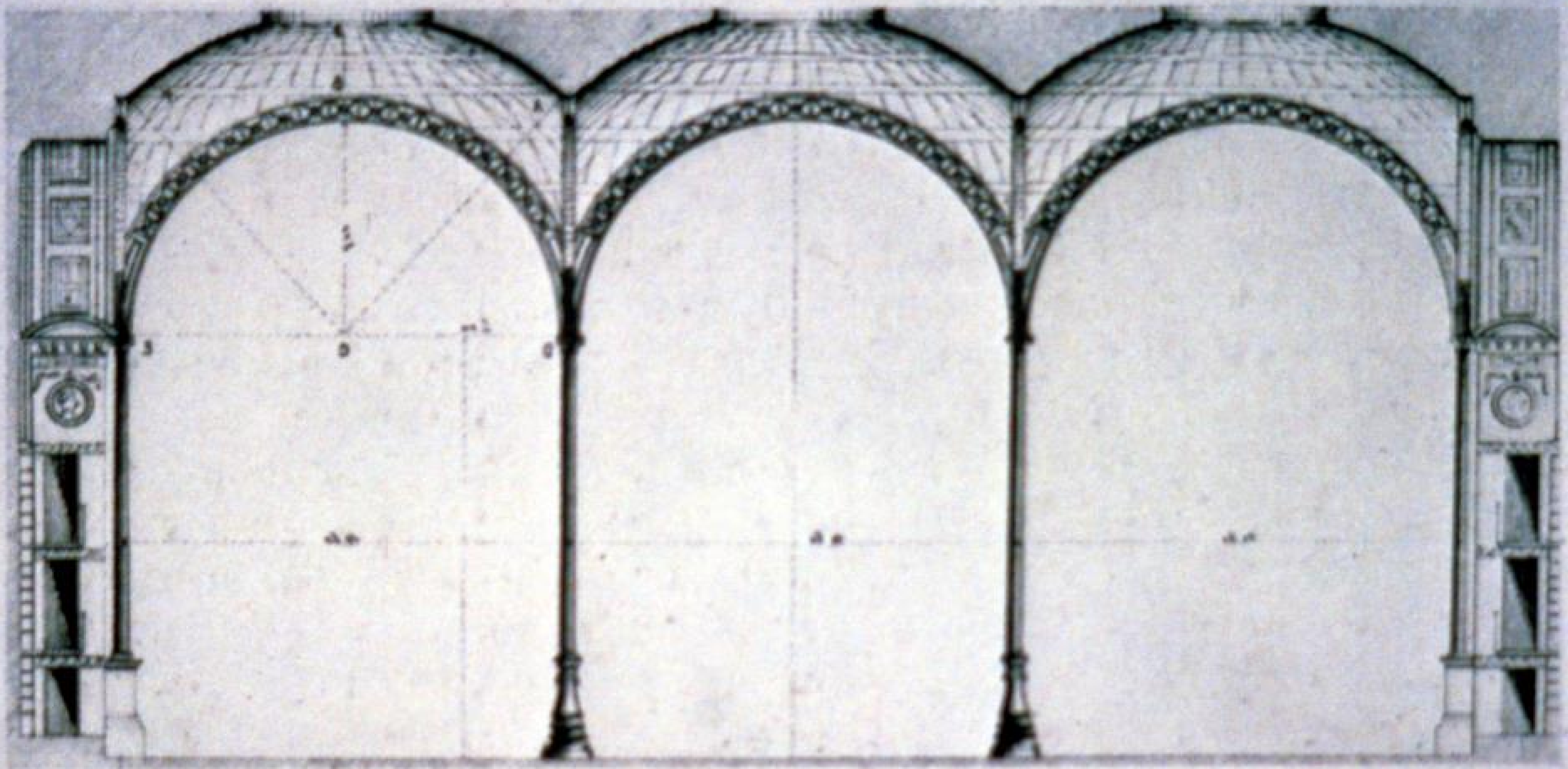


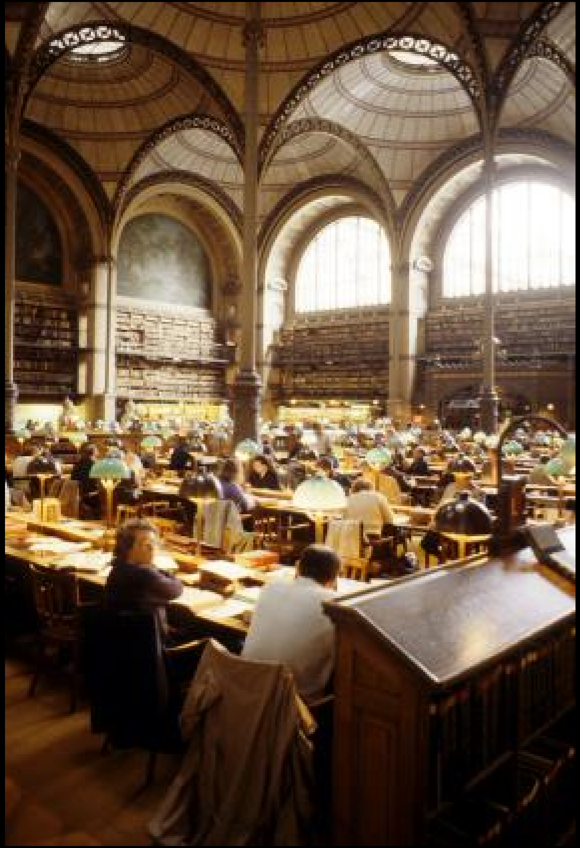


Bibliothèque Sainte-Genevieve d'Henri Labrouste à Paris (1838-50)



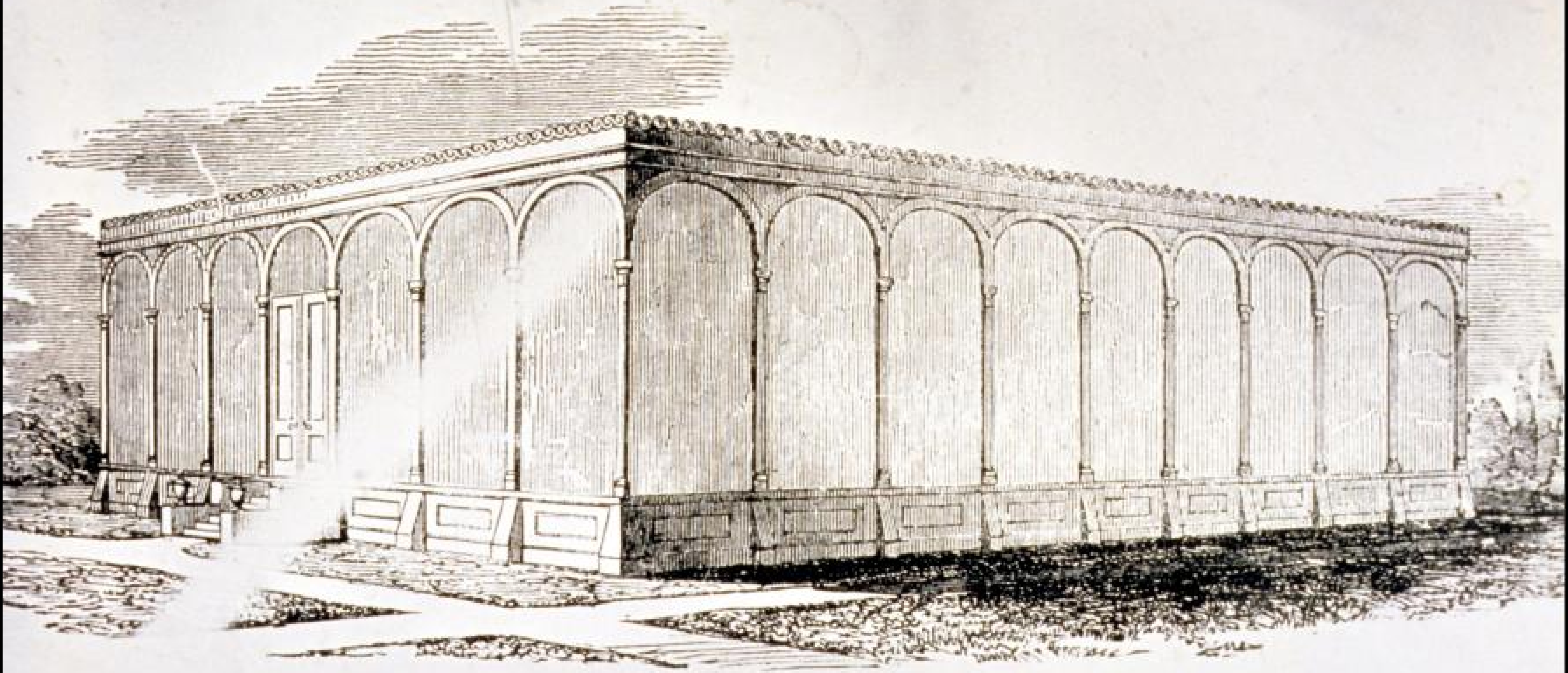
Biblioteque Nationale de France
Paris, France
Henri Labrouste
1862 to 1868



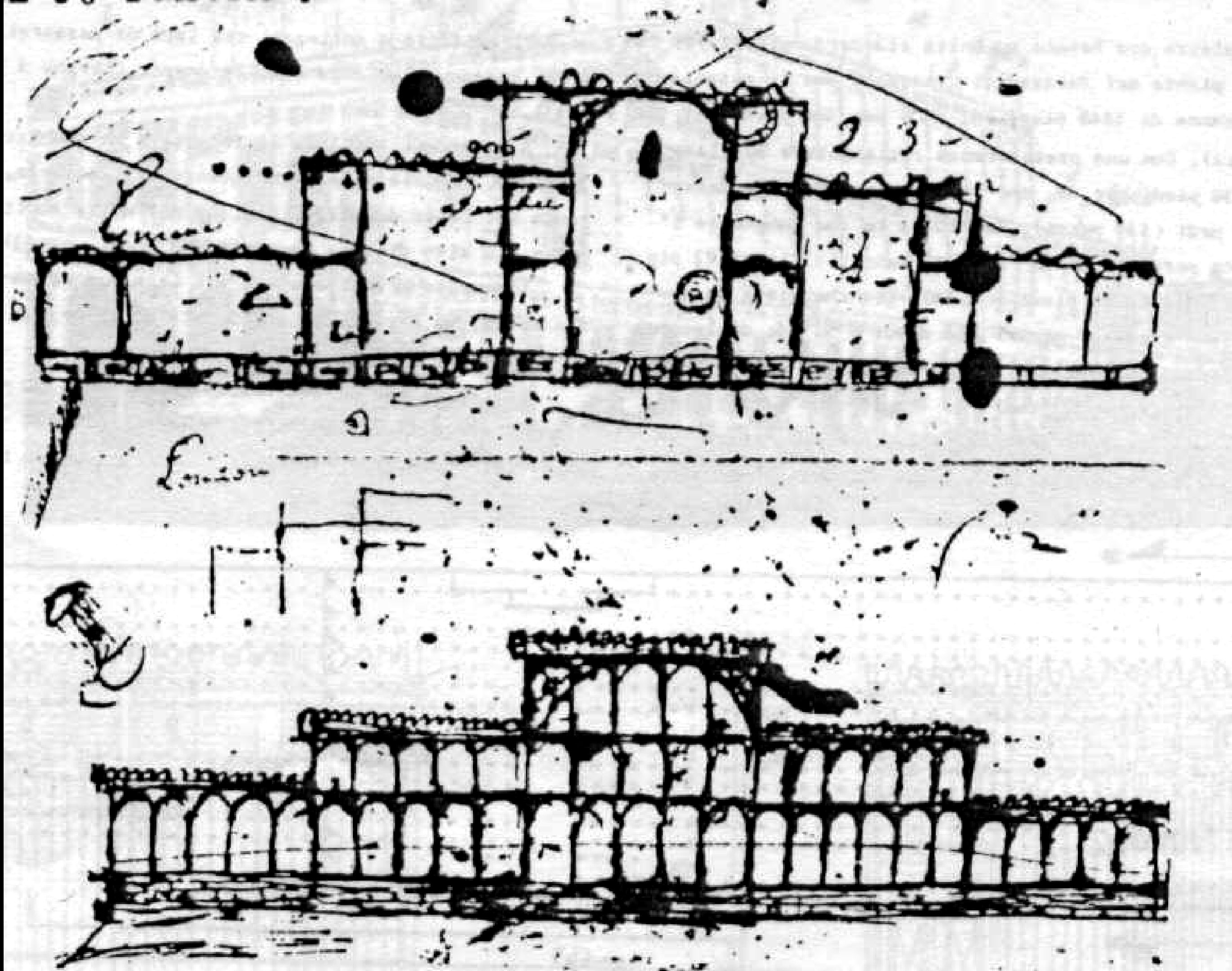

Invention usually requires
NEED

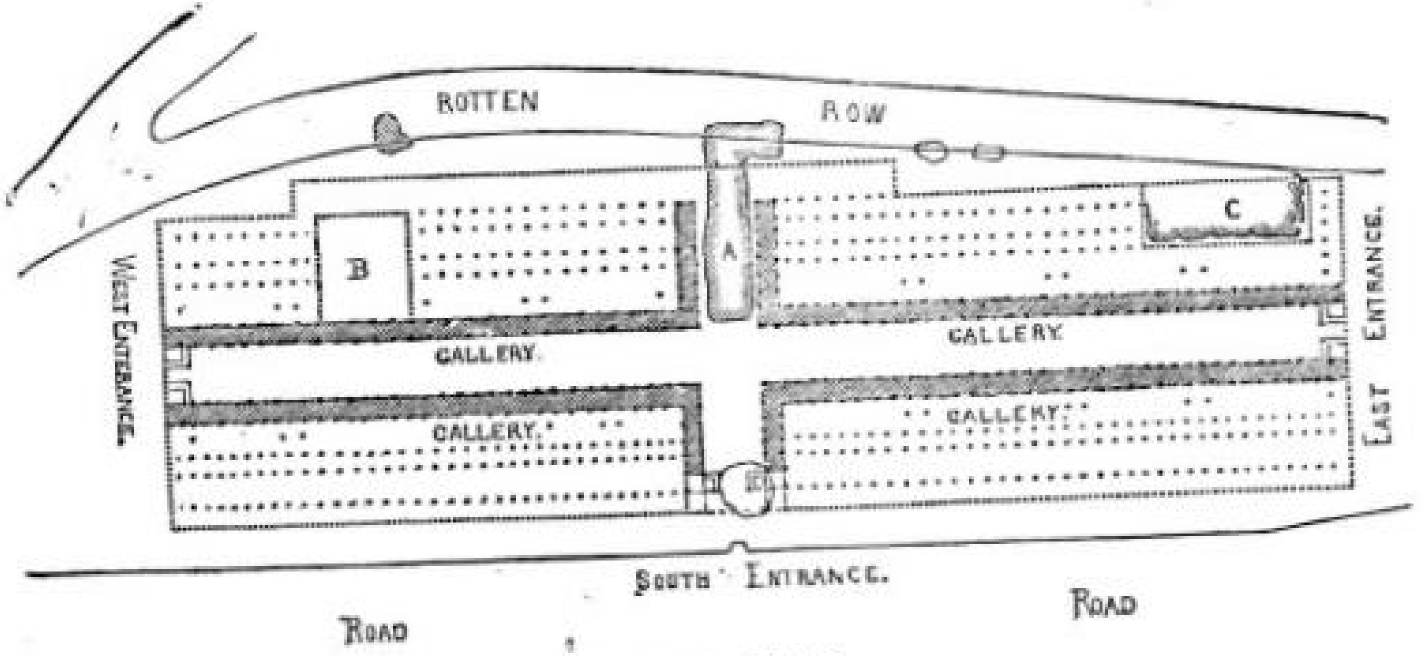
Sir Joseph Paxton
British Gardener
1803 - 1865



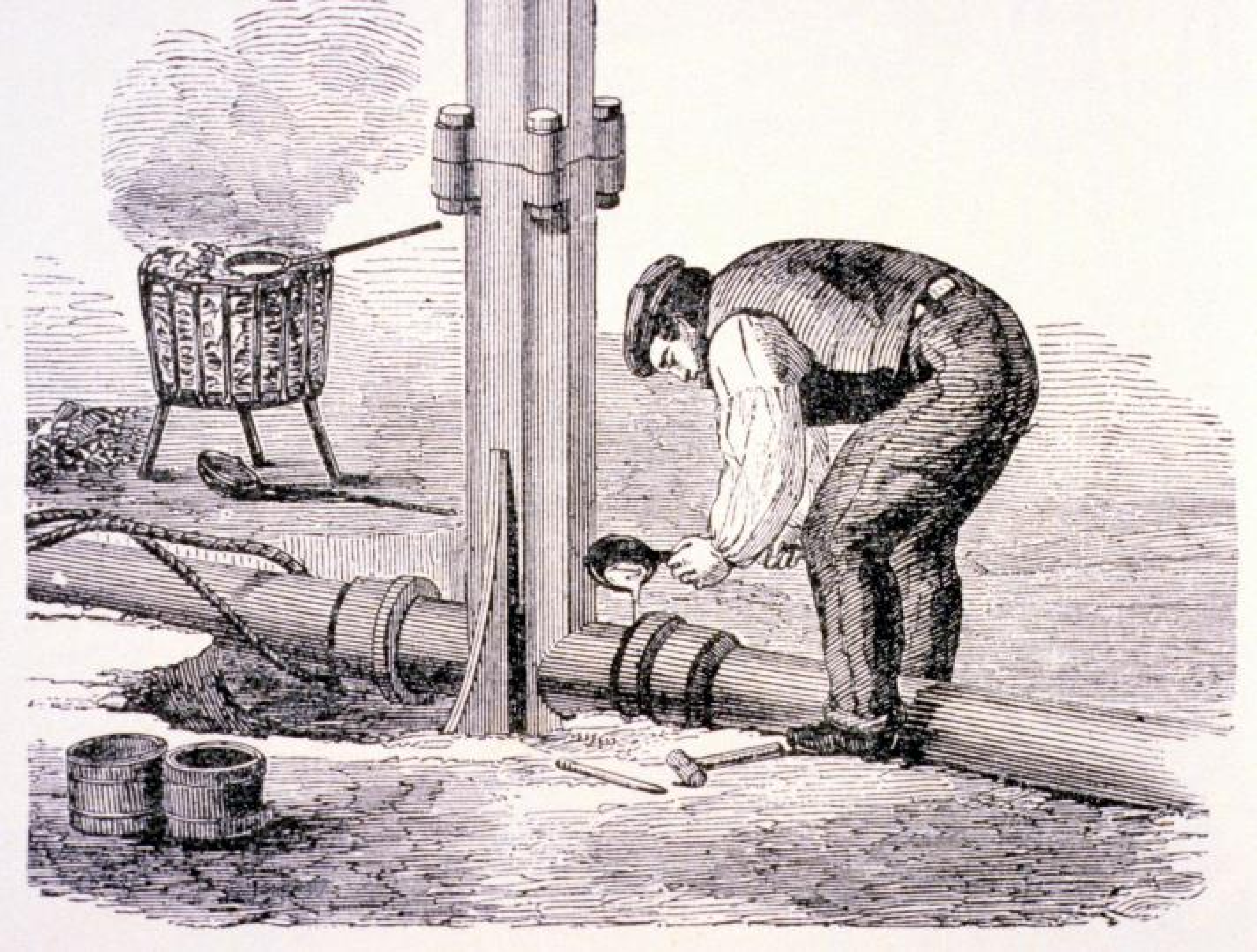
THE NEW VICTORIA REGIA HOUSE.—EXTERIOR.

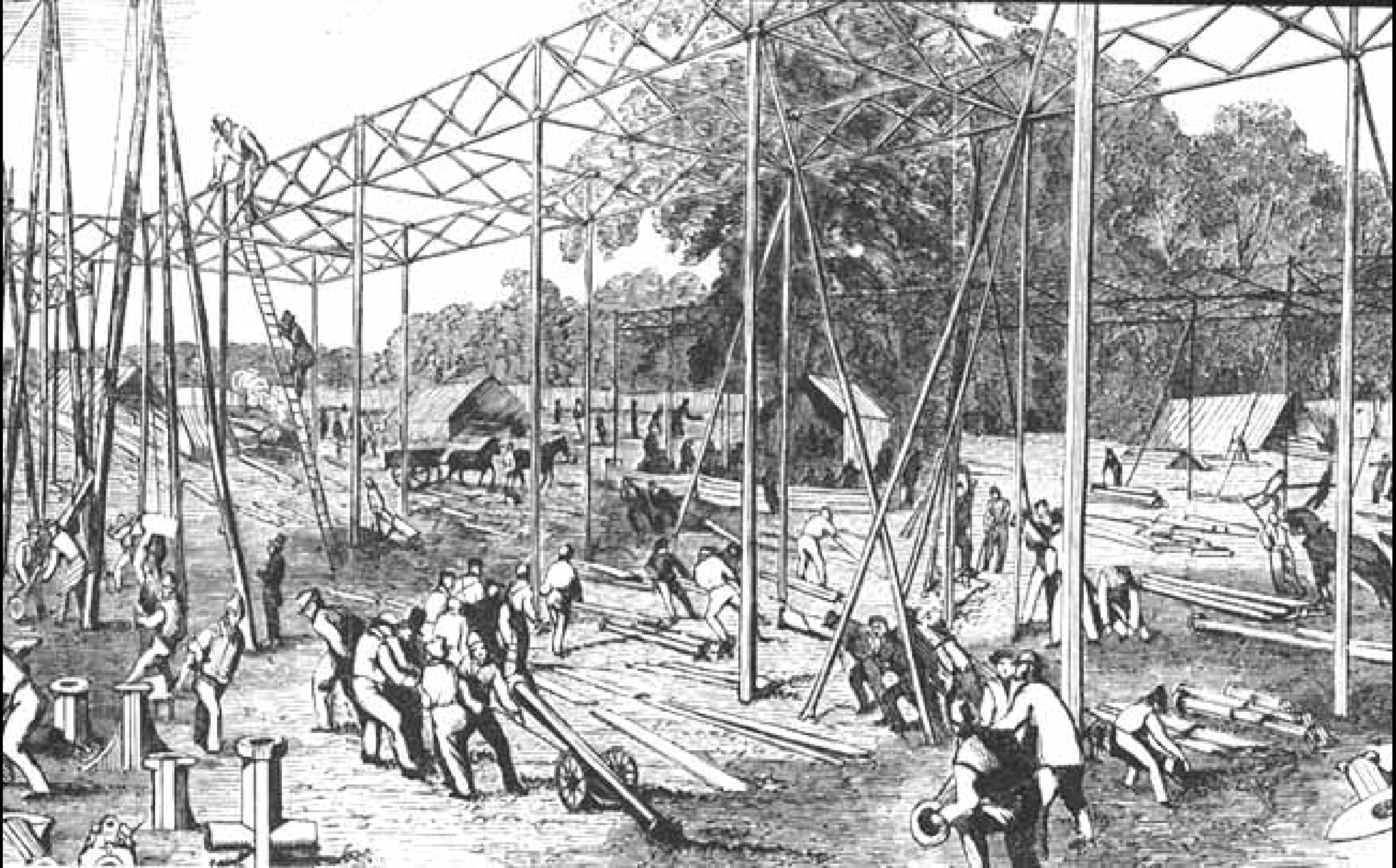
The Great Exhibition 1851
Hyde Park, London, England
Sir Joseph Paxton

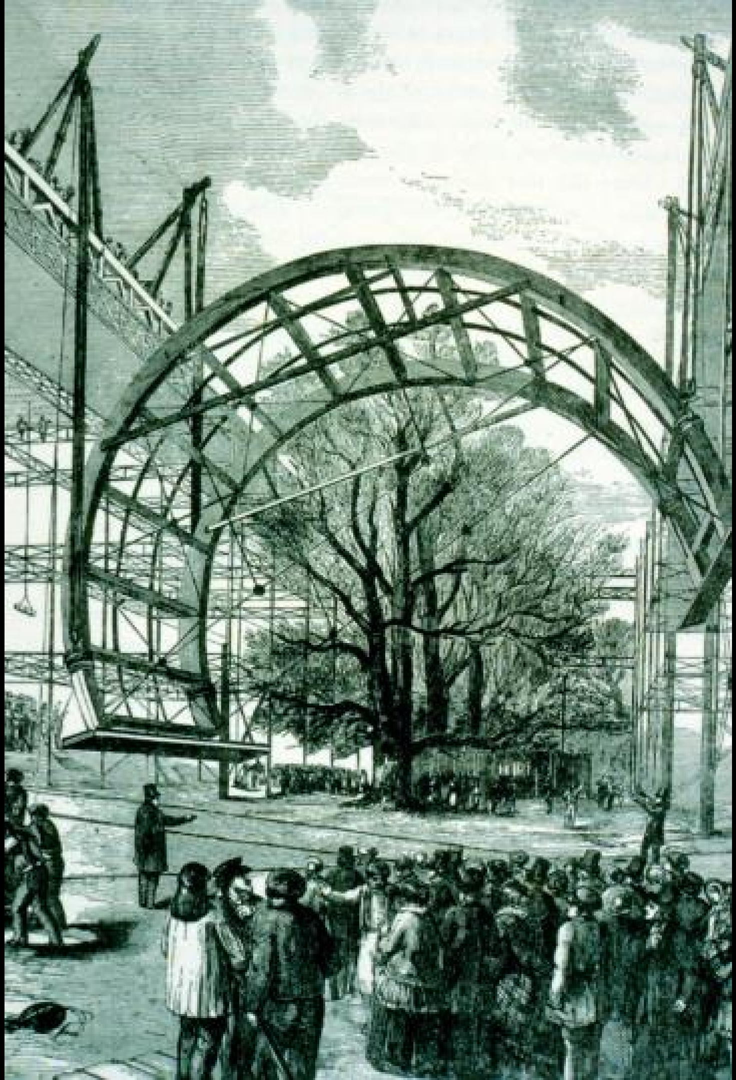


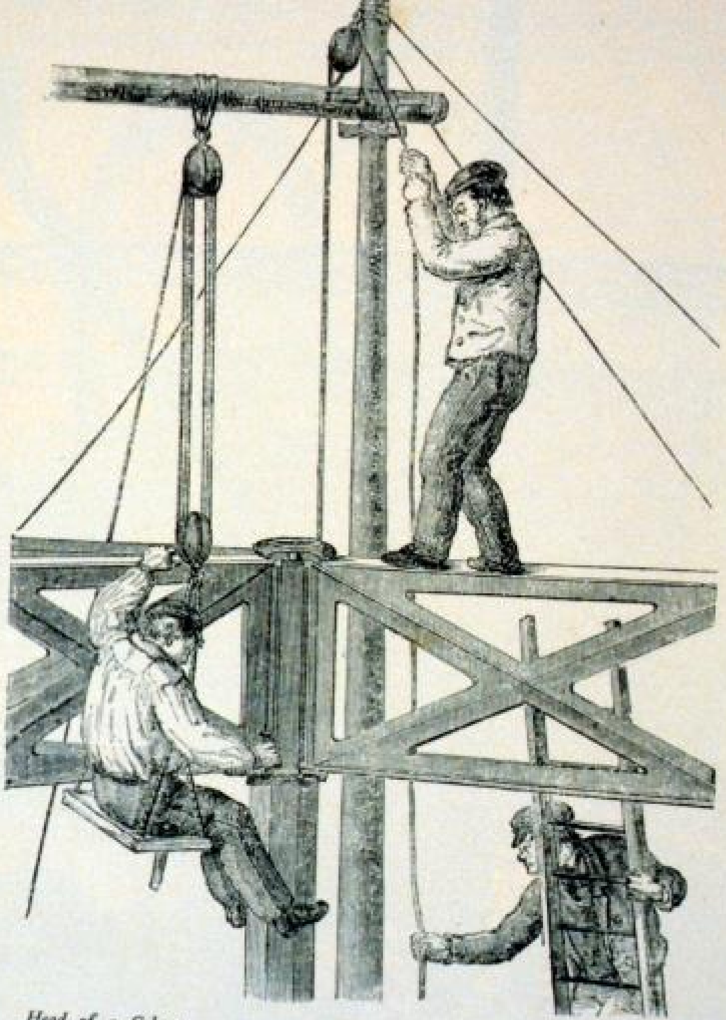

ROTTEN
ROW
WEST ENTRANCE.
B
A
C
GALLERY.
GALLERY.
GALLERY.
GALLERY.
EAST ENTRANCE.
SOUTH ENTRANCE.
ROAD
ROAD

GROUND PLAN.

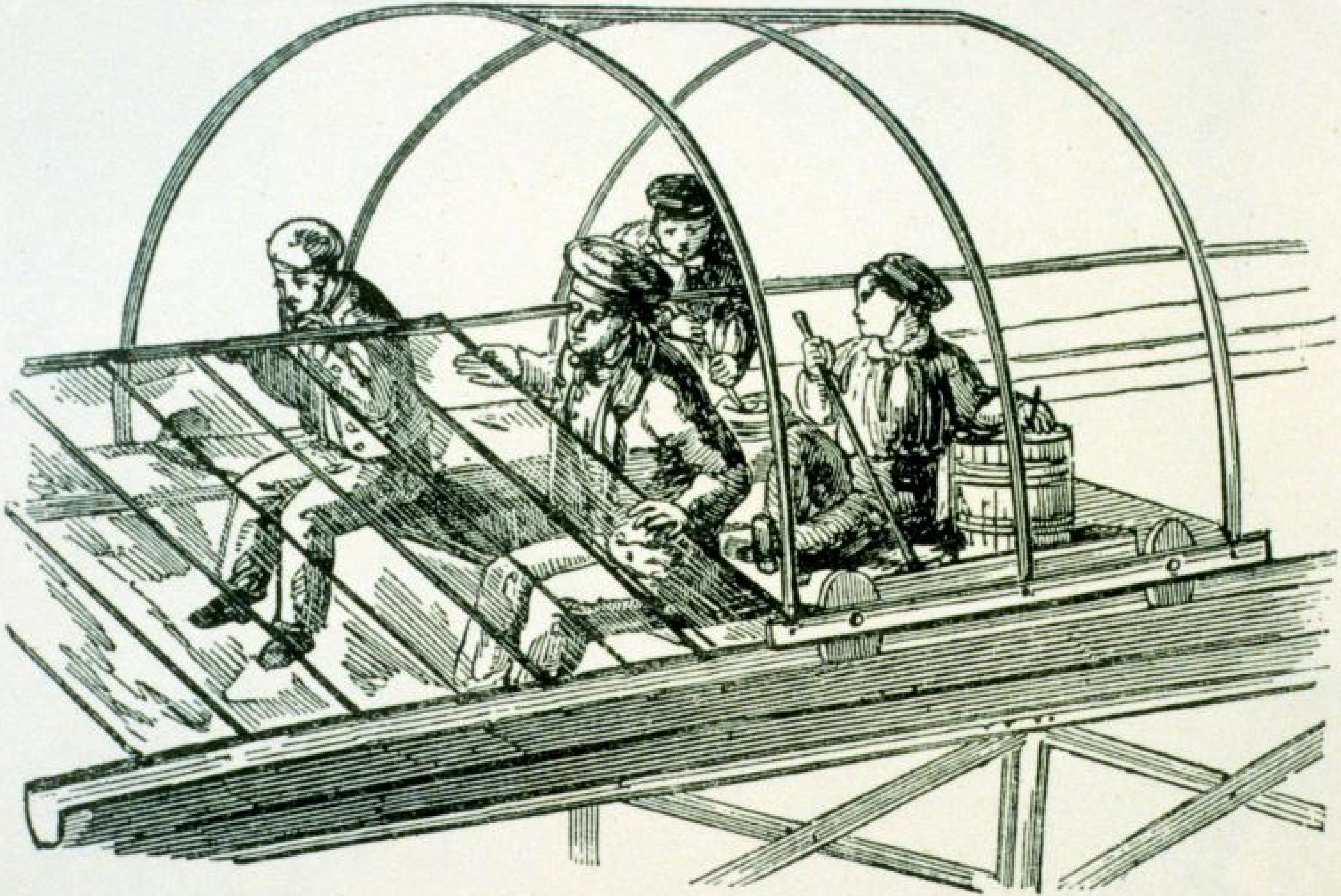








Head of a Column.



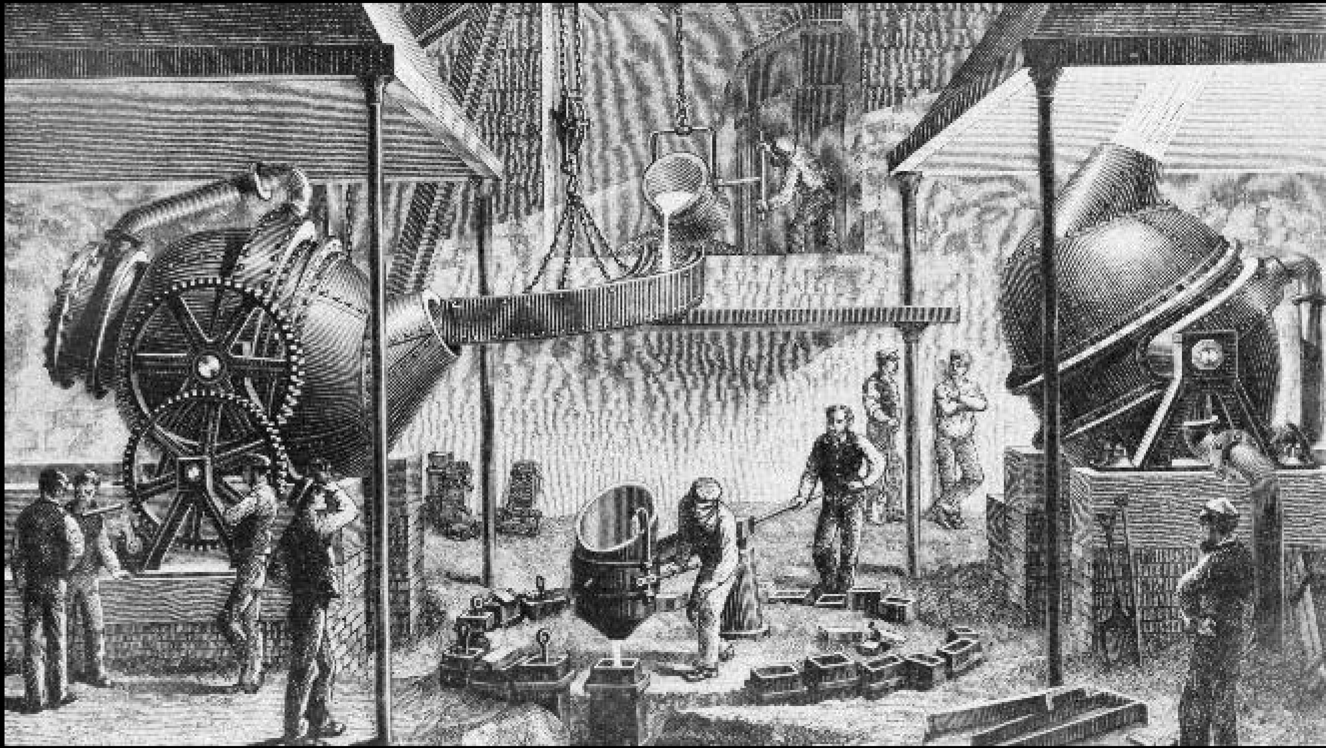
Glazing Waggon.


nmsi


nmsi

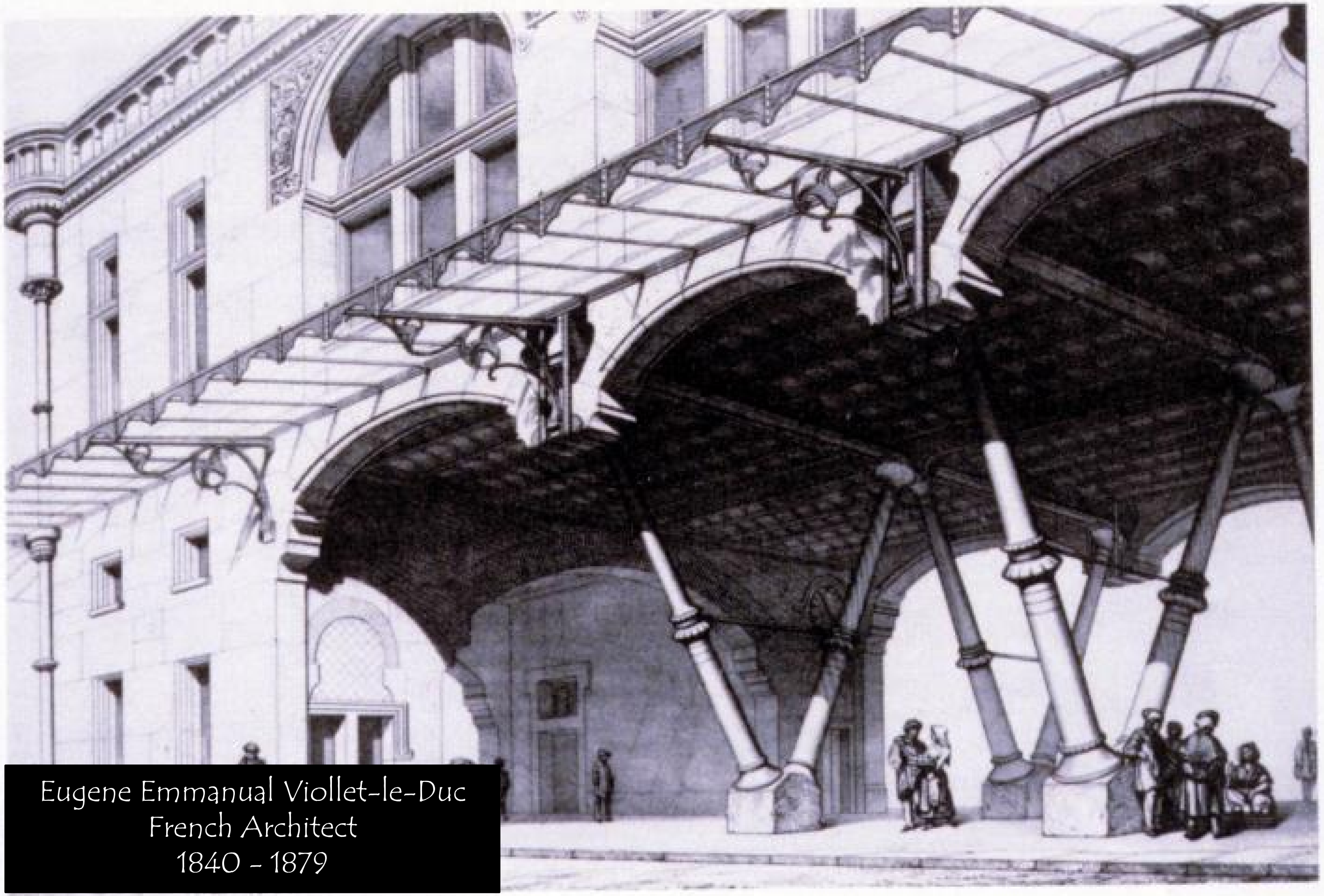
Bessemer Process
~noun *metallurgy*
A process of producing steel in which impurities are removed by forcing a blast of air/oxygen through molten iron

[Origin: 1855-60; after Sir Henry Bessemer]



https://dozr.com/blog/bessemer-process

Plate 48. Eugène Viollet-le-Duc. Project for an Hotel de Ville (Viollet-le-Duc *Atlas*, pl. 23)



Eugene Emmanual Viollet-le-Duc
French Architect
1840 - 1879

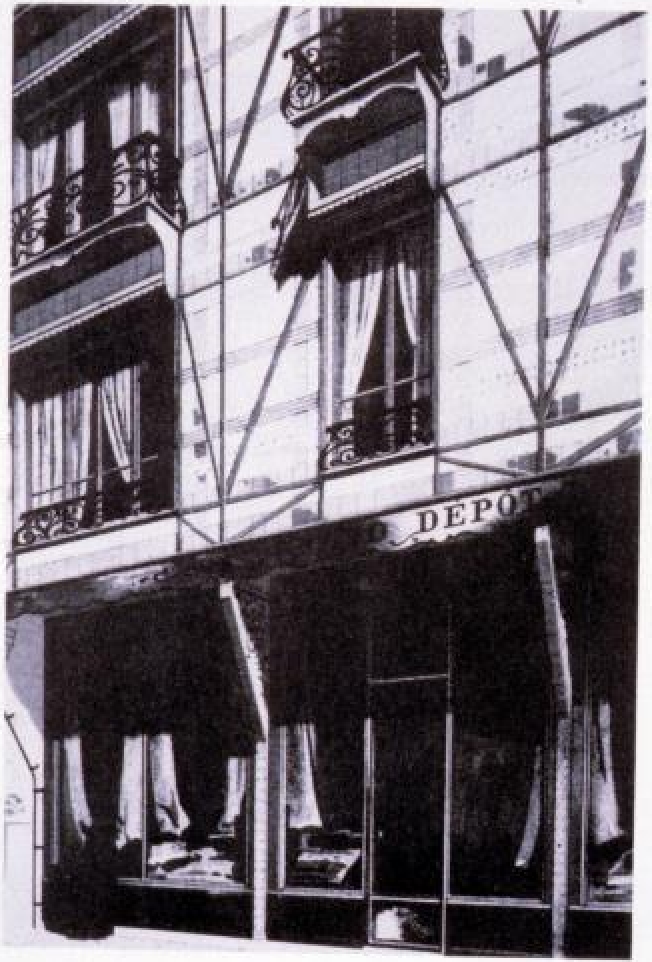


Plate 64. Eugène Viollet-le-Duc. Unpretentious shop and apartment building, 1863 (Viollet-le-Duc, *Atlas*, p. 36)

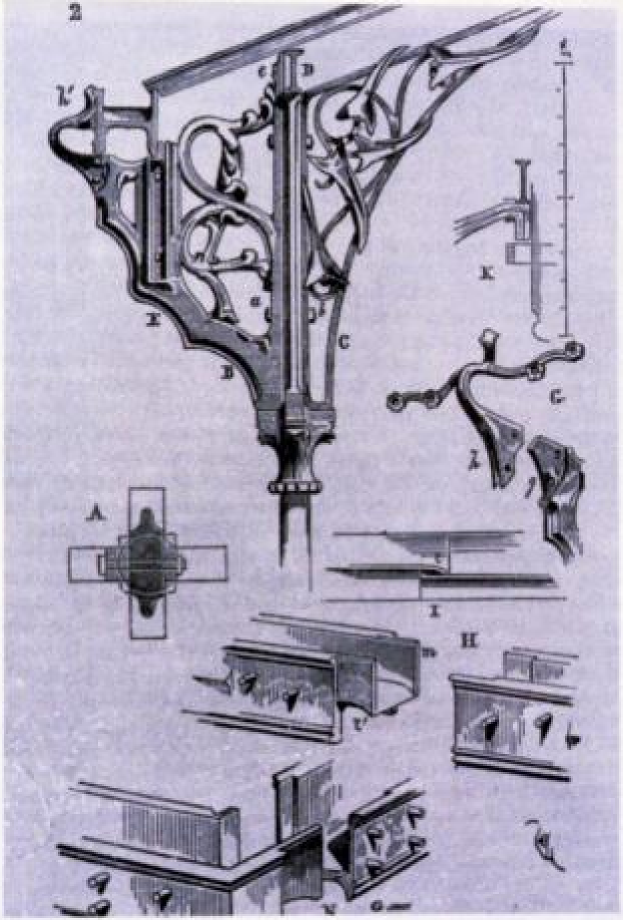
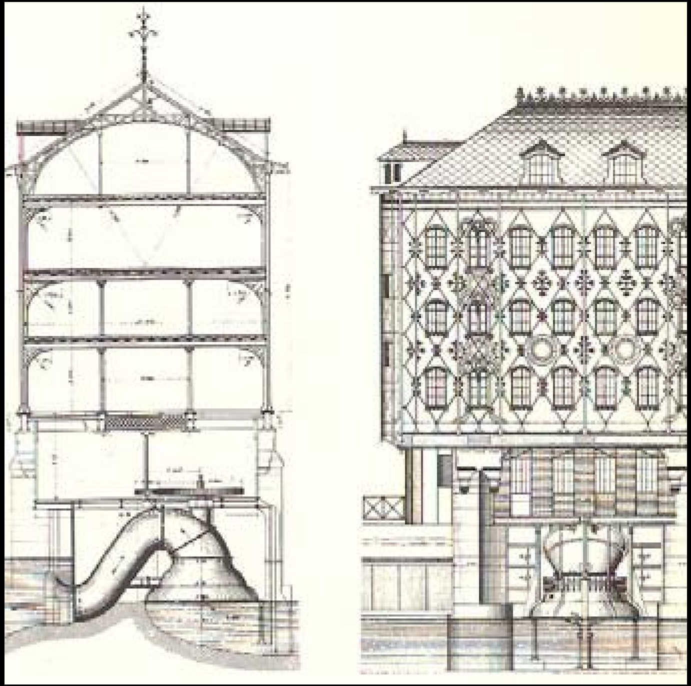


Plate 49. Eugène Viollet-le-Duc. Project for an Hotel de Ville (Viollet-le-Duc, Lecture XIII, p. 125)

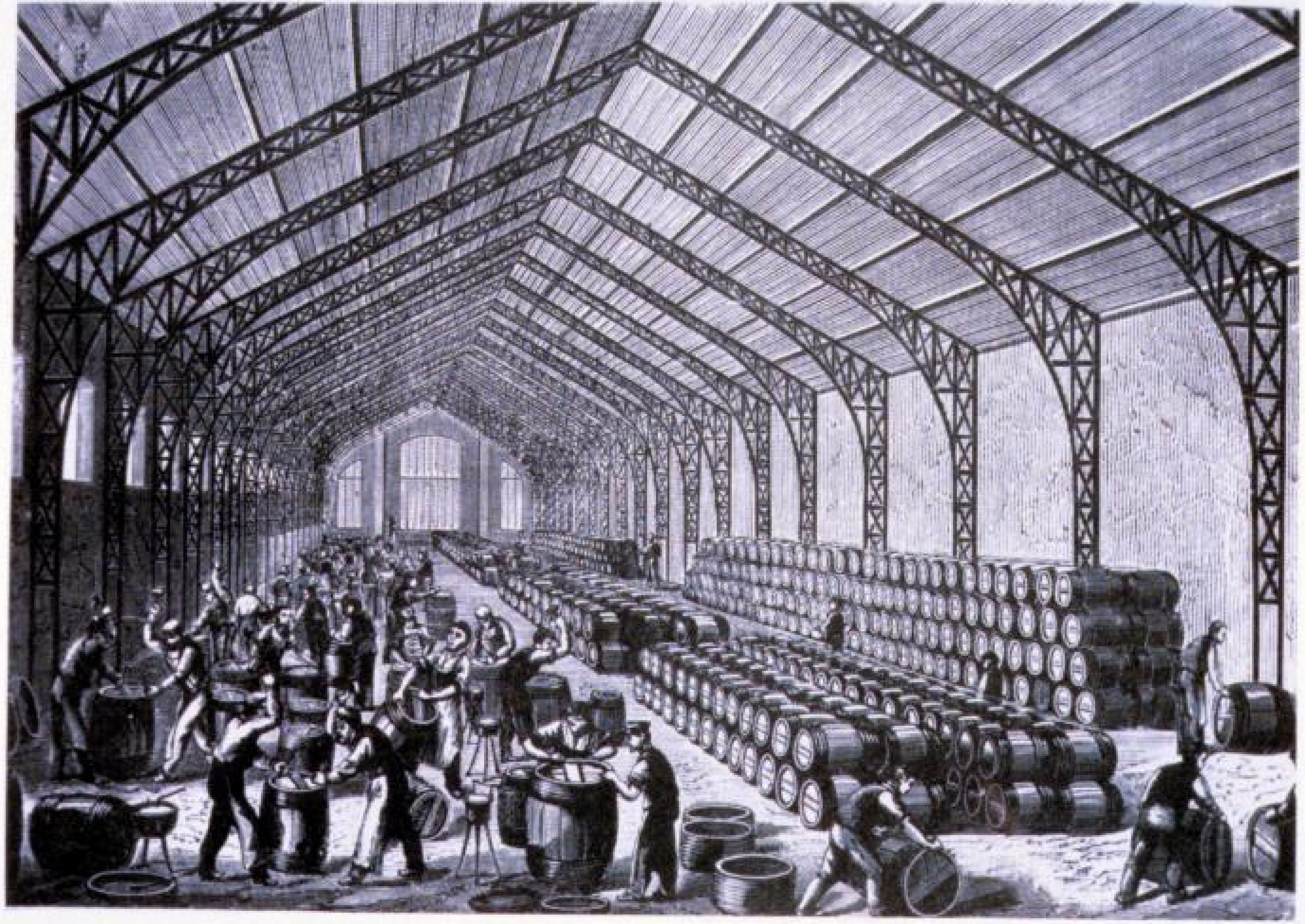
Menier Chocolate Factory
Noisiel sur Marne, France
Jules Saulnier
1872



Looking for larger clear SPANS to accommodate industrial processes/machines

Exhibition Buildings

Plate 54. Alphonse Gosset. Moët and Chandon Wine Establishment, Epernay, c. 1879 (Turgan, XIII, 1880, p. 41)



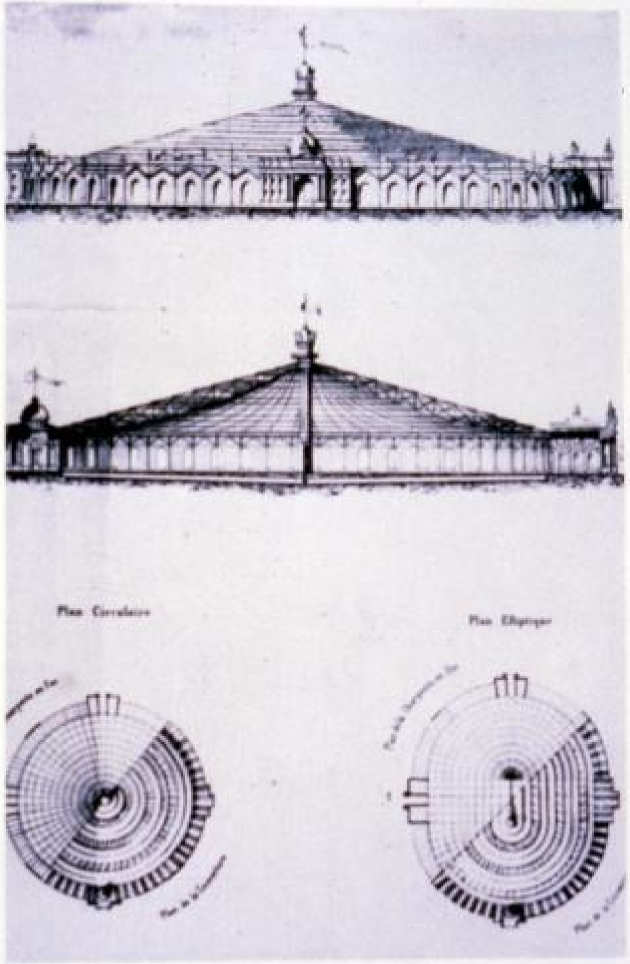
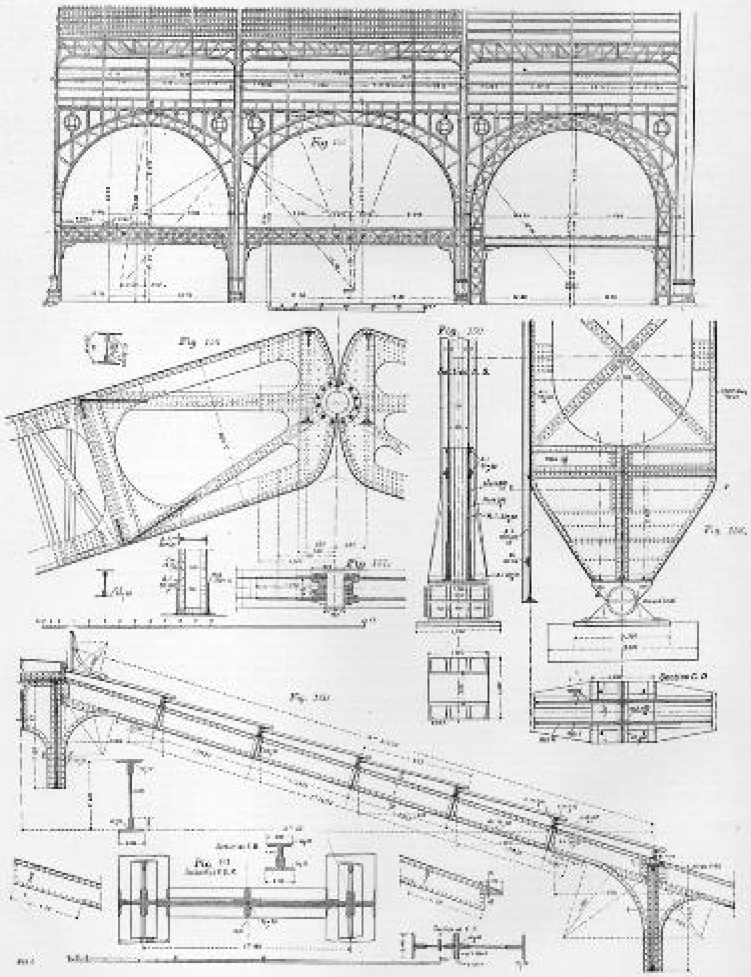


Plate 41. Paul Grieumard. Project for the International Exhibition Building of 1867, published in 1865 (Grieumard, pl. 1)

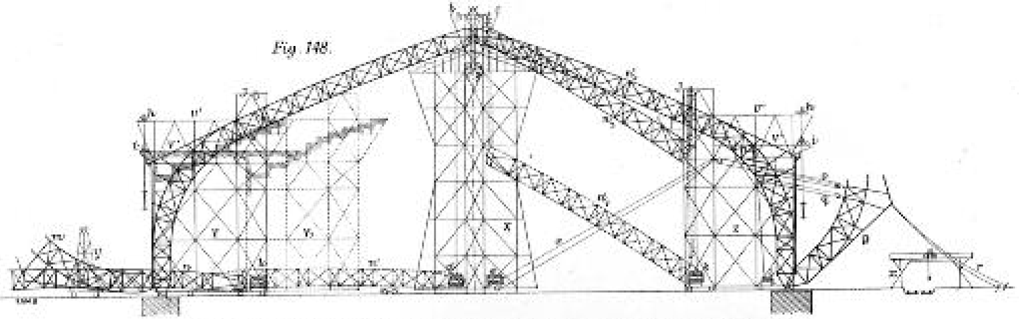
Galerie des Machines
Exposition Universale
Paris, France
Victor Contamin Engineer
1889

DETAILS OF ROOF OF MACHINERY HALL AND OF SIDE GALLERIES.

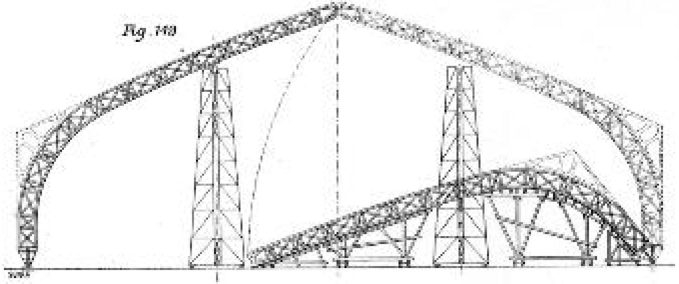
(For Description, see page 462.)



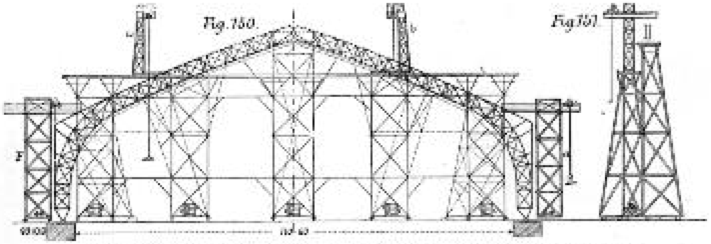
THE MACHINERY HALL



MODE OF ERECTING MACHINERY HALL ROOF; THE FIVES LILLE COMPANY. (See page 457.)

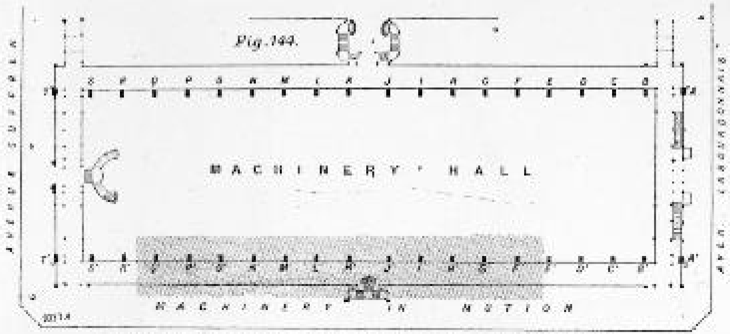


PROPOSED MODE OF ERECTING MACHINERY HALL ROOF. (See page 457.)



MODE OF ERECTING MACHINERY HALL ROOF; MM. CAIL ET CIE. (See page 458.)

THE MACHINERY HALL.



PLAN SHOWING POSITION OF PIERS AND STAIRCASES. (See page 453.)

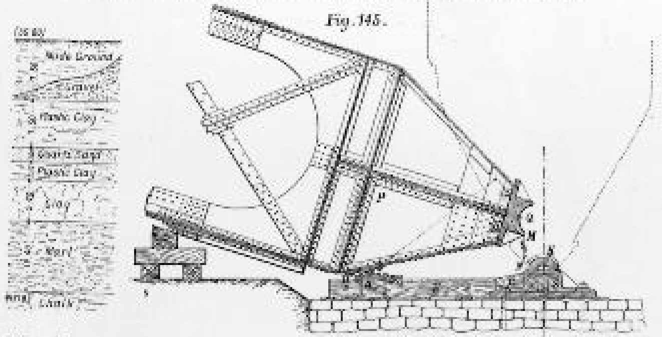
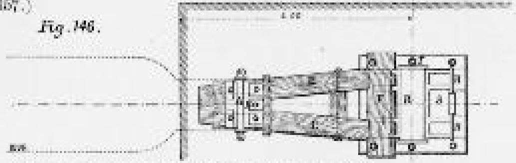
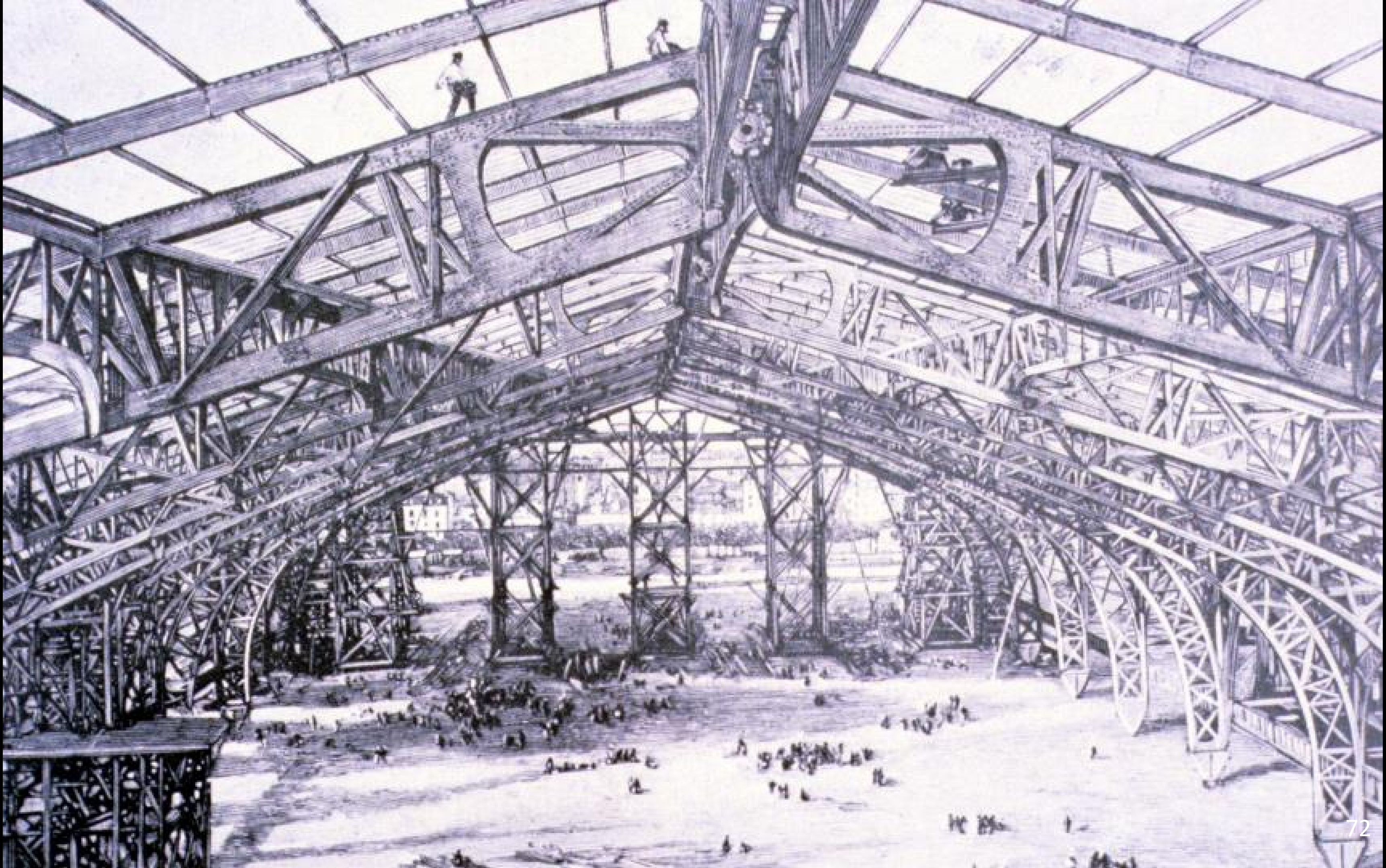
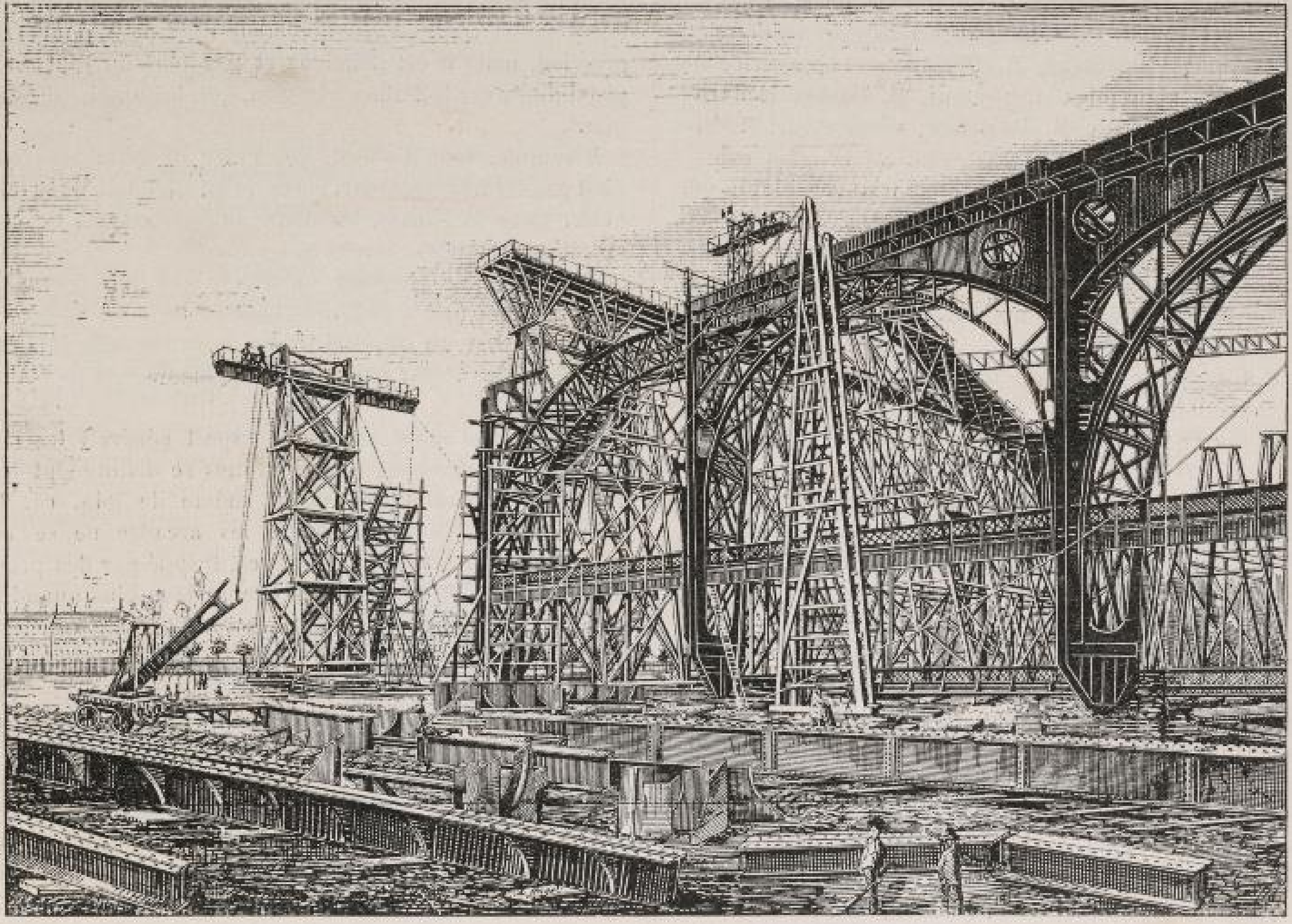


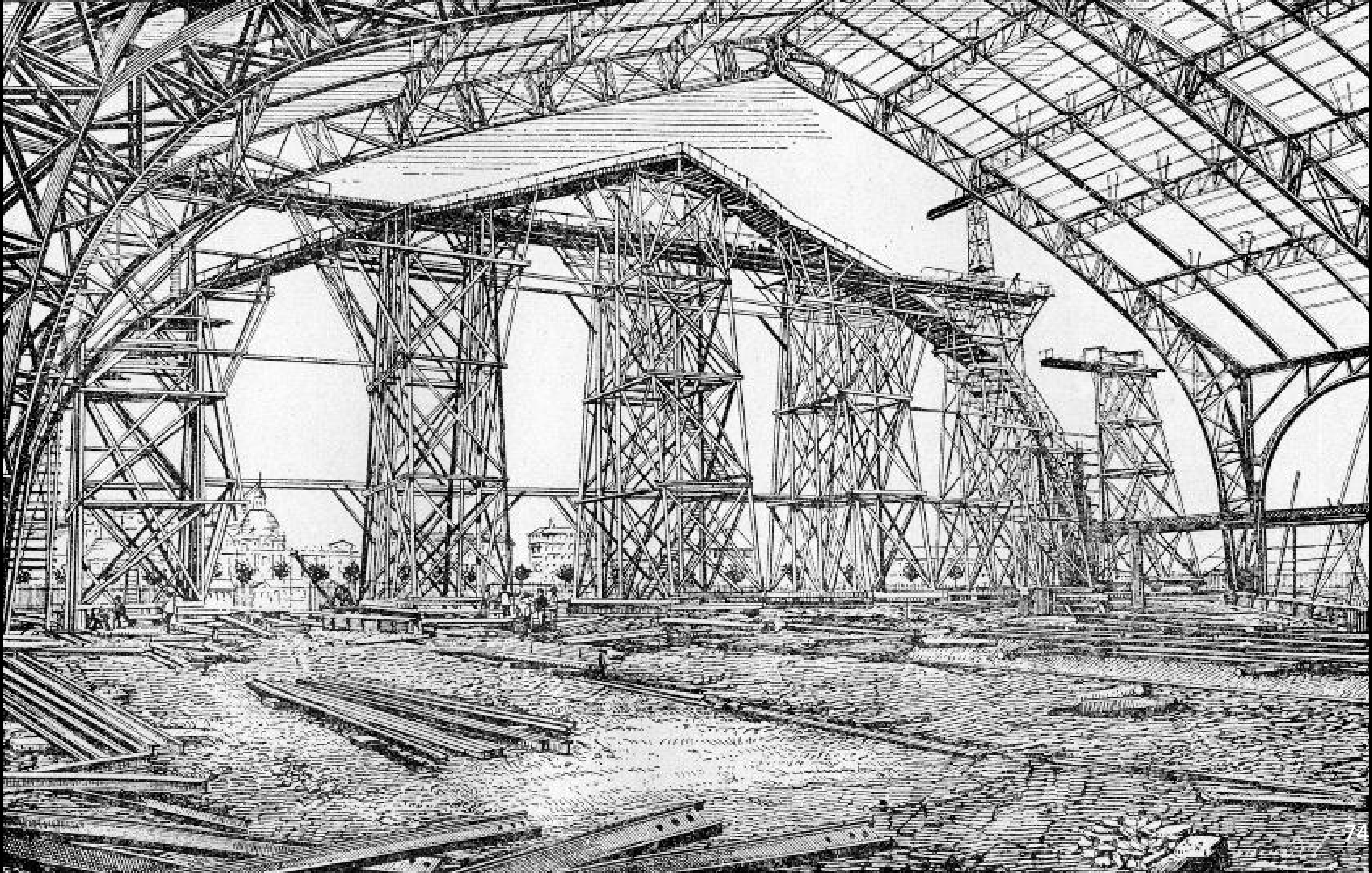
FIG. 147. (See page 457.)

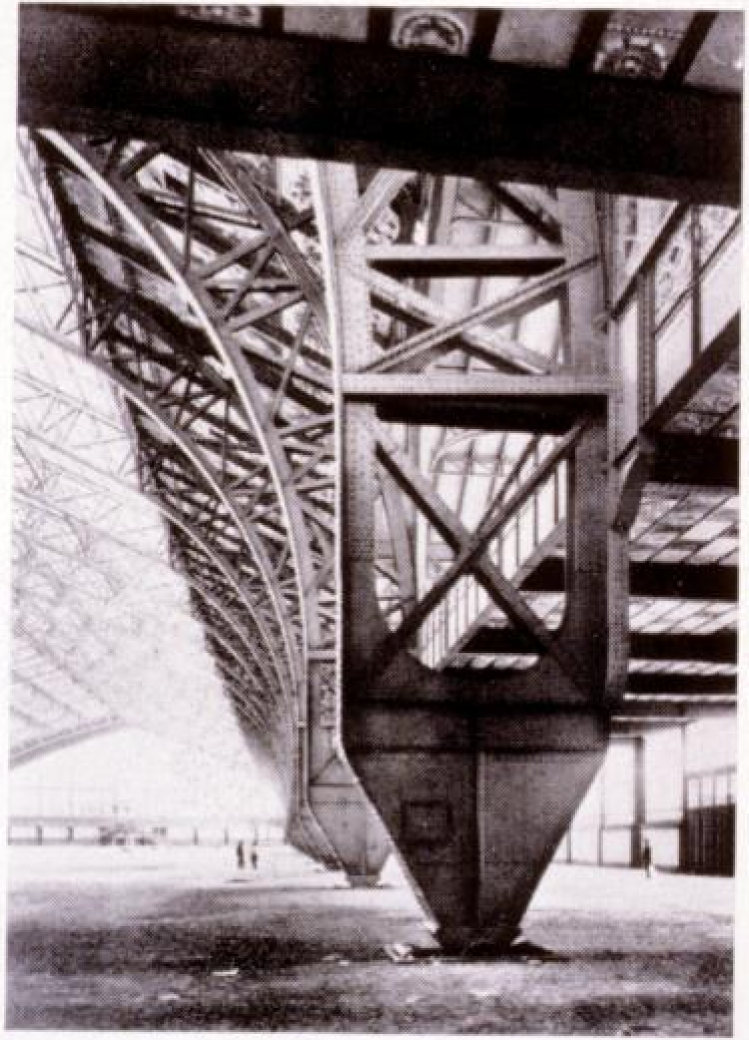


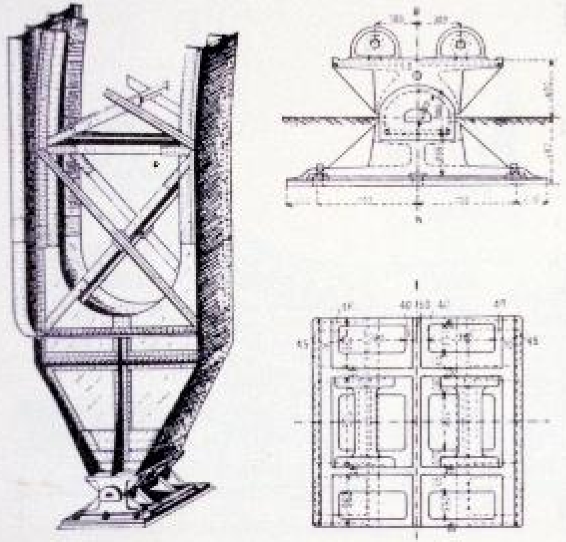
MODE OF ERECTING PRINCIPALS. (See page 458.)




Le montage des grandes fermes de la Galerie des Machines.







14 Contamin and Dutert,
Galerie des Machines, Paris, 1887-89.
Detail of the hinged supports.


706. - PARIS. - La Galerie des Machines (VIIe). - G. I.

Eiffel Tower
Great Exposition 1889
Paris, France
Gustav Eiffel
324m

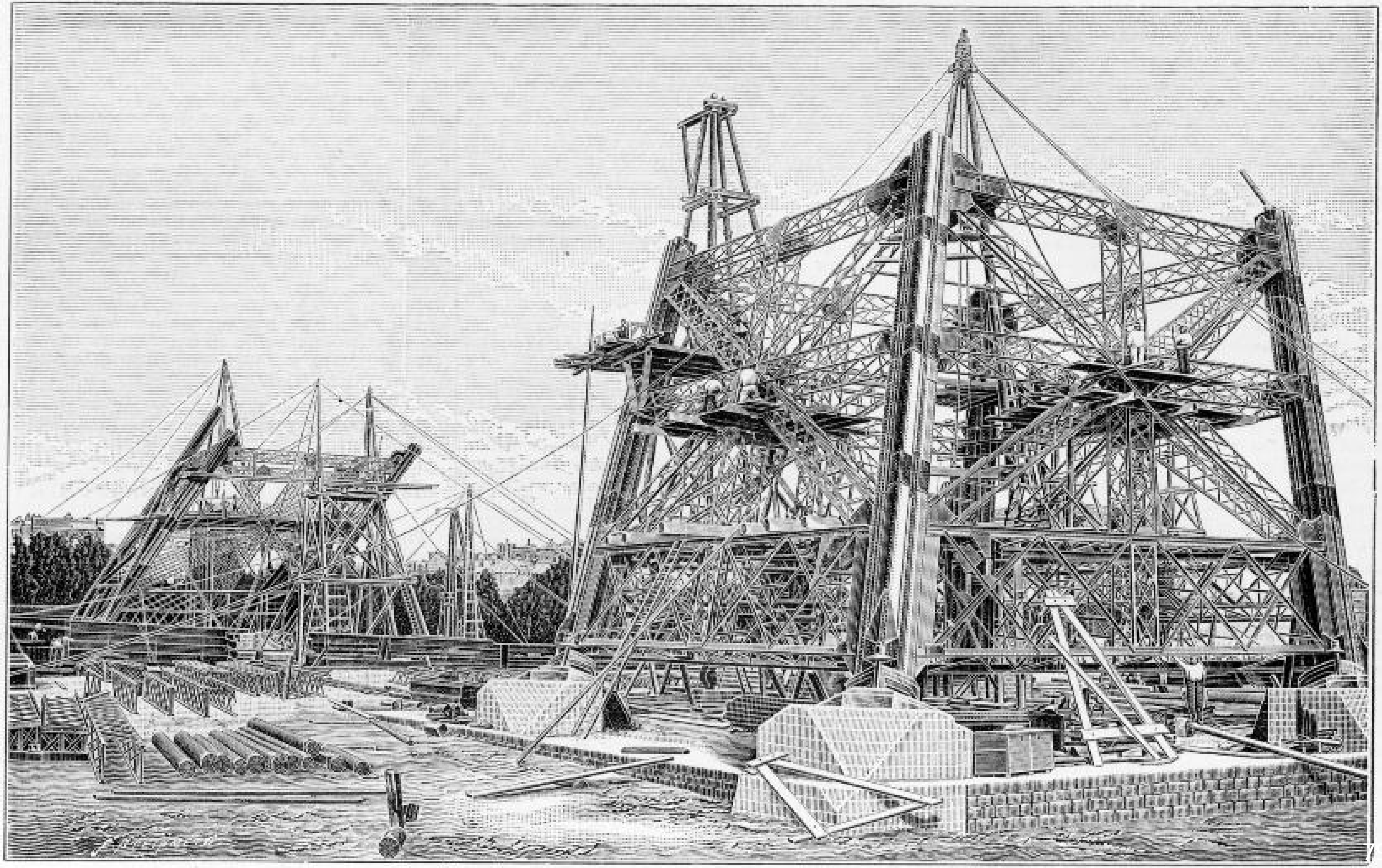


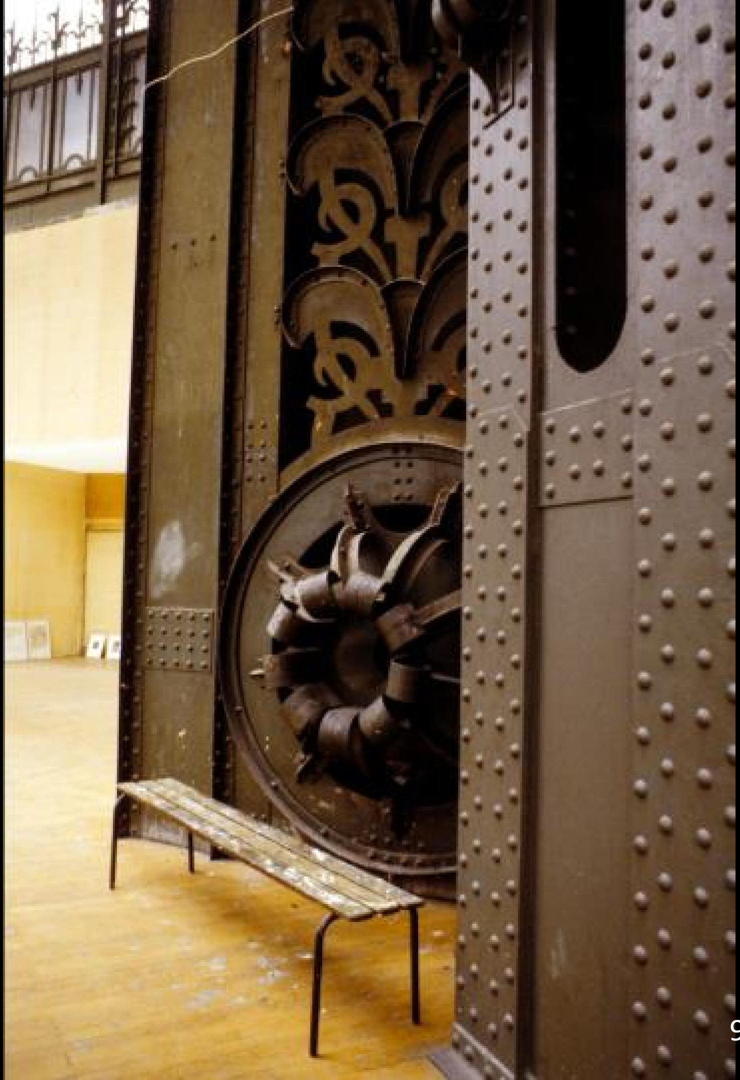
Fig. 37. The Eiffel Tower, Column No. 4; September, 1887.


ACIERIES

Grand Palais des Champs Elysees
Universal Exposition of 1900
Paris, France
1900

Paris Metro Entrances
Hector Guimard
1900 to 1913
Art Nouveau Style


OLITIQUE · VOYAGES · TOU

Train Stations and Railroads

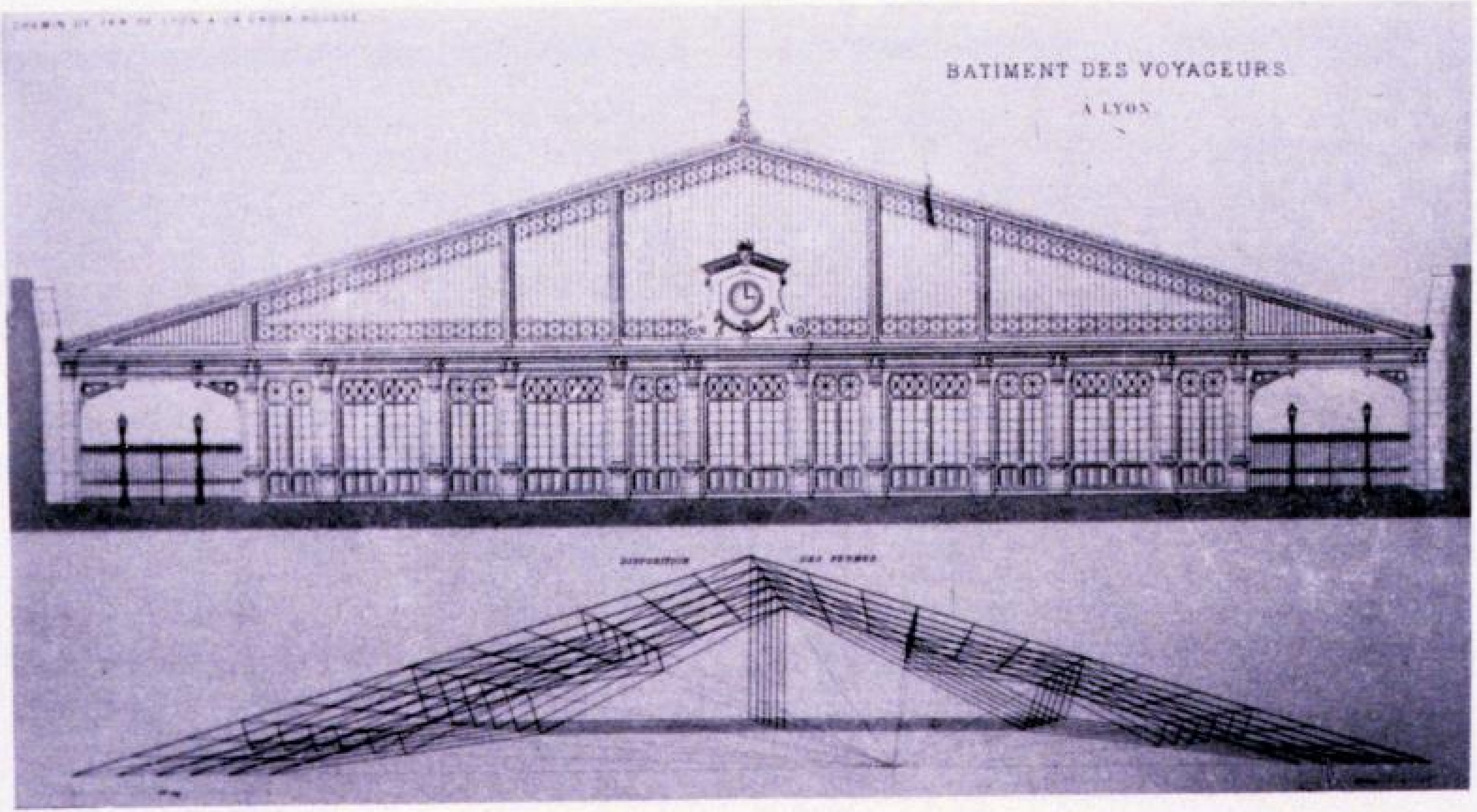


Plate 13. François Cendrier and A. Julien. Gare de Perrache, Lyon, 1855 (*Révue générale de l'architecture*, XVIII, pl. 17)

Paddington Station
London, England
Isambard Kingdom Brunel Engineer
1838

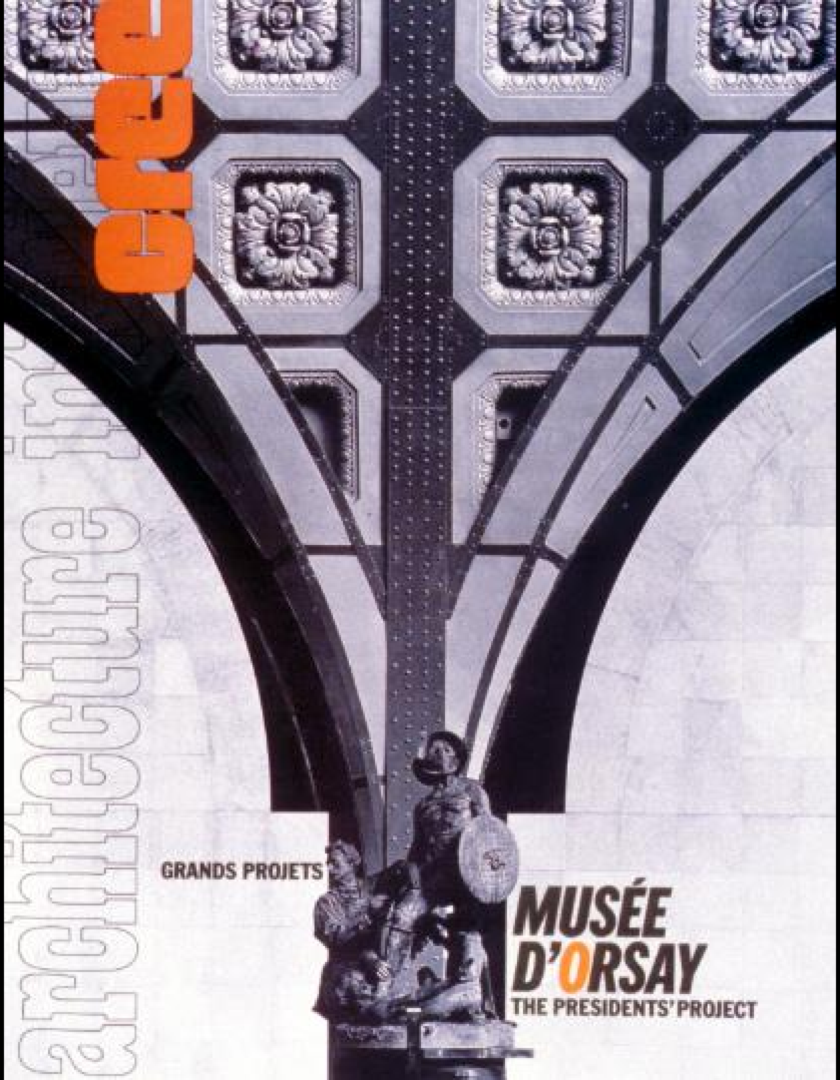
St. Pancras Station
London, England
William Henry Barlow Architect
1868

Kings Cross Station
London, England
George Turnbill and Lewis Cubitt
1852

Liverpool Street Station
London, England
1874


MARKS &
SPENCER

Gare d'Orsay
Victor Laloux, Lucien Magne and Emile Benard
Paris, France
1900
Renovated to Musee d'Orsay
Gae Aulenti Architect
1986


arca
architecture intérieure
GRANDS PROJETS
MUSÉE
D'ORSAY
THE PRESIDENTS' PROJECT


← A visiteurs individuels
← B

Steel/Iron and Glass

Atrium Roofs

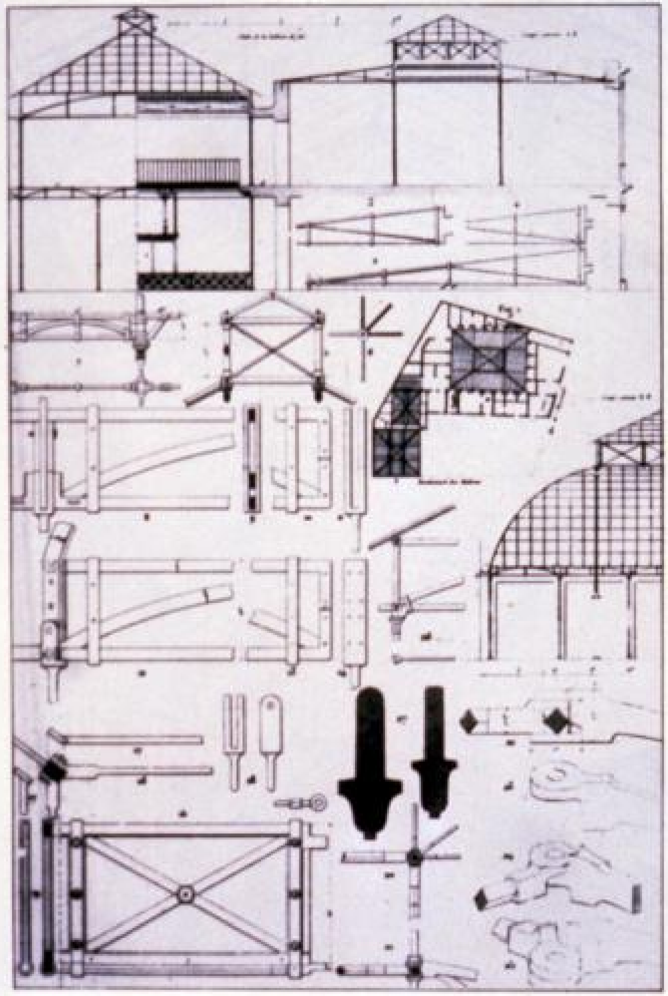
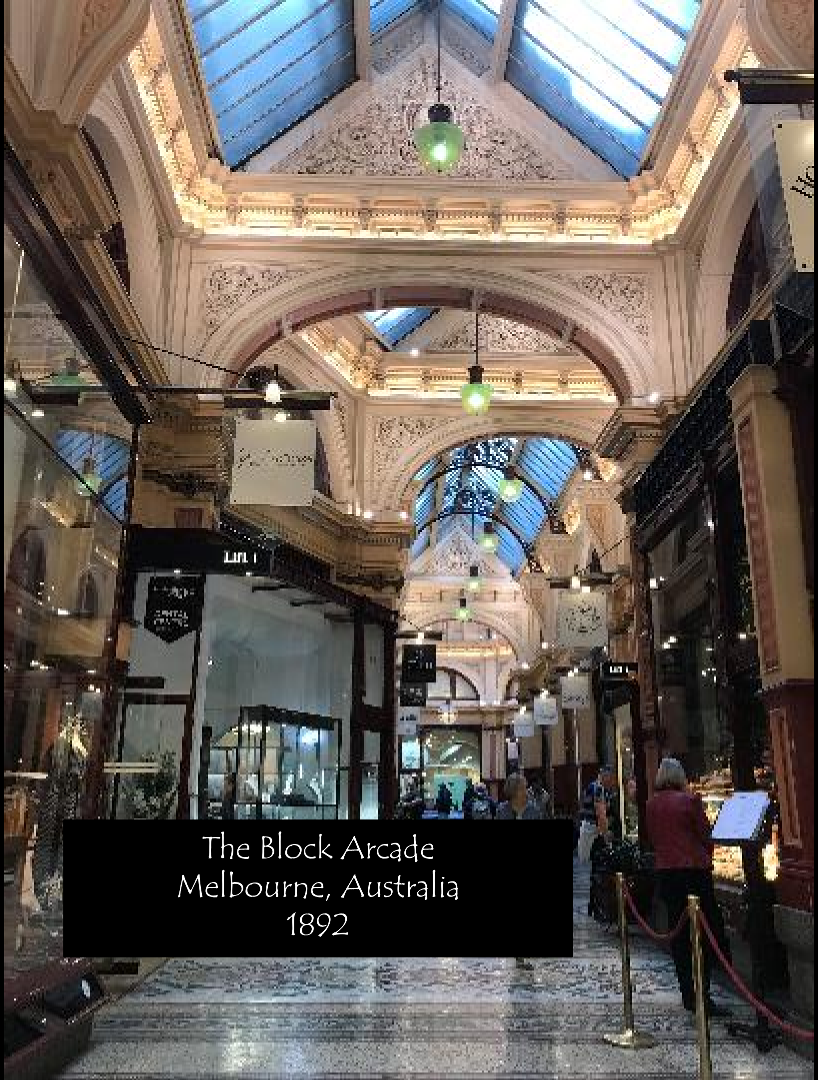


Plate 20. Tavernier. Galerie de Fer, Paris, 1829 (Thiollet, 1832, pl. 26)

Plate 19. Passage des Princes, Paris, 1860 (Frances H. Steiner)



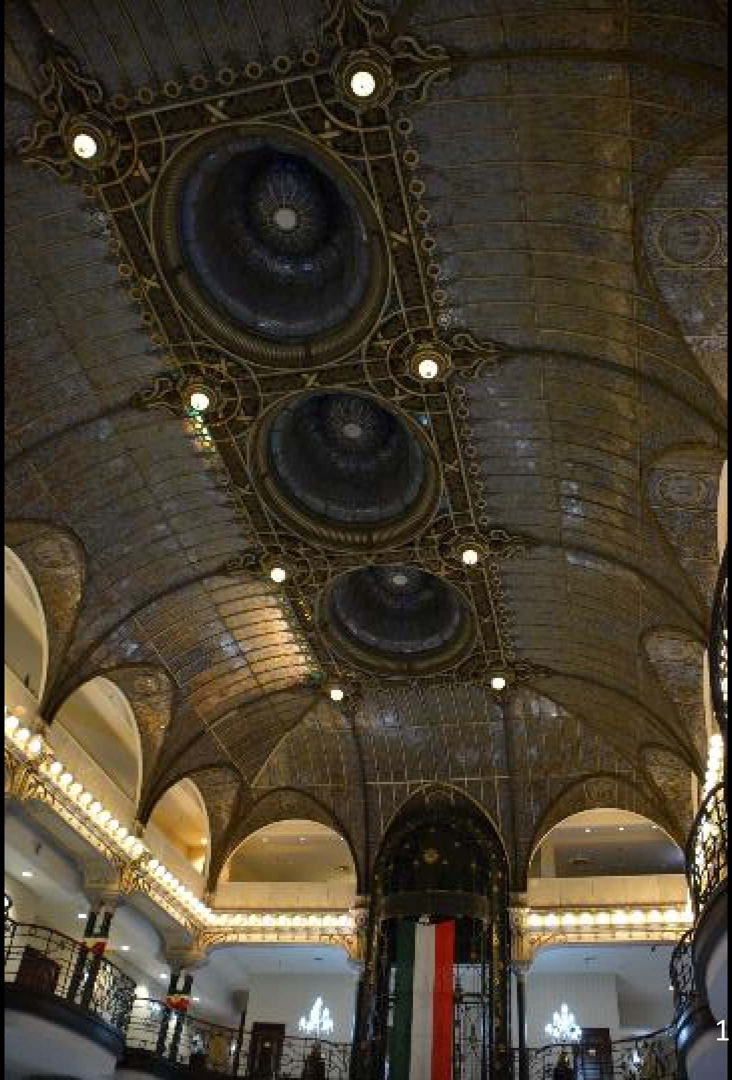
The Block Arcade
Melbourne, Australia
1892

Galeries Lafayette
Paris, France
Georges Chedann Architect
Art Nouveau Style
1912

Glass by Tiffany

Gran Hotel Cuidad de
Mexico
Mexico City
Art Nouveau
1899

Glass by Tiffany

The Rookery
Chicago, Illinois, USA
Burnham and Root
1891
Glass Court
Frank Lloyd Wright
1905

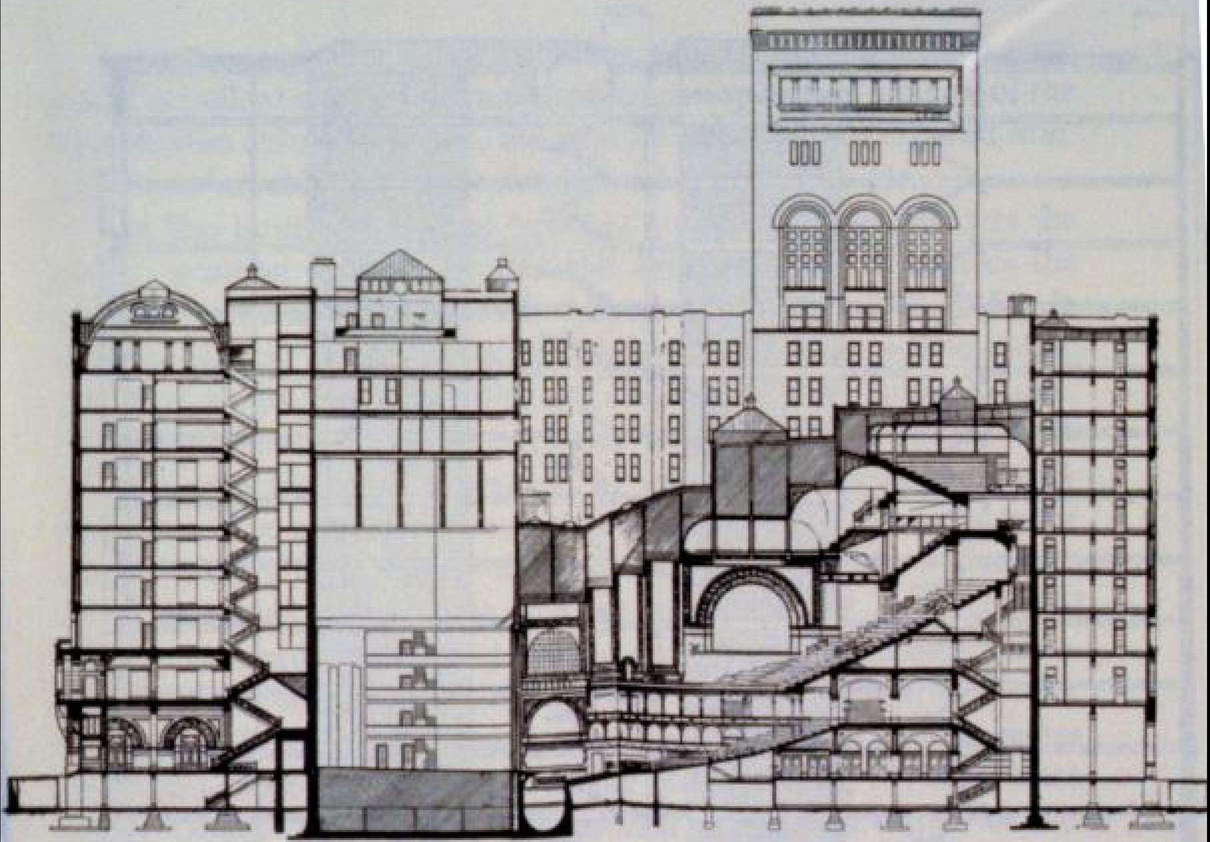

bank
bank
bank
OPTICAL


bank

Steel Framing
-
Multi-storey buildings
to
Skyscrapers

Auditorium Building
Dankmar Adler & Louis Sullivan
Chicago, Illinois, USA
1889

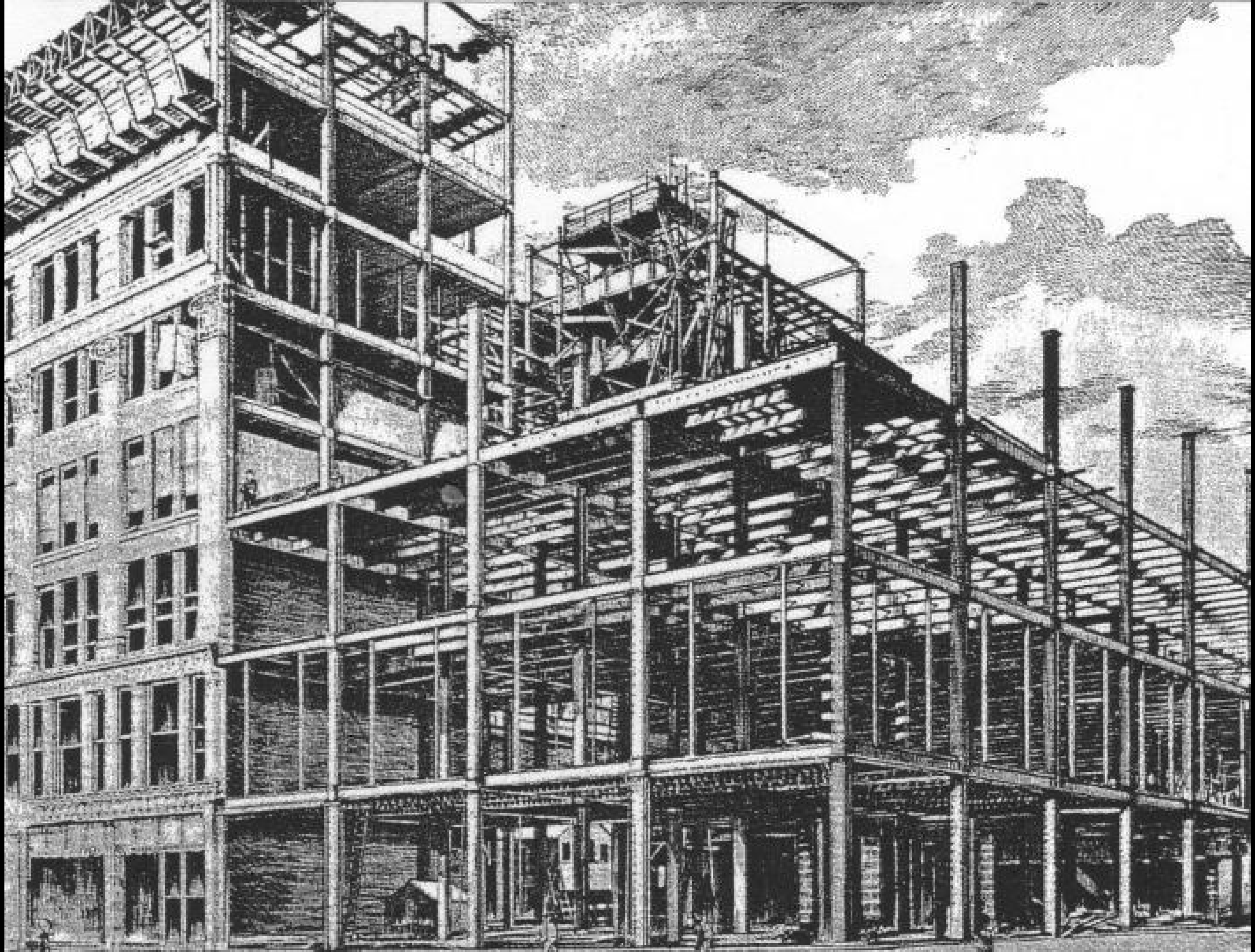
40. Auditorium Building, Chicago, Ill., 1887–89. Adler and Sullivan, architects. Longitudinal section. The interior framework of the Auditorium embraced every structural technique in iron available at the time.

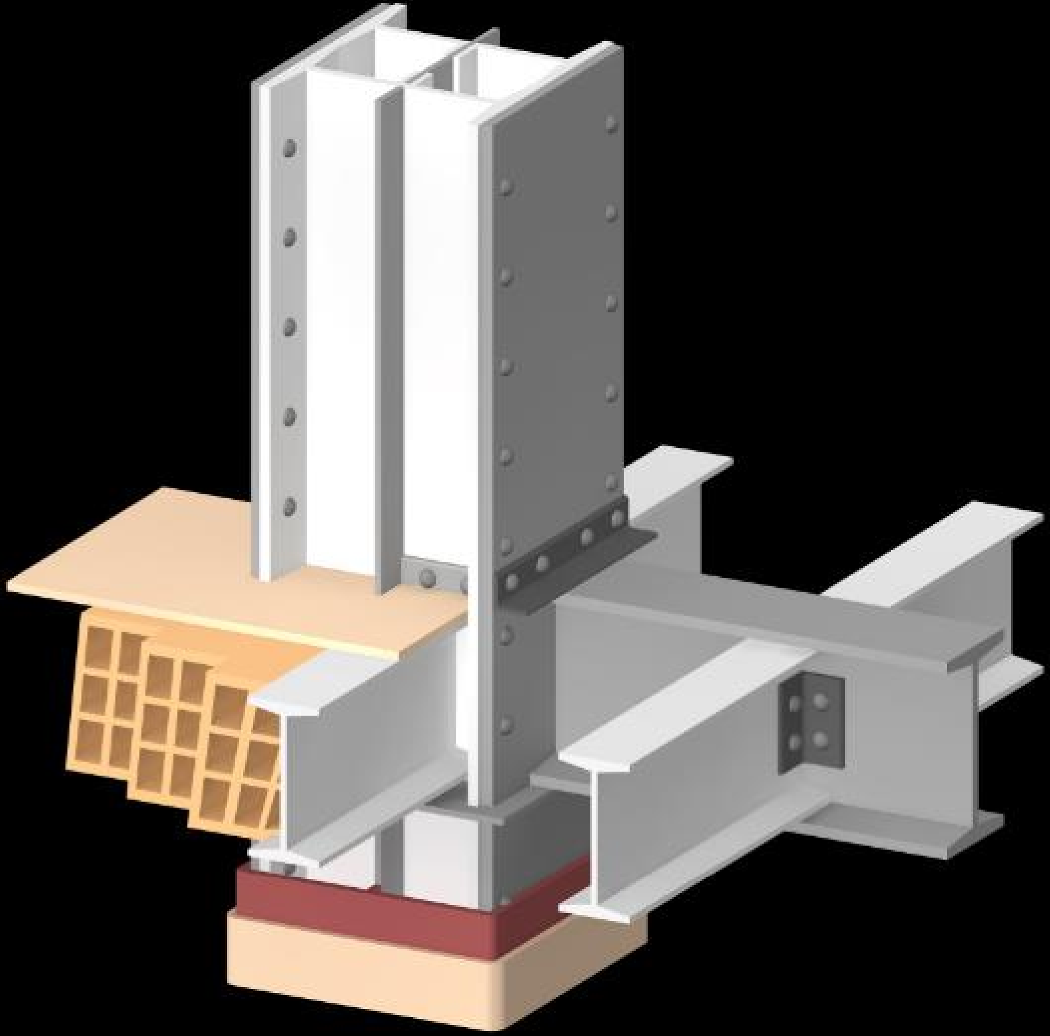


William Le Baron Jenney
Architect and Engineer
Father of the Skyscraper
1832 - 1907

The Fair Store
Chicago, Illinois
William Le Baron Jenney
1874

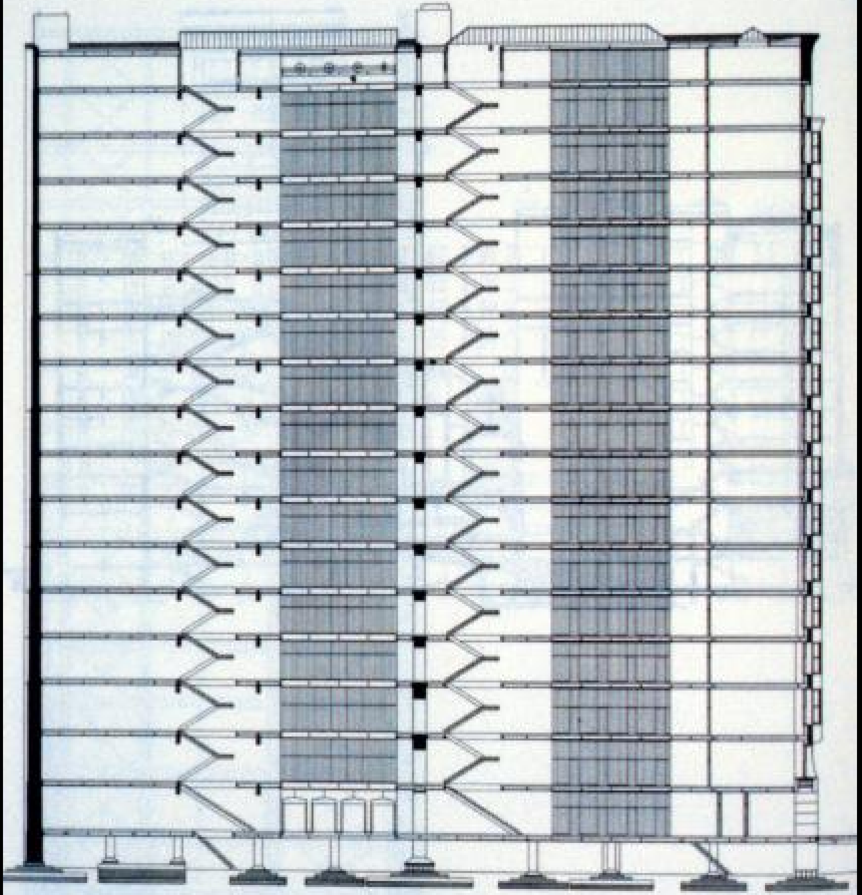
The department store was a new building type.

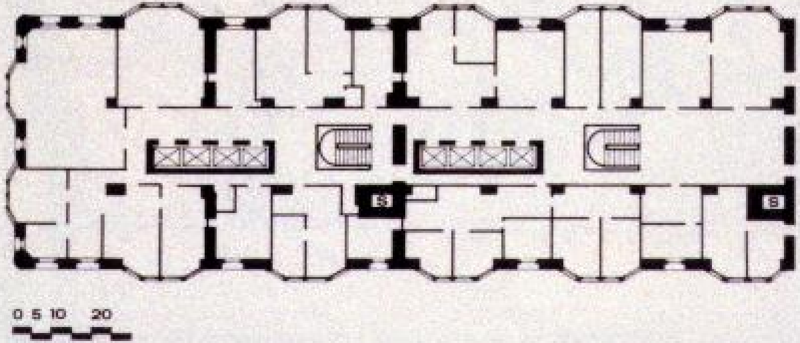




Monadnock Building (north half)
Chicago, Illinois
Burnham & Root
1891

41. Monadnock Building, Chicago, Ill., 1889-91. Burnham and Root, architects. Longitudinal section. The heavy masonry walls were already out of date in Chicago by the time John Wellborn Root designed this architectural landmark, but the interior iron frame of the Monadnock embodied the most advanced principles.



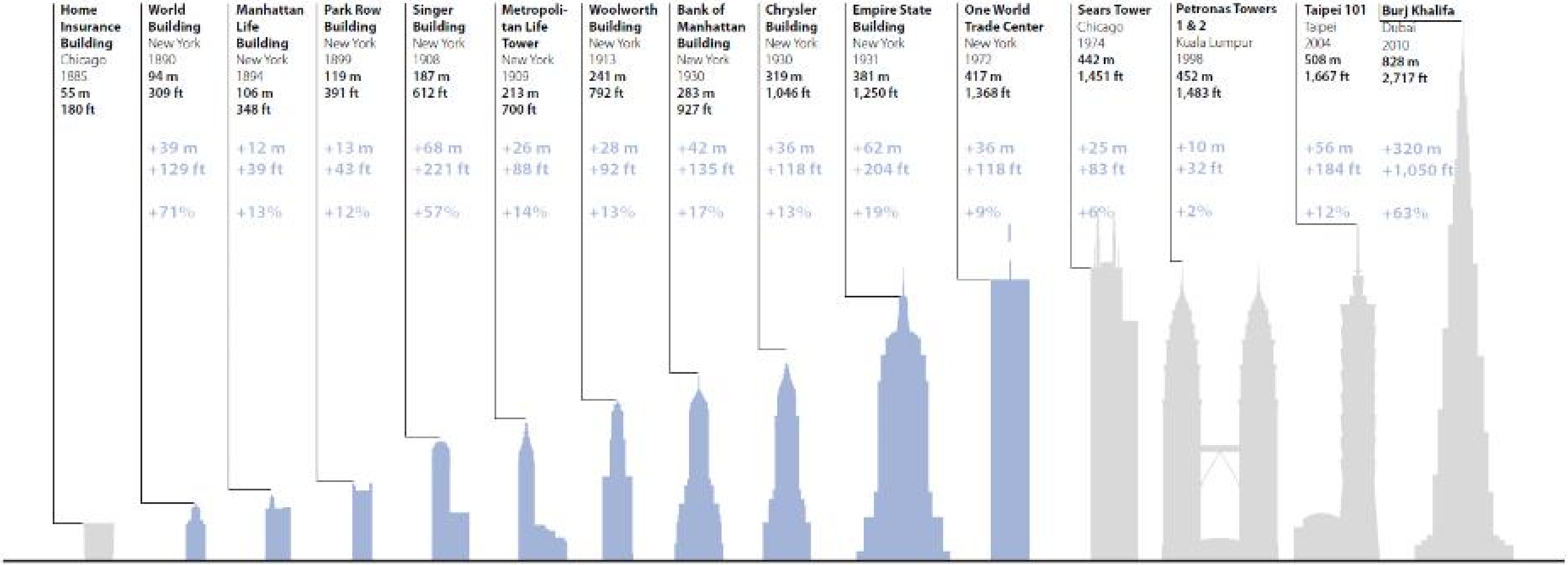


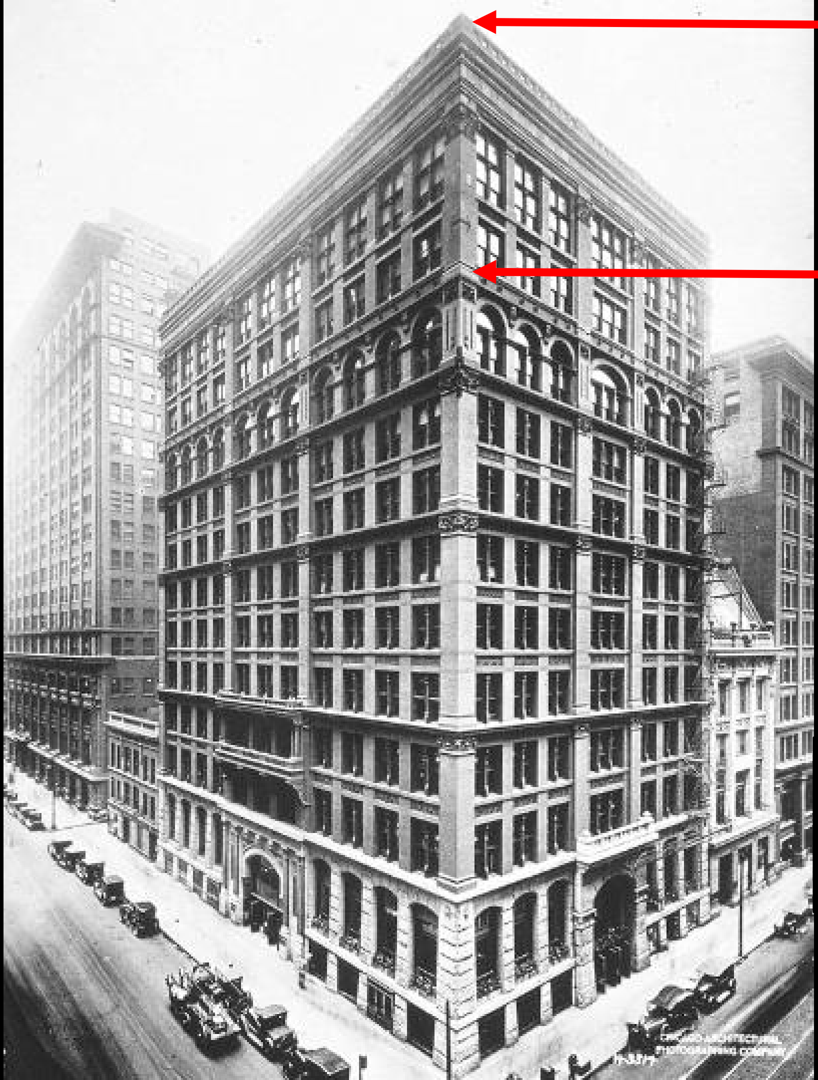
26 *Root, Monadnock Block, Chicago, 1891. Typical floor plan.*

History of the "World's Tallest Building"

According to CTBUH Height Criteria: Height to Architectural Top

NYC Buildings Non-NYC Buildings



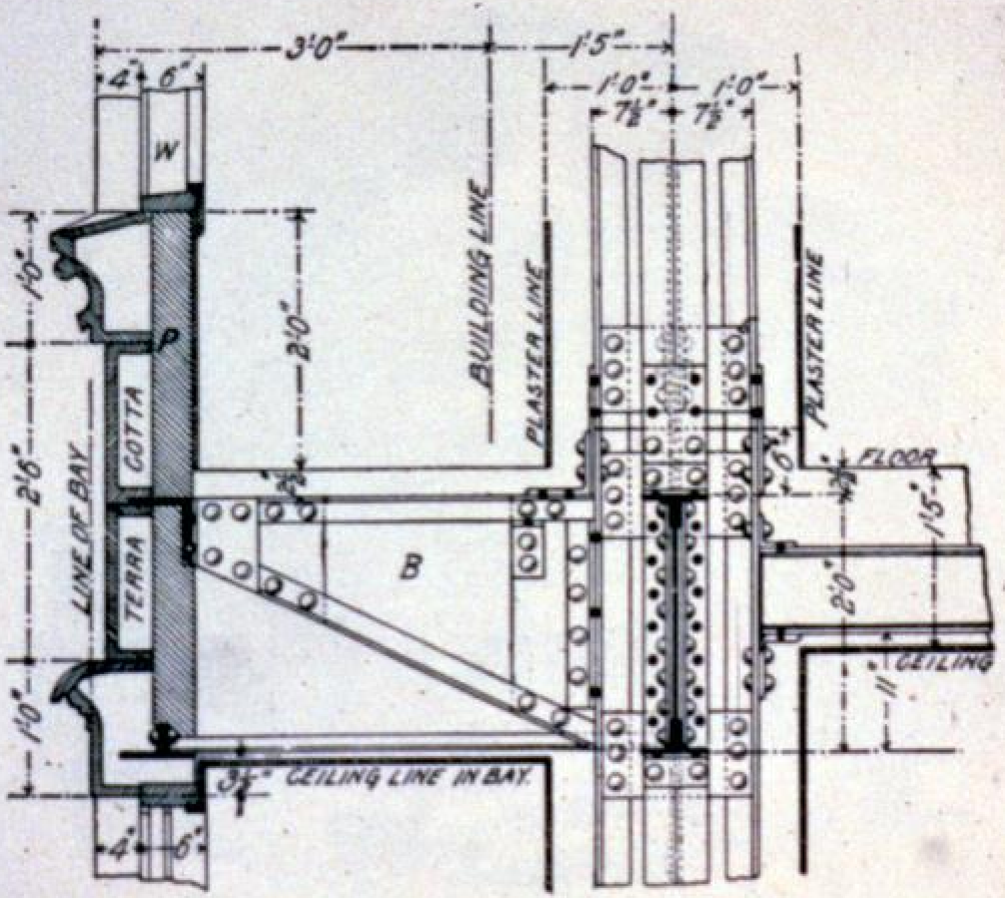


2 storey addition

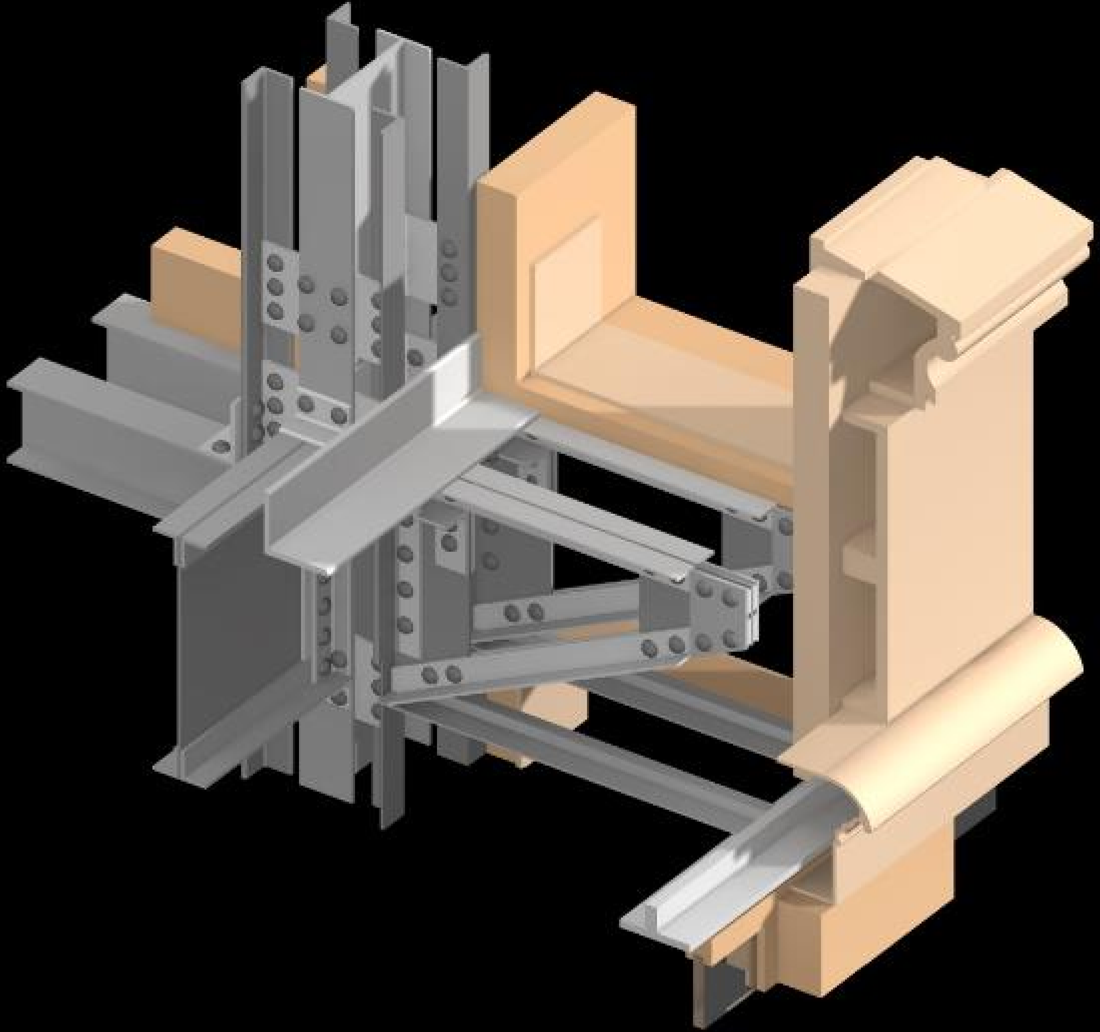
Original 10 storey height

Home Insurance Building
Chicago, Illinois
William Le Baron Jenney
1885

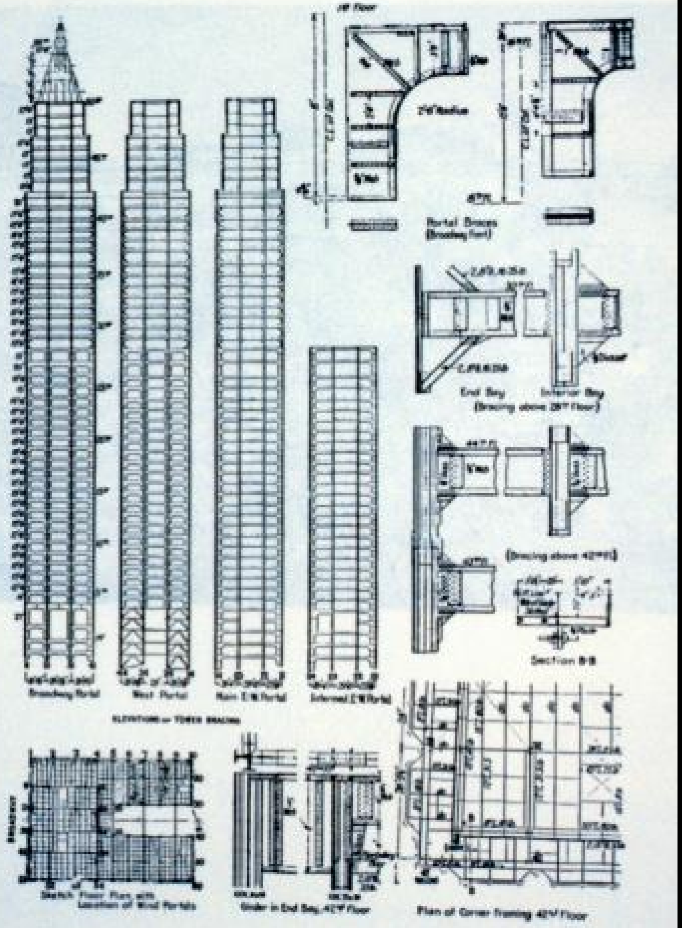
Reliance Building
Chicago, Illinois
Burnham, Root & Atwood
1895
First real curtainwall skyscraper



27 Atwood and Burnham, Reliance Building, Chicago, 1890 / 94-95. Cross section of window bay.



67. Woolworth Building, New York City, 1911–13. Cass Gilbert, architect; Gunvald Aus Co., engineers. Elevations and details of the steel frame. The Woolworth was the highest building in the world at the time of its construction and was supported on the most elaborately braced steel frame.

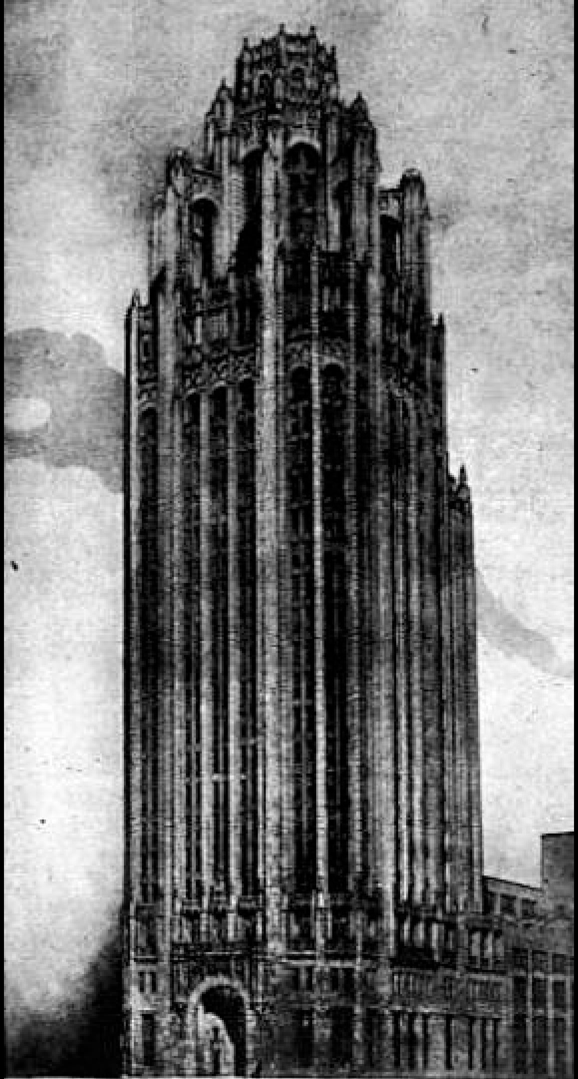


Woolworth Building
New York City, USA
1913

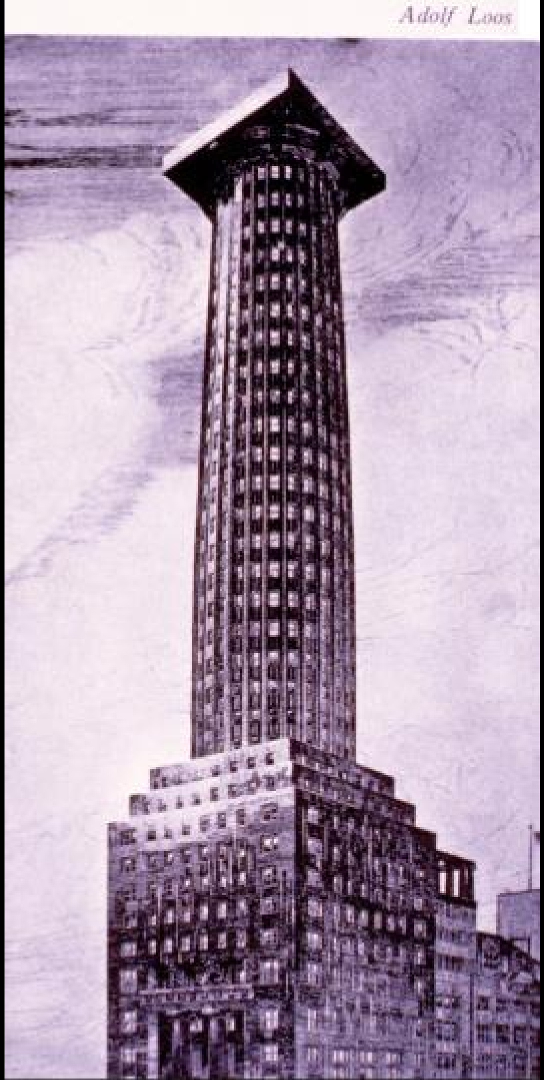
The role of the Competition in Inventing a New Typology

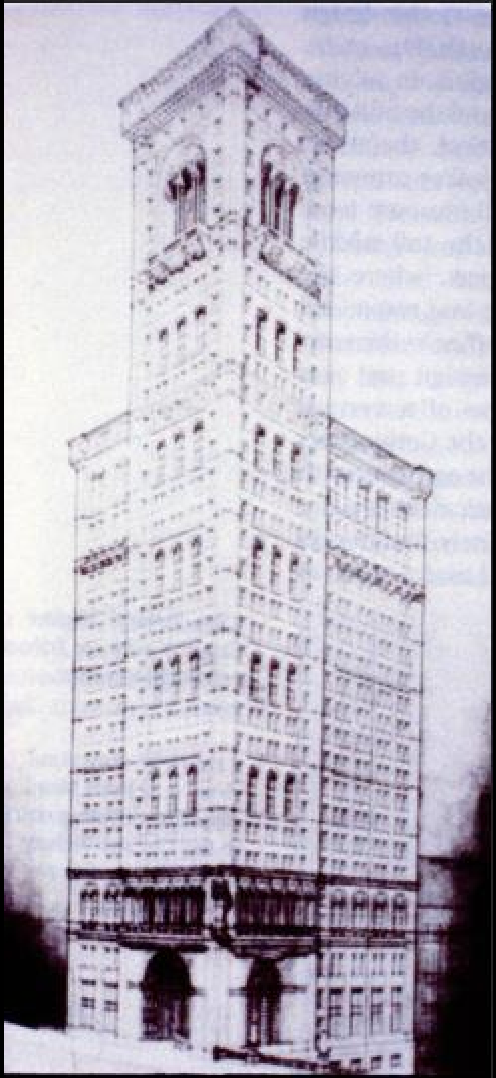
What is a Skyscraper??

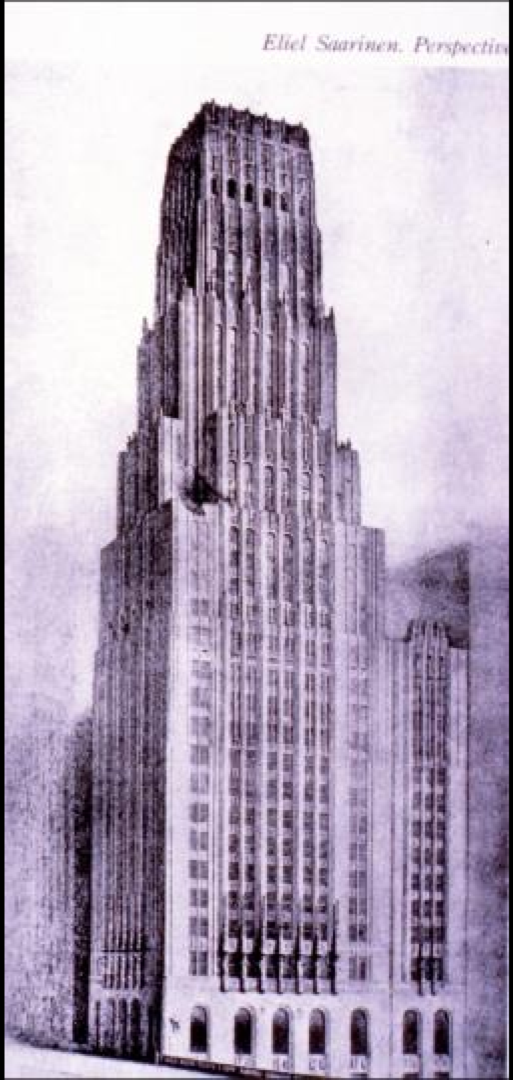
Mies van der Rohe
Idea for a glass skyscraper for Berlin
1921

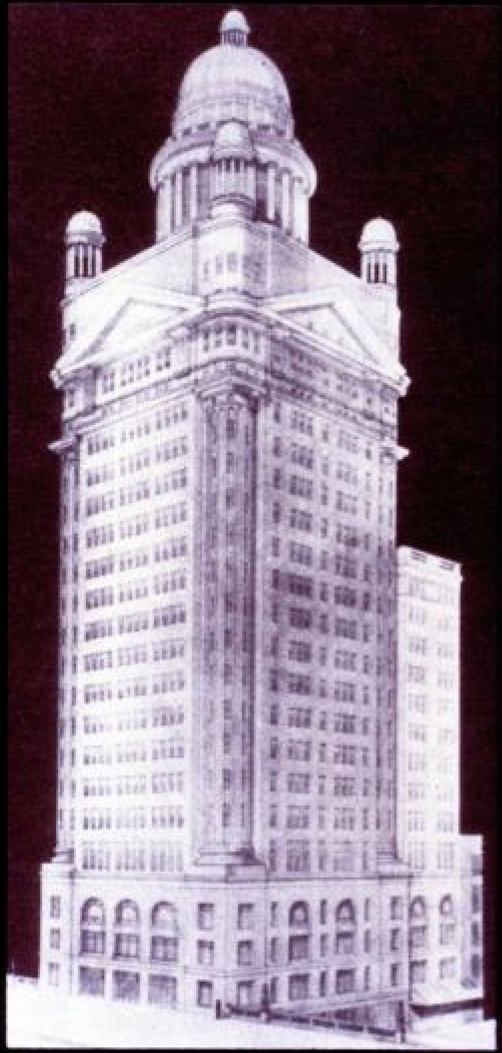


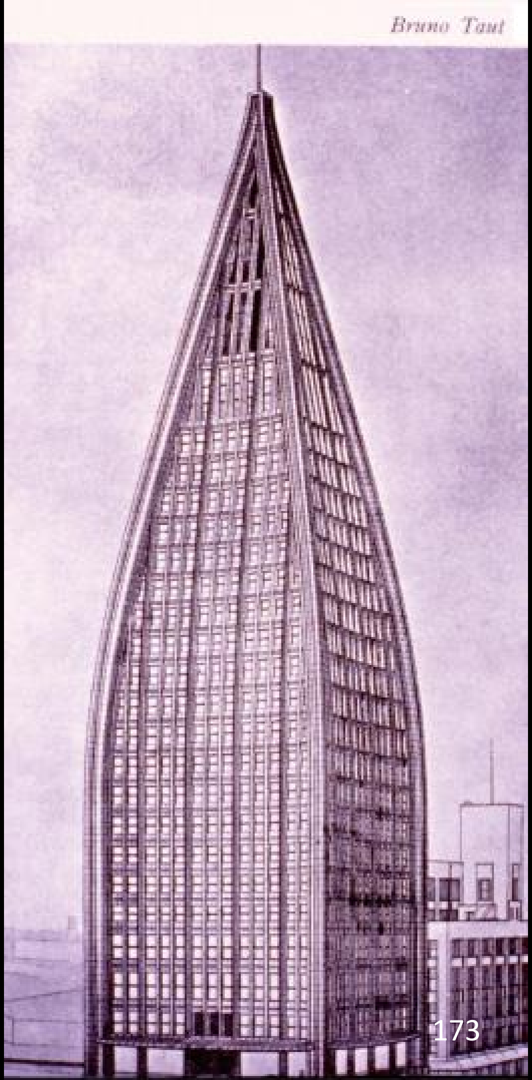
Winning Entry for the Chicago Tribune
Tower Competition 1923
John Mead Howells and Raymond Hood

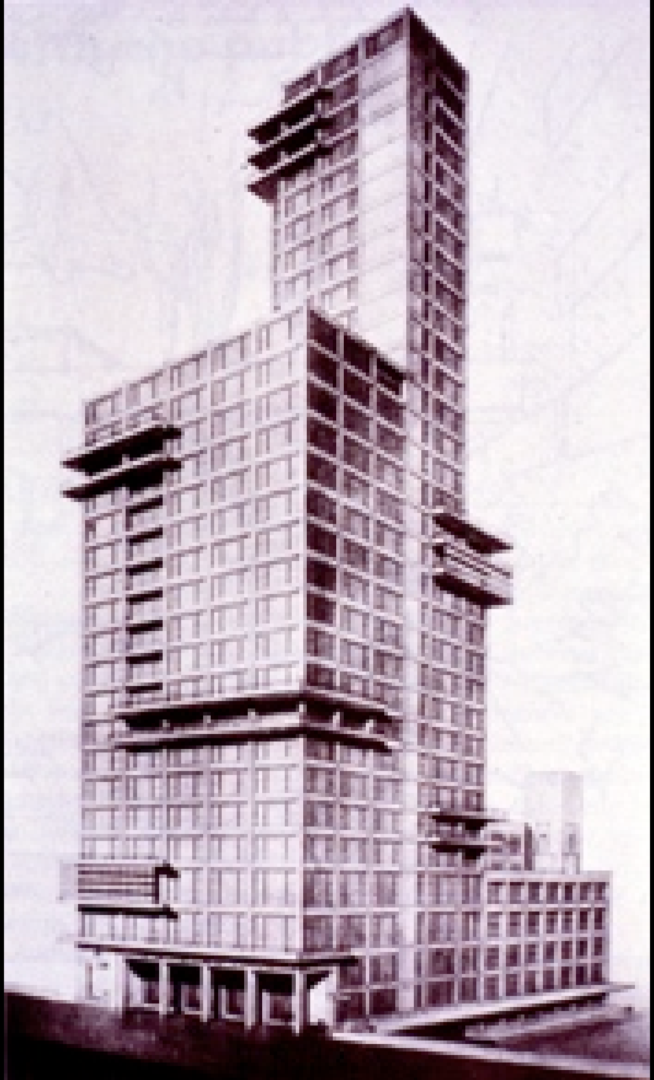

Adolf Loos

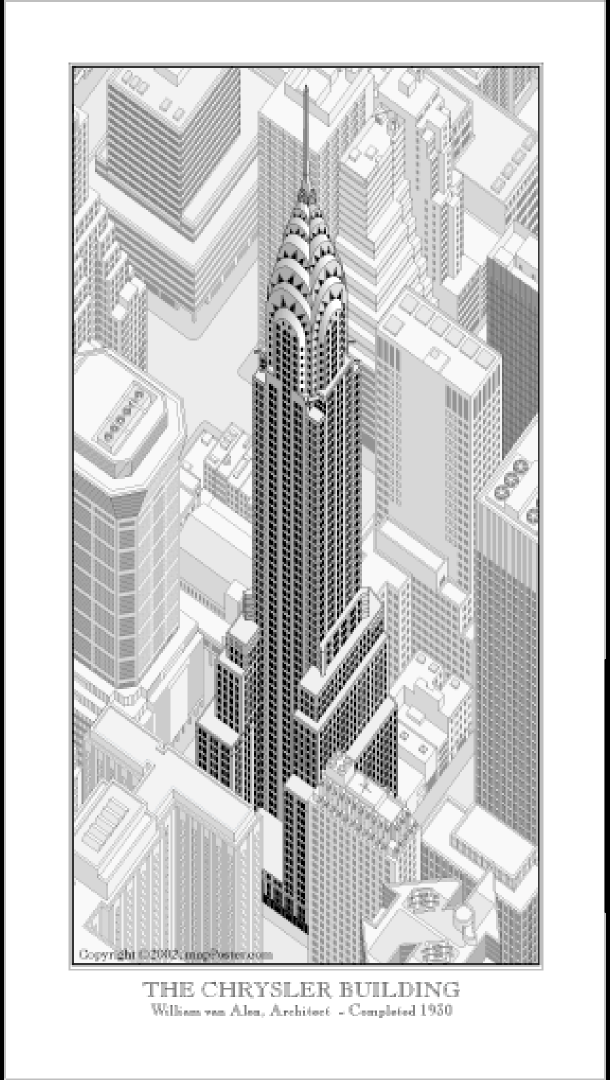



Eliel Saarinen. Perspective



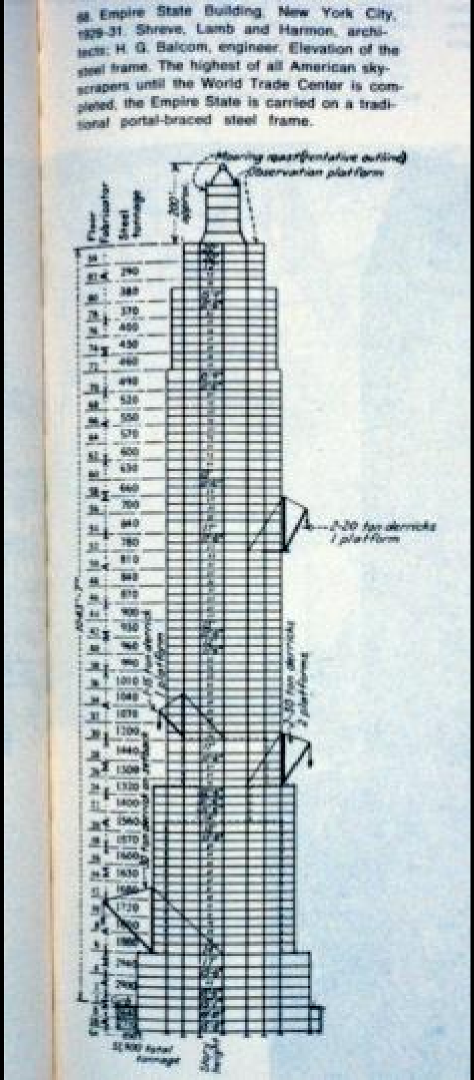

Bruno Taut





Chrysler Building
New York City
1930
319m

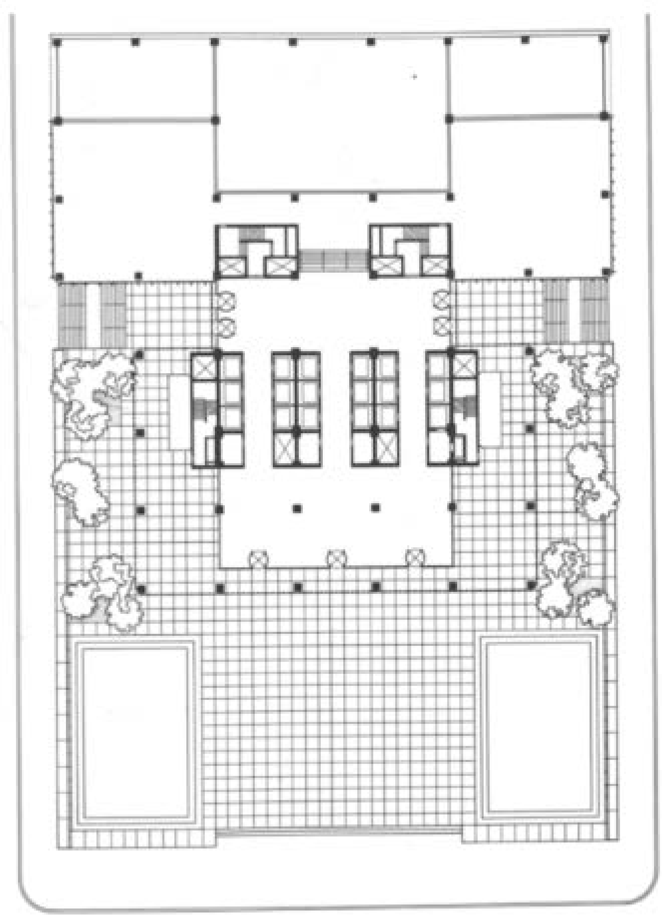
Art Deco Style

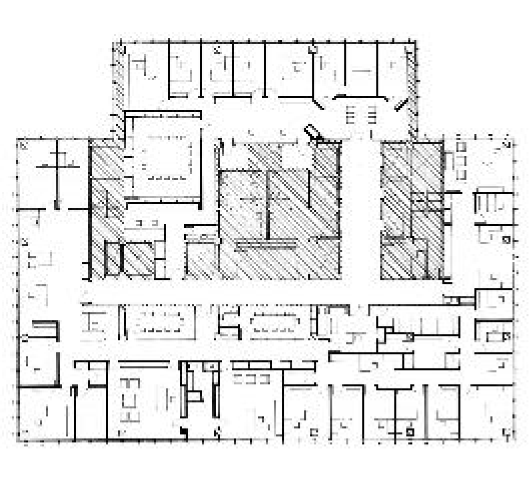


68. Empire State Building, New York City, 1929-31. Shreve, Lamb and Harmon, architects; H. G. Balcom, engineer. Elevation of the steel frame. The highest of all American skyscrapers until the World Trade Center is completed, the Empire State is carried on a traditional portal-braced steel frame.

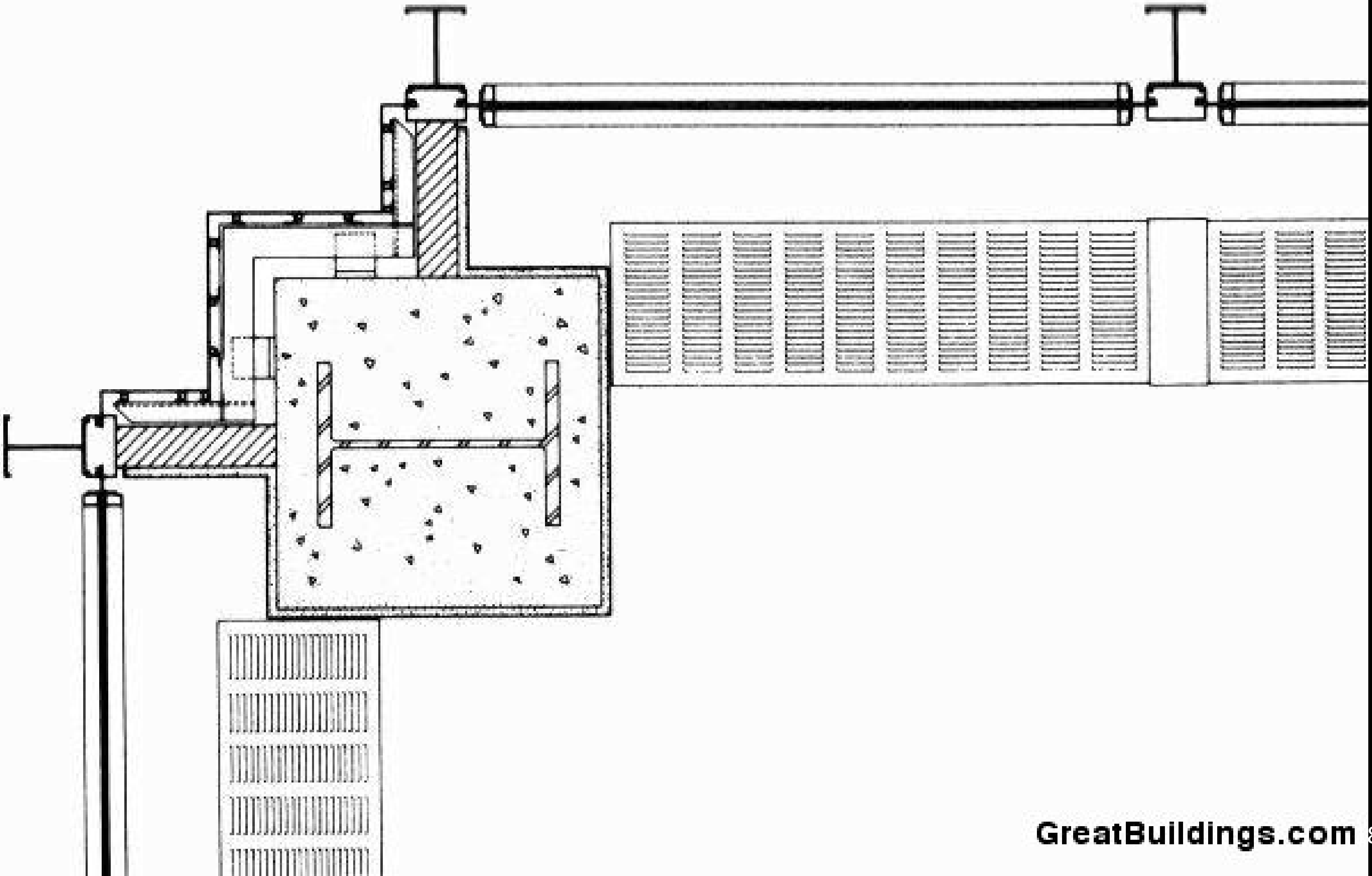
Empire State Building
New York City, USA
1931
381m

Seagram Building
New York City
Ludwig Mies van der Rohe
1958
157m

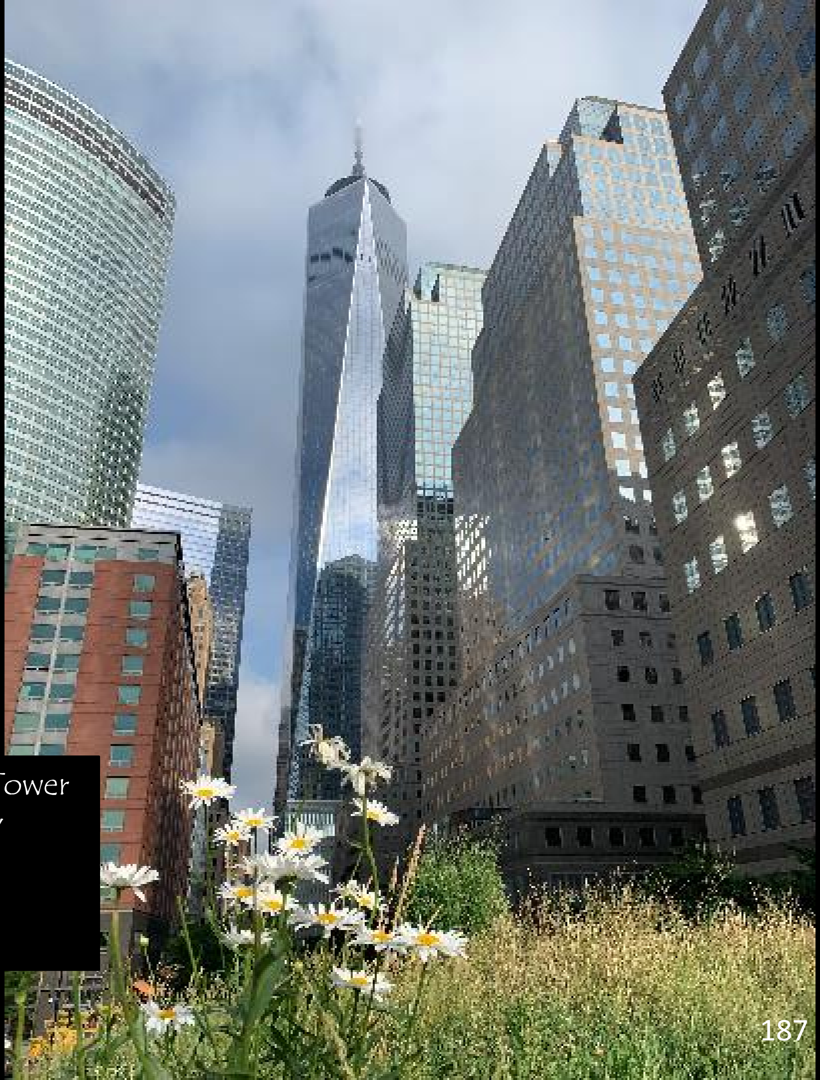





Park Ave



Lever House
New York City
Skidmore Owings and Merrill
1952
94m



New World Trade Tower
New York City
SOM
2014
546.2m

John Hancock Center
Chicago, Illinois
SOM and Fazlur Khan
1970
344m

Sears Tower (Willis)
Chicago, Illinois
SOM and Fazlur
Khan
1972
442m

The Shard
London, UK
Renzo Piano
2013
244m

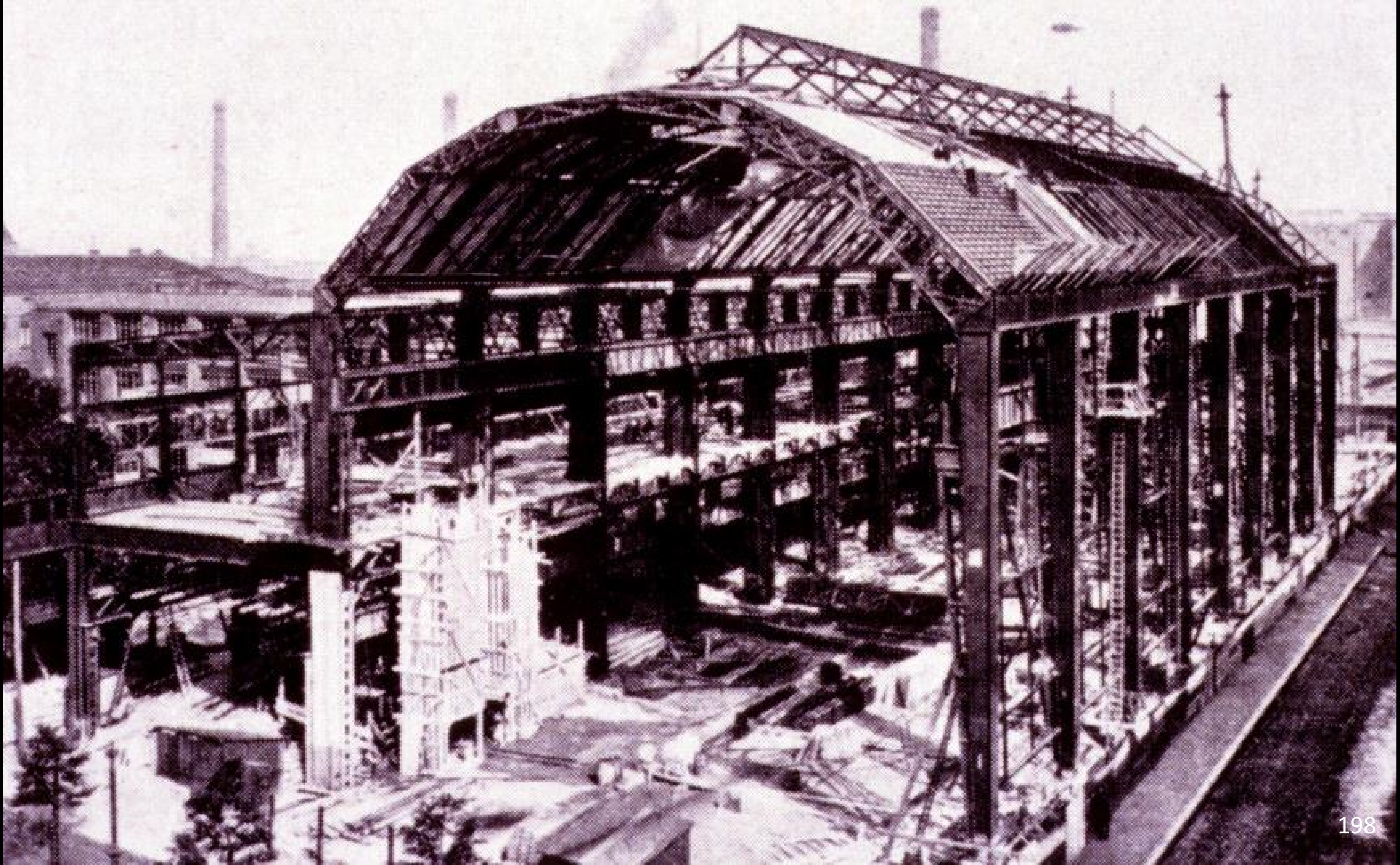
Gateway Arch
St. Louis, Missouri
Eero Saarinen
1963
192m

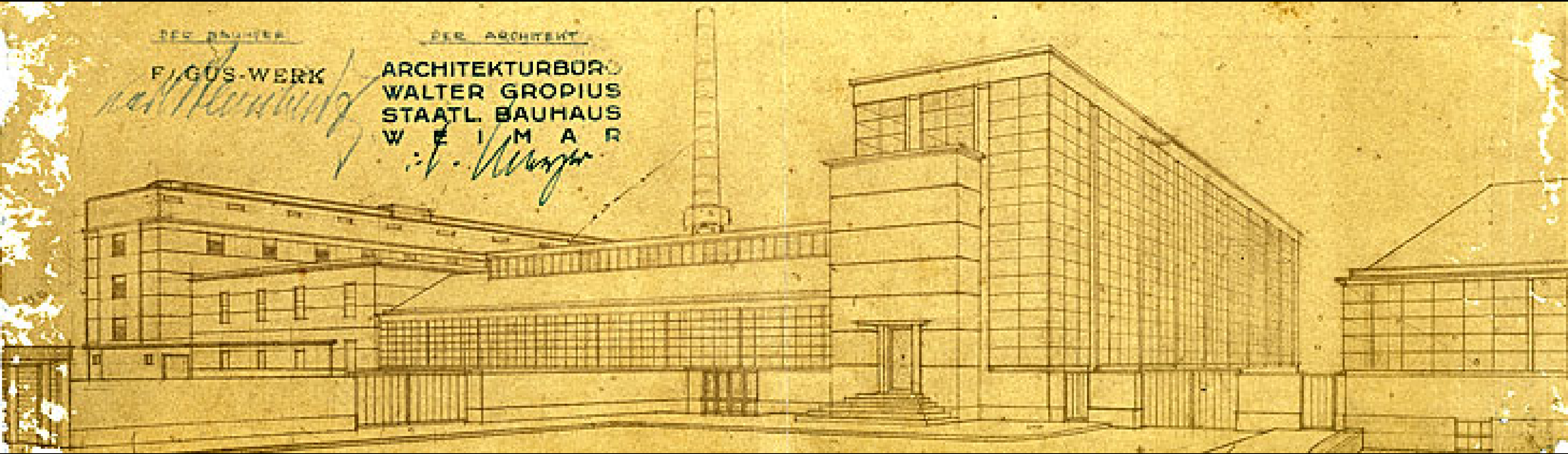
From Iron to Steel
~ technique to technology~

Low-rise framing

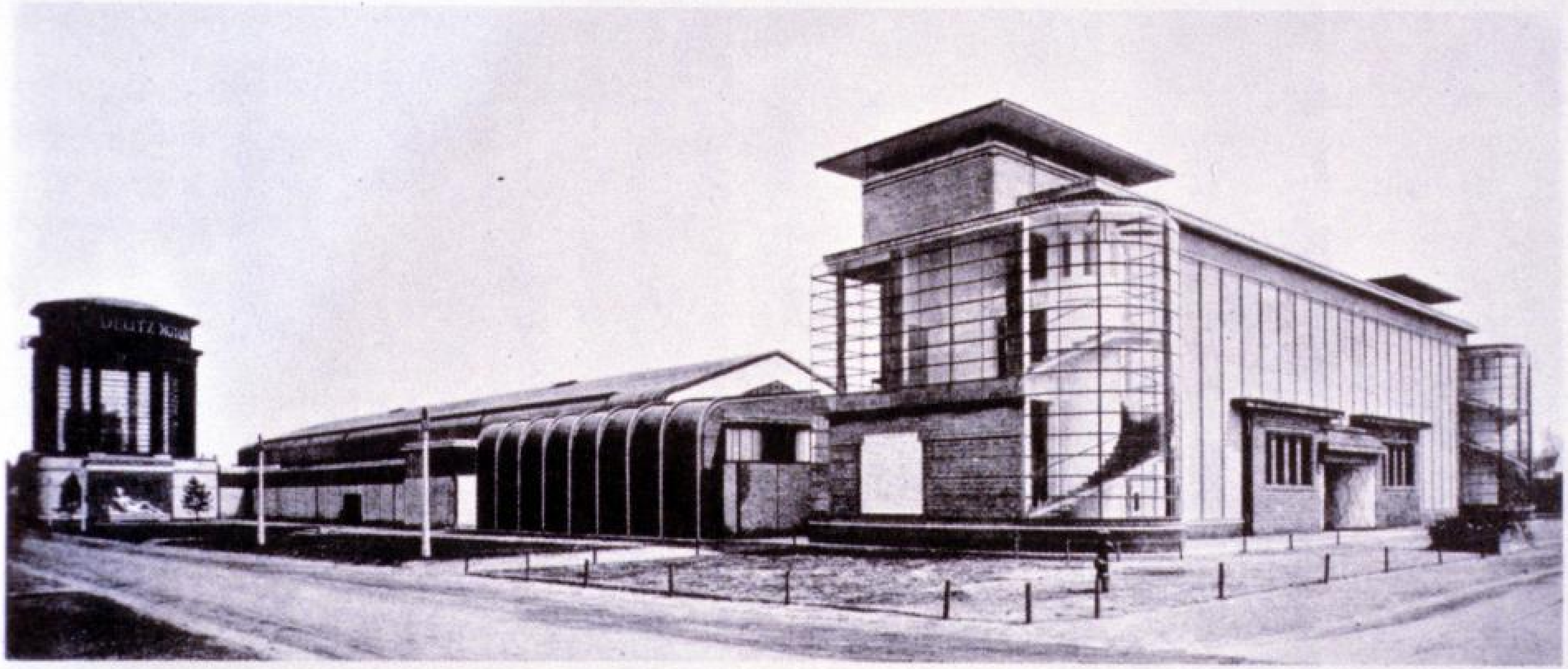
AEG Turbine Factory
Berlin, Germany
Peter Behrens Architect
1909


AEG

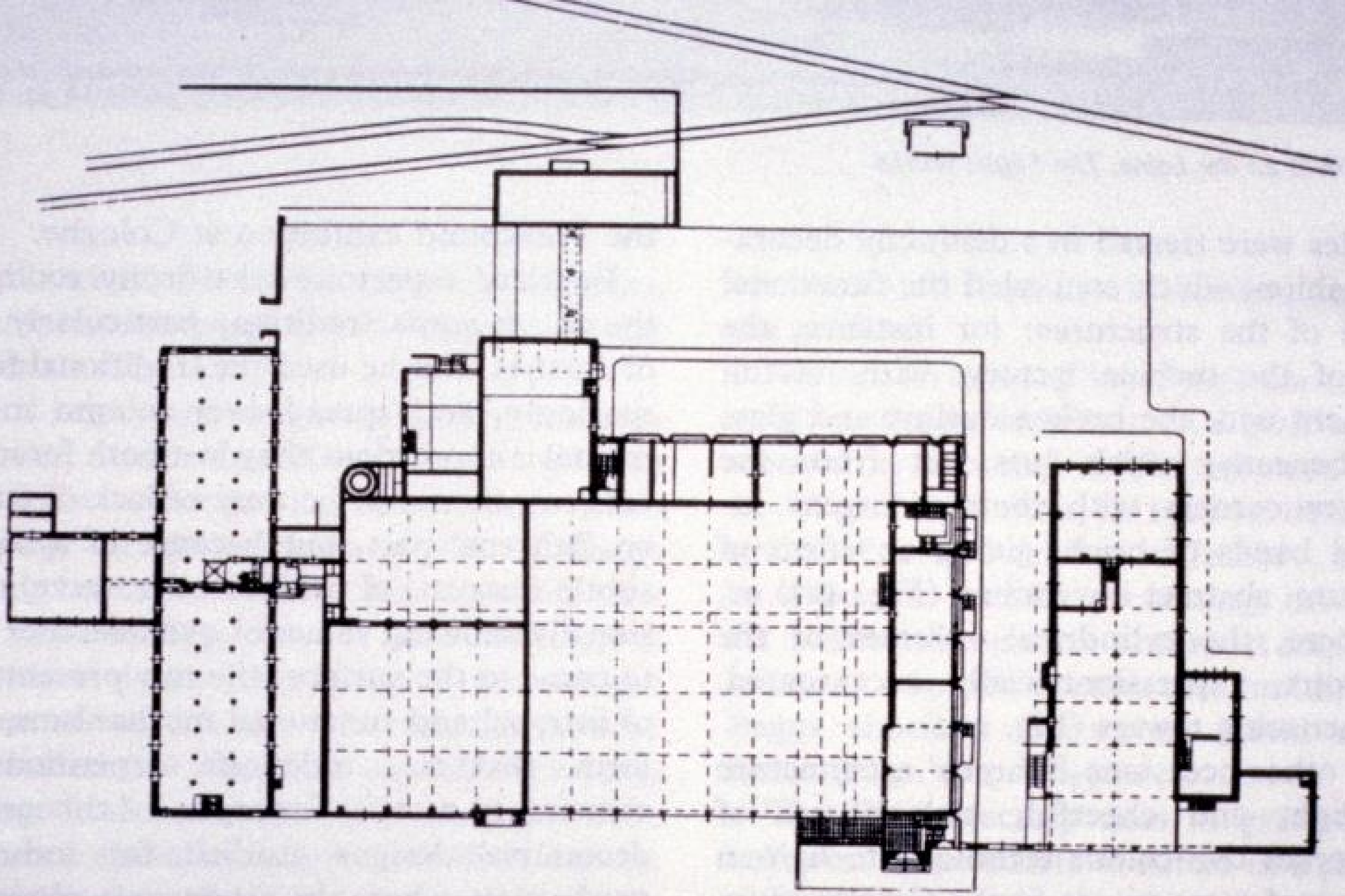




Fagus Factory
Alfeld, Germany
Adolph Meyer & Walter Gropius
1911



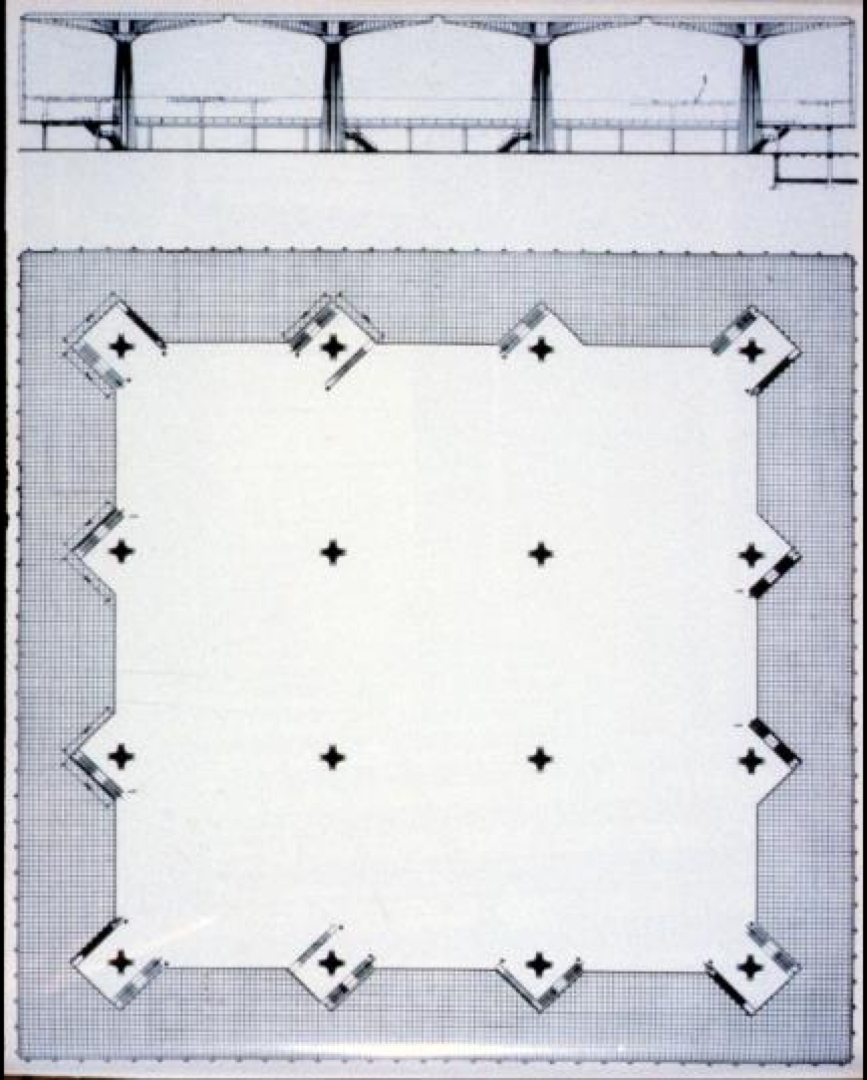
430, 431 W. Gropius and A. Meyer, Detail of the Fagus works and the model factory at the exhibition of the Werkbund in Cologne, 1914 (from G. A. Platz, op. cit.)

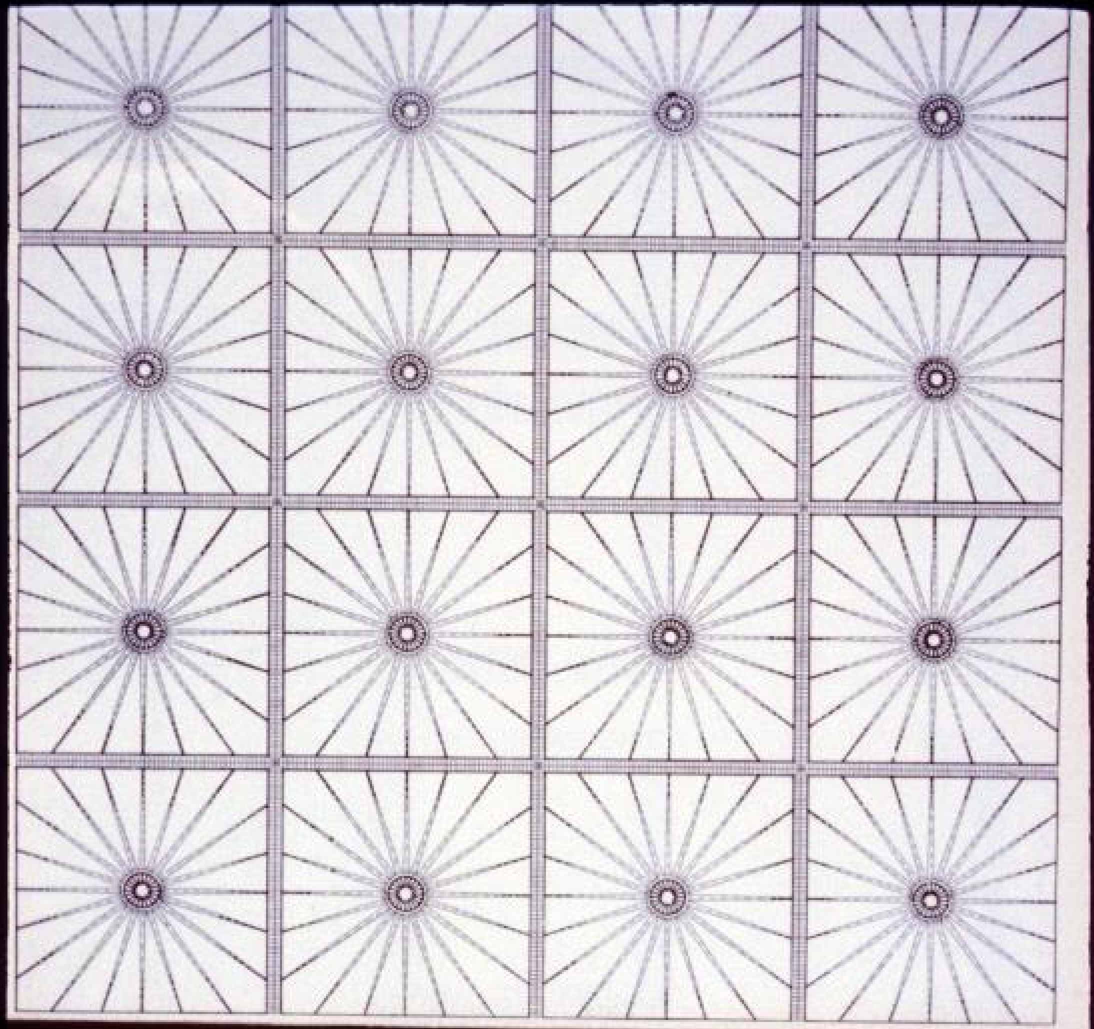


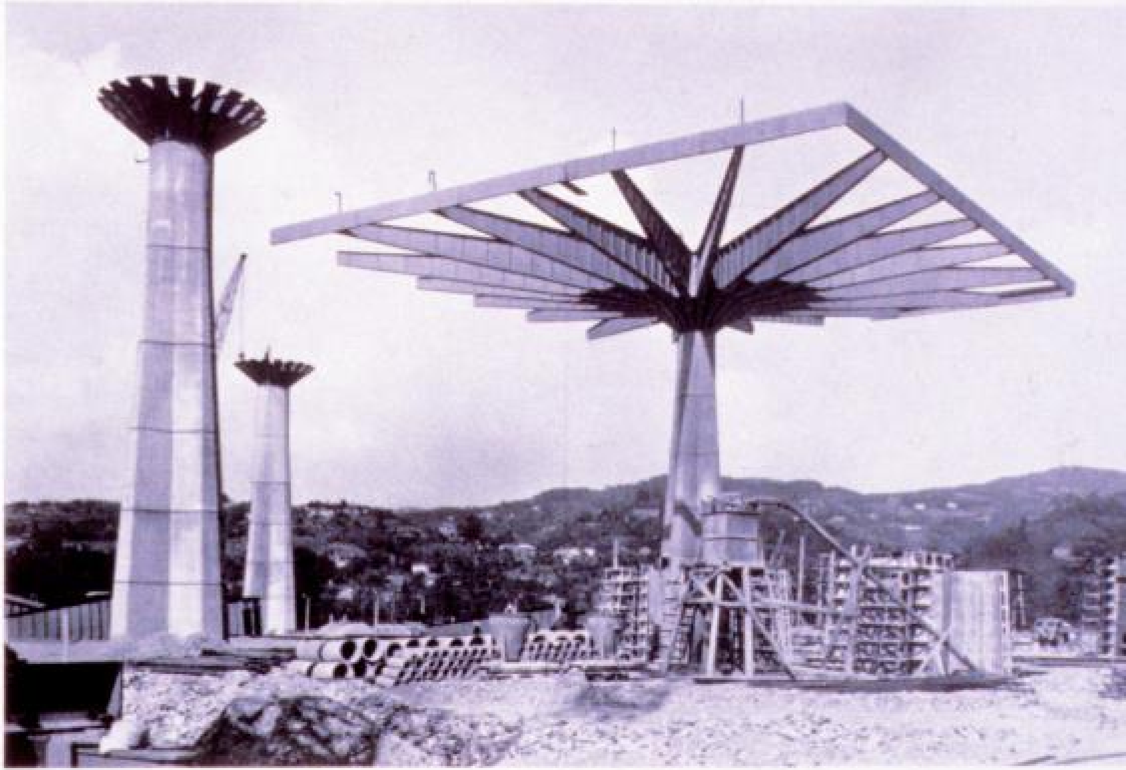
426, 427 *Alfeld an der Leine, The Fagus works (W. Gropius and A. Meyer 1911)*


FAGUS

Torino Esposizioni
Turin, Italy
Pier Luigi Nervi
1948

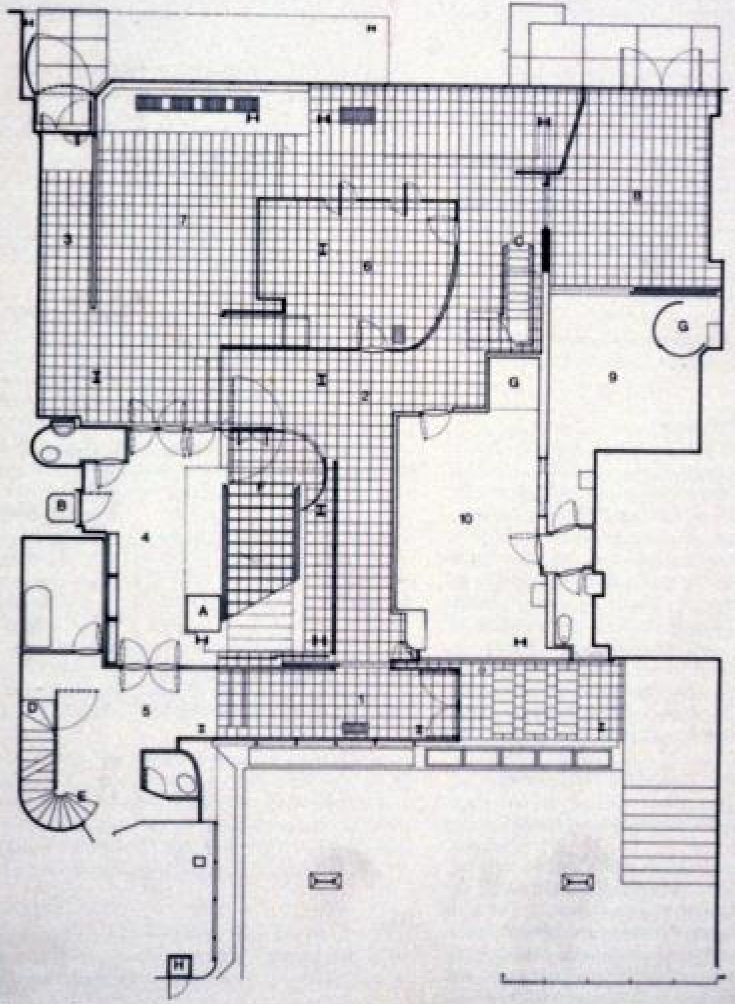






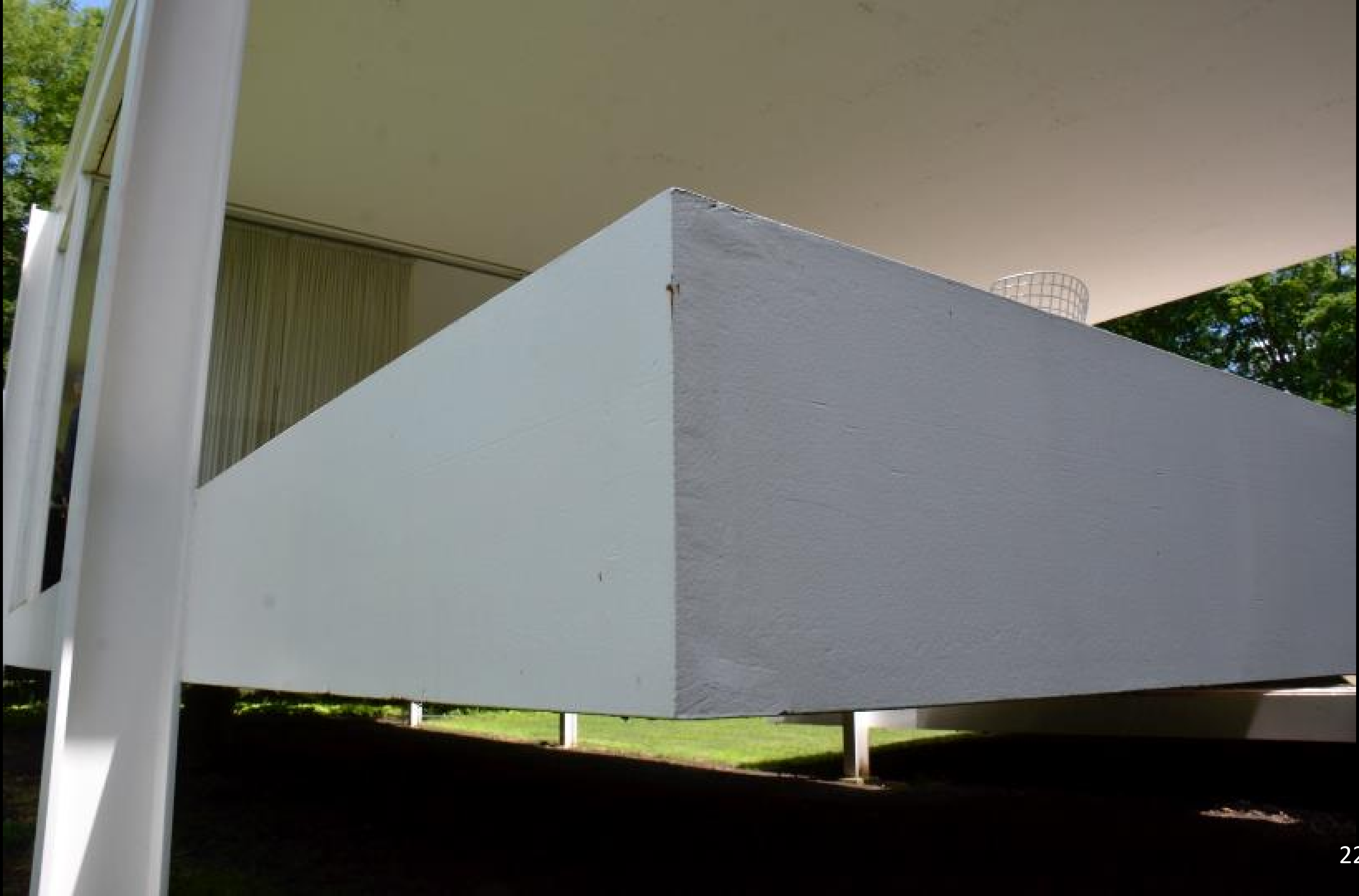
Residential Buildings

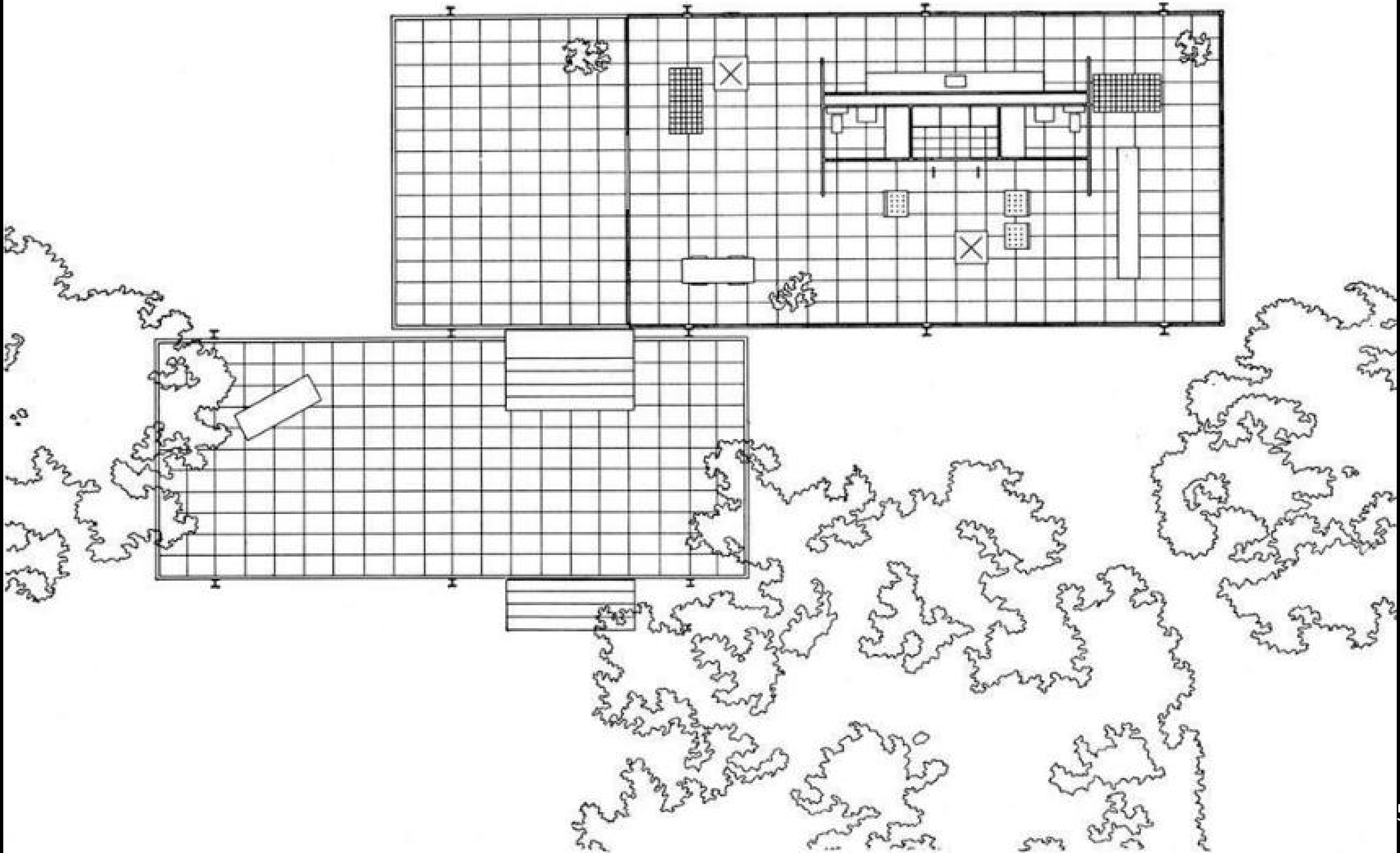
Maison de Verre
Paris, France
Pierre Chareau
1932

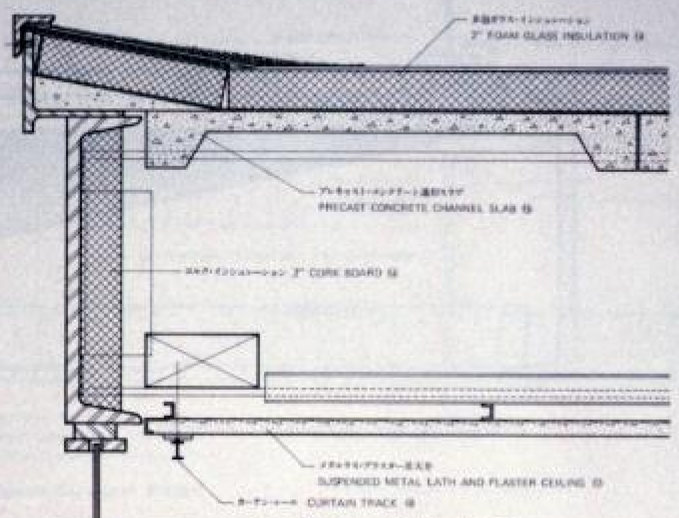


Ground floor plan

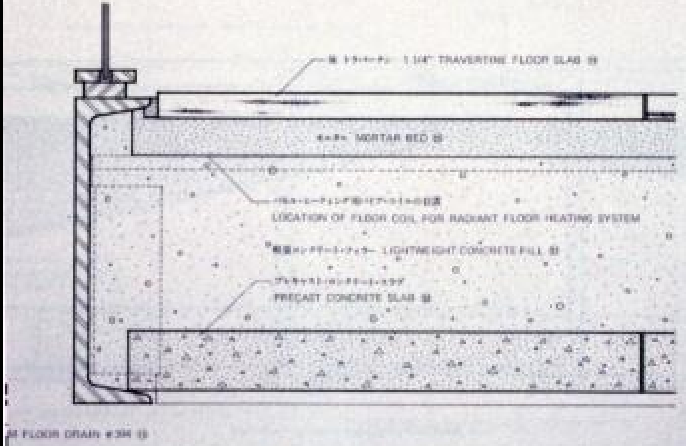
Farnsworth House
Ludwig Mies van der Rohe
Plano, Illinois
1951



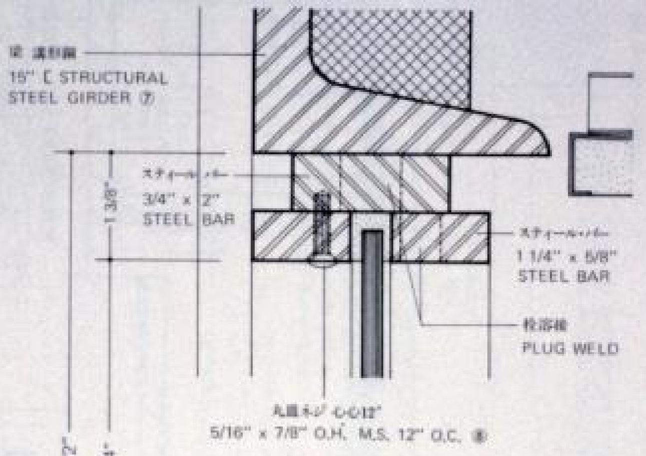




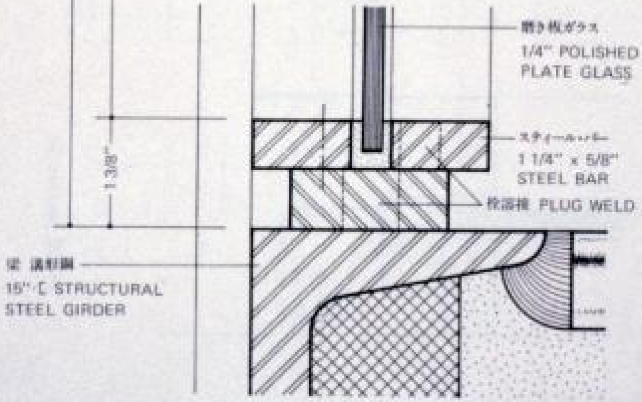
屋根断面図 Section C-C through Roof



床断面図 Section C-C through Floor



断面図 Section 109



断面図 Section 110

S. R. Crown Hall
Illinois Institue of Technology
Chicago, Illinois, USA
Ludwig Mies van der Rohe
1956

From Iron to Steel
~ technique to technology~

Tensile Structures

Iron and steel were able to resist
TENSION forces
Completely changing the range of
possibility in structural design

cables = steel "rope"

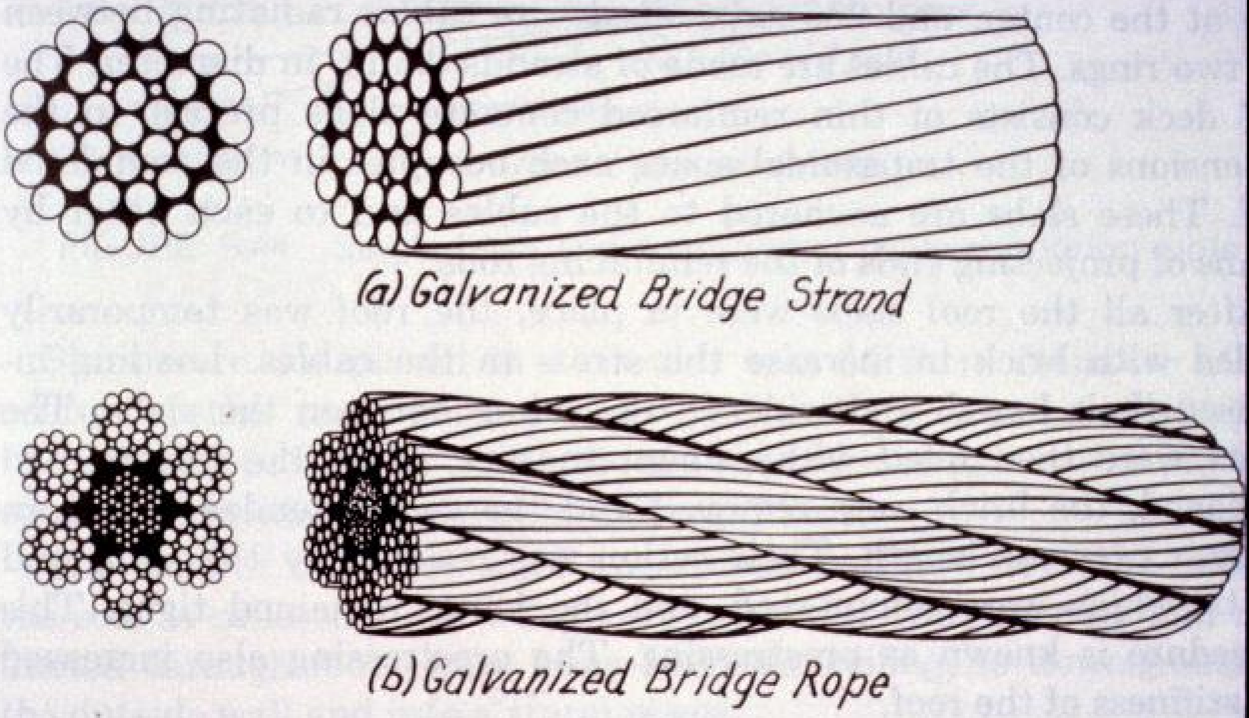
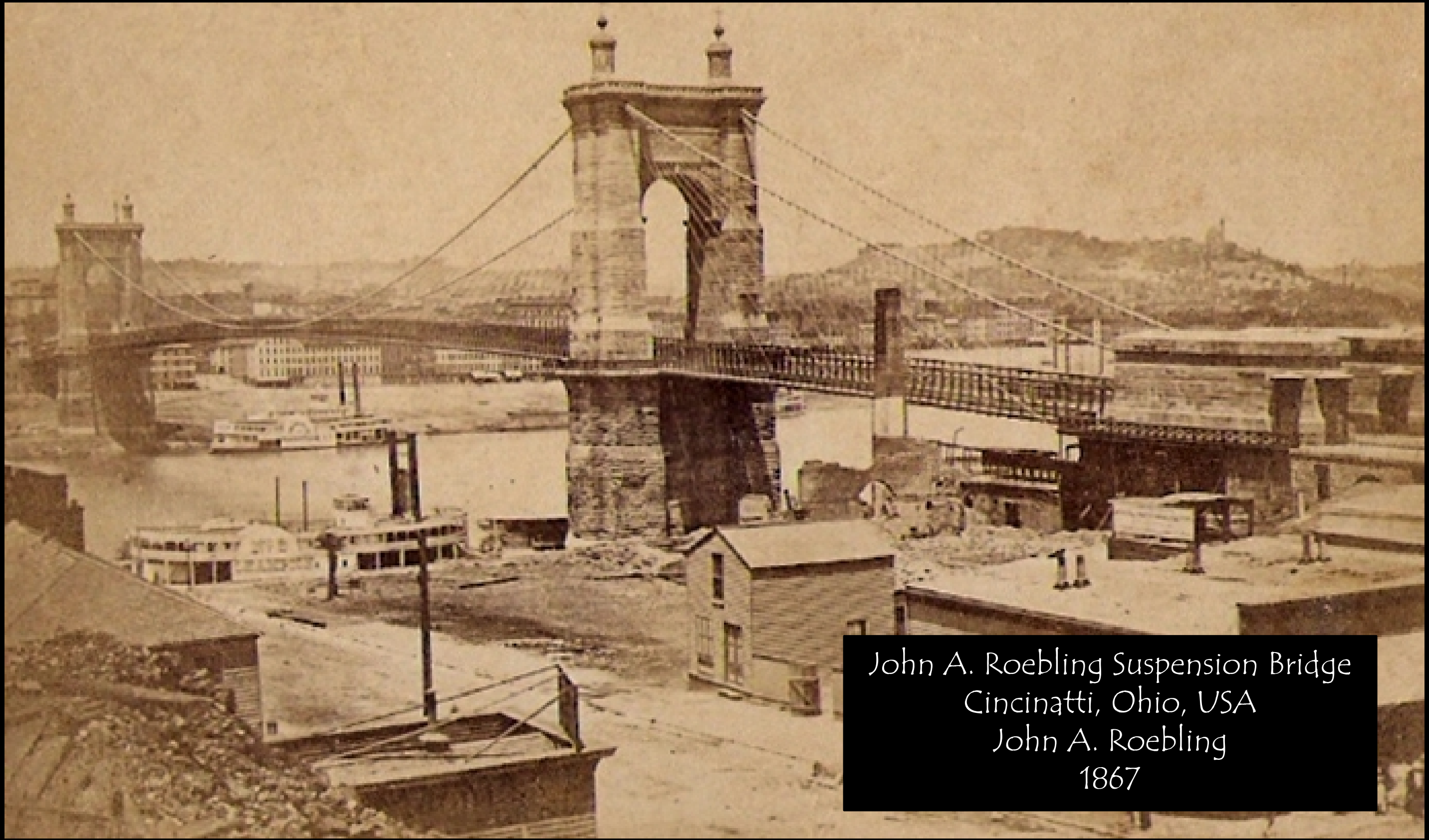


FIGURE 6.43 Wire strand and rope.

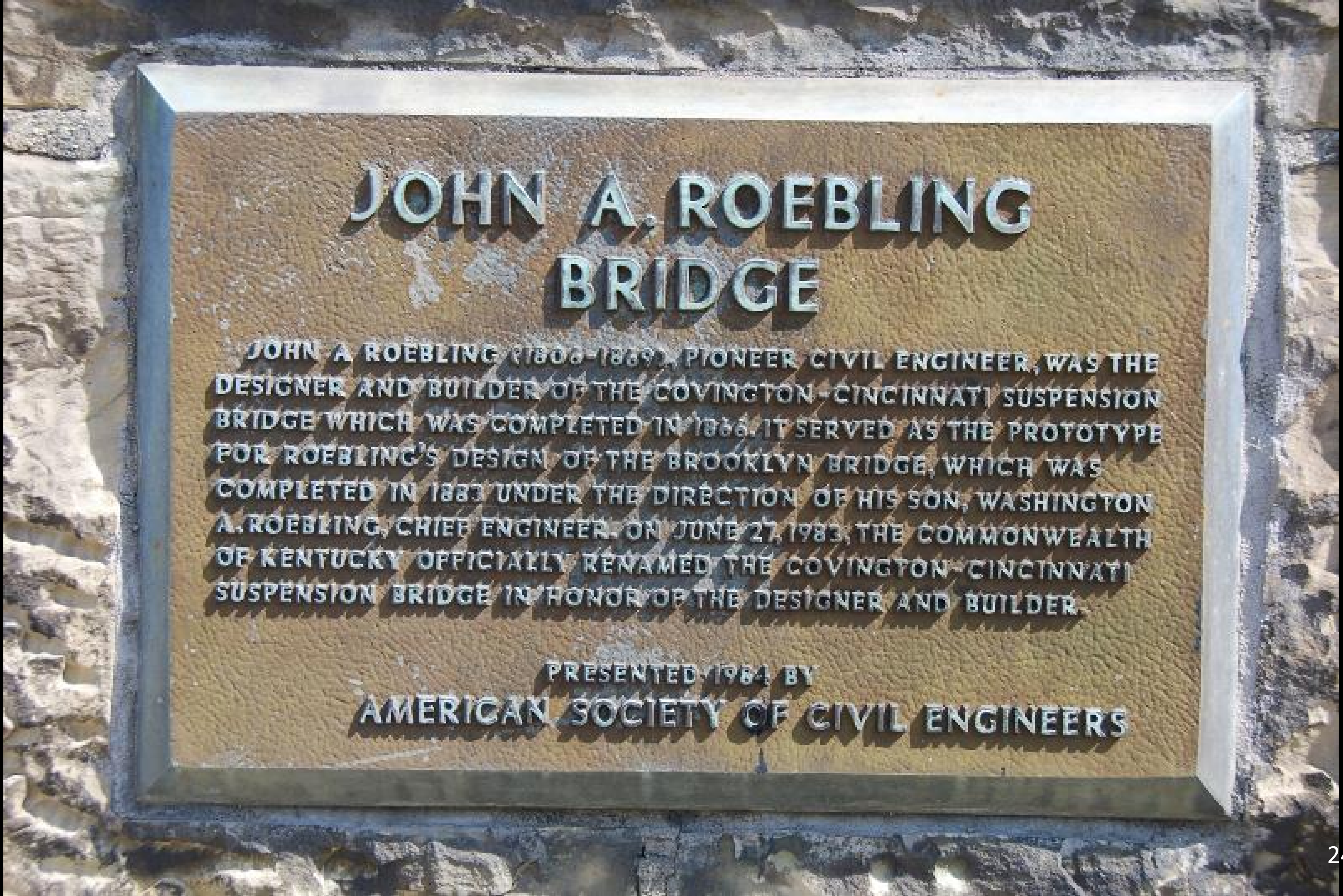
Bridges

New possibilities for greater spans between abutments due to cables



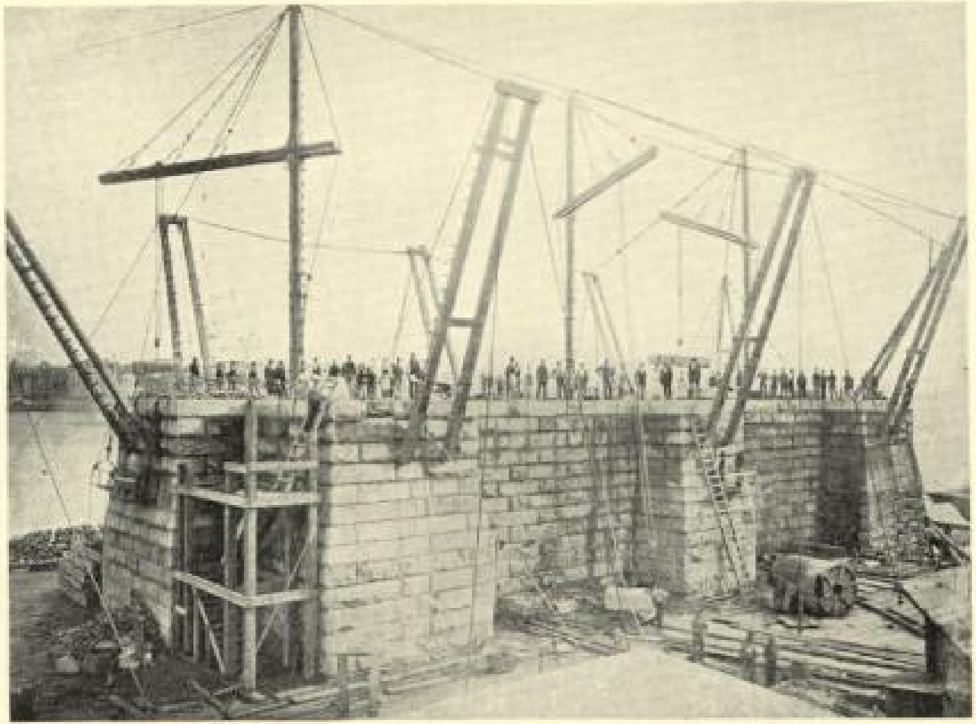
John A. Roebling Suspension Bridge
Cincinatti, Ohio, USA
John A. Roebling
1867


John A. Roebling Bridge
1867


JOHN A. ROEBLING
BRIDGE
JOHN A. ROEBLING (1806-1869), PIONEER CIVIL ENGINEER, WAS THE DESIGNER AND BUILDER OF THE COVINGTON-CINCINNATI SUSPENSION BRIDGE WHICH WAS COMPLETED IN 1866. IT SERVED AS THE PROTOTYPE FOR ROEBLING'S DESIGN OF THE BROOKLYN BRIDGE, WHICH WAS COMPLETED IN 1883 UNDER THE DIRECTION OF HIS SON, WASHINGTON A. ROEBLING, CHIEF ENGINEER. ON JUNE 27, 1983, THE COMMONWEALTH OF KENTUCKY OFFICIALLY RENAMED THE COVINGTON-CINCINNATI SUSPENSION BRIDGE IN HONOR OF THE DESIGNER AND BUILDER.
PRESENTED 1984 BY
AMERICAN SOCIETY OF CIVIL ENGINEERS


CANADA
33817S
S12E

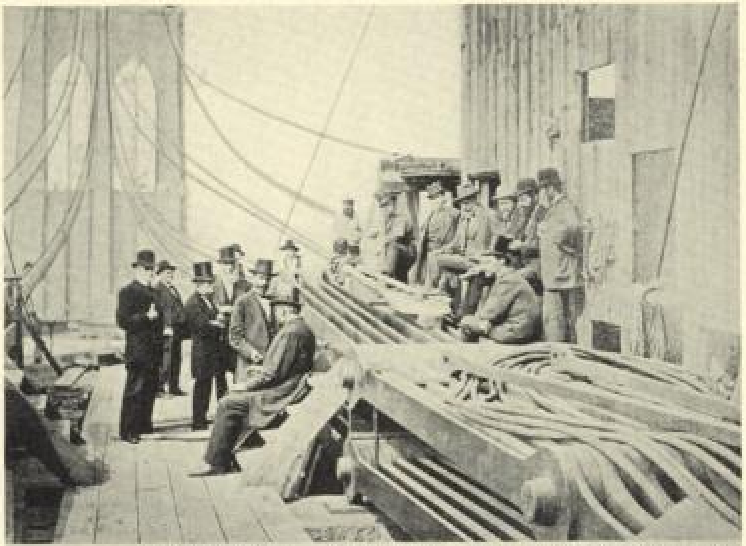
Brooklyn Bridge
New York City, USA
John A. Roebling
1893



New York Masonry Tower under construction. Tower completed July, 1876.

Brooklyn Anchorage—October, 1878.

The photograph shows how the cables are fastened to the Anchor Bars leading to the Anchor Plates under the masonry.



HENRY C. MURPHY, Pres. WM. DEMPSEY, Foreman of Riggers W. HILDENBRAND, Ch. Draftsman
JOHN H. PRENTICE, Treas. WM. H. PAINE, Asst. Engr. E. F. FARRINGTON, Master Carpenter
C. P. QUINTARD, Secy. CHARLES C. MARTIN, 1st Asst. Engr.
WM. VAN DER BOSCH, Draftsman F. COLLINGWOOD, Asst. Engr.
GEO. W. McNULTY, Asst. Engr.

Brooklyn Bridge looking toward Manhattan—1933.

Brooklyn Bridge. Wire cables under construction. Last cable wire was run October 5, 1878.

10781-86 EAST RIVER AND DOWNTOWN, NEW YORK. FROM BROOKLYN BRIDGE.
PHOTO. BROWN BROS., NEW YORK.


Brooklyn and Manhattan Bridges, New York
Borden's Peerless
EVAPORATED
MILK

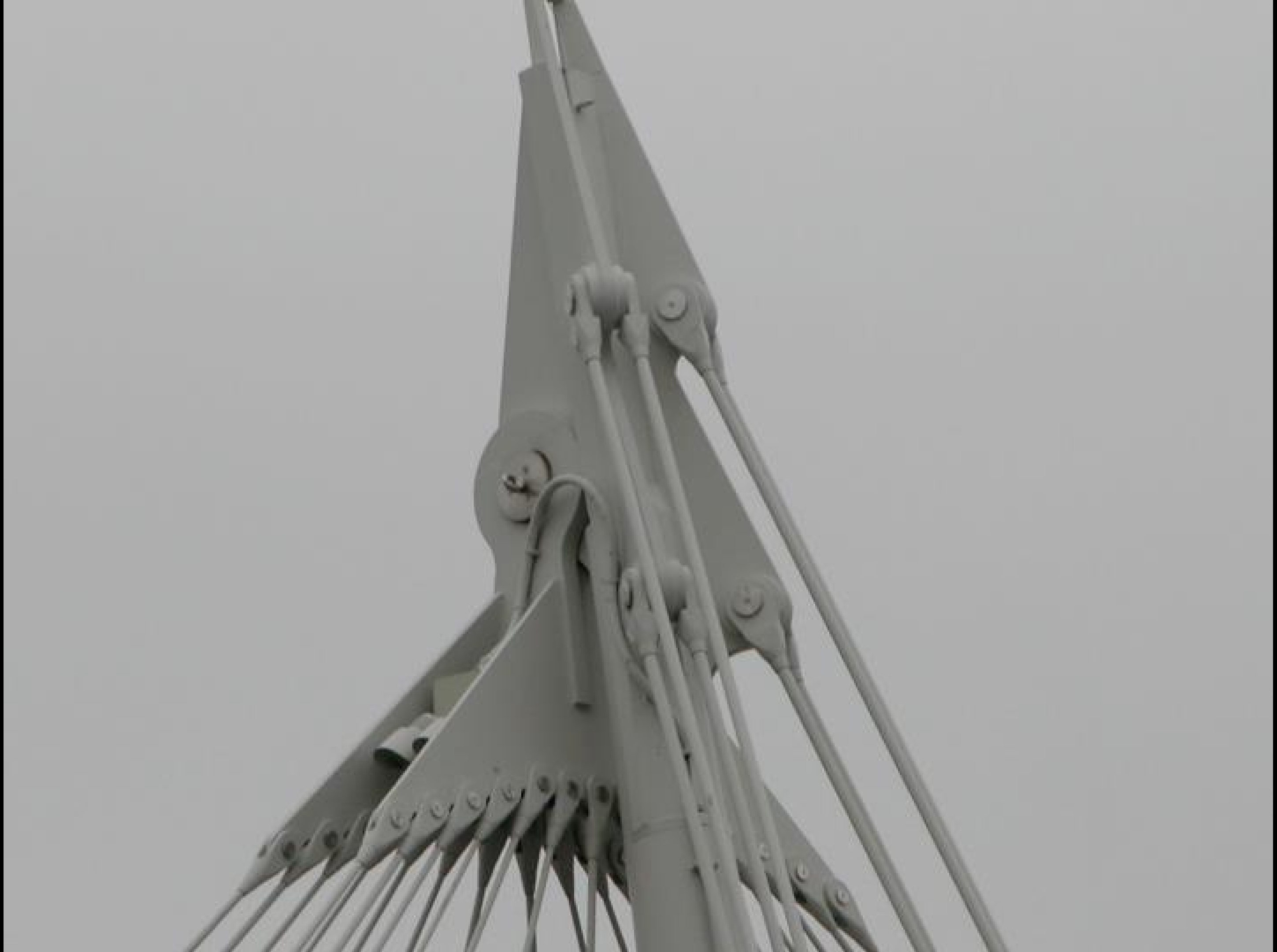
Pedestrian Bridge
Dalian, China

Humber Bay Arch Bridge
Toronto, Ontario
Montgomery Sisam Architects
1994

London Millennium Footbridge
London, England
Sir Norman Foster and Partners
Arup Engineers
2000


OLD MUTUAL

Golden Jubilee Bridge
London, England
Lifshutz Davidson Sandilands Architects
WSP Group Engineers
2000



Kurilpa Bridge
Brisbane, Australia
Cox Rayner Architects
Arup Engineers
Tensegrity cable stayed bridge
2009

Tensile structures

~

Taking advantage of what steel does BEST

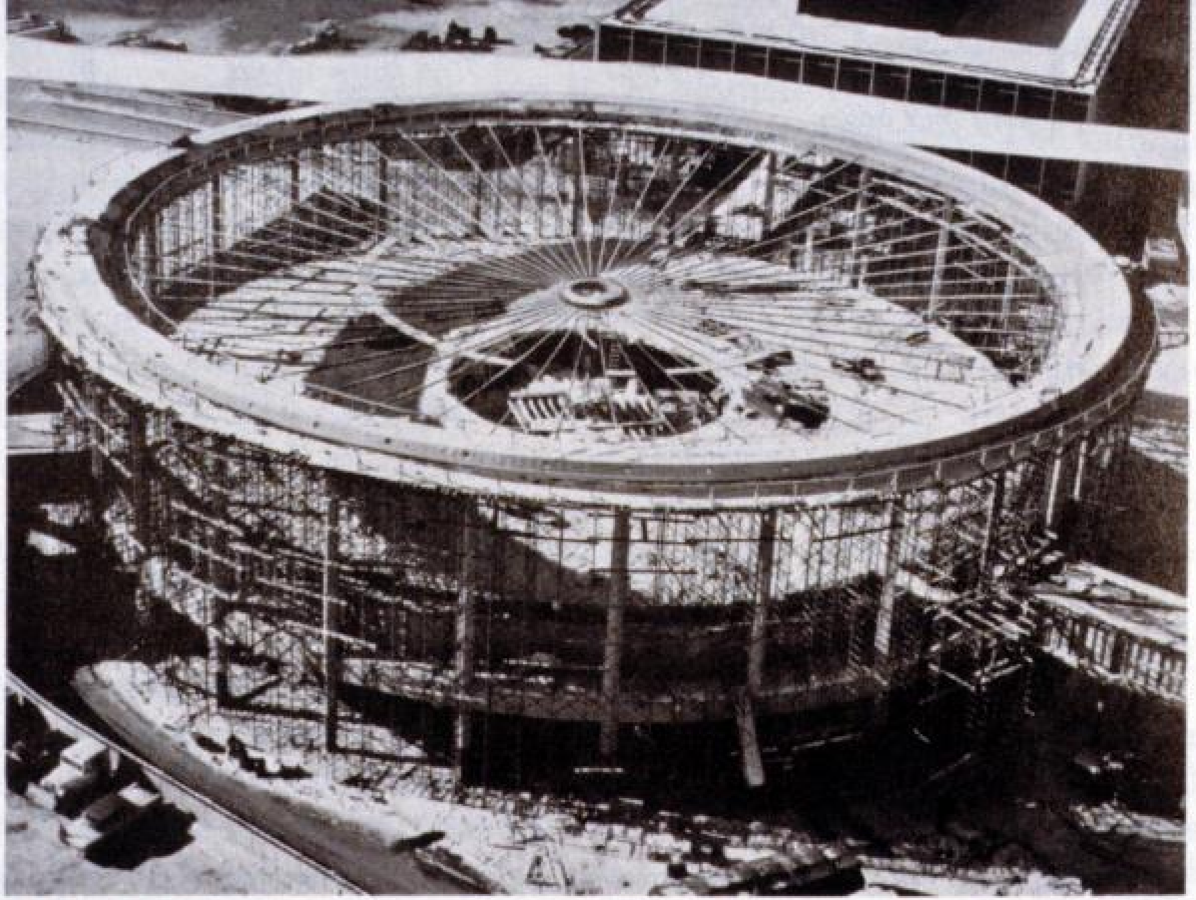


FIGURE 6.45 Single-layer, cable-supported roof. Chicago O'Hare International Airport Restaurant. Architects and Engineers: C. F. Murphy Associates. Roof Contractor: E. H. Marhoefer, Jr. Cables furnished by John A. Roebling's Sons Division, Colorado Fuel and Iron Corp.


12ft. - 6in.
ECOLAB

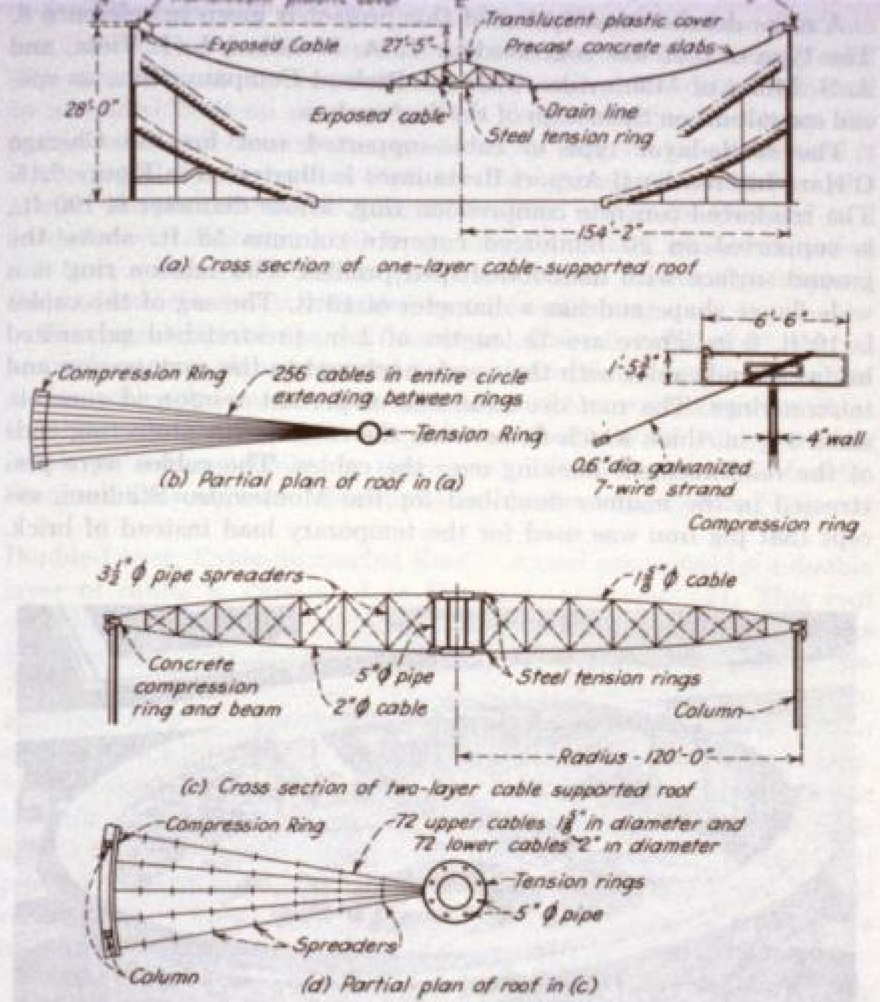
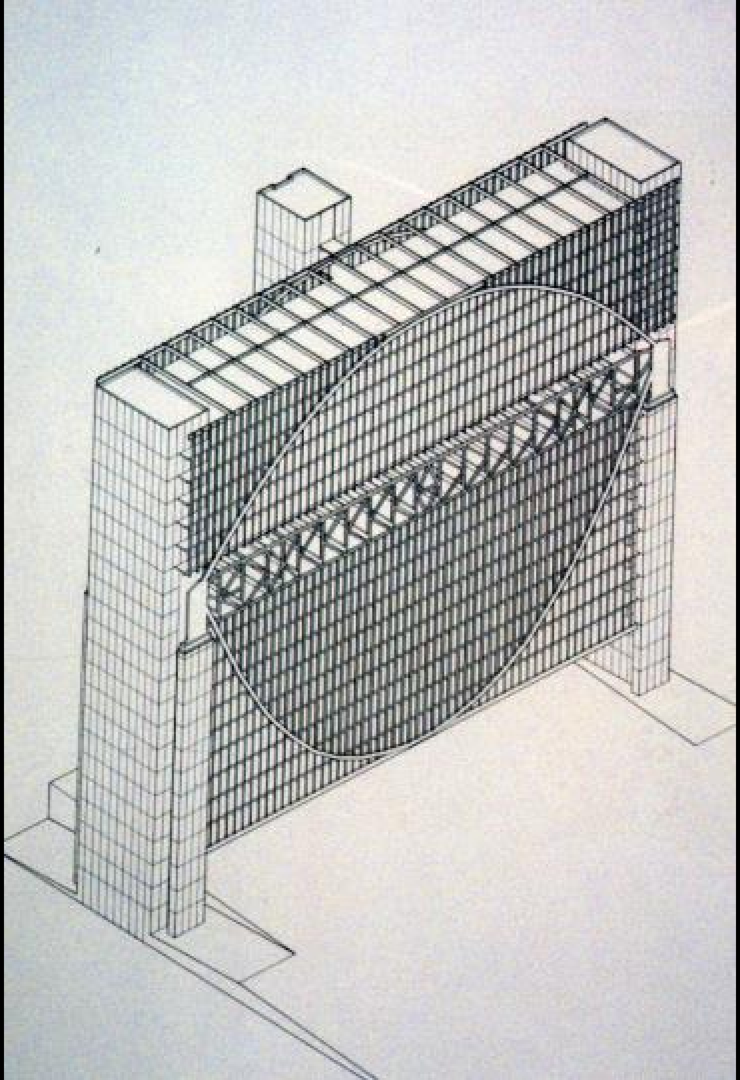


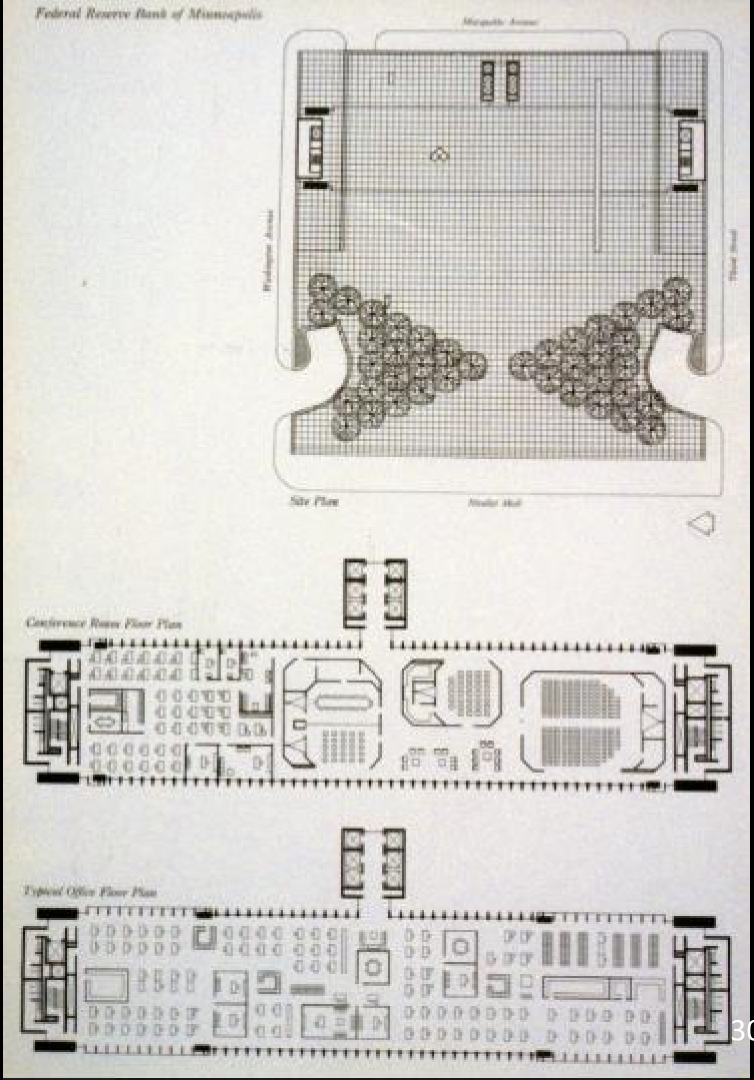
FIGURE 6.44 Single-layer and double-layer cable-supported roofs.

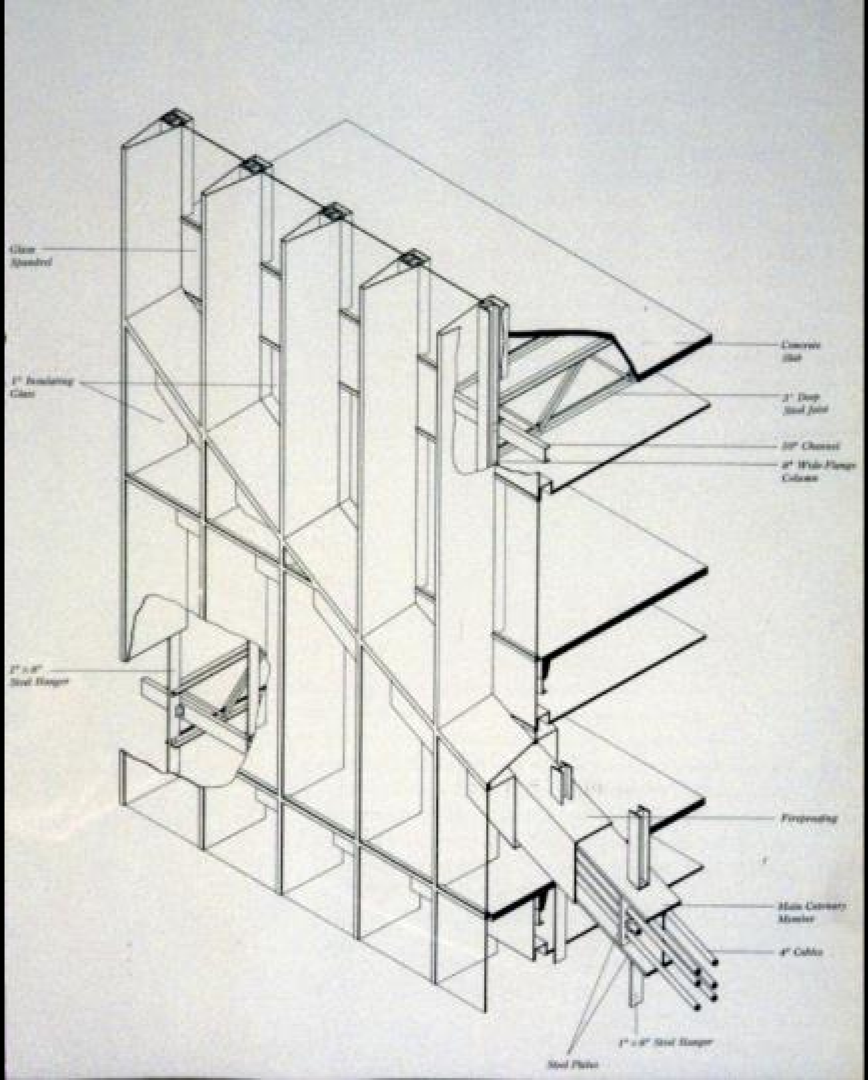
Munich Olympic Stadium
Munich, Germany
Frei Otto & Guntar Benisch
1972

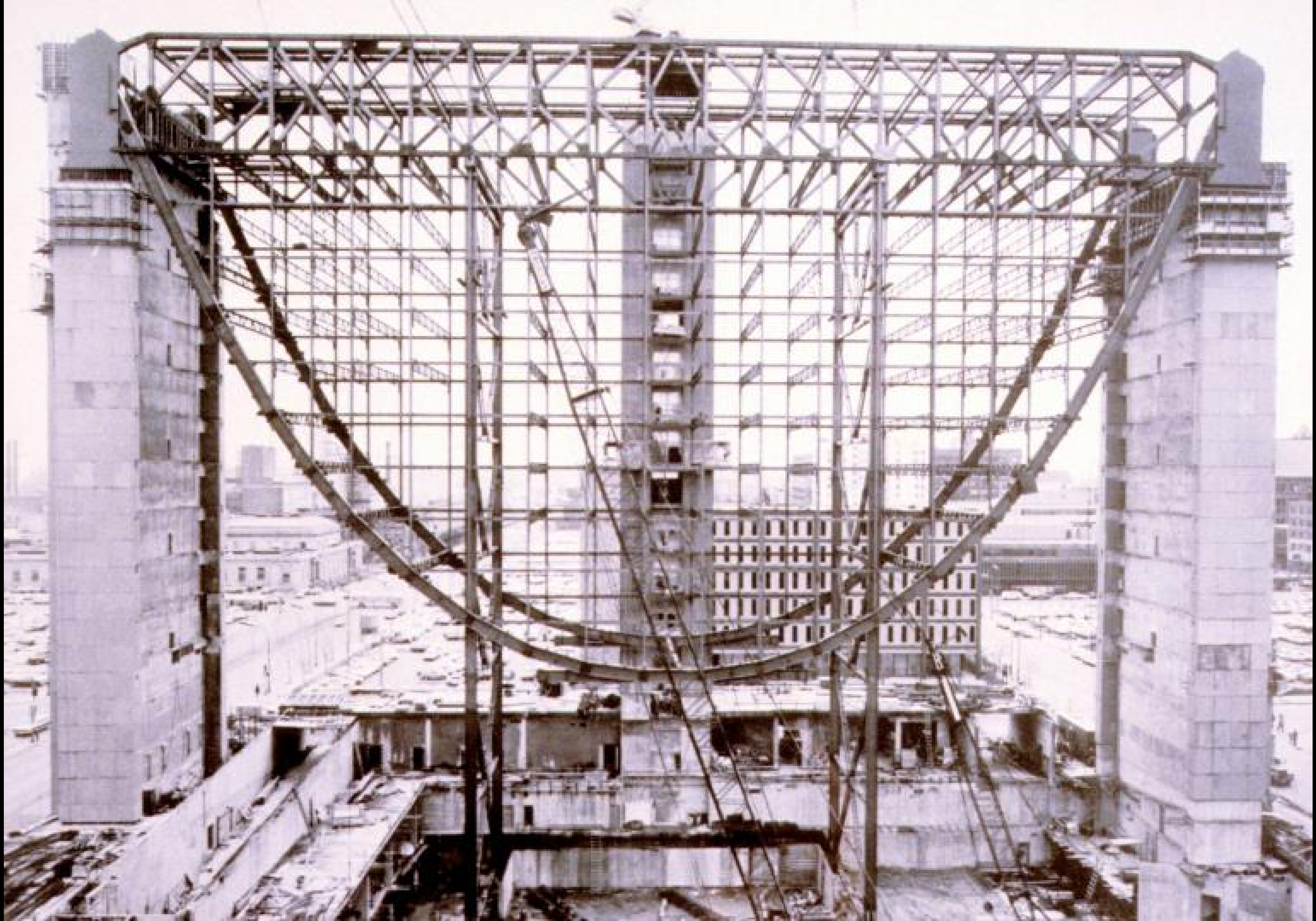

Walk on the roof?
Why not?

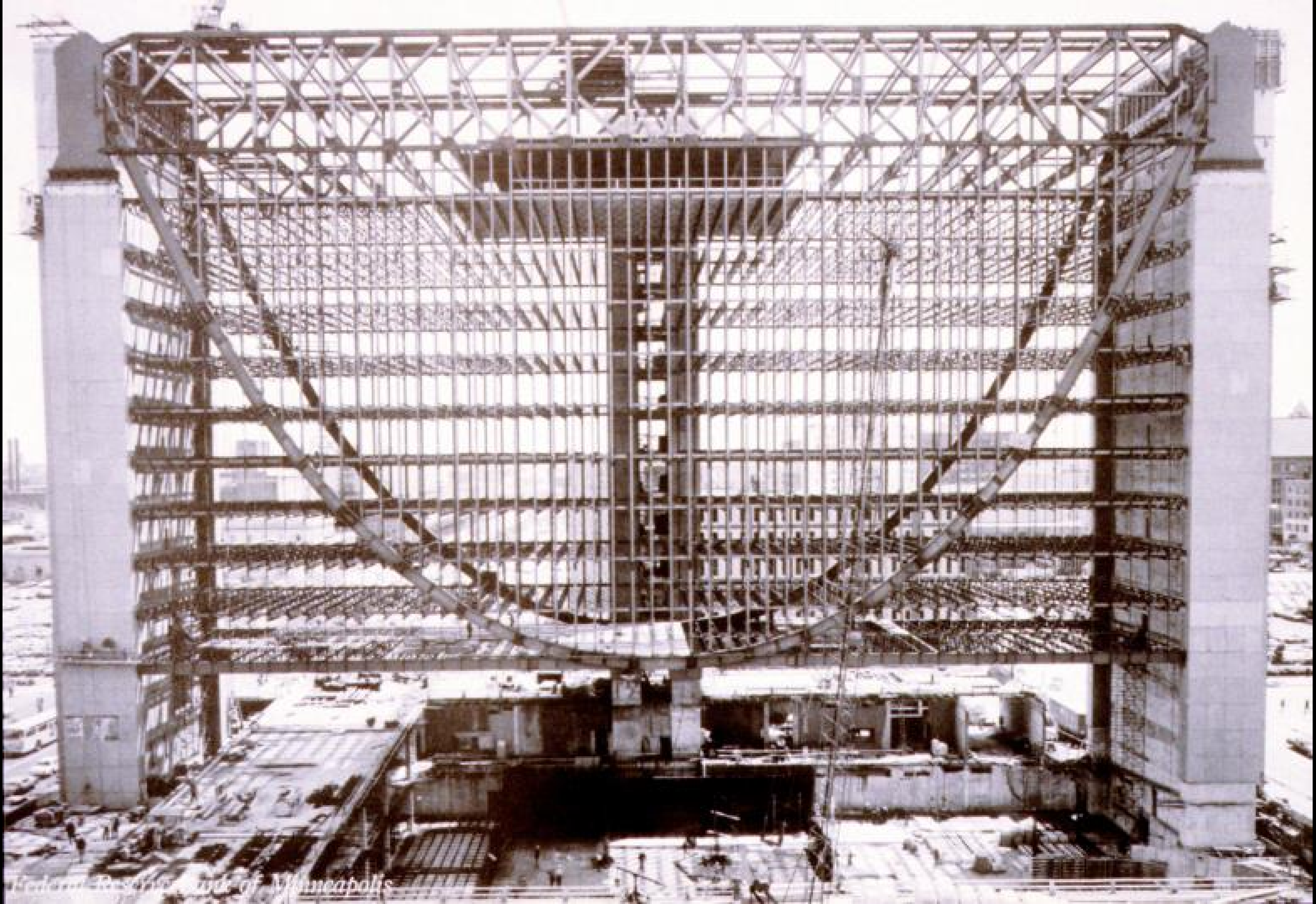
Marquette Plaza
(formerly Federal Reserve Bank)
Minneapolis, Minnesota, USA
Gunnar Birkerts
1973




Federal Reserve Bank of Minneapolis
Site Plan
Conference Room Floor Plan
Typical Office Floor Plan


Glass Spandrel
1" Insulating Glass
Concrete Slab
10" Channel
8" Wide-Flange Column
Fireproofing
Main Catenary Member
4" Cables
Steel Plates





The Sony Centre
Berlin, Germany
Helmut Jahn
2000

Quadracci Pavilion
Milwaukee Art Museum
Milwaukee, Wisconsin
Santiago Calatrava
2001

You can remelt/recycle steel indefinitely without losing any quality

The majority of the steel used today is from recycled scrap

New more efficient furnaces are reducing the CO_2 emissions from steel manufacturing