Engineering and the Modern World

Transformation of Society by Engineering

CEE 102: Prof. Michael G. Littman
Course Administrator: Hiba Abdel-Jaber hiba@princeton.edu

Computers allowed for NOTETAKING ONLY
Please - NO Cell Phones, Texting, Internet use

Language, History, and Meaning of Engineering

Scientific: formulas
relationships

Social: innovators
changes in society

Symbolic: images
changes in vision

Language, History, and Meaning of Engineering

Scientific: formulas
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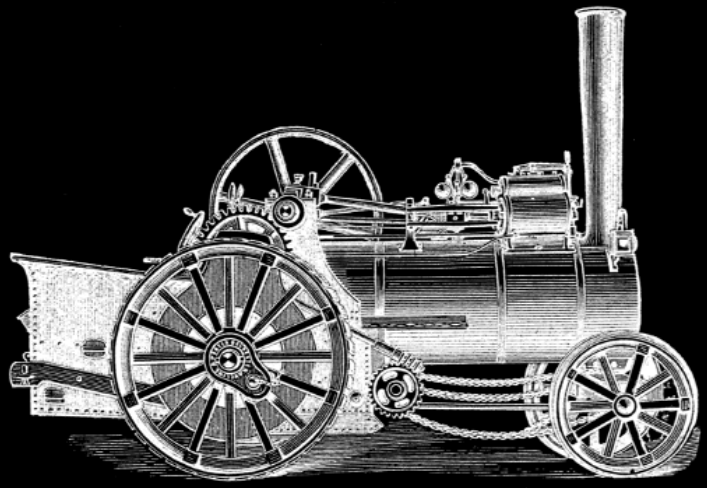
Symbolic

Transformation of Vision

Thomas Cole

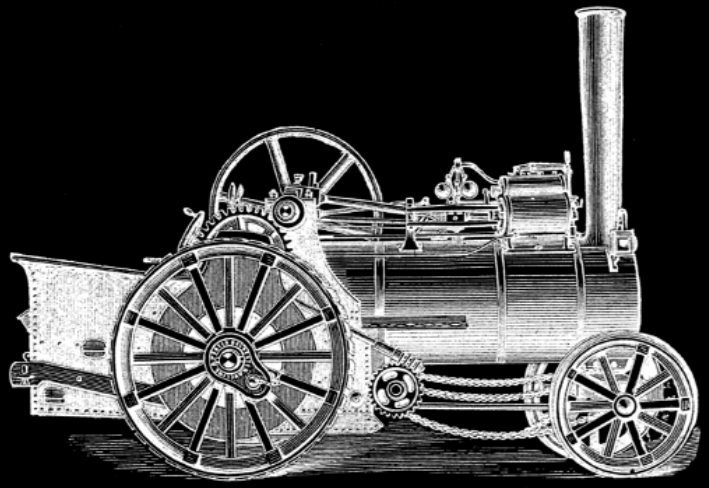
1828 - 1846

Steamboat – artist to landscape



Steam Tractor – tames nature

Steamboat – artist to landscape



Steam Tractor – tames nature

Building an Urban Society

structures

machines

networks

processes

Building an Urban Society

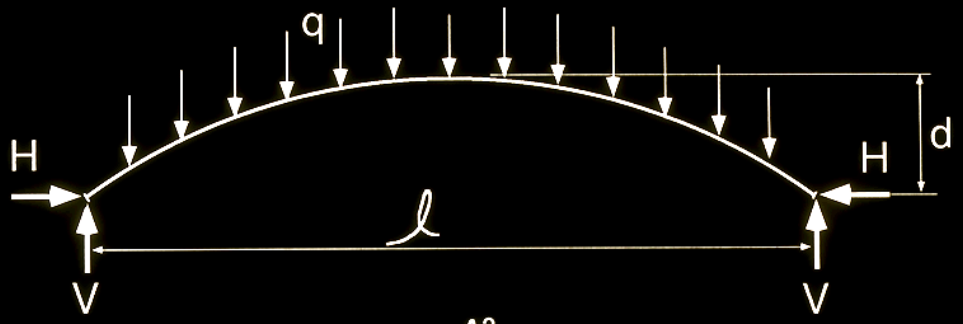
- structures
- machines
- networks
- processes

Scientific

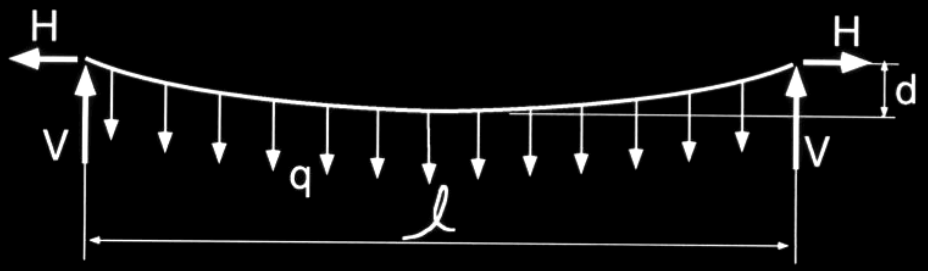
Transformation of Nature

Thomas Telford

1814 – 1826



$$H = \frac{q l^2}{8d}$$



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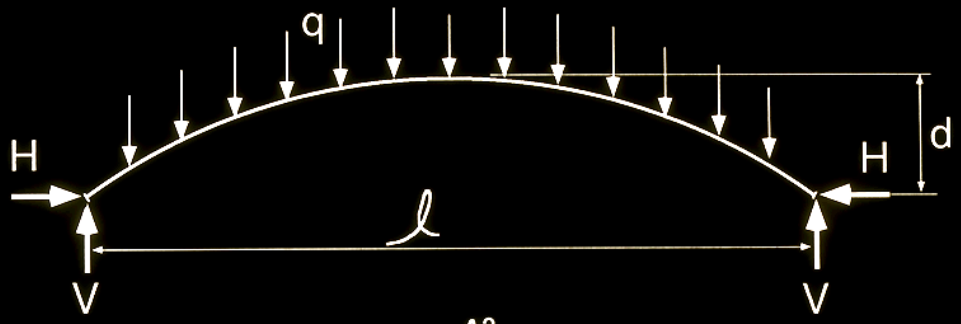

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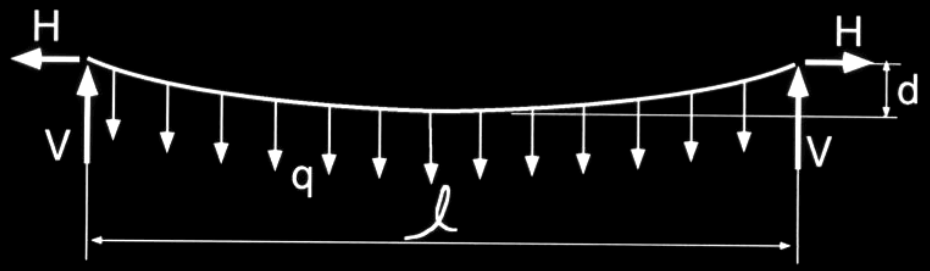


$$H = \frac{q\,l^2}{8d}$$

Structures: Cable or Arch

Vertical Deck Weight : q *l*

Transformed by Form : *l* / d

Into Horizontal Force : H

George Washington Bridge - 1931

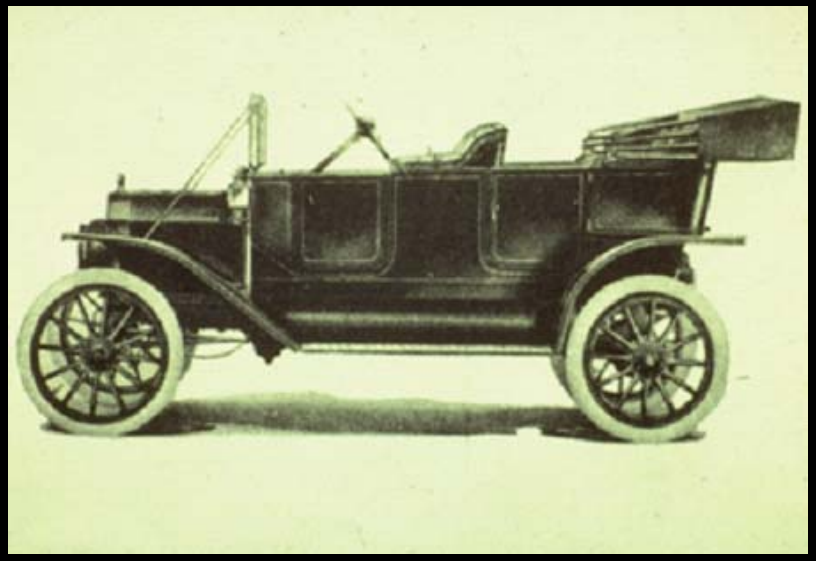
Structures: Cable or Arch

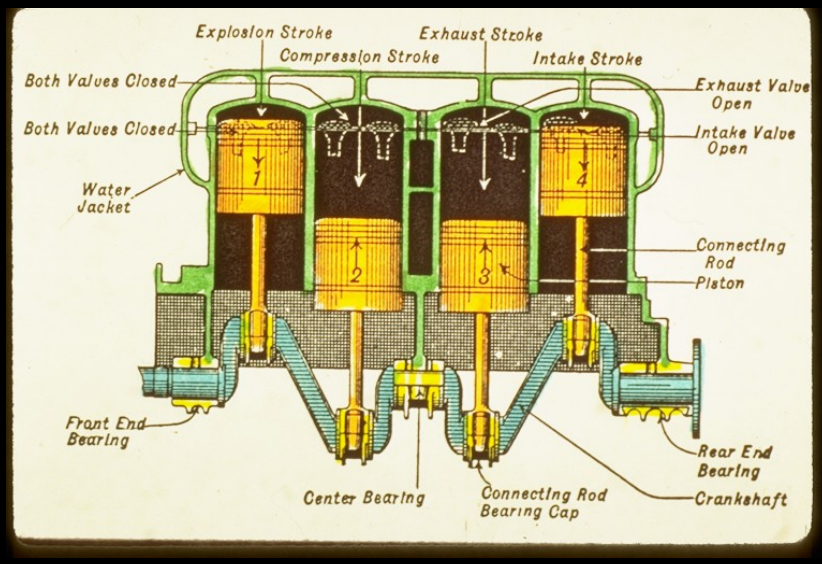
Vertical Deck Weight : q *l*

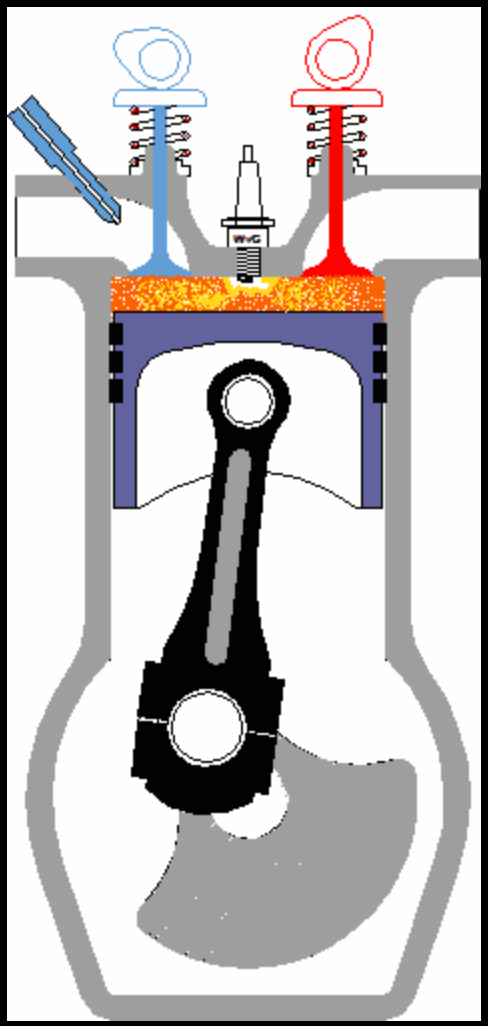
Transformed by Form : *l* / d

Into Horizontal Force : H

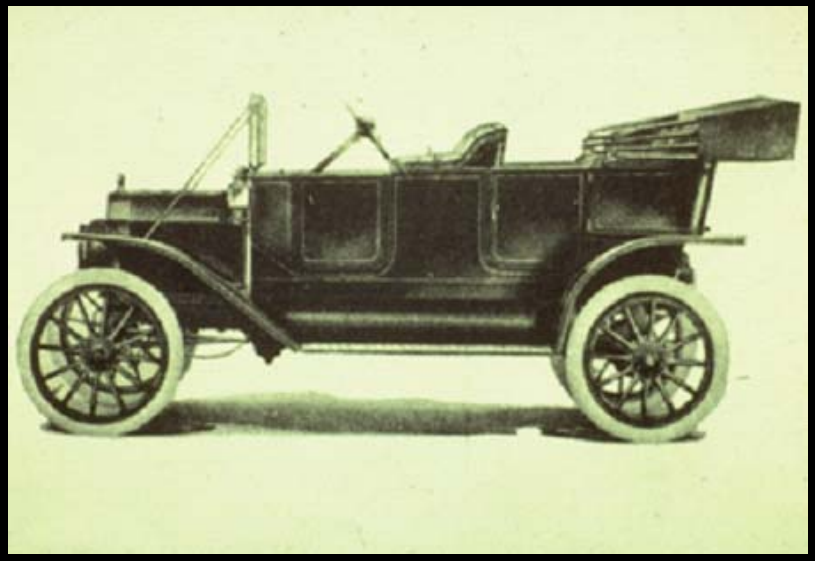
George Washington Bridge - 1931

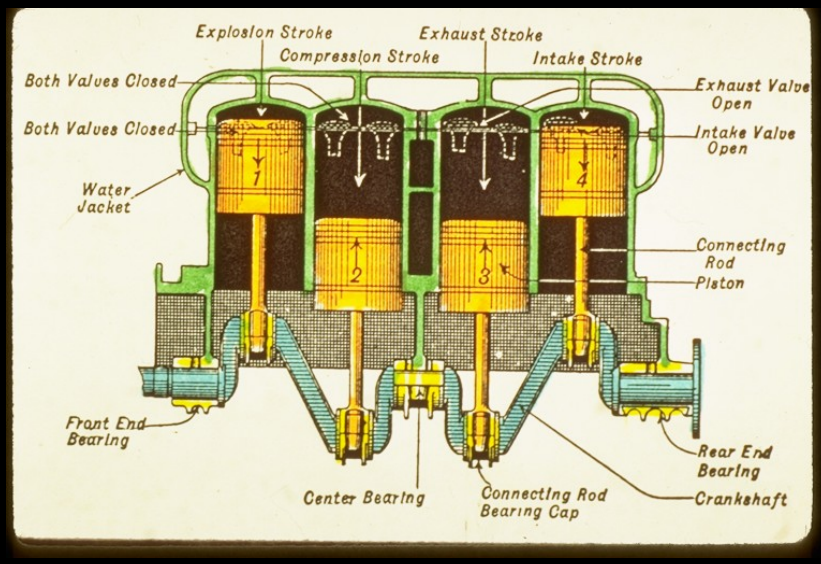




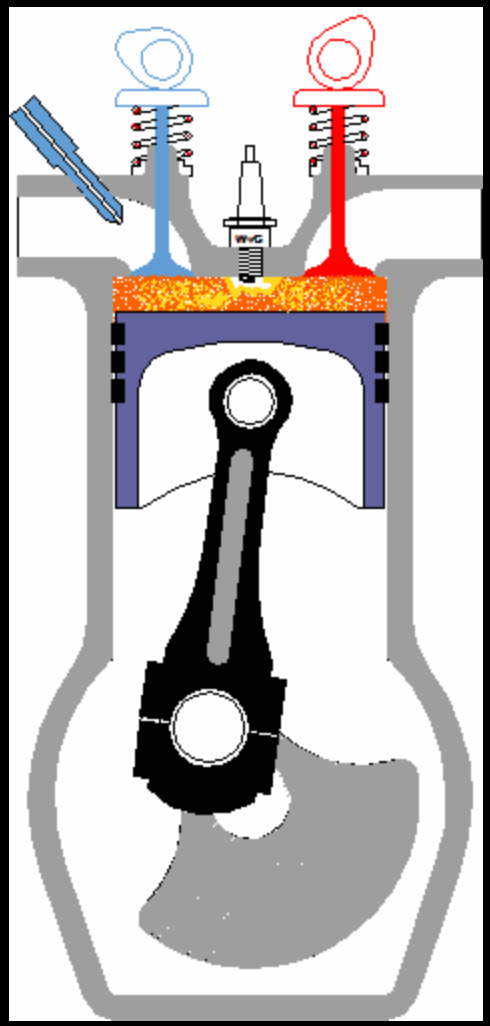


P = pressure
L = stroke
A = area
N = frequency





Thermodynamics: Heat to Work



P = pressure
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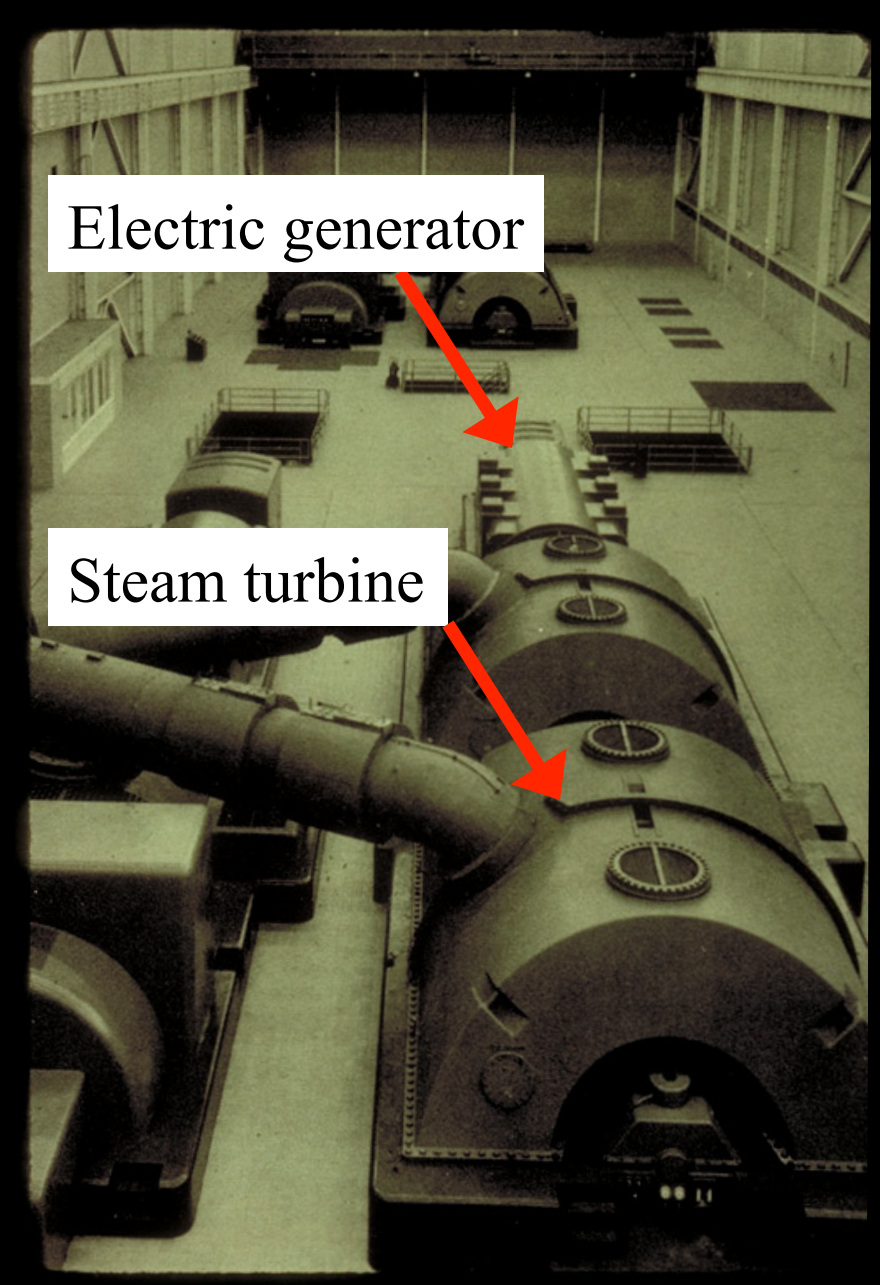
Machines: Piston Engine

Piston Force : P A

Maintained at Speed : L N

Transformed to Horsepower : Hp

Thermodynamics: Heat to Work



Coal-Fired Steam to Electricity

Machines: Piston Engine

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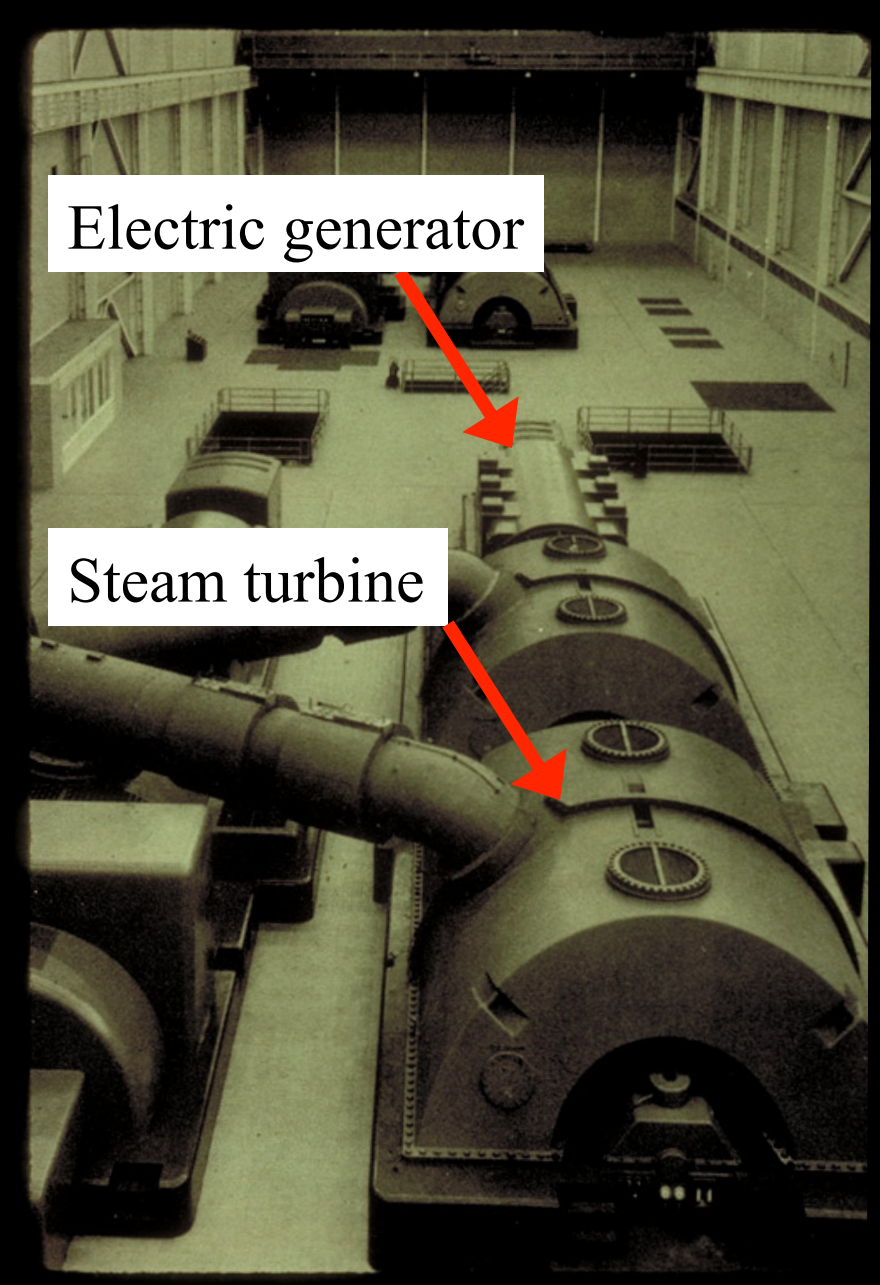

Coal-Fired Steam to Electricity

Networks: Electric Generator

$$P_{Watts} = V\ I$$

Generator Voltage : V

Maintained at Current : I

Transformed to Power : P_{Watts}

Networks: Electric Generator

$$P_{Watts} = V\ I$$

Generator Voltage : V

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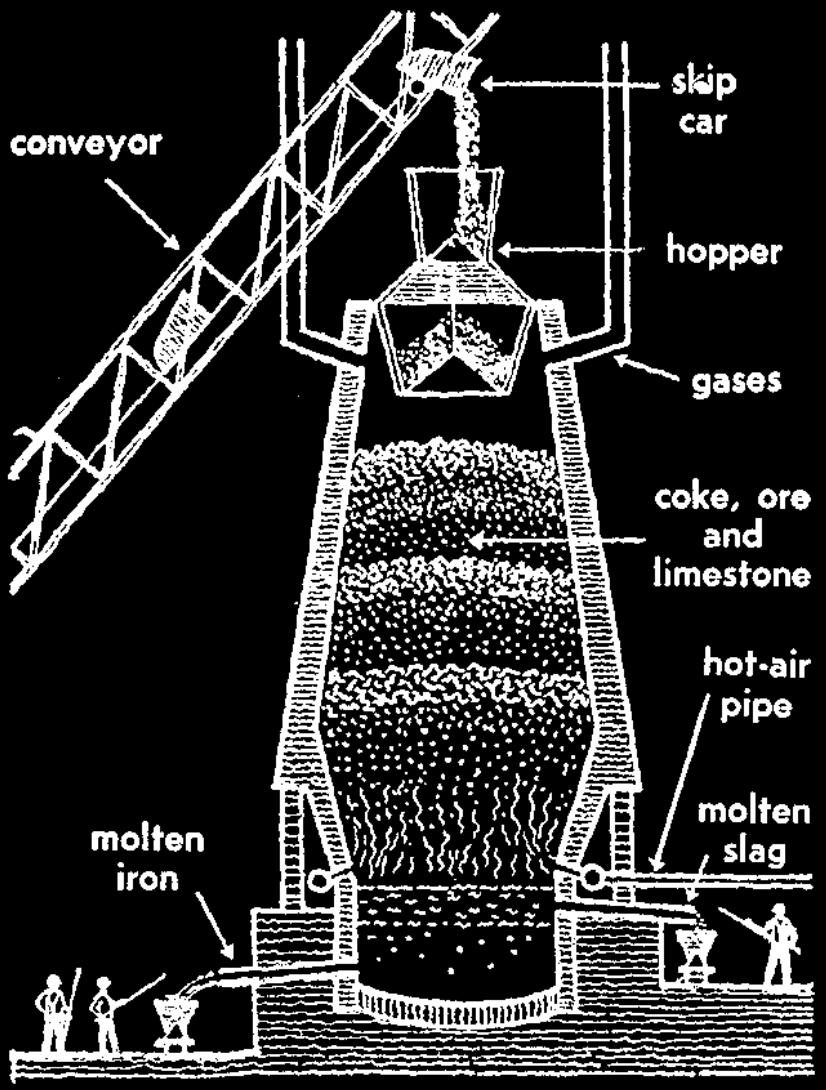
Transformed to Power : P_{Watts}



Coal-Fired Hematite (Fe_2O_3) to Iron

Process: Blast Furnace

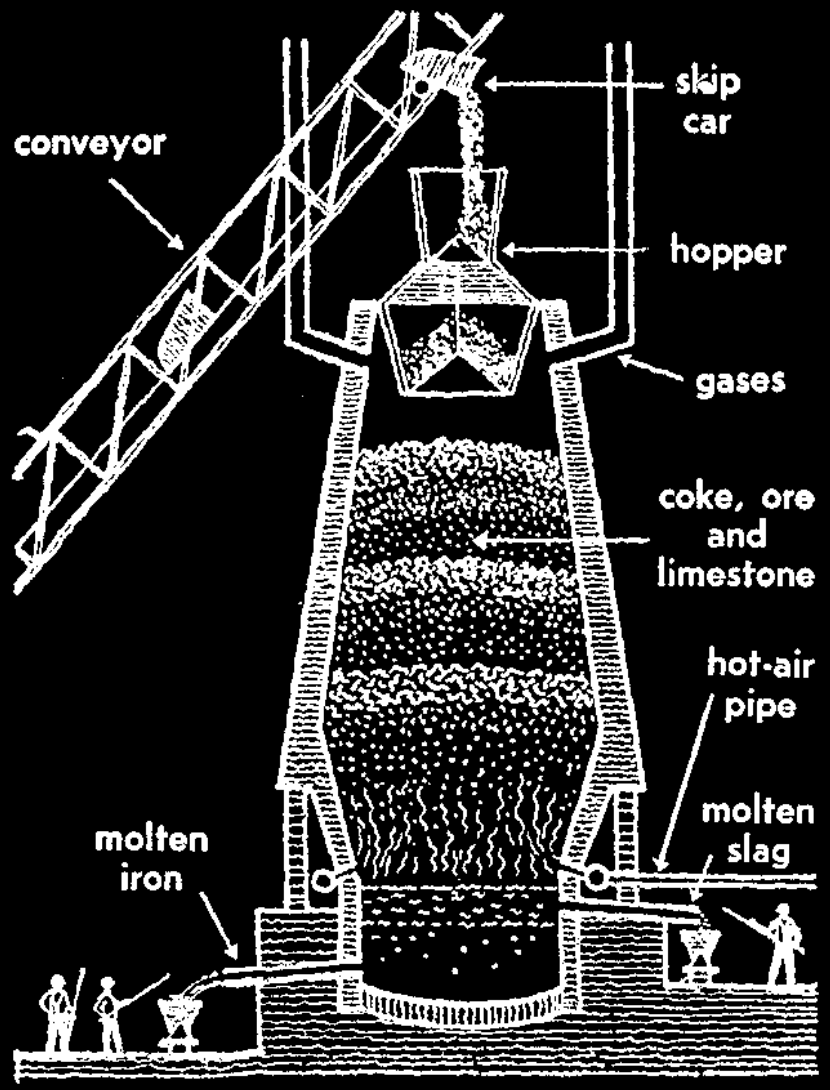
$Fe_2O_3 + 3C + (3/2)O_2 \rightarrow 2Fe + 3CO_2$

Iron Ore : Fe_2O_3

Heated with Coal (Coke) : C

and Air : O_2

Transformed into Iron : Fe



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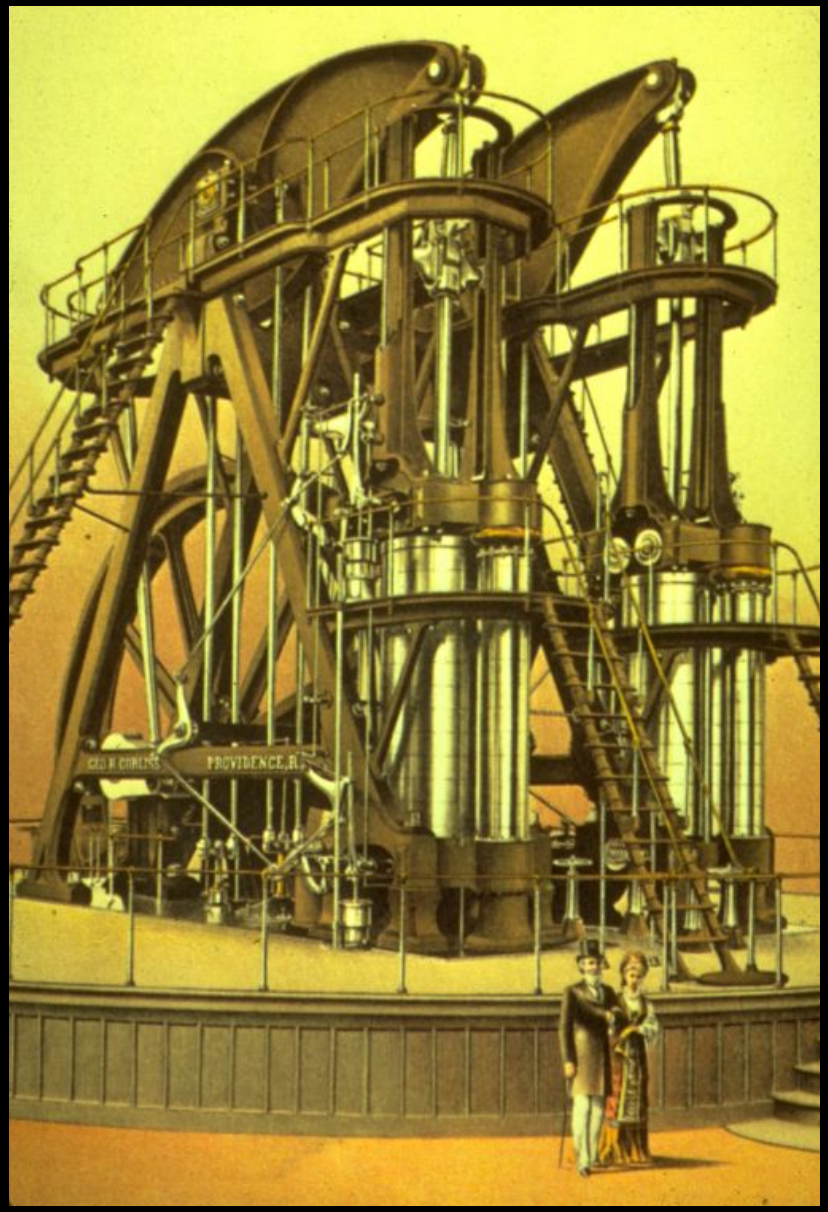
Social

Transformation of Society

Structures and Machines

Politics of Public Works

Economics of Private Enterprise



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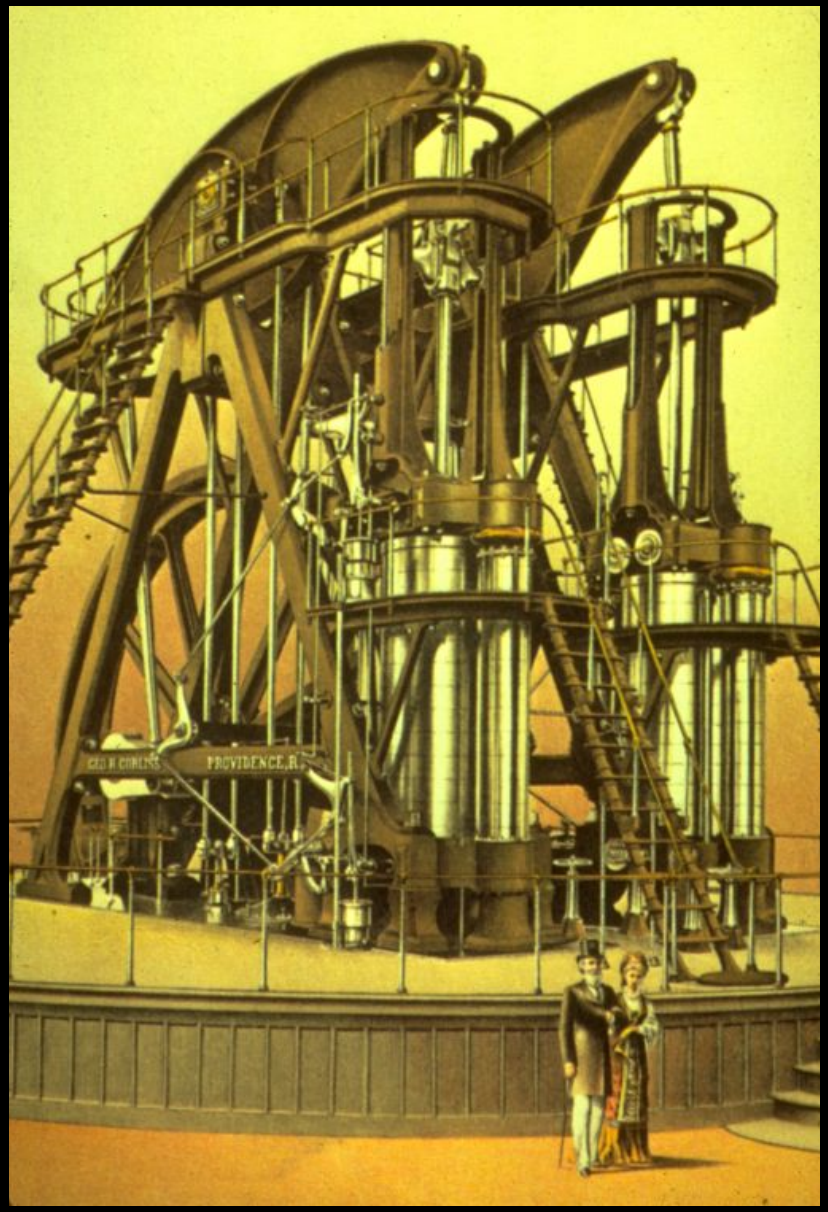


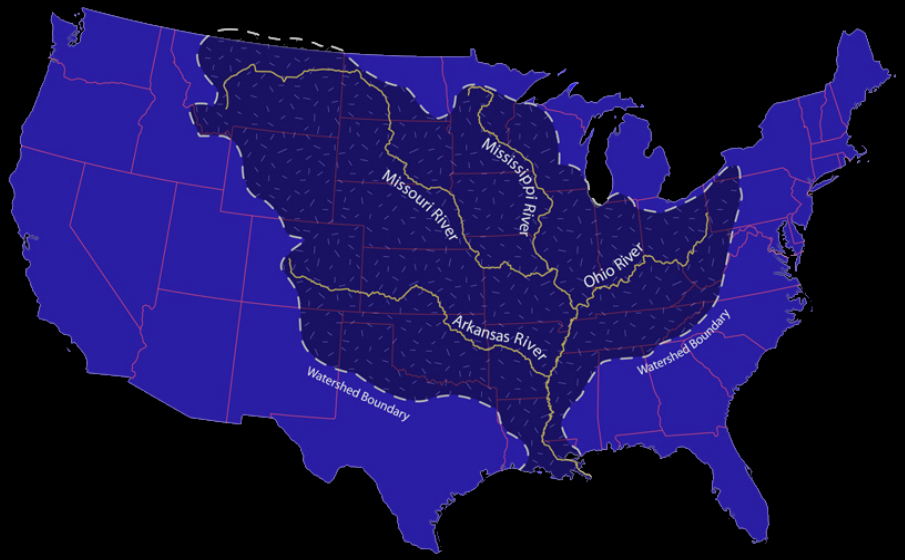
Social

Transformation of Society

Networks and Processes

Industry Restructures Regions

Public Resources and Private Profit



Transportation: River to Rail

Social

Transformation of Society

Networks and Processes

Industry Restructures Regions

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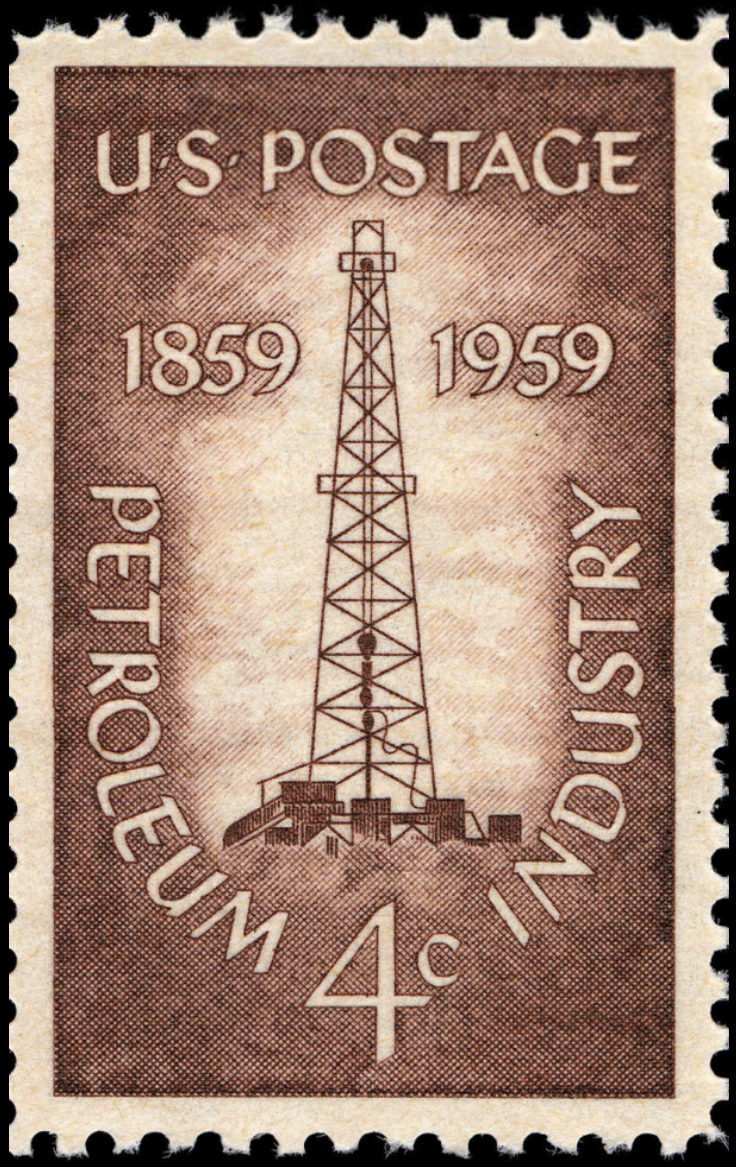

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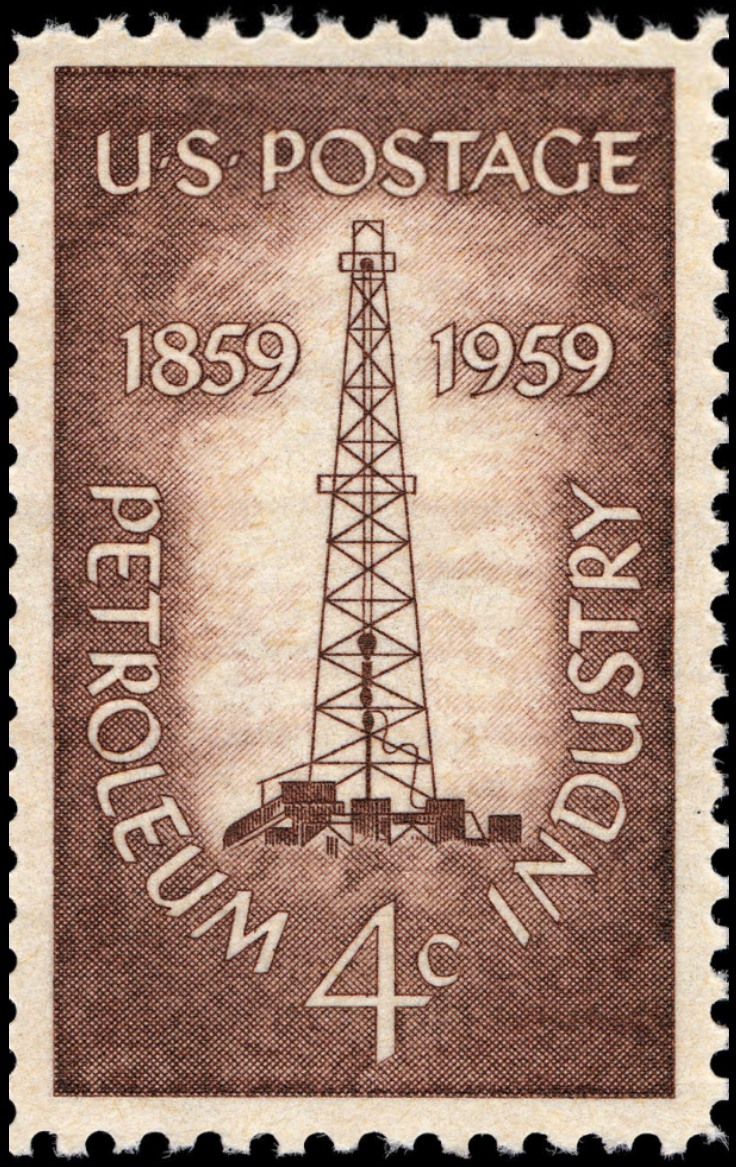
Networks and Processes

Industry Restructures Regions

Public Resources and Private Profit

Resources: Oil to Wealth



Resources: Oil to Wealth

Social

Transformation of Society

Politics: Territorial Development

Age of Iron and Steel

1. Independence, Iron, and Industry: 1776 – 1855
2. Connecting the Continent: 1830 – 1876

Age of Power and Speed

3. The Rise of the Great American Industries: 1876 – 1939
4. Regional Restructuring: 1921 – 1964
5. Information and Infrastructure: 1946 –

Social

Transformation of Society

Politics: Territorial Development

Age of Iron and Steel

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Independence, Iron, & Industry
1776 - 1855

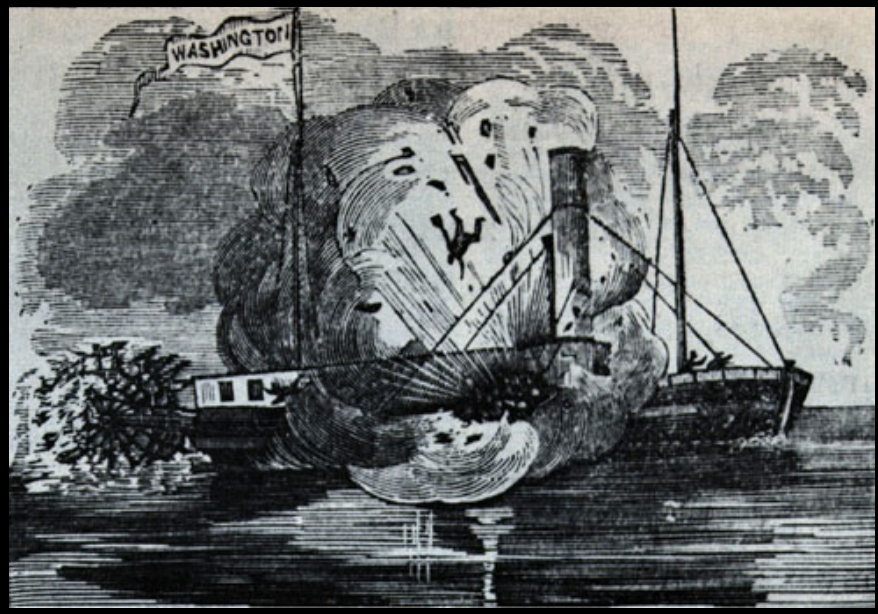
Fulton, Livingston
and the steamboat

Lowell, Francis
and textiles

Stephenson, Thomson
and railroads

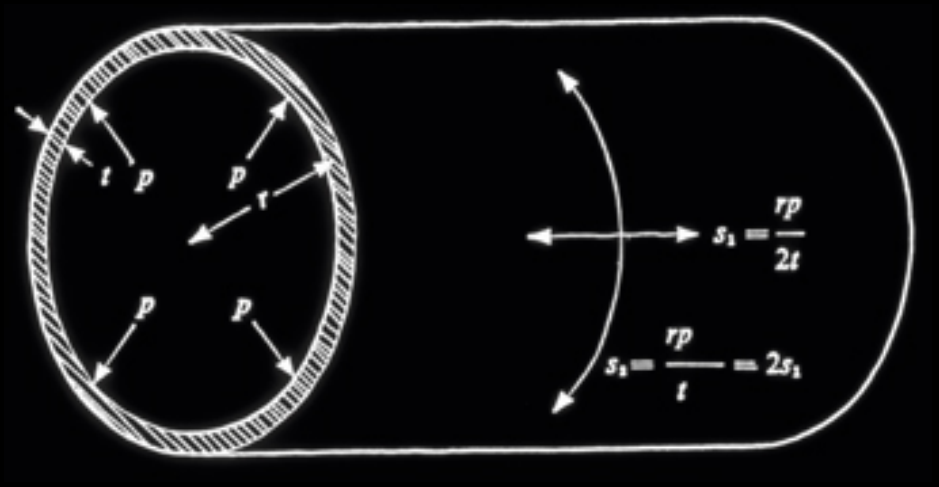
"The whole of France fits into the Mississippi Basin six times over."

"The whole of France fits into the Mississippi Basin six times over."

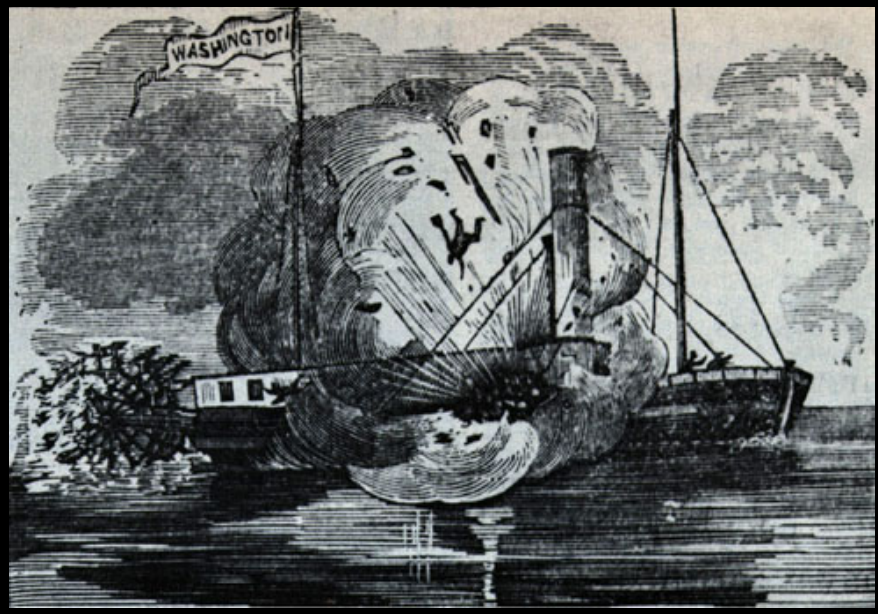


Mississippi River 1824

Economics versus Safety



$$f_1 = \frac{Pr}{h}$$



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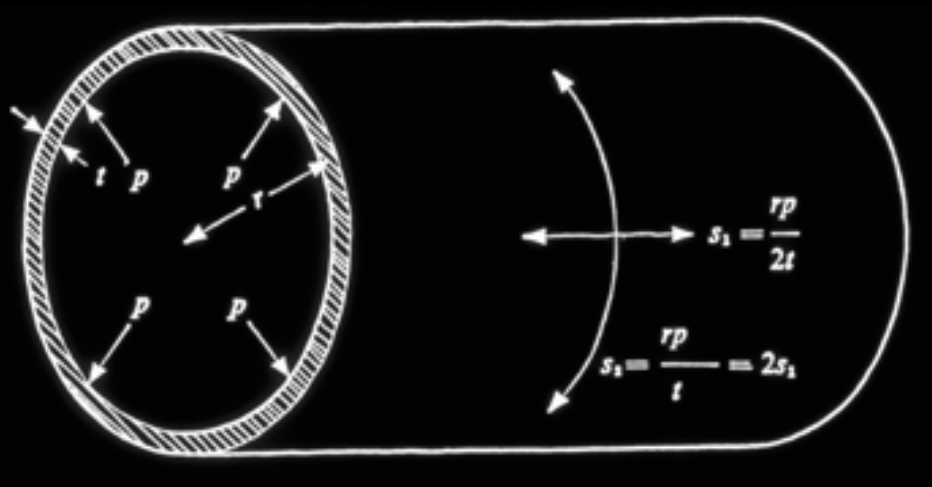

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Boiler Explosions

Franklin Institute

STRESSES

Alfred Guthrie

STATISTICS

Mark Twain

STORIES

Boiler Explosions

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STORIES

Connecting the Continent
1830 - 1876

Stanford
and the continental railroad

Henry, Morse
and the telegraph

Carnegie, Holley
and steel rails


1950


1971
Amtrak Route
Non-Amtrak Railroad

Federal Highway Act - 1956

Transportation: Rail to Road

Federal Highway Act - 1956

The Rise of the Great Industries
1876 - 1939

SPEED

Ford and Model T

The Wright Brothers and Flyer

Douglas and DC – 3

Transportation: Rail to Road

The Rise of the Great Industries
1876 - 1939

SPEED

Ford and Model T

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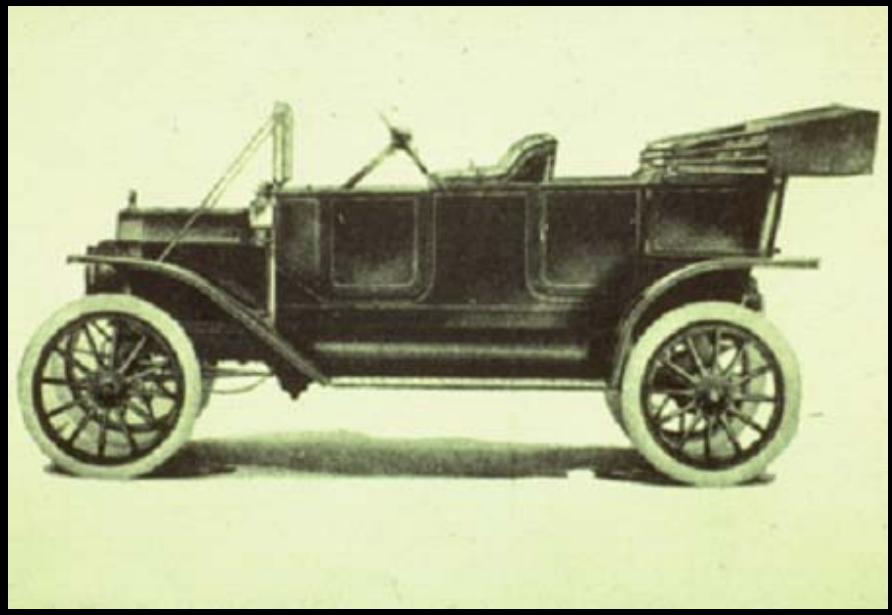
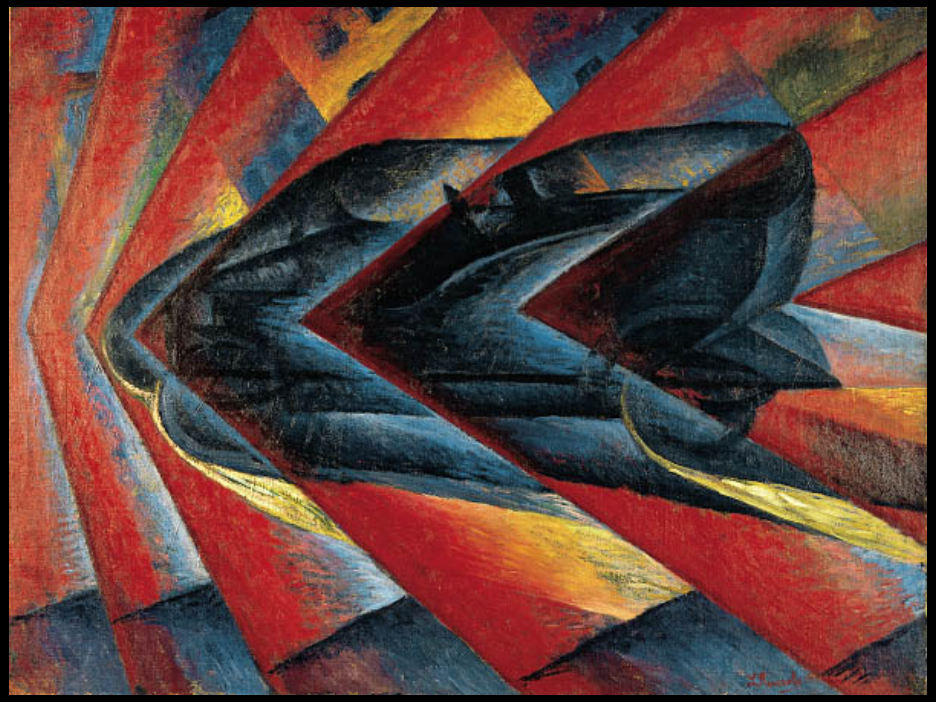
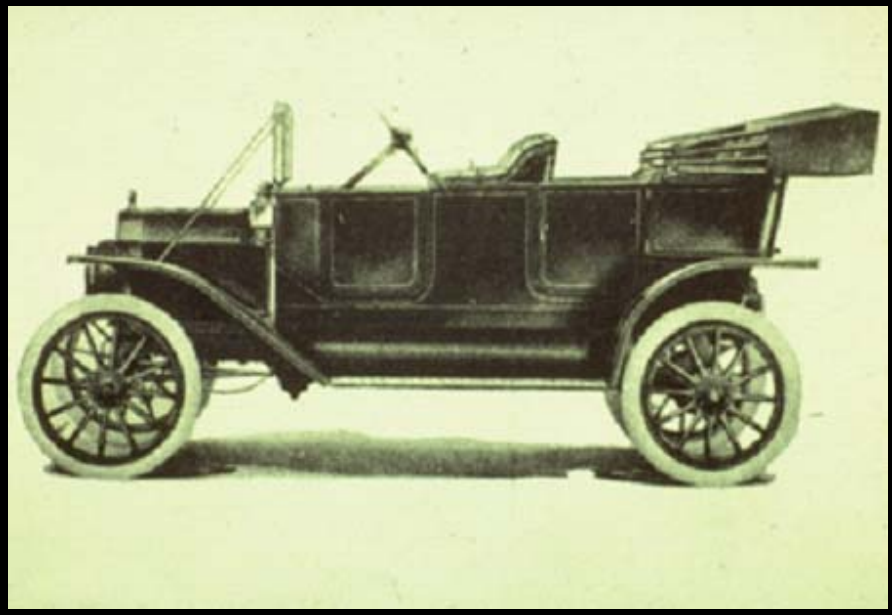
Douglas and DC – 3





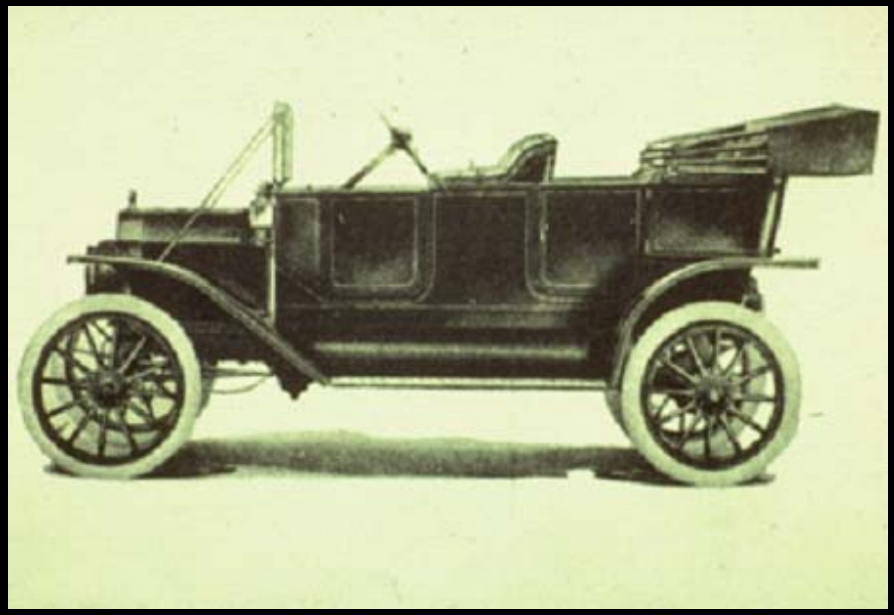


The Rise of the Great Industries
1876 - 1939

POWER

Edison, Westinghouse
and electricity

Rockefeller, Burton
and oil refining



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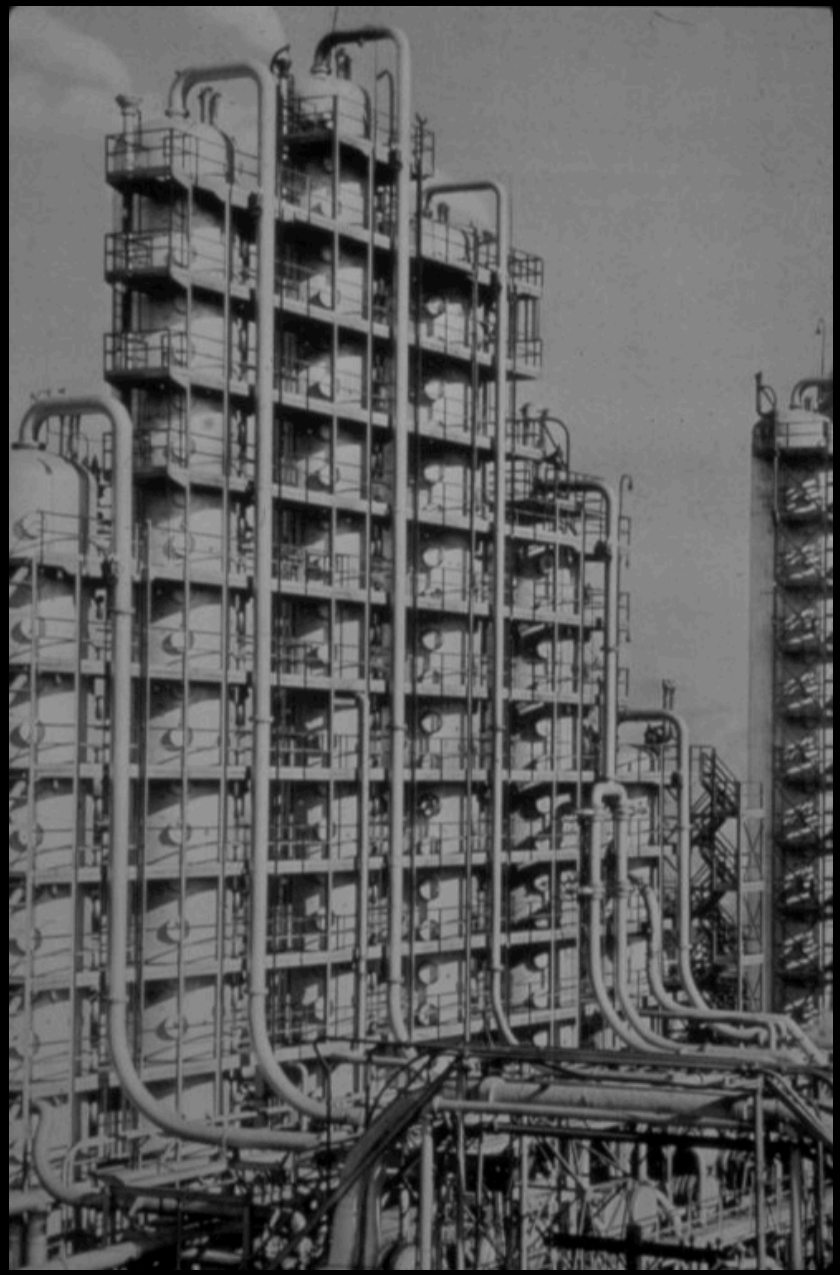
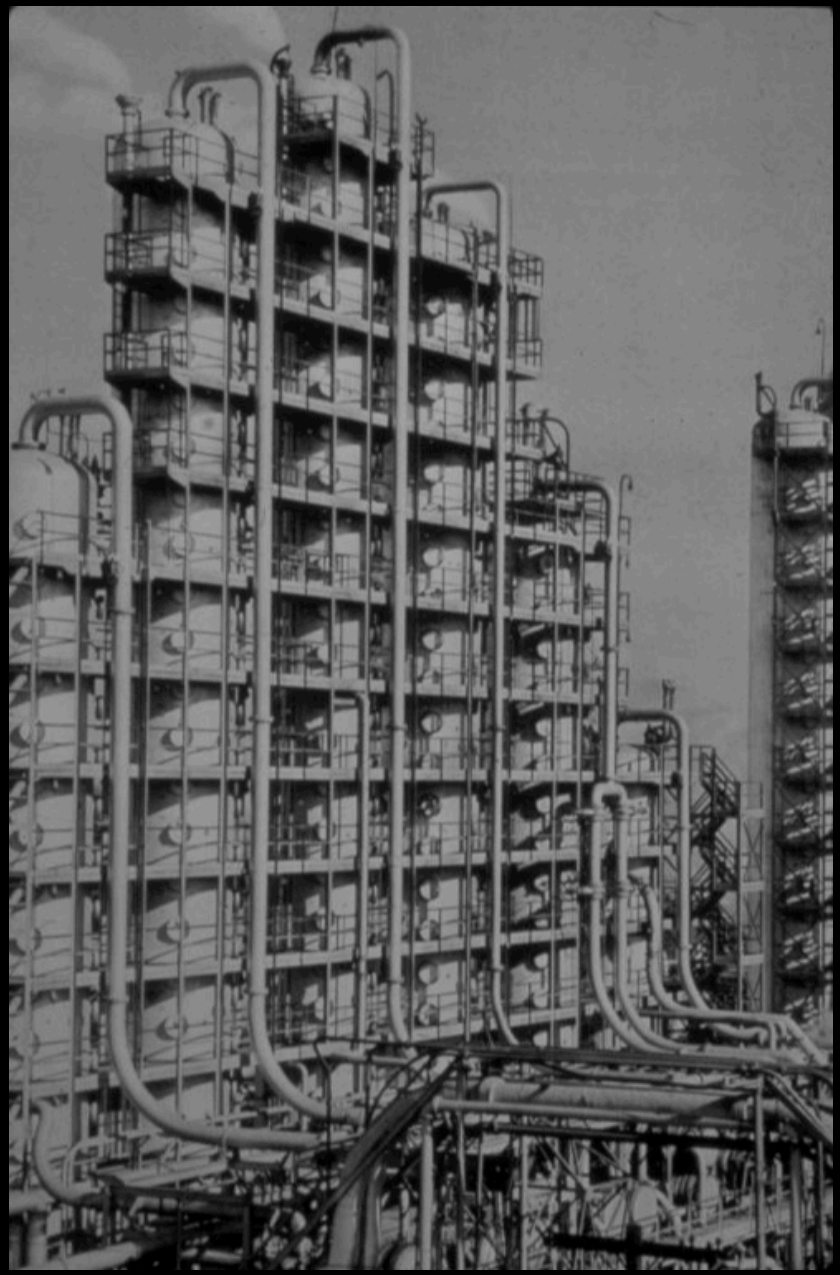
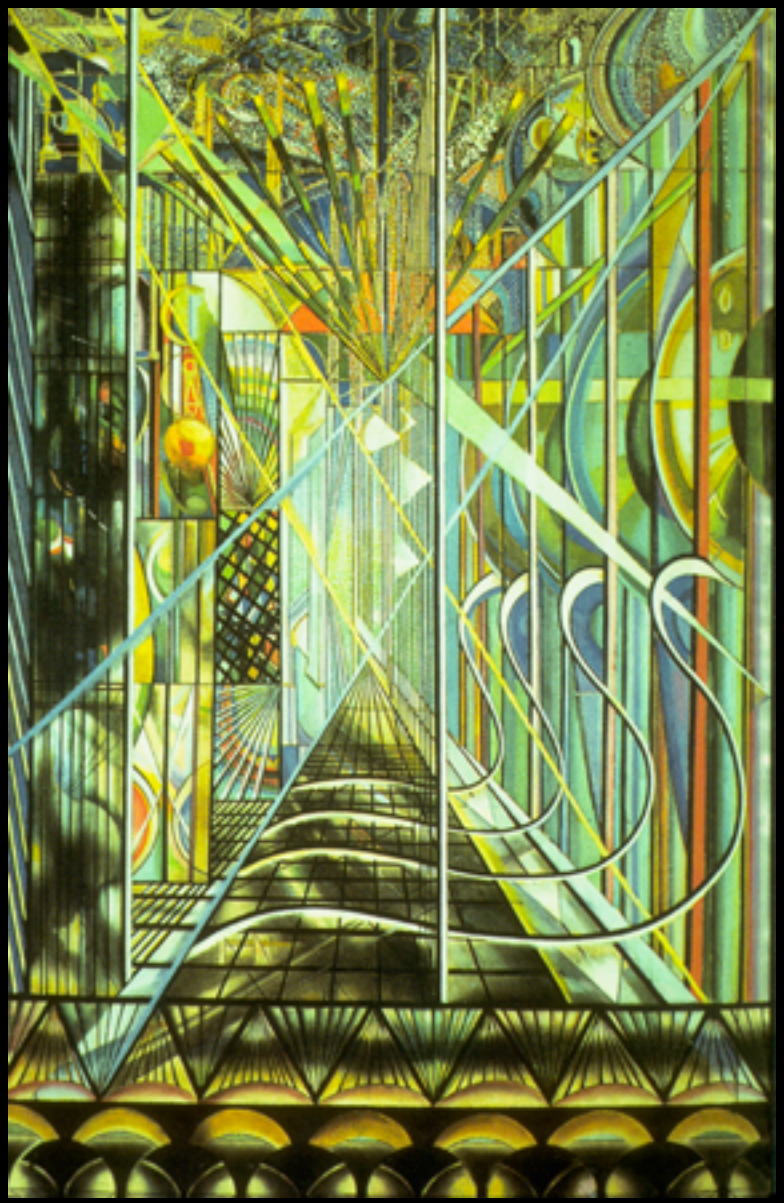
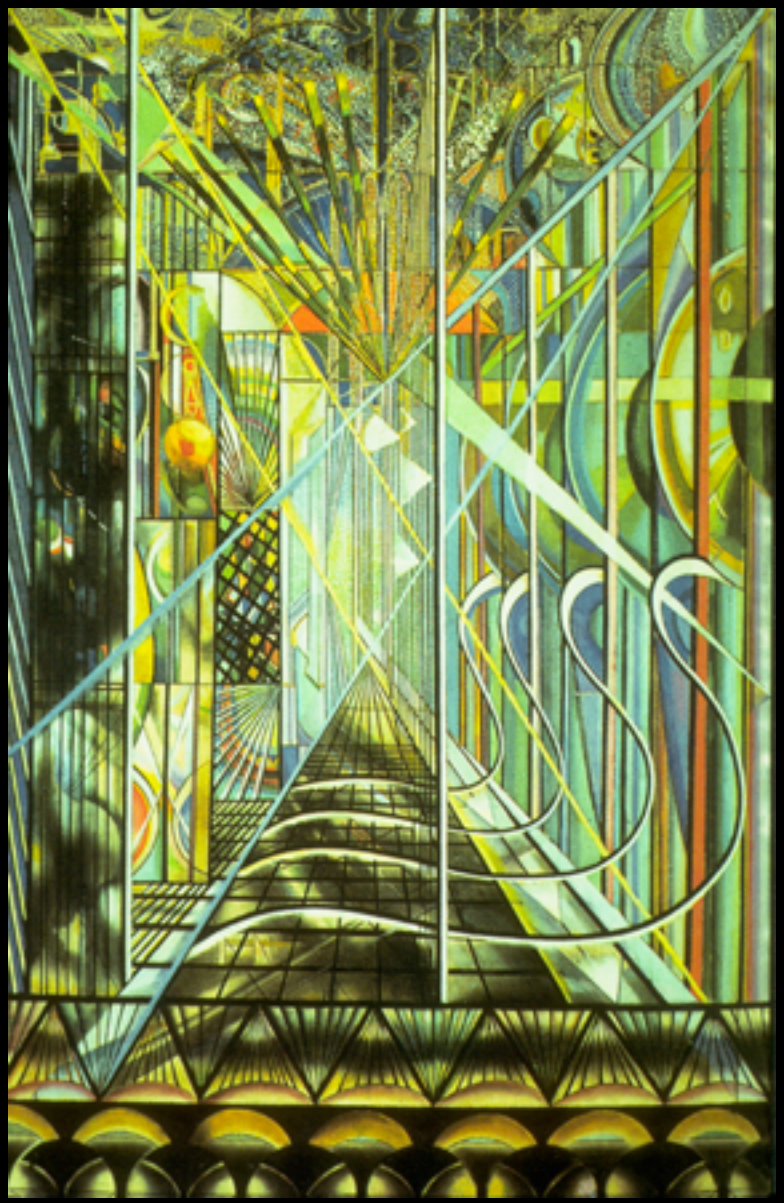






Hoover Dam lit by its own Power



Hoover Dam lit by its own Power

Regional Restructuring
1921 - 1964

POWER

Morgan and Lilienthal
and Tennessee Valley Authority

Crowe
Hoover Dam and Los Angeles

Regional Restructuring
1921 - 1964

SPEED

Ammann
and the Port Authority of NY & NJ

Douglas
Streamline, Shapes, and Style

Regional Restructuring
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Streamline, Shapes, and Style

Santa Clara Valley

Santa Clara Valley

Santa Clara Valley

Silicon Valley

Information and Infrastructure 1946 –

INFORMATION

Kilby, Noyce
and the integrated circuit

Turing, Von Neumann
and the computer

Silicon Valley

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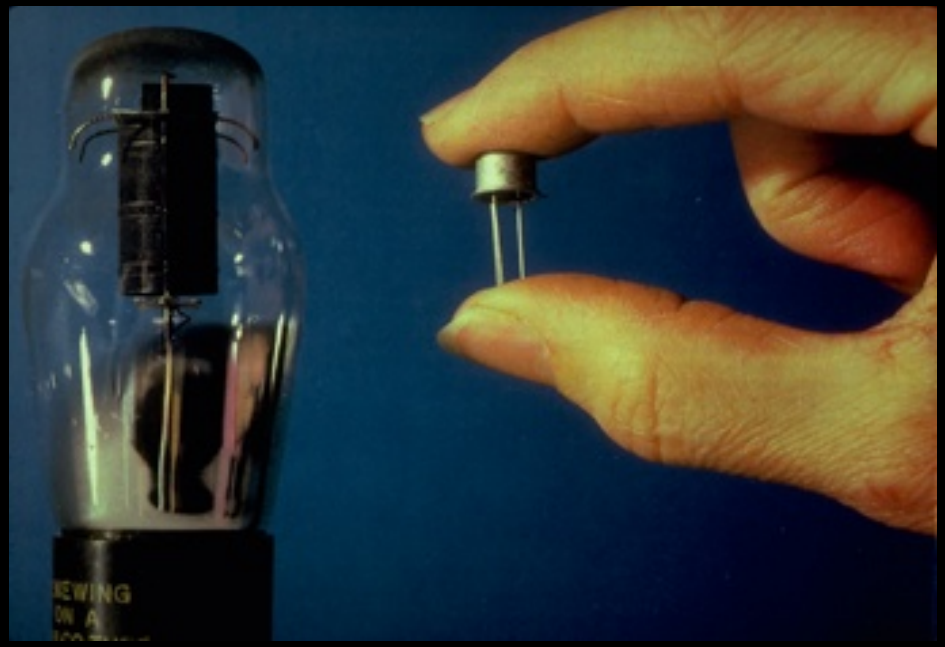
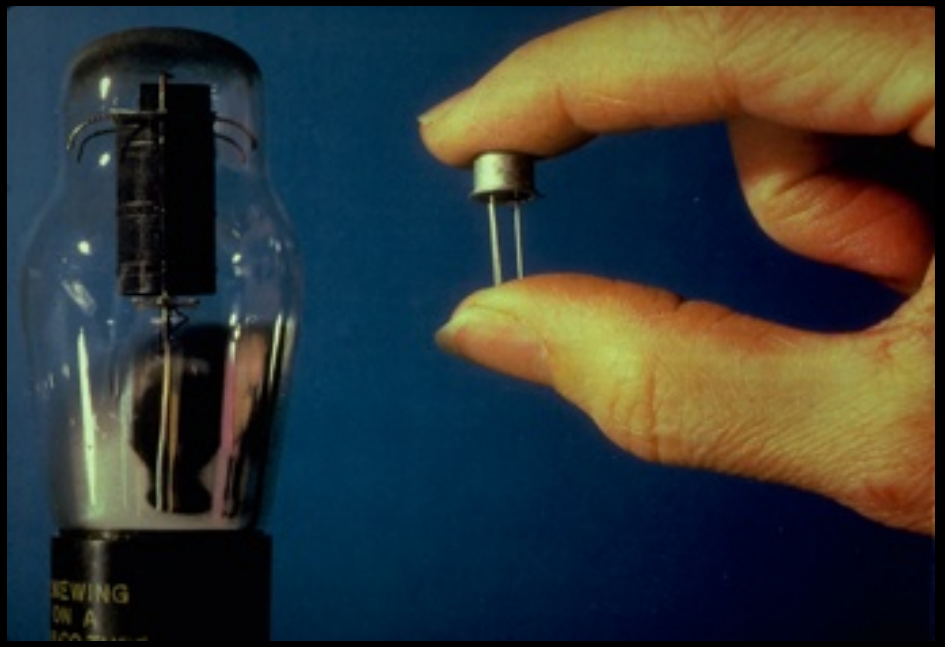
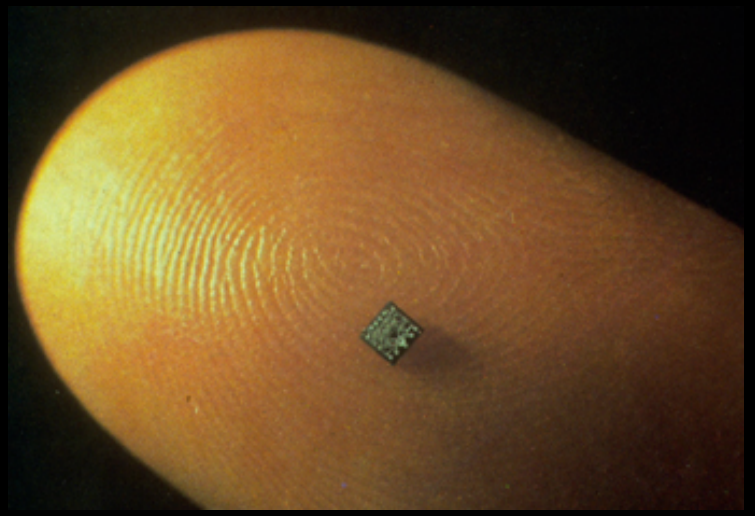


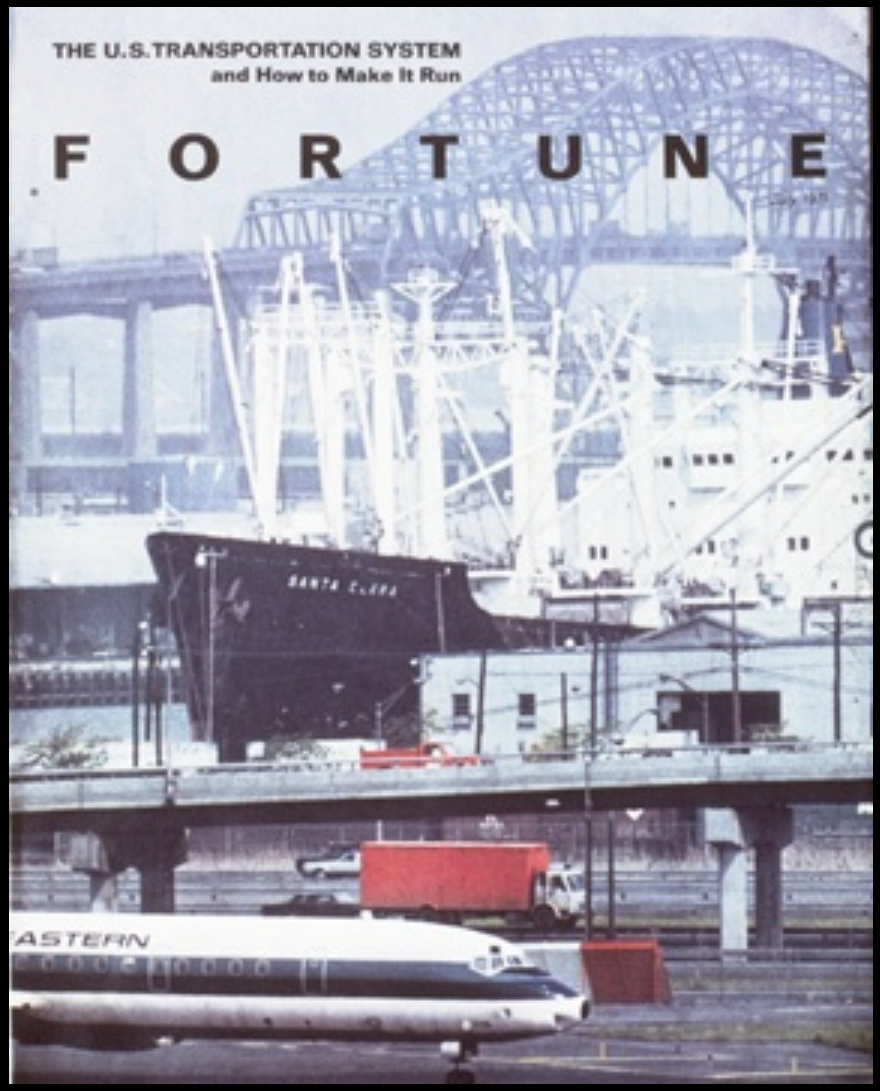


The Microchip

1958—**The monolithic idea:**
Jack St. Clair Kilby
TEXAS INSTRUMENTS

1959—**The integrated circuit:**
Robert Noyce
FAIRCHILD





Infrastructure

- **River and Rail**
- **Road and Airway**
- **Grid and Pipeline**

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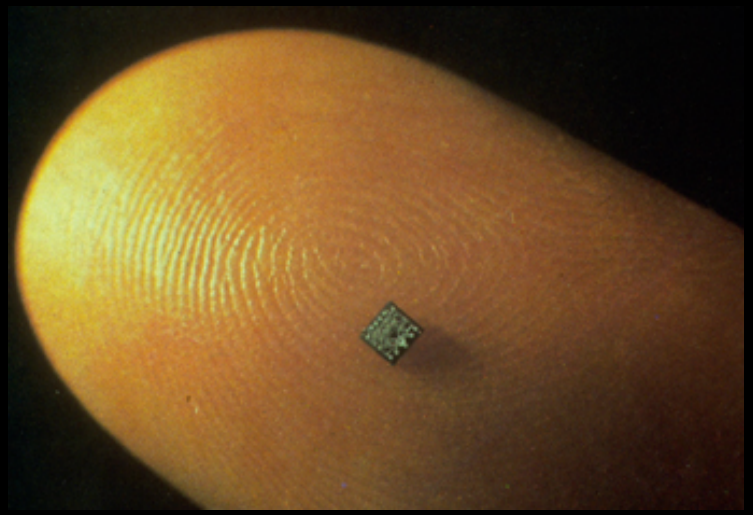

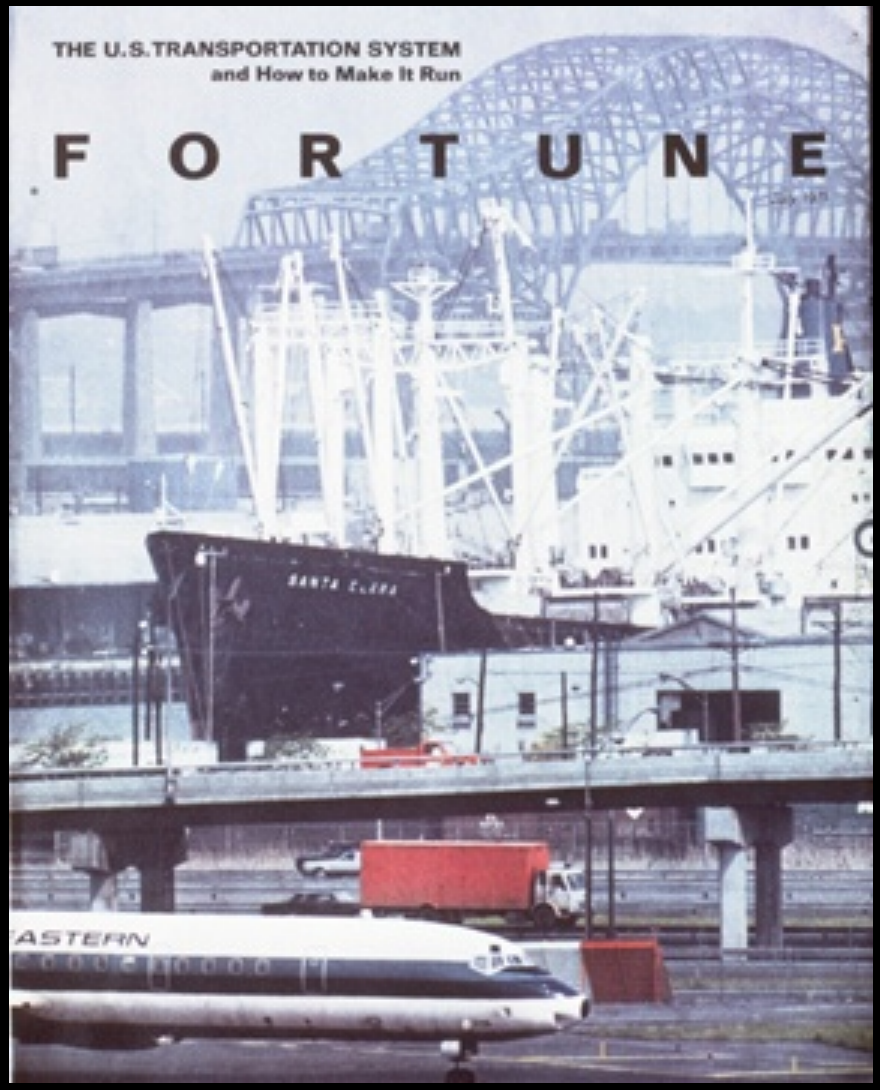

Information and Infrastructure 1946 –

2003 – Northeast Blackout

2005 – New Orleans Flood

2007 – Minneapolis Bridge Collapse

2010 – Gulf Oil Spill

Infrastructure

- **River and Rail**
- **Road and Airway**
- **Grid and Pipeline**

Information and Infrastructure 1946 –

Power: Smart Grid

Energy: Wind, Solar

Materials: Composites

Information: GPS, Wi-Fi

Information and Infrastructure 1946 –

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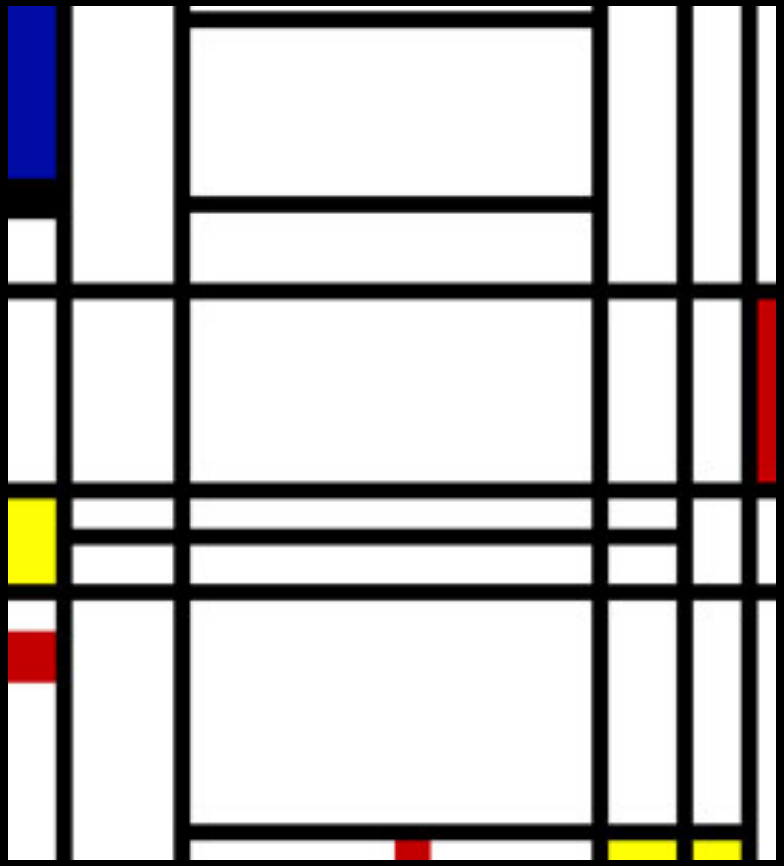

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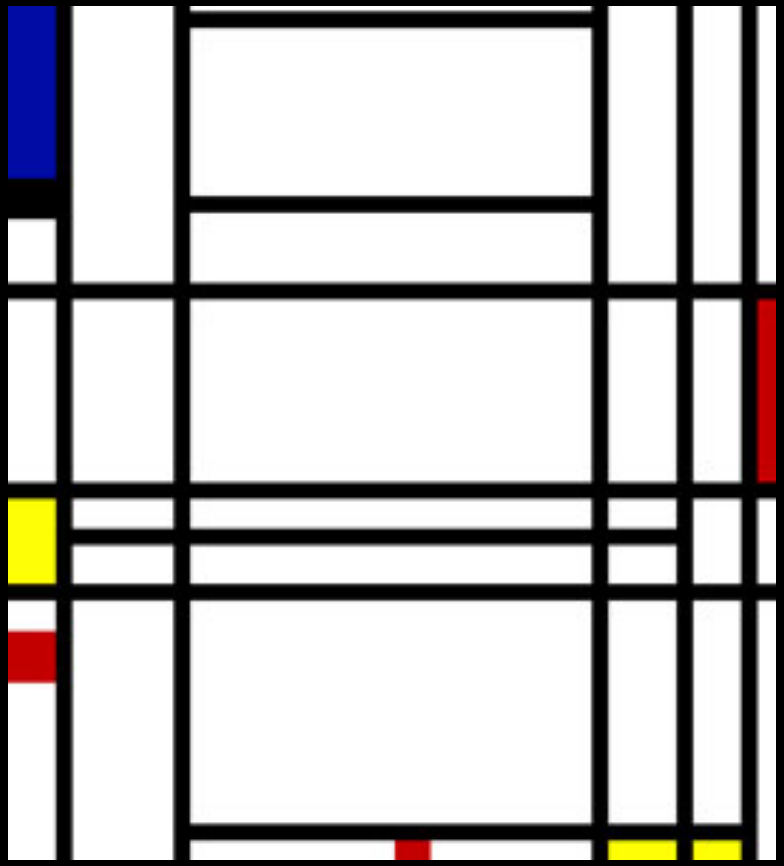

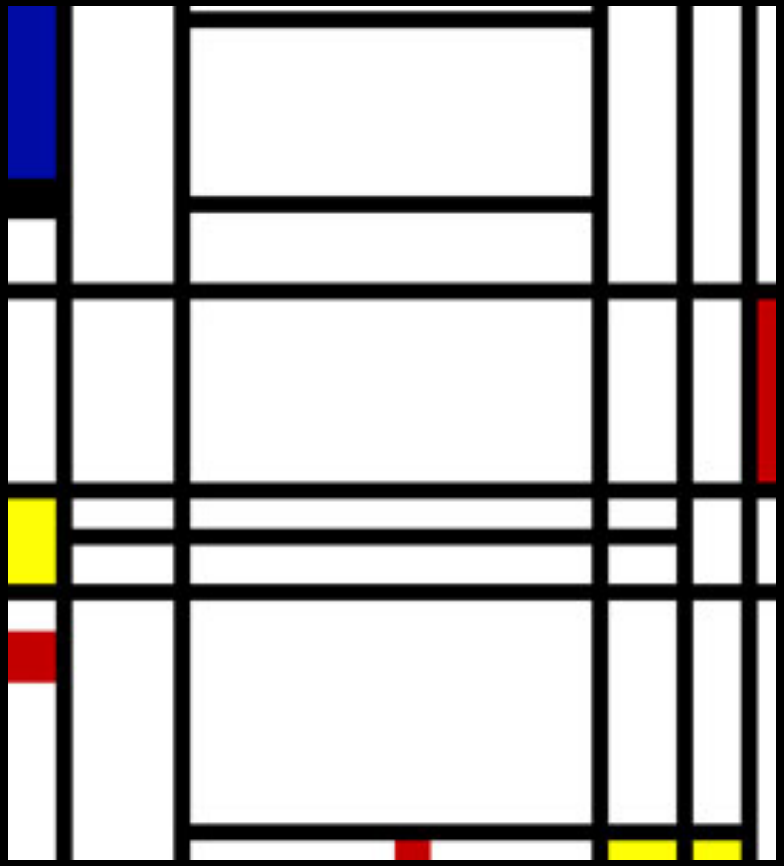

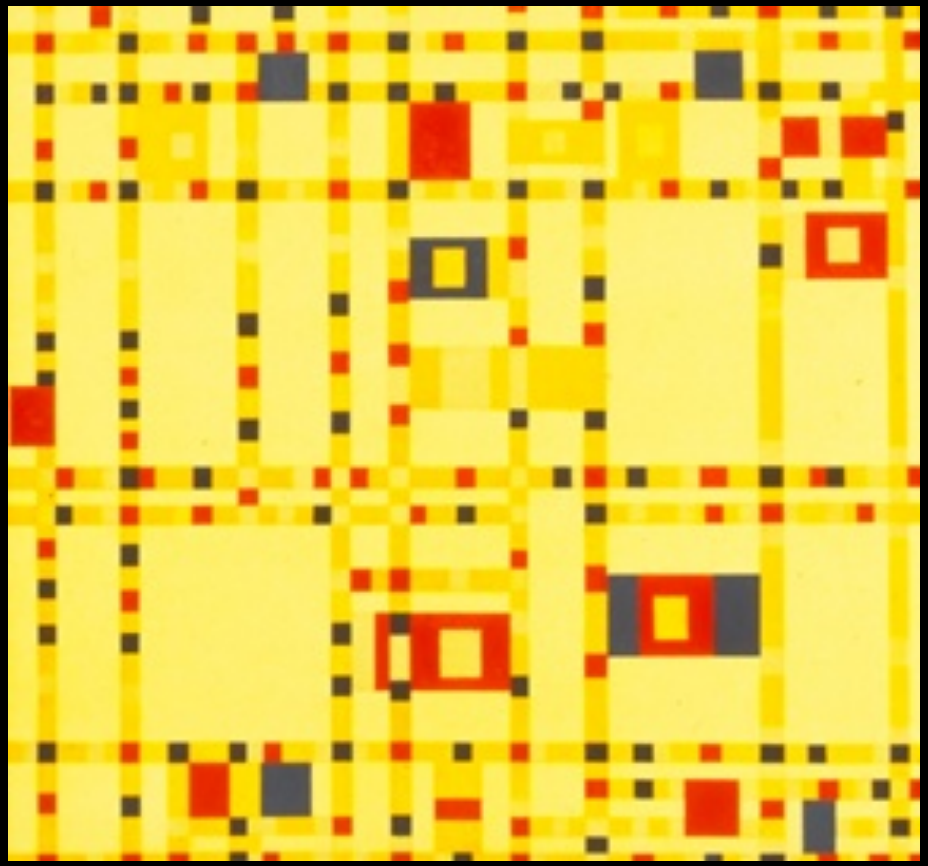

Course Objectives

What are the great works of modern engineering?

Who are key innovators?

What are their contributions?

What was their experience?

What is a radical innovation?

How do innovations happen?

How has the modern world been transformed by engineering?