British and American Rail

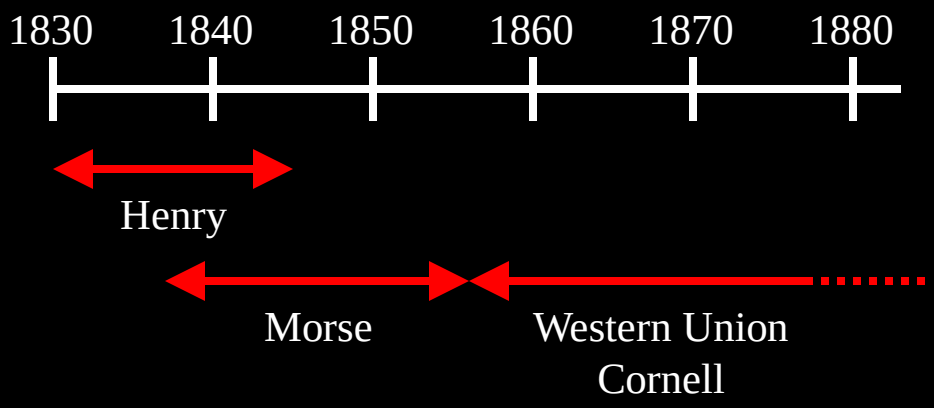
Iron Road – Transformation from Canal and River to Rail
Races and Competitions

CEE 102: Prof. Michael G. Littman
Course Administrator: Jack Reilly jpr2@princeton.edu

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

Connecting the Continent

1830 - 1883

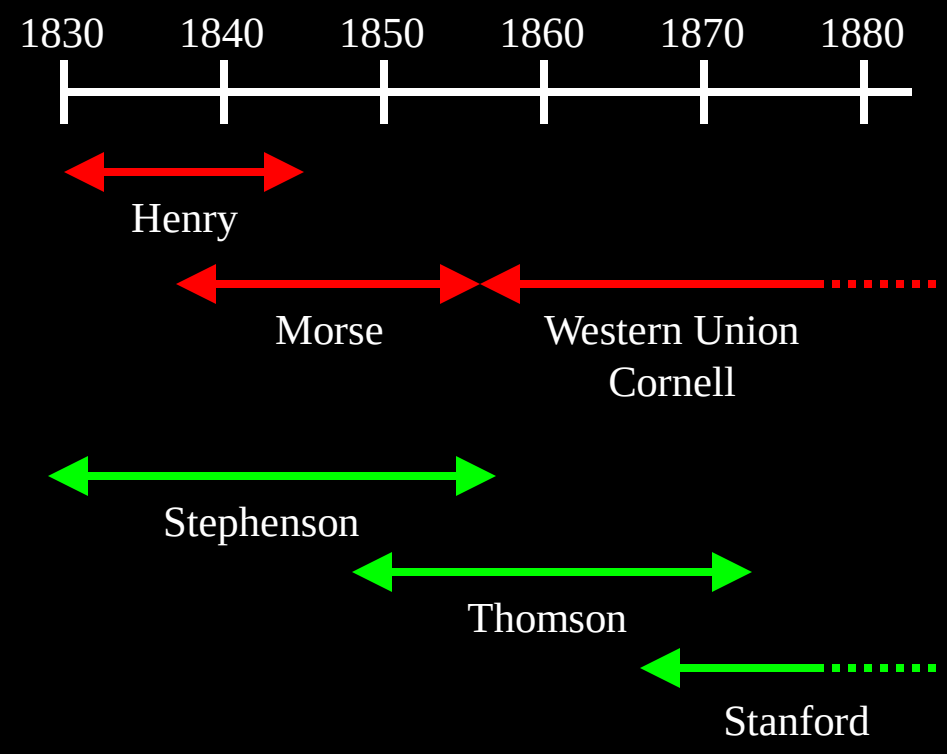


Joseph Henry

Samuel Morse

Connecting the Continent

1830 - 1883



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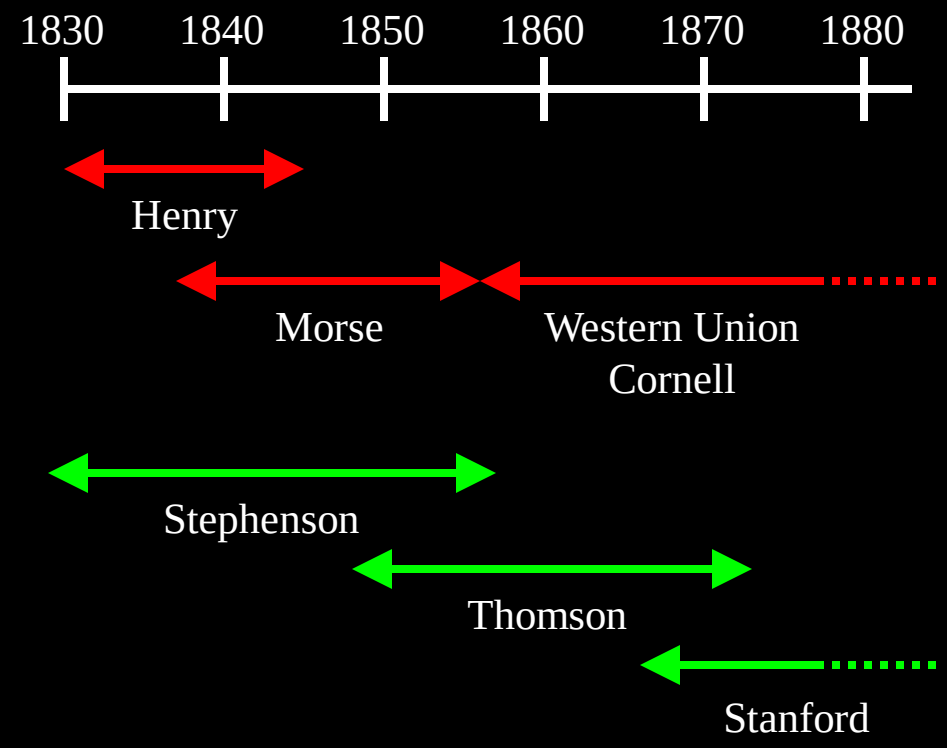
1883 – ‘Sun Time’ to ‘Standard Time’

Connecting the Continent

1830 - 1883



Boston & Lowell RR - 1835

1883 – ‘Sun Time’ to ‘Standard Time’

British and American Rail

Formula: Traction and Power

History: Connecting Cities and Connecting the Continent

Vision: Railroad and Art

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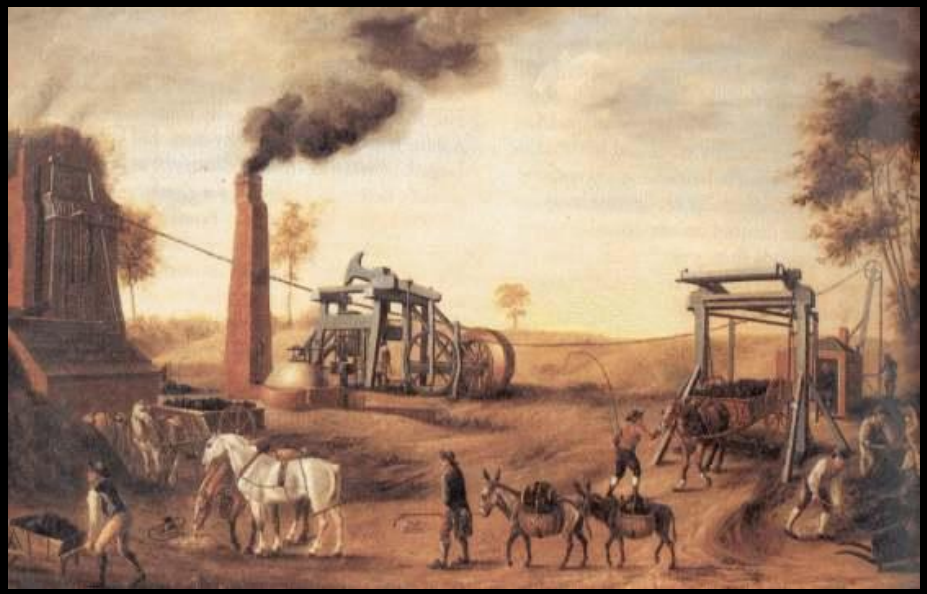


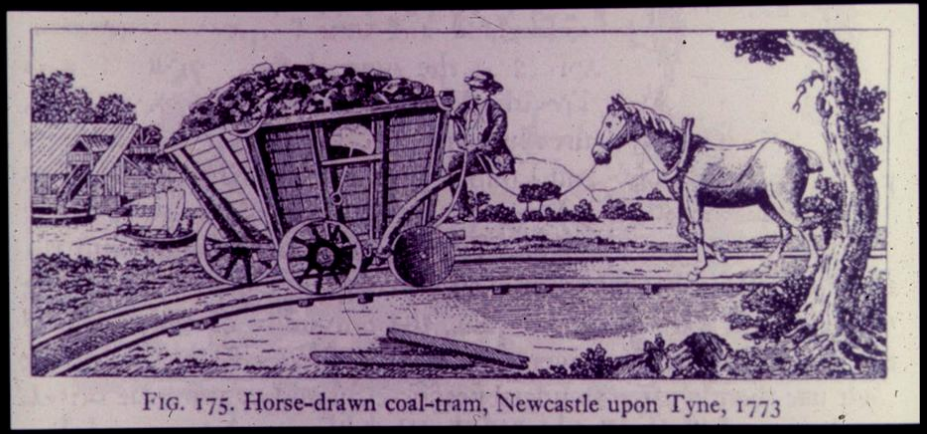
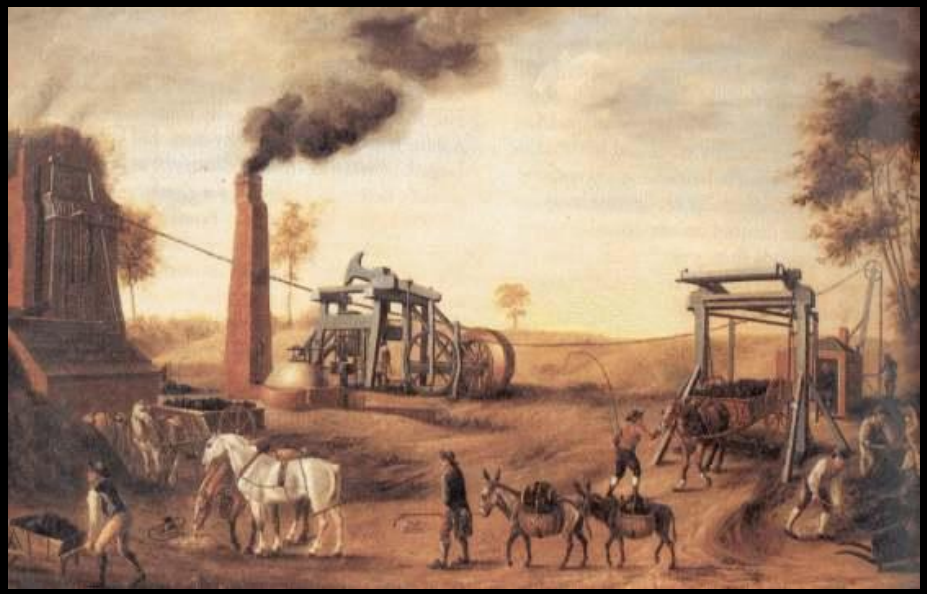
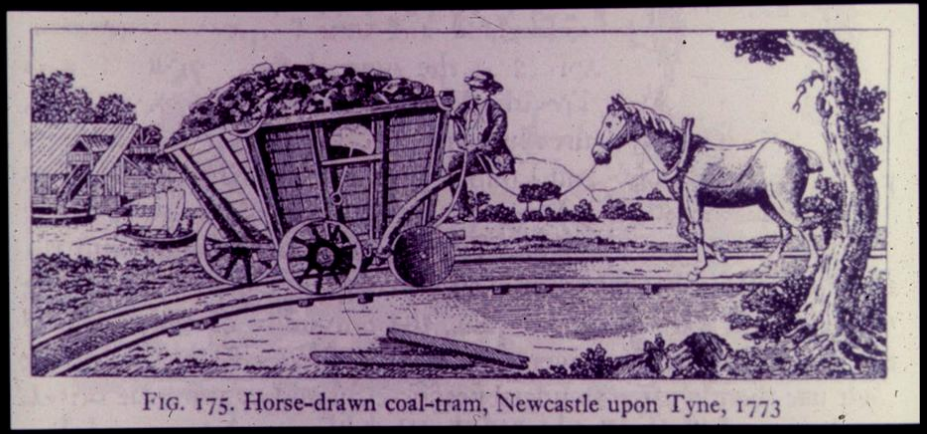


FIG. 175. Horse-drawn coal-tram, Newcastle upon Tyne, 1773

" A horse on an iron road would draw ten tons for one ton on a common road"





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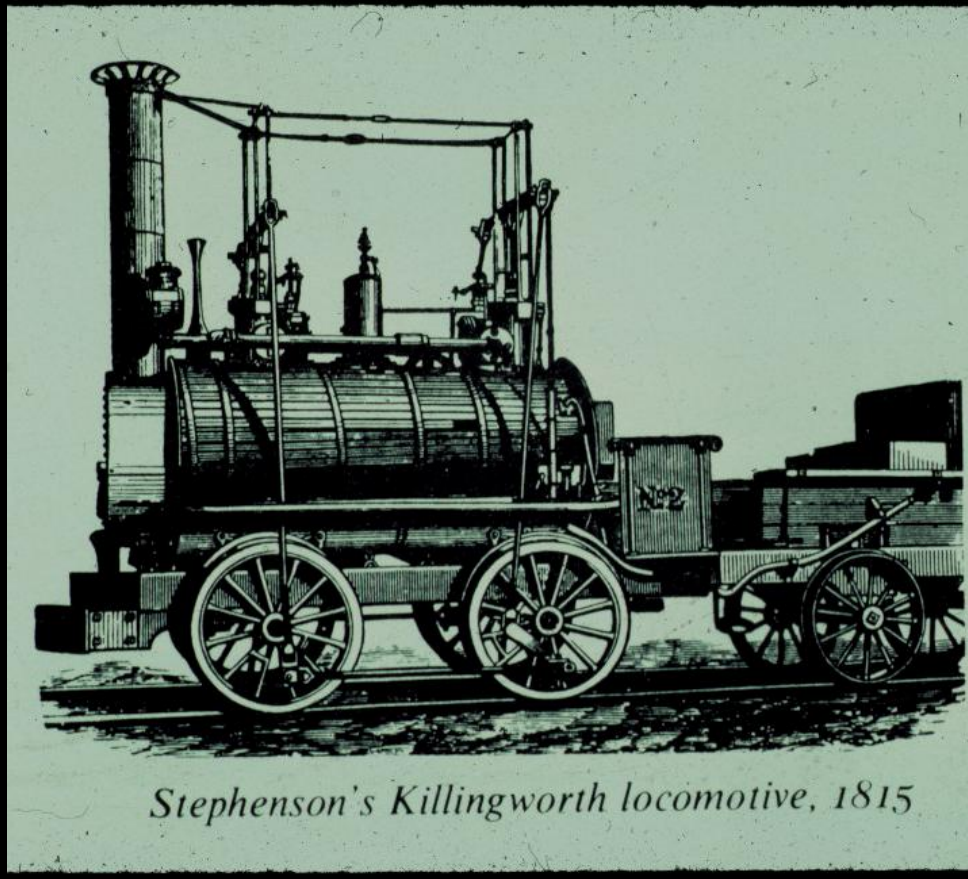

Stephenson's Killingworth locomotive, 1815

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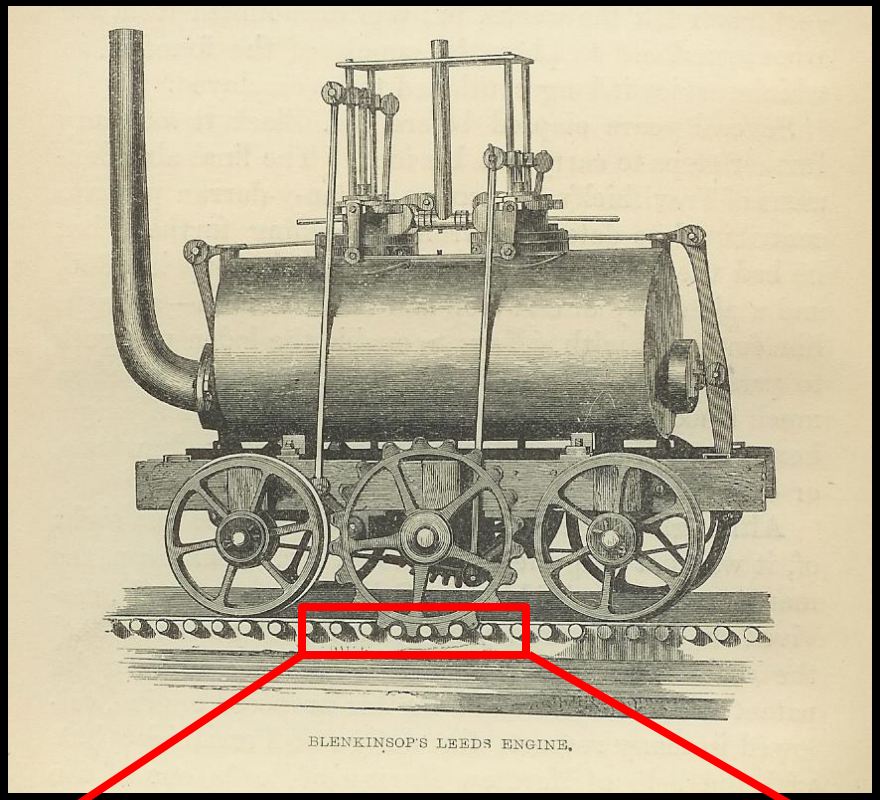
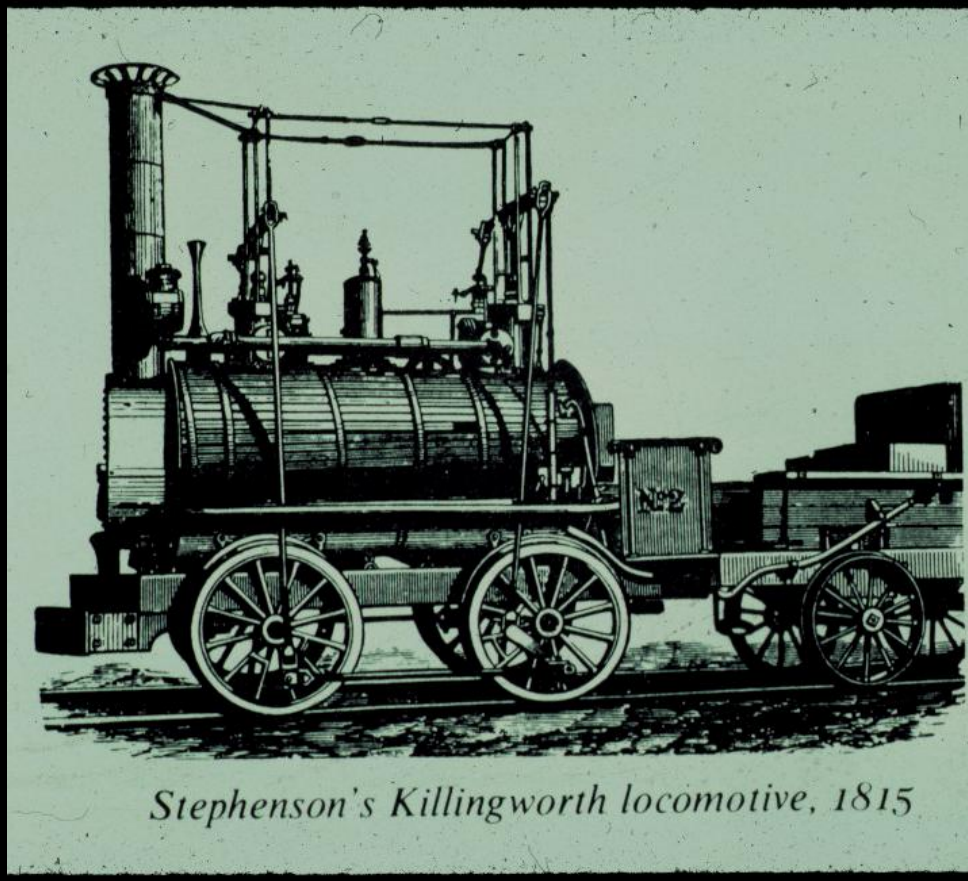
" The Blutcher (locomotive) is worth fifty horses"





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ENGINEER

Studied previous works

Made numerical calculations

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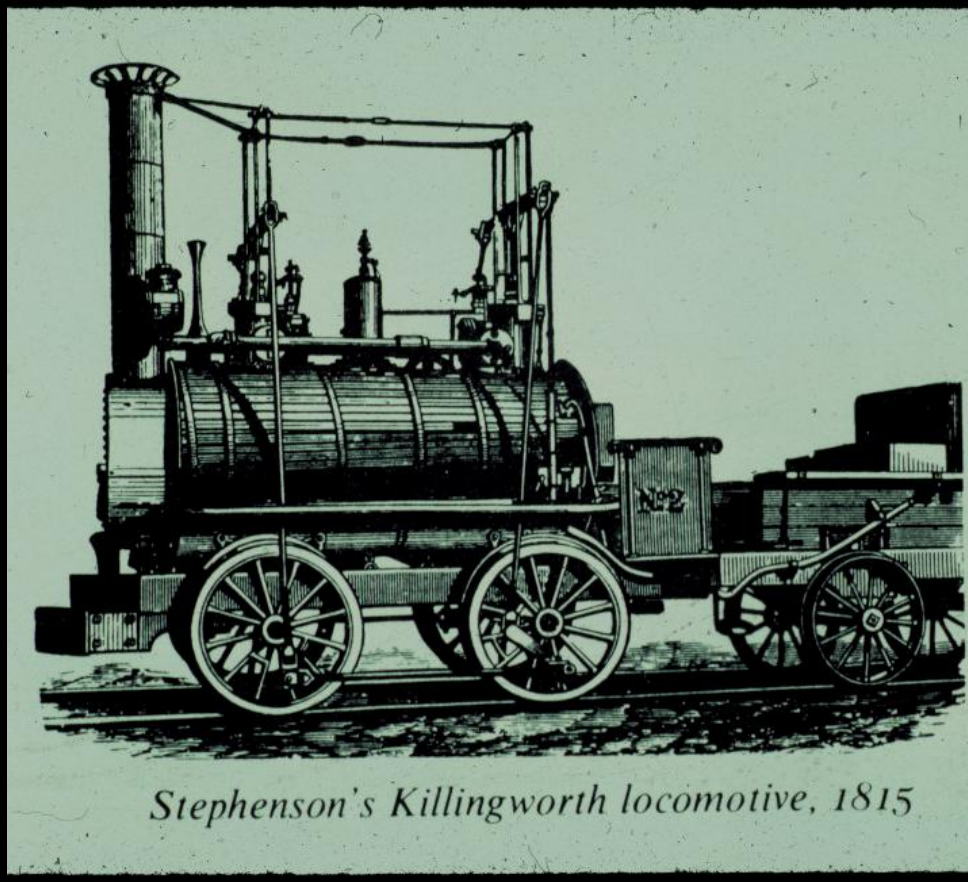

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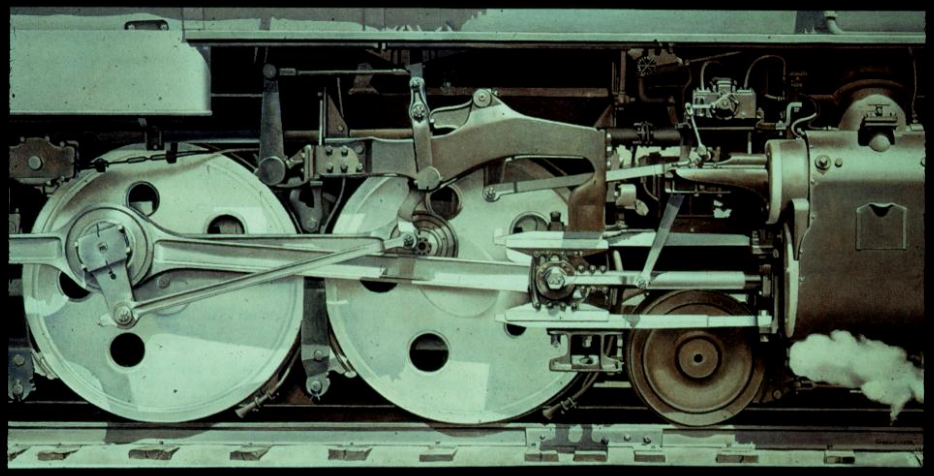
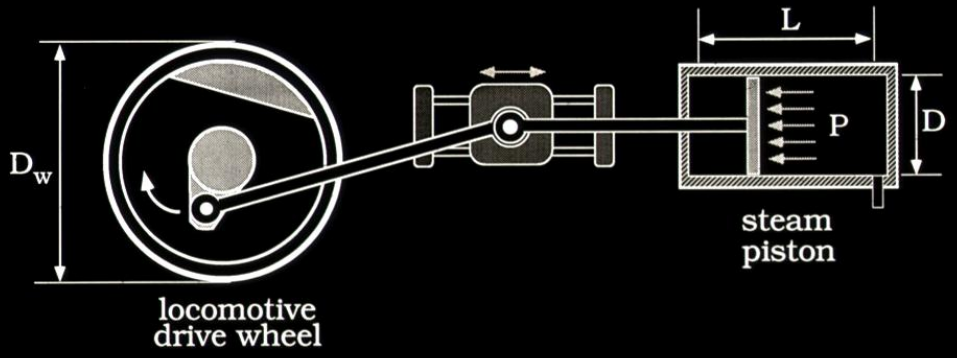


Charles Sheeler's "Rolling Power"



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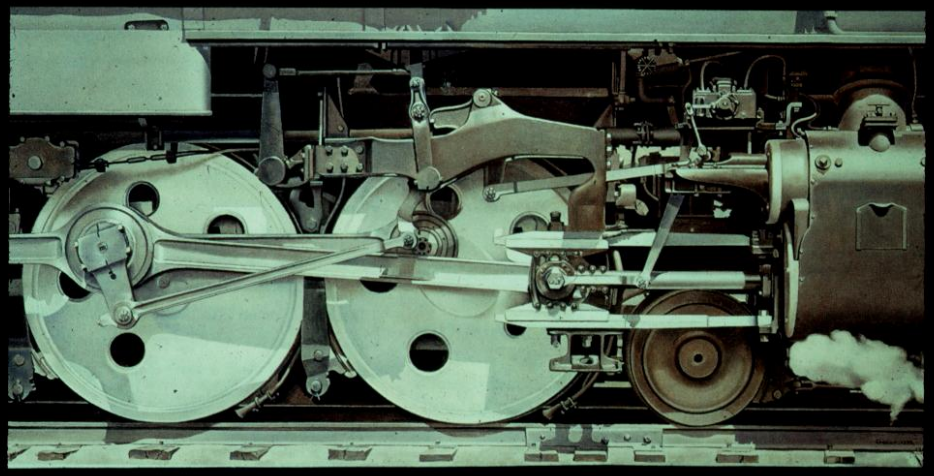

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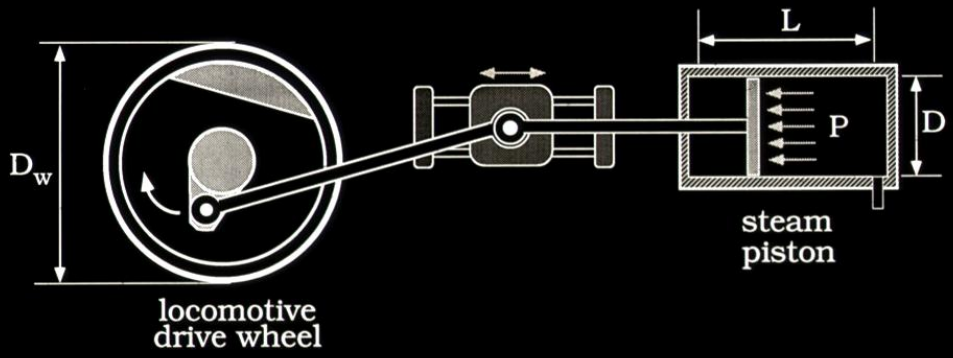
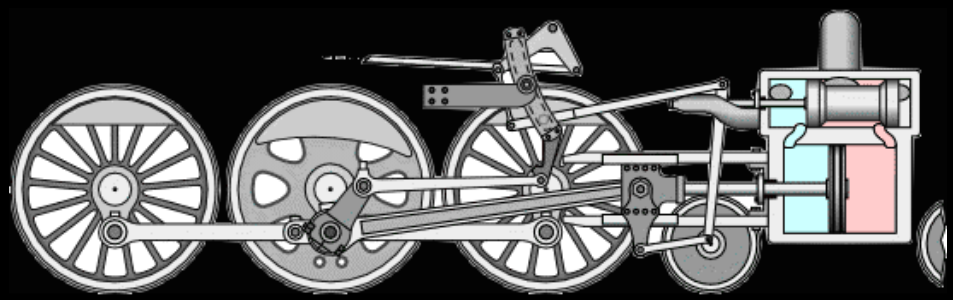
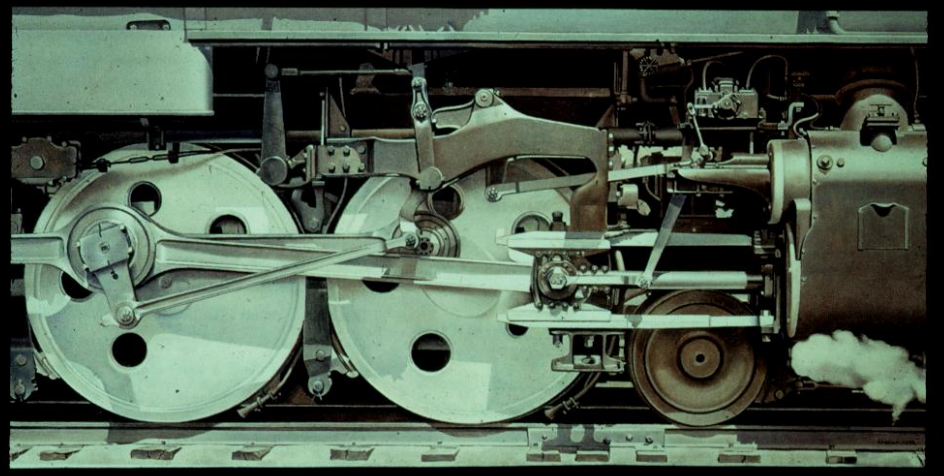




Darlington to Stockton-on-Tees

"The First Public Railway"



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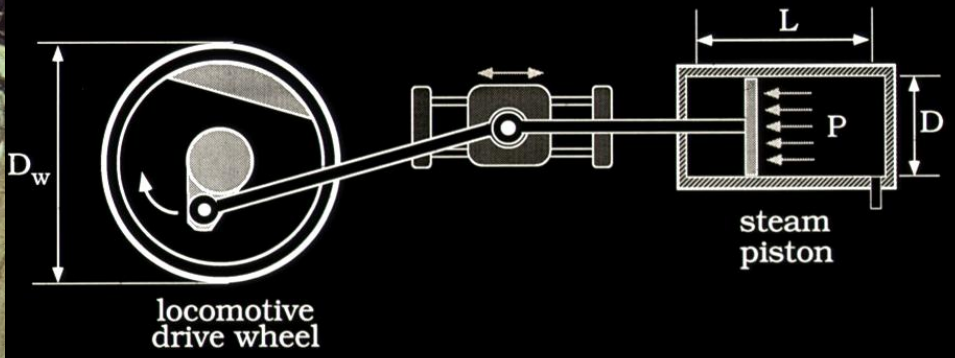

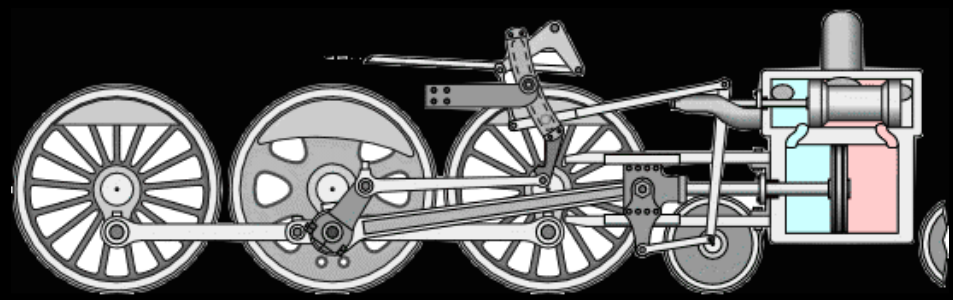

Darlington to Stockton-on-Tees

"The First Public Railway"

Early British Rail Lines
George and Robert Stephenson

Liverpool → Manchester

London→ Birmingham
→ Liverpool

Chester → Holyhead

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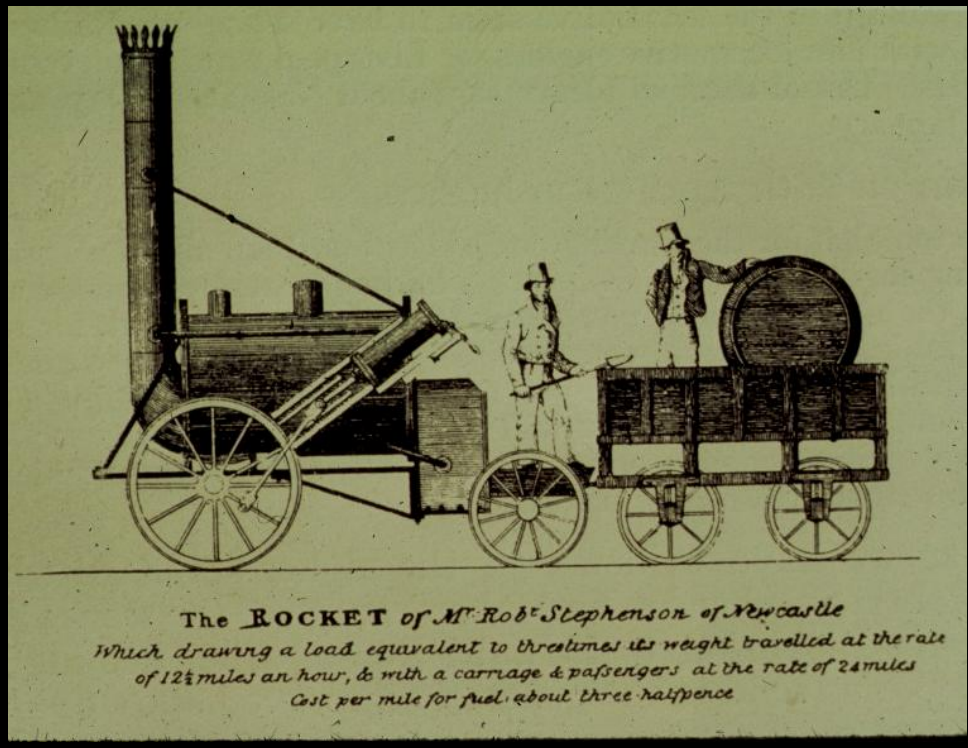

The Rocket of Mr Rob't Stephenson of Newcastle
Which drawing a load equivalent to threetimes its weight travelled at a rate of 12½ miles an hour, & with a carriage and passengers, at a rate of 24 miles
Cost per mile for fuel about three halfpence

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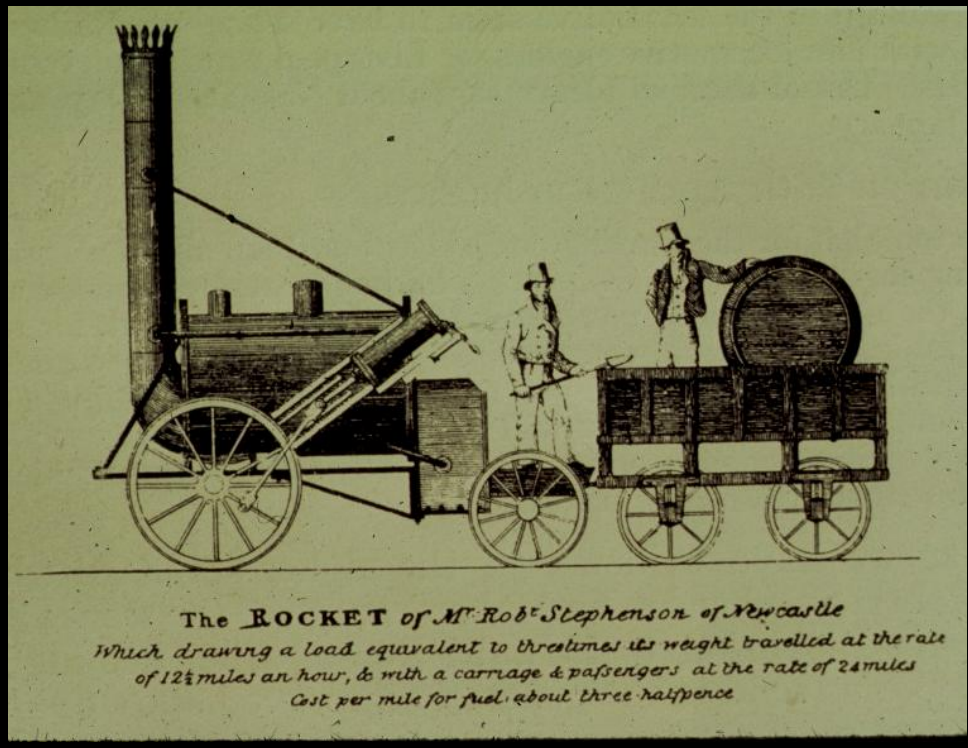
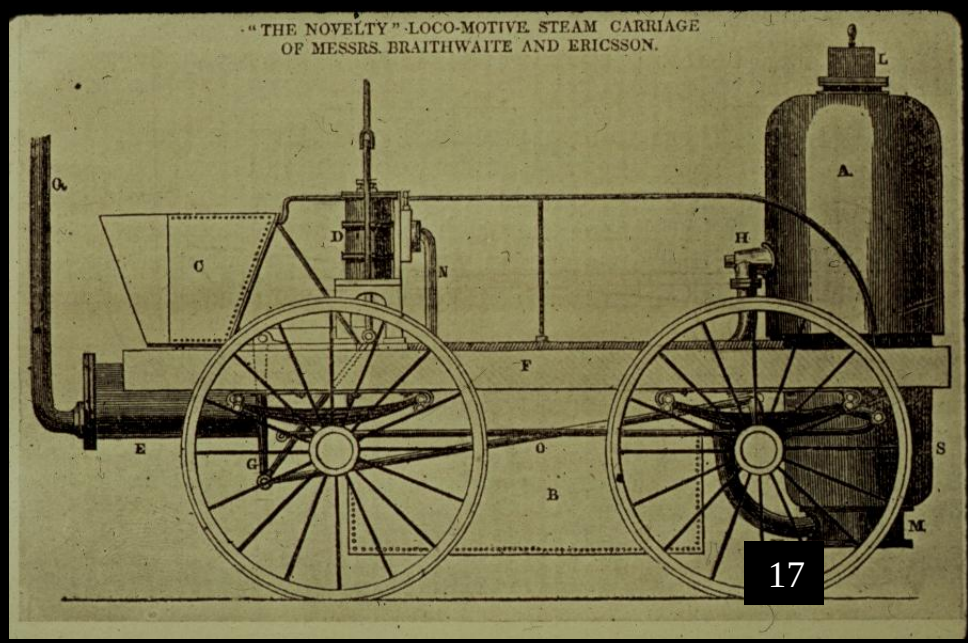
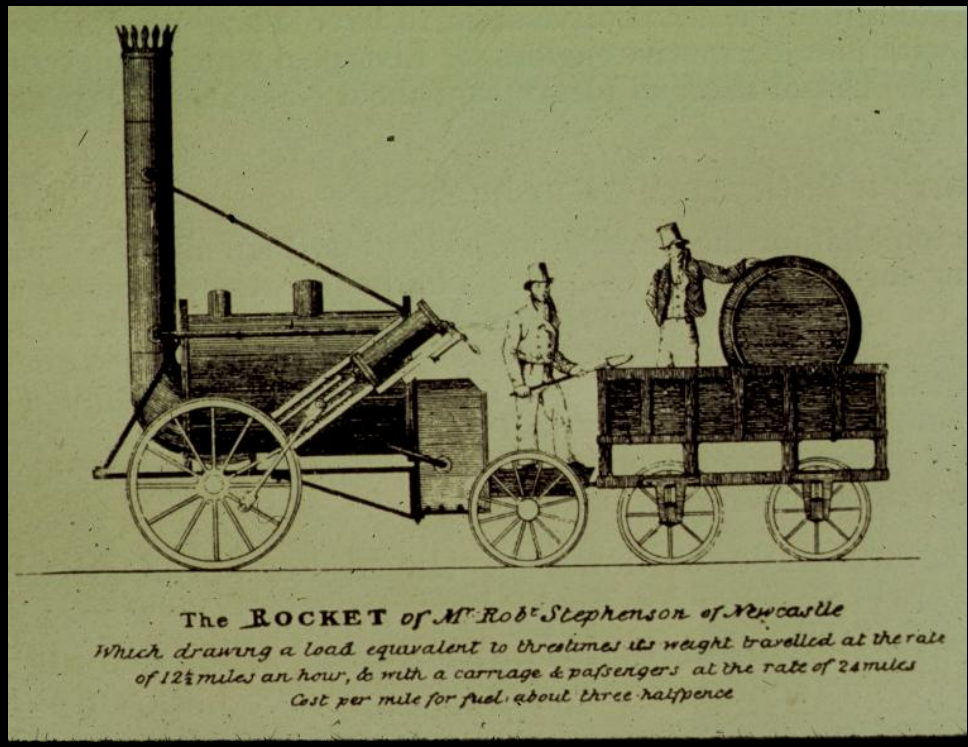


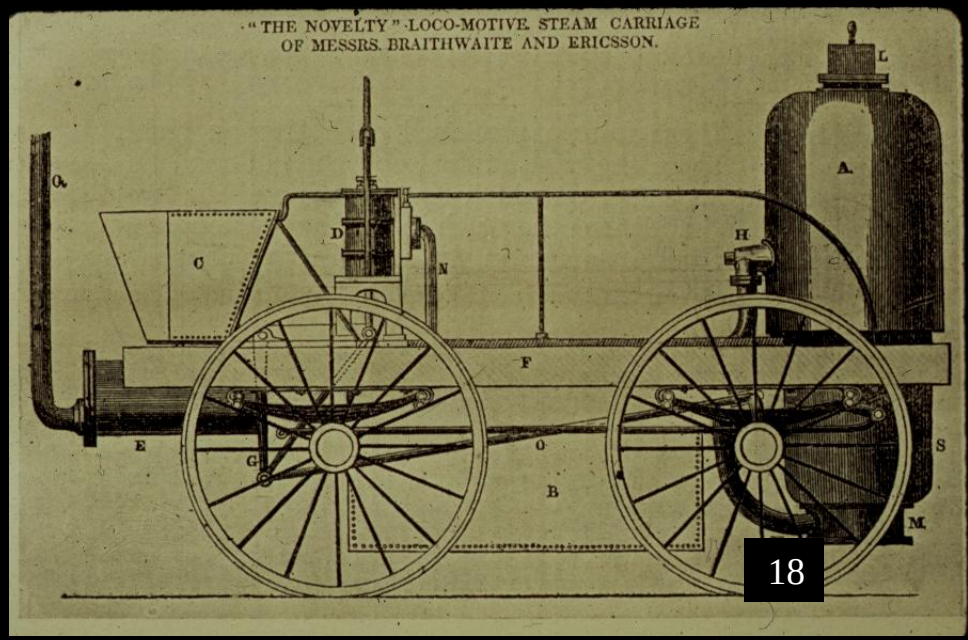
The ROCKET of Mr Robt Stephenson of Newcastle
Which drawing a load equivalent to three times its weight travelled at the rate of 12½ miles an hour, & with a carriage & passengers at the rate of 24 miles
Cost per mile for fuel about three halfpence



Races and Competitions

Fulton	- Monopoly	- 1807
Stephenson	- Sales	- 1829
Ford	- Capital	- 1899





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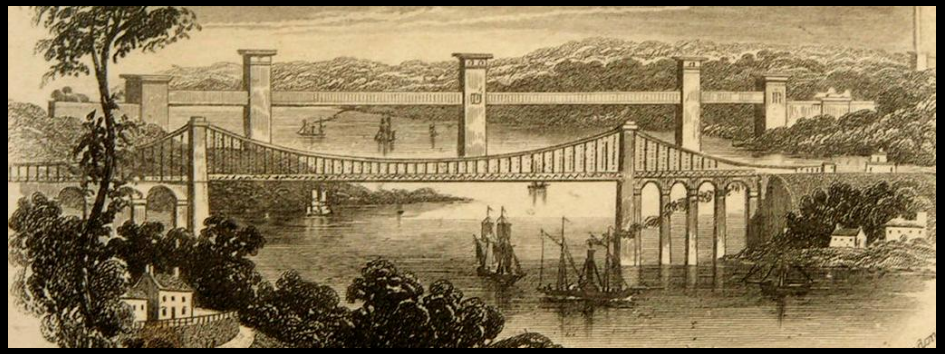
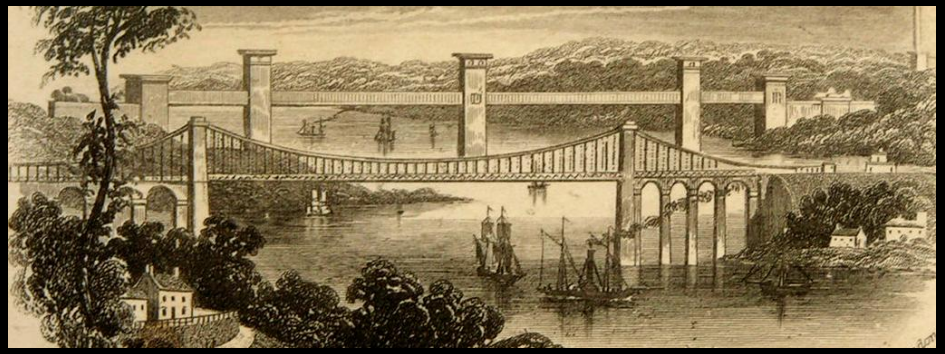


BRIDGES

Robert Stephenson's 'Britannia'

Thomas Telford's 'Menai Straits'

Robert Stephenson



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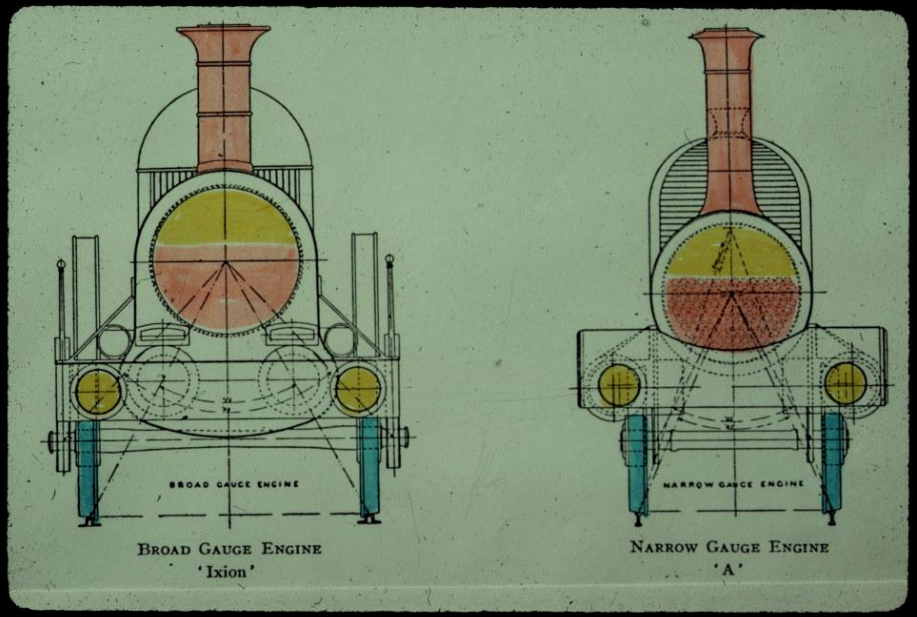
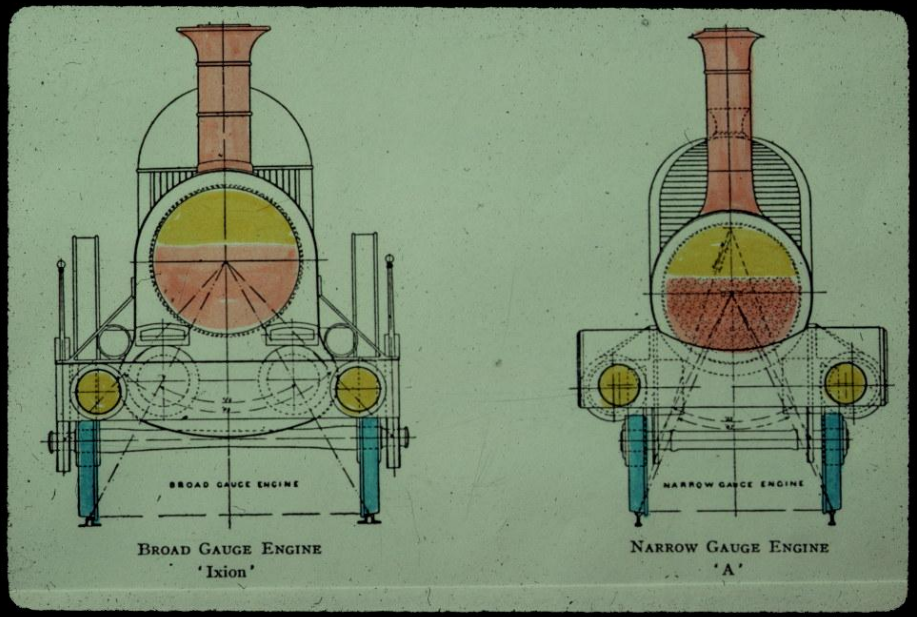
Isambard Kingdom Brunel



BROAD GAUGE ENGINE
'Ixion'

NARROW GAUGE ENGINE
'A'

Isambard Kingdom Brunel



Gauge War

Stephenson	4' 8.5"	1829
Brunel	7' .25"	1838
Gauge Act		1846

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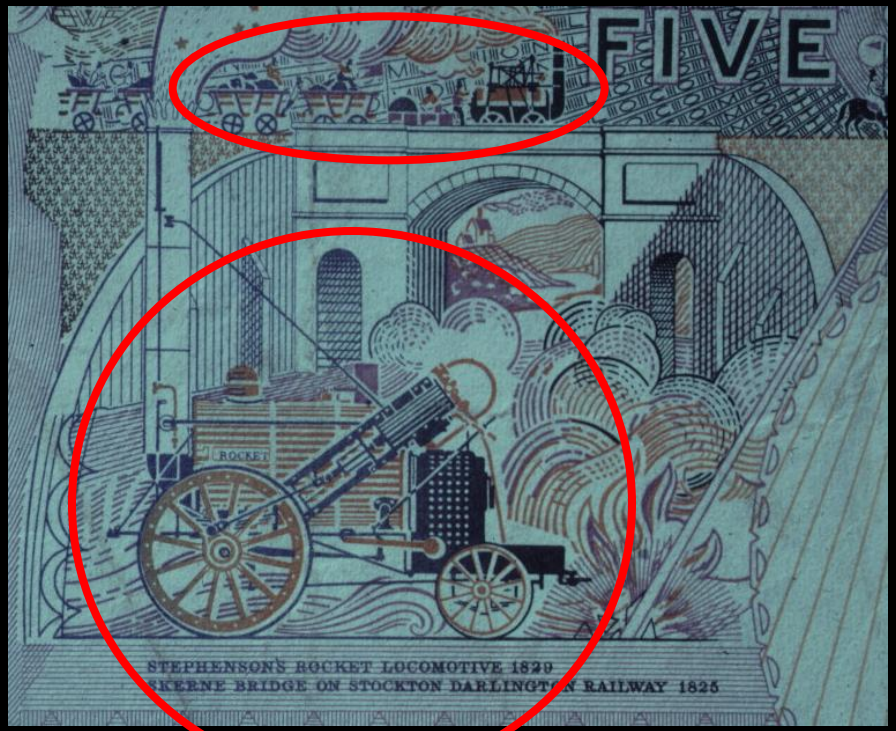
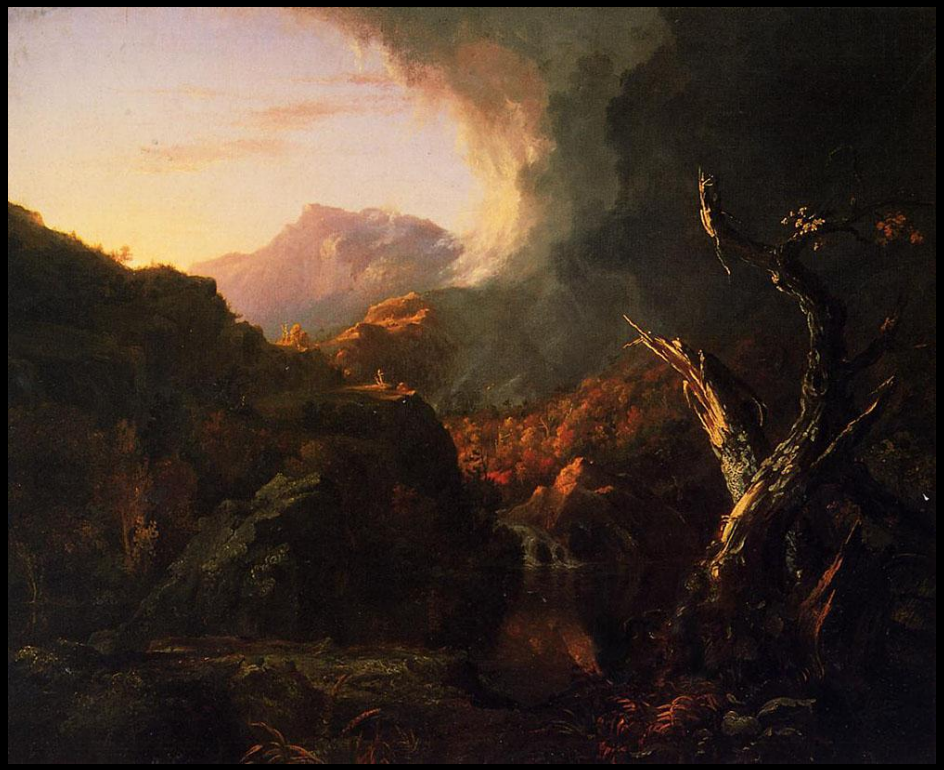
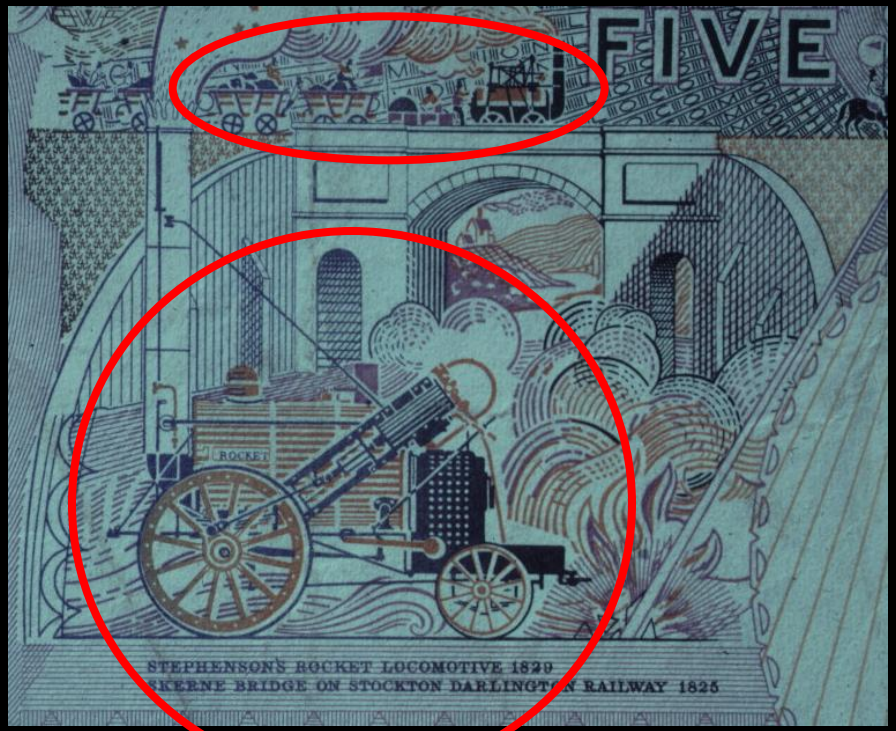
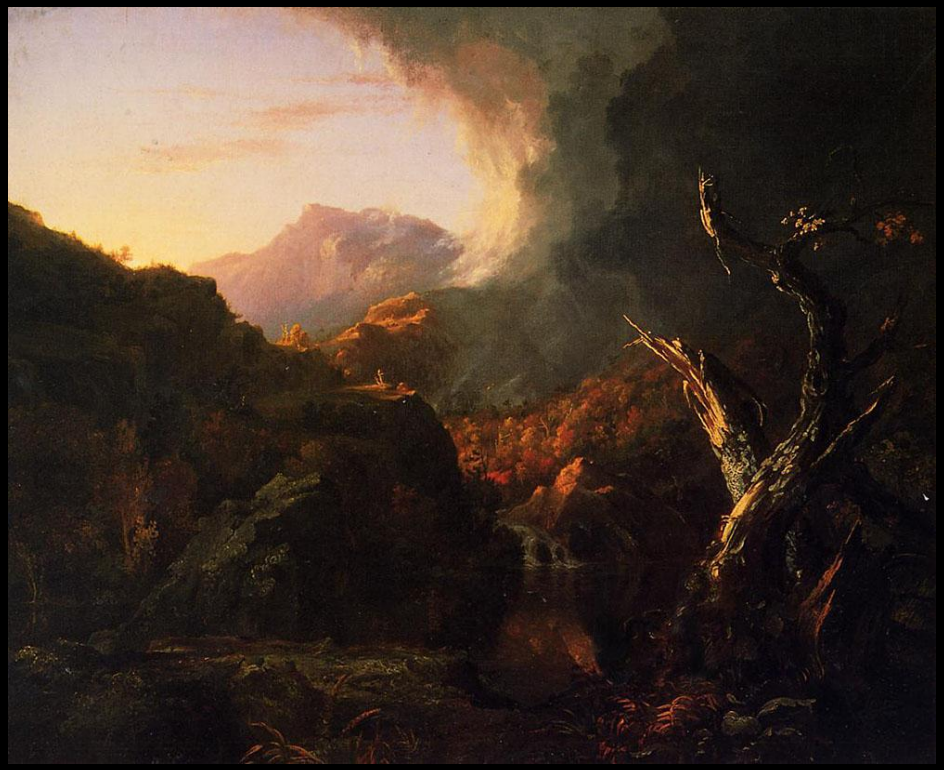
£5 BANK of ENGLAND
FIVE POUNDS
George Stephenson 1781-1848


FIVE
ROCKET
STEPHENSON'S ROCKET LOCOMOTIVE 1829
SKERNE BRIDGE ON STOCKTON DARLINGTON RAILWAY 1825





Cole's "Landscape with Dead Tree"



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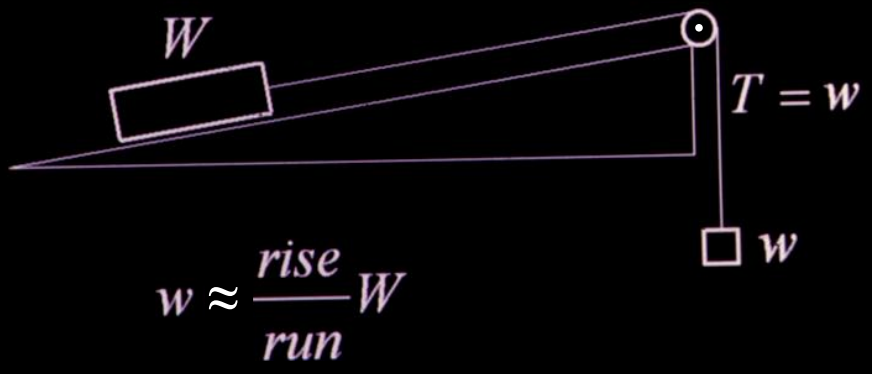
Force to climb a grade



$$w \approx \frac{rise}{run} W$$

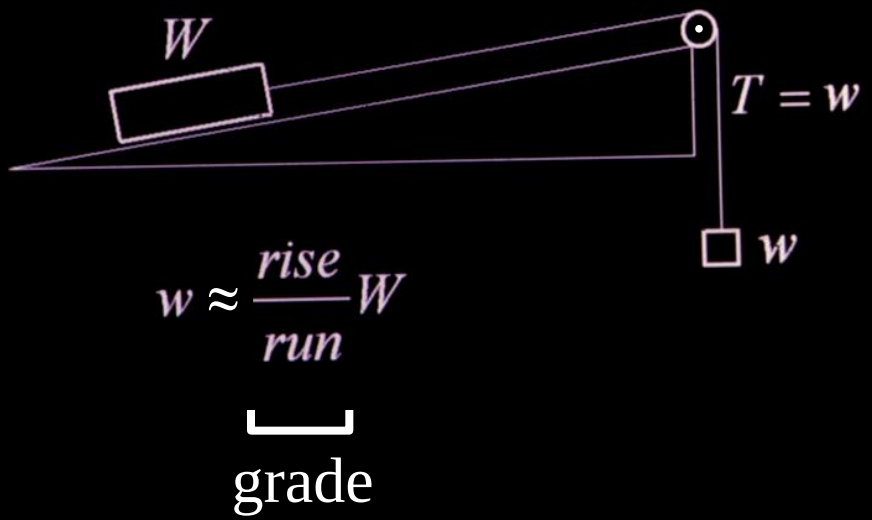
grade

W,w weight
T tension

Force to climb a grade

Measure weight of Loco and Cars

Demonstrate traction force needed to climb a hill



W,w weight
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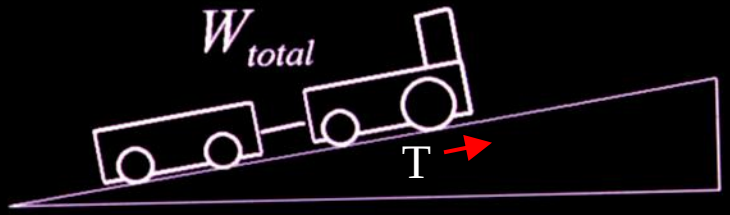
Power to climb a grade



$$T \approx \frac{rise}{run} W_{total}$$

$$Hp = \frac{TV}{33{,}000}$$

T traction

Force to climb a grade

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grade

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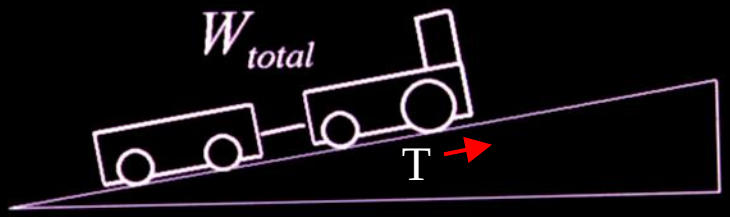
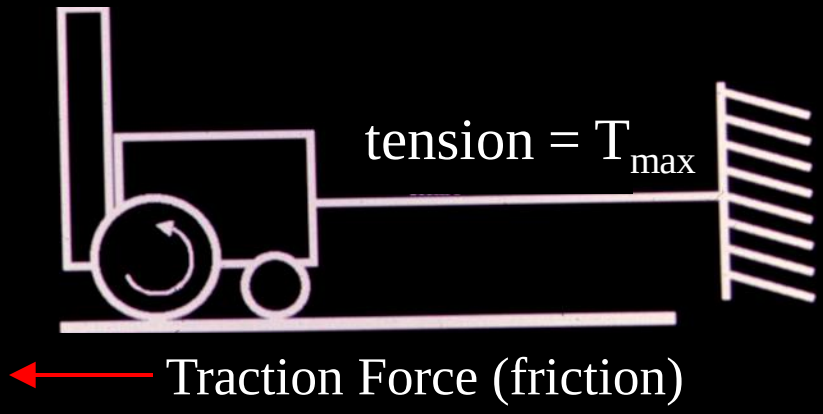
Power to climb a grade



$$T \approx \frac{rise}{run} W_{total} \qquad Hp = \frac{TV}{33{,}000}$$

T traction

Traction Limit – wheels slip



$$T_{max} = 0.2\ W_{Loco}$$

Friction coefficient

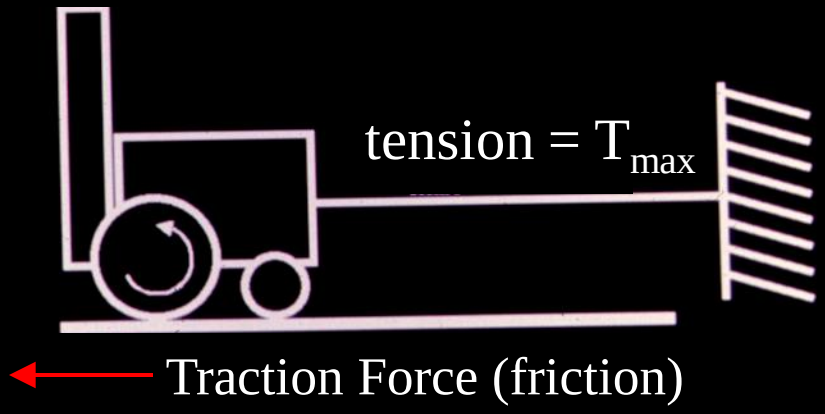
Demonstrate challenge of large grade when towing a large load

Demonstrate fix by increasing weight of Locomotive

Conclusions:

- Gentle grades (< 2%)
- Heavy Locomotives
- Powerful Locomotives

Traction Limit – wheels slip



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VIDEO – Wheel sparks due to slip

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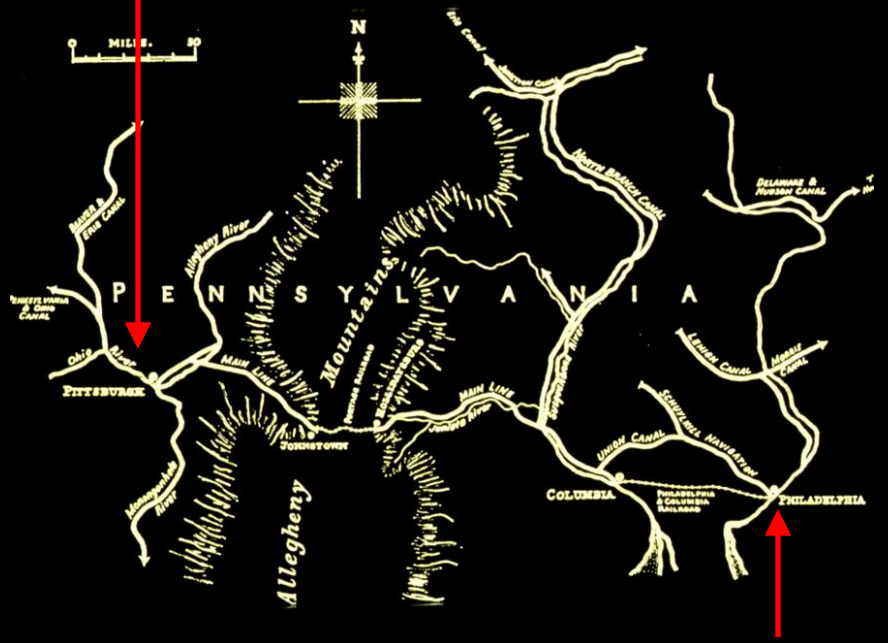
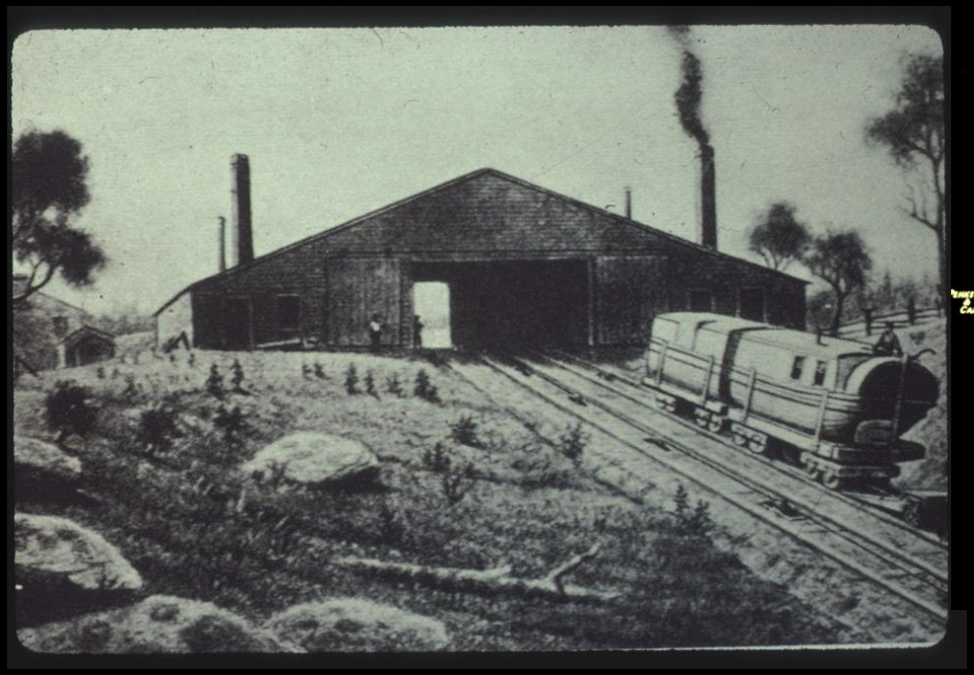
PITTSBURGH



PHILADELPHIA

Four-day Trip in 1834



Allegheny Portage Railroad -
canal boats pulled up mountain by
stationary steam engine and rope

PITTSBURGH

PHILADELPHIA

Four-day Trip in 1834

Connecting Port to Industry

New York - 1825

Erie Canal to Buffalo

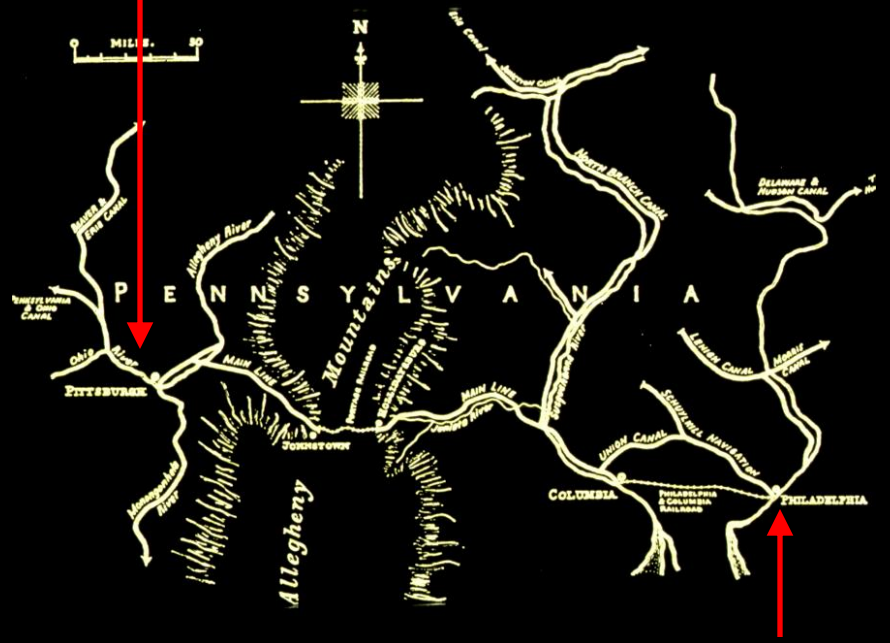
Philadelphia - 1834

Railroad and Canal to Pittsburgh

Boston - 1835

Railroad to Lowell

PITTSBURGH



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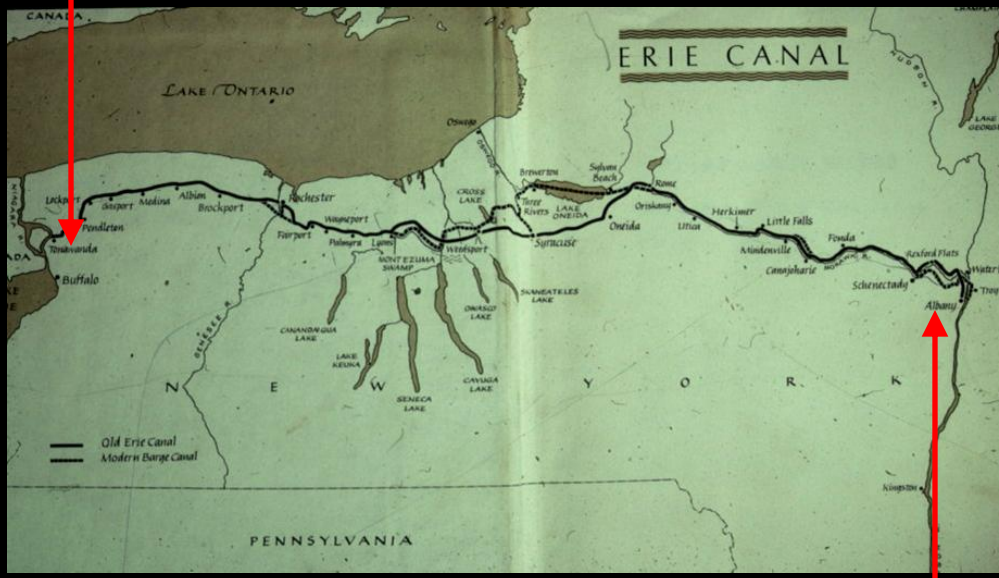

Albany

Connecting Port to Industry

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Erie Canal to Buffalo

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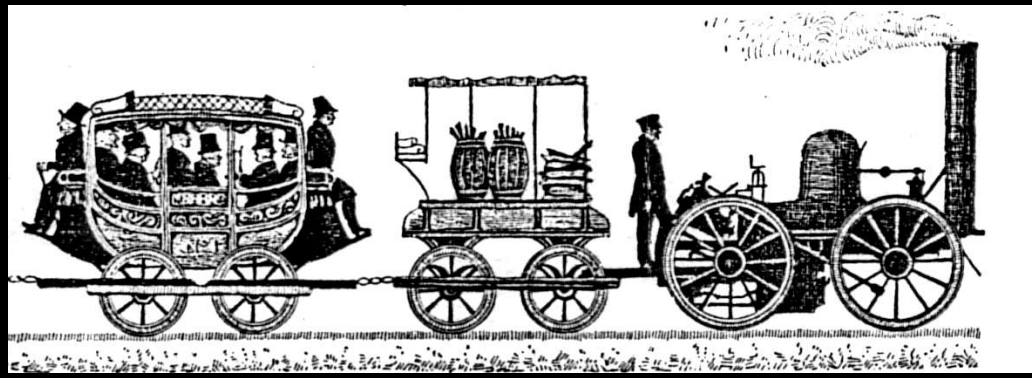
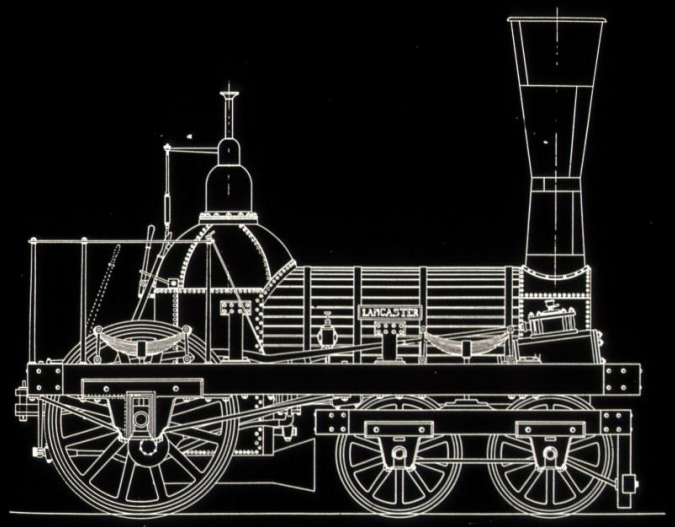
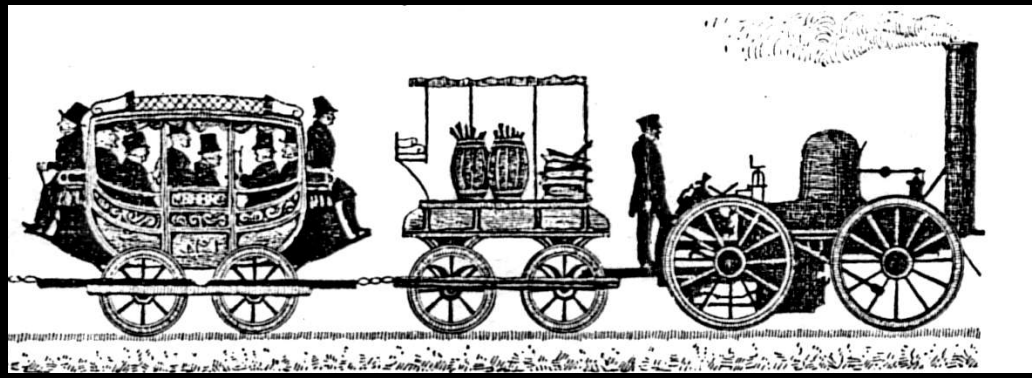
Railroad to Lowell



The Dewitt Clinton



The Lancaster



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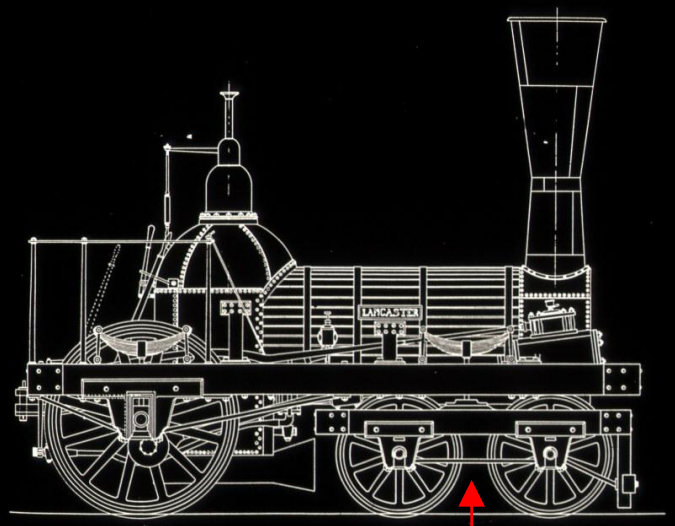
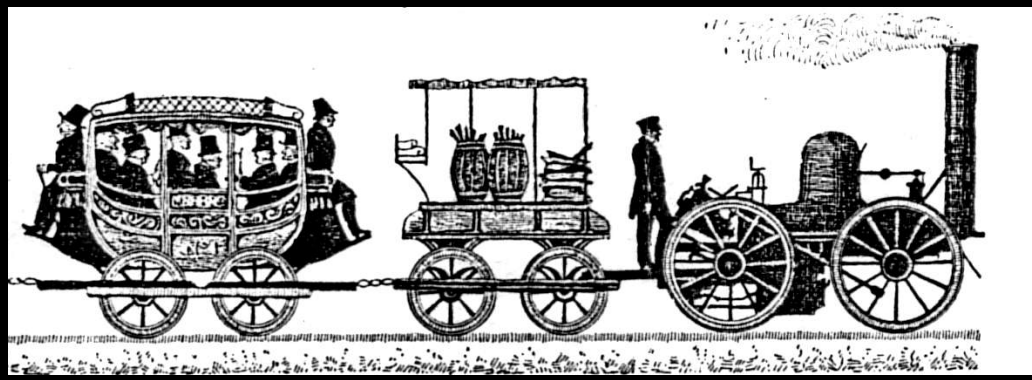


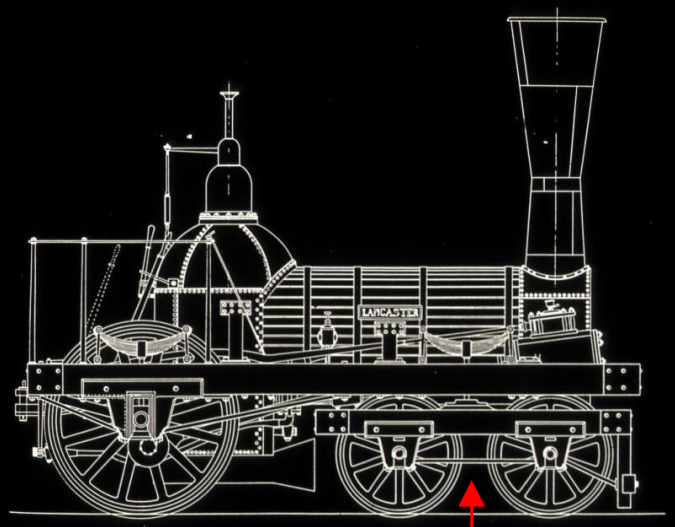
Swivel truck

American-style locomotive



Inline design

British-style locomotive



Swivel truck

American-style locomotive

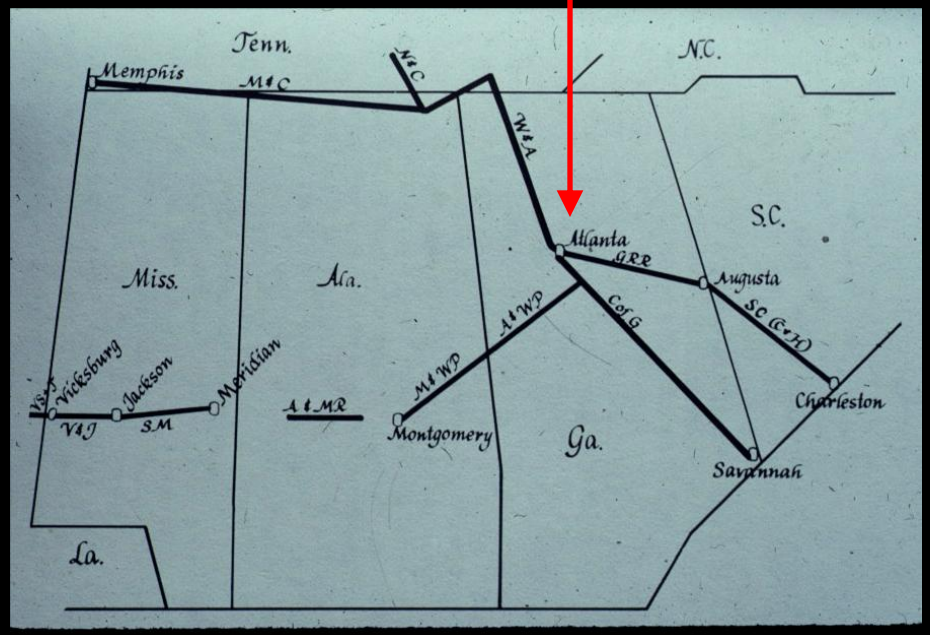
J. Edgar Thomson

1834 Georgia RR
engineer

1848 Pennsylvania RR
engineer

1852 Pennsylvania RR
president

Atlanta



Railroad supports inland growth

J. Edgar Thomson

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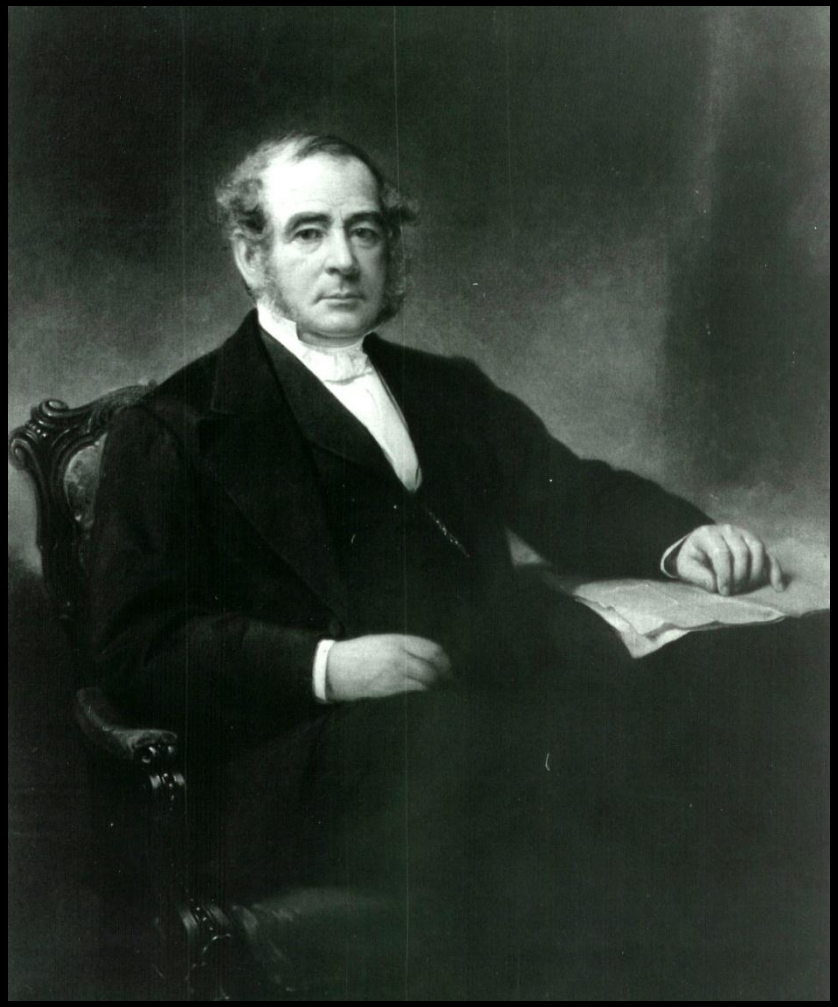
engineer

1848 Pennsylvania RR
engineer

1852 Pennsylvania RR
president



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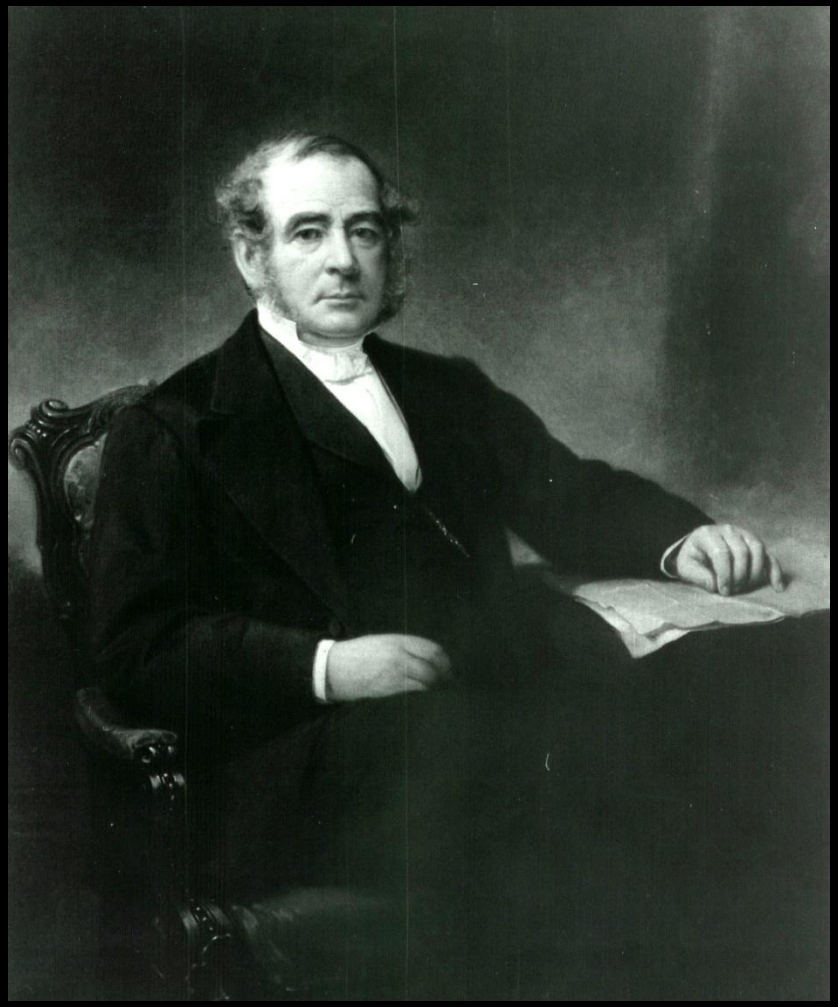

J. Edgar Thomson and PRR

Scientific: technological trendsetter

Social: profits returned to company

Symbolic: world's largest transportation network

Railroads – America's First Big Business

US Railroad Map in 1860

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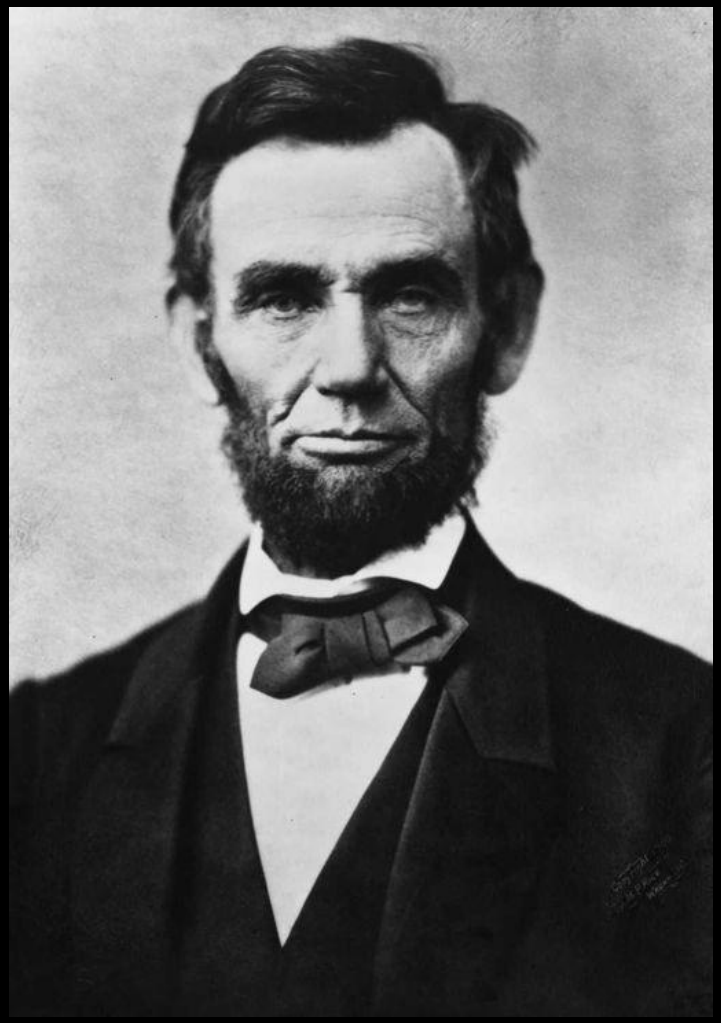


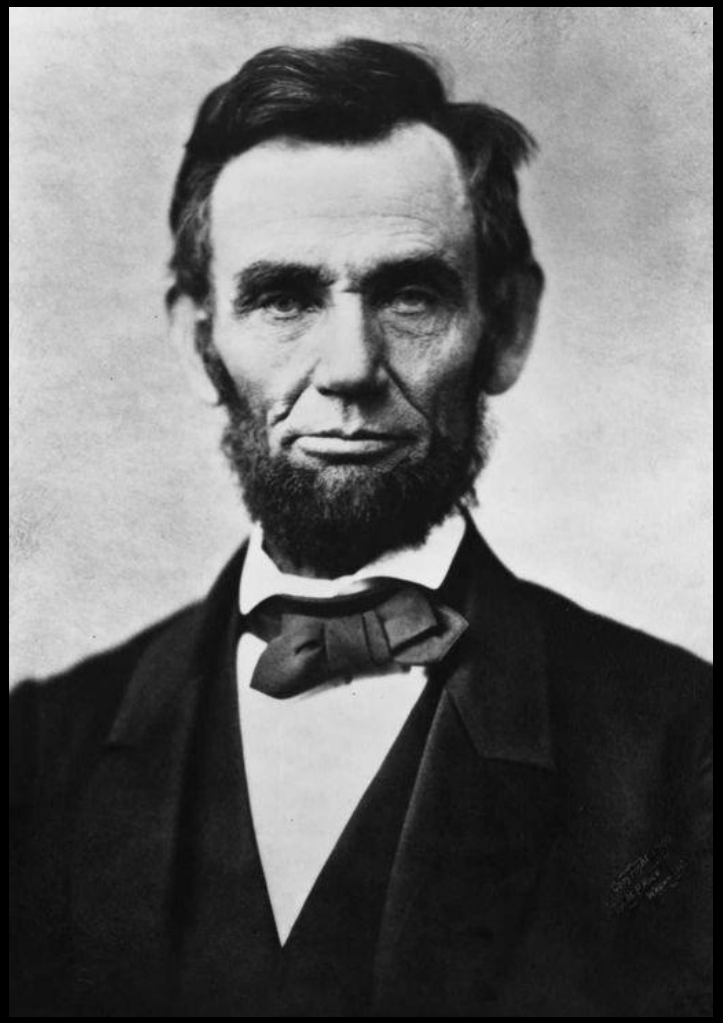
Illinois Central Railroad attorney

Chicago and St. Louis

east-west vs. north-south

railroads vs. steamboats

Civil War favors Chicago



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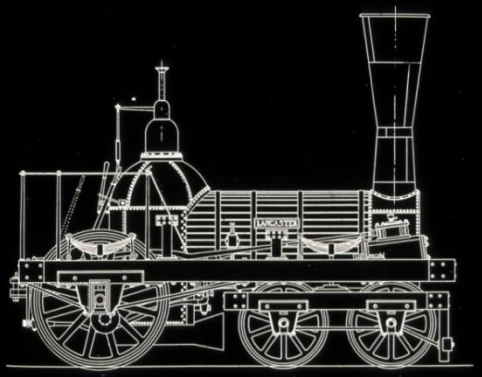
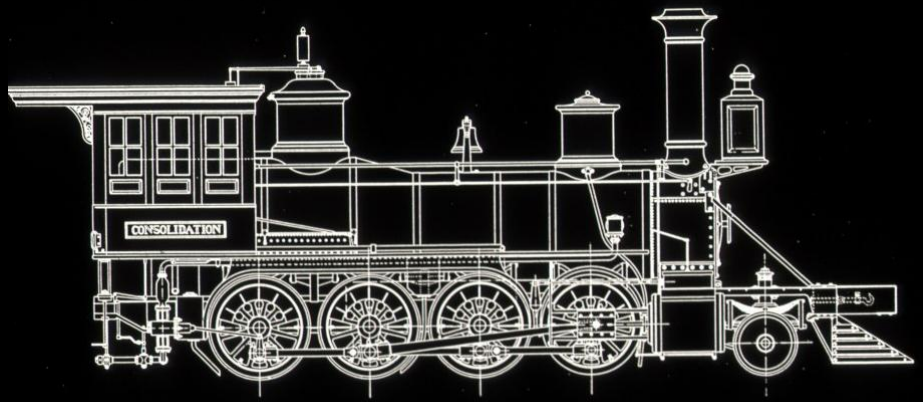
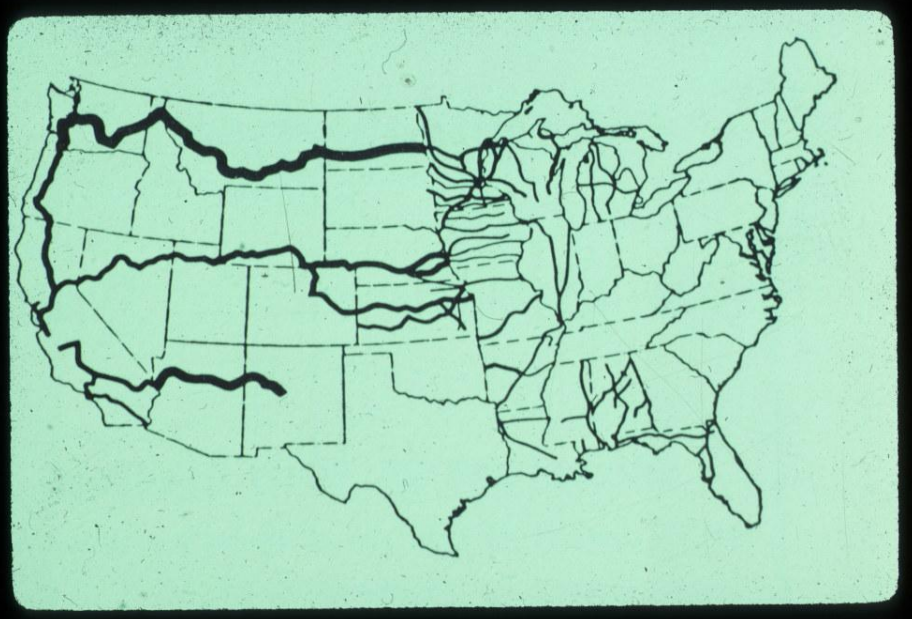
Land Grants hasten RR and Telegraph

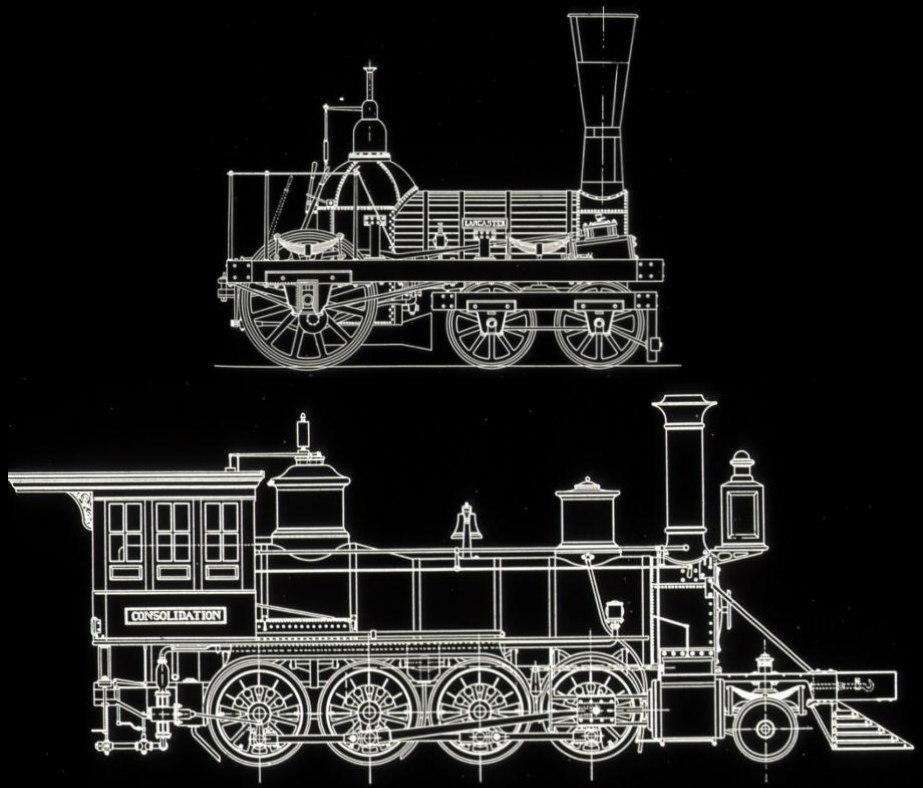




$$Hp = \frac{T\,V}{33{,}000}$$



Land Grants hasten RR and Telegraph



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Timber Trestle Bridge

Timber Trestle Bridge

Leland Stanford
1824 - 1893

1862 - 63	Governor of California
1869	Promontory Point, Utah - Central Pacific Railroad
1885	Founded Stanford University

May 10, 1869

Leland Stanford
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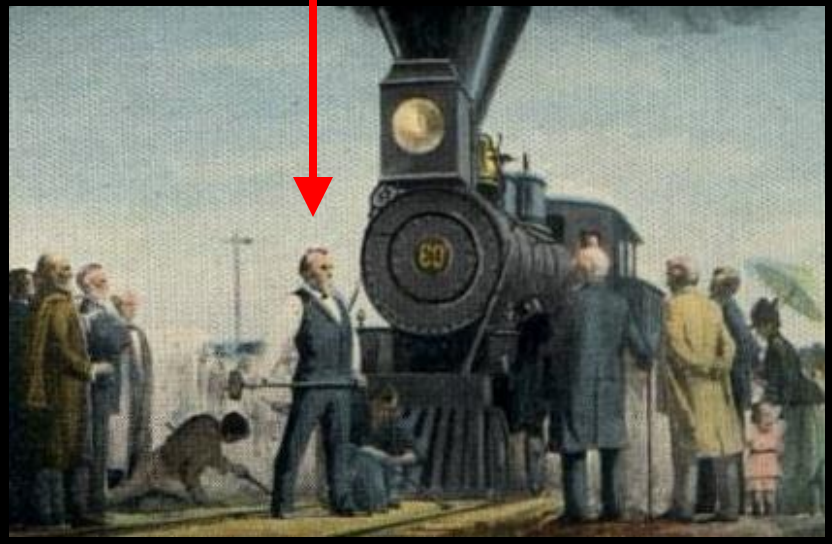
Leland Stanford



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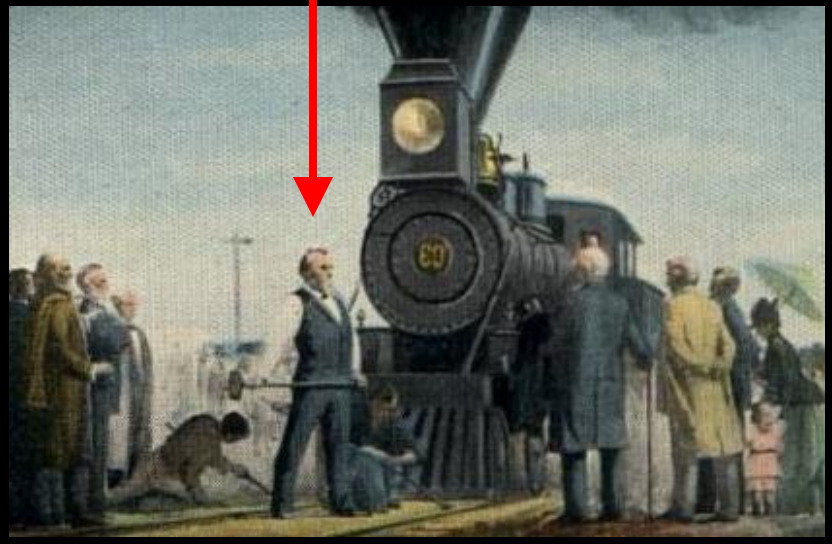

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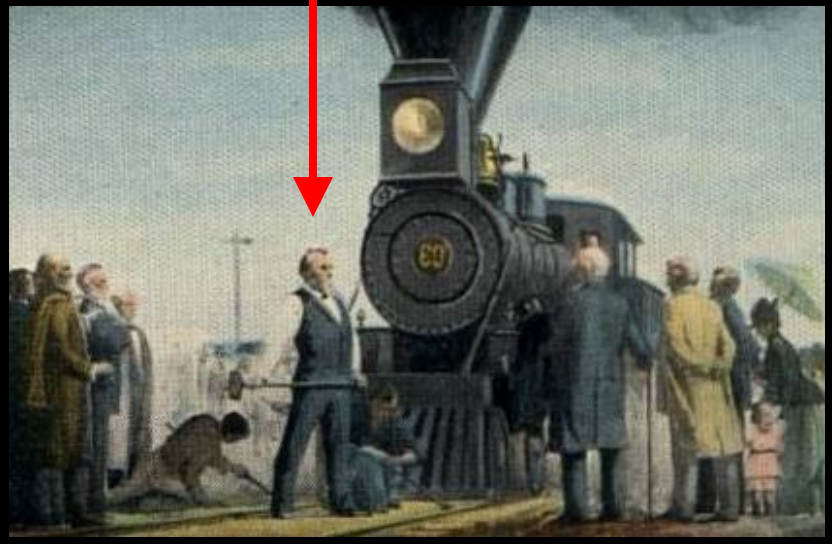
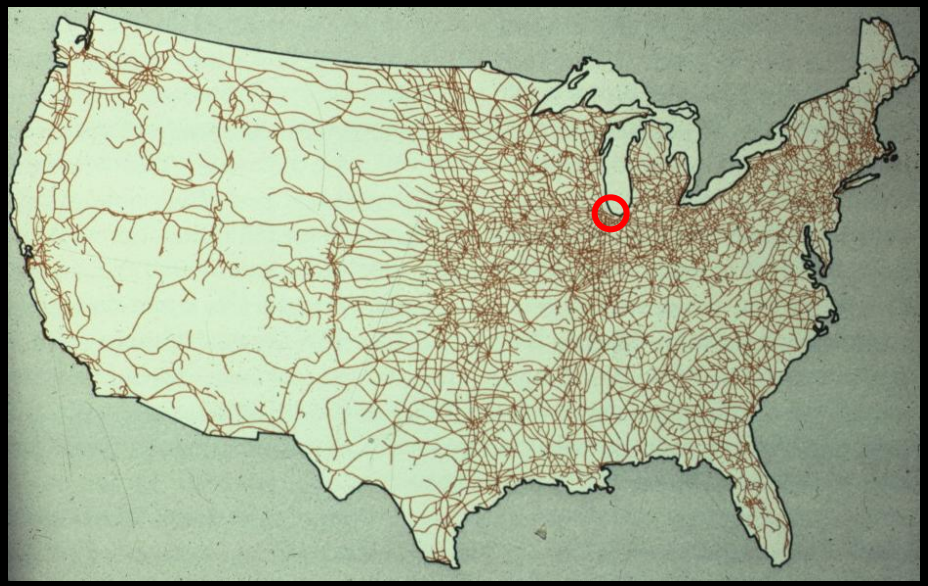
Golden Spike - Stanford University Museum of Art

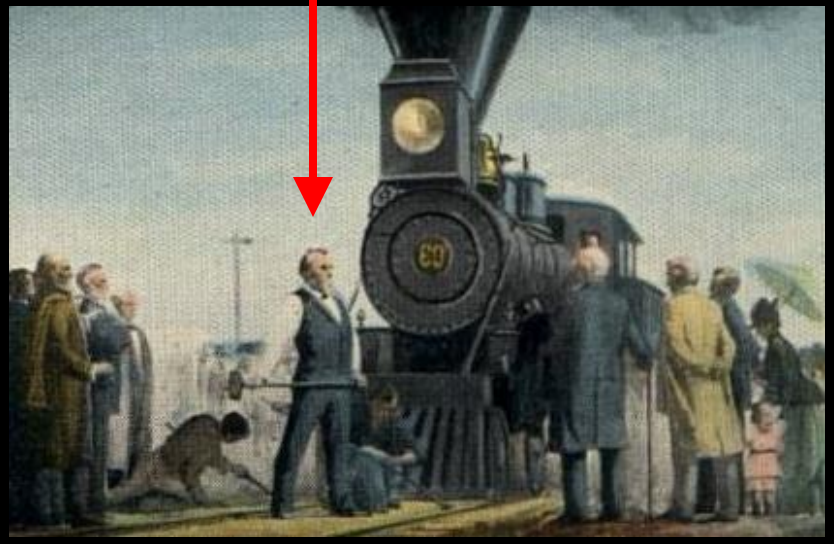
Leland Stanford

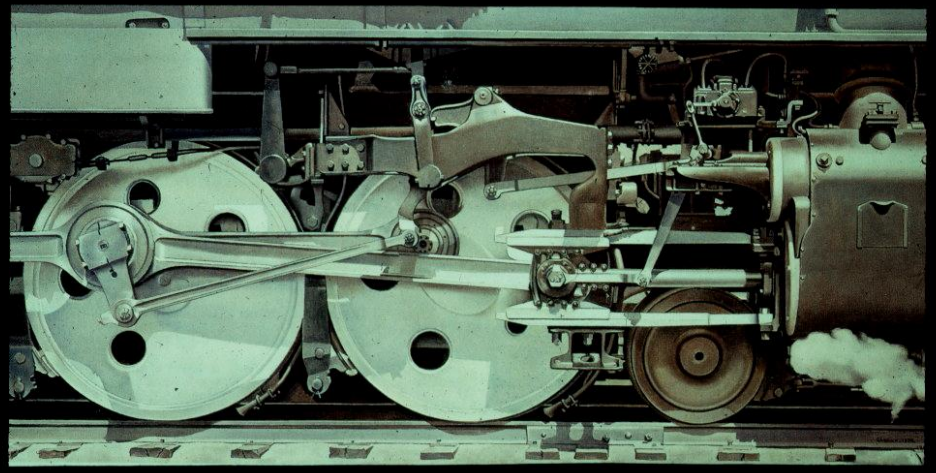




River to Rail

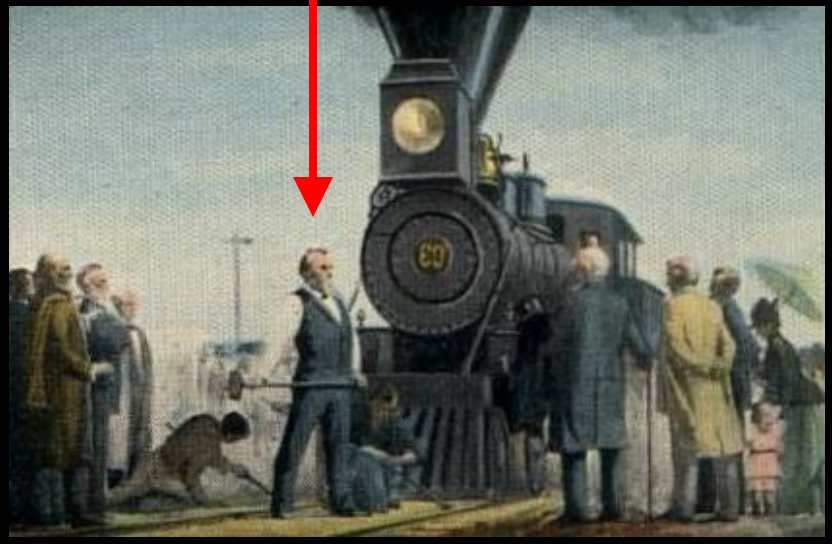
Leland Stanford

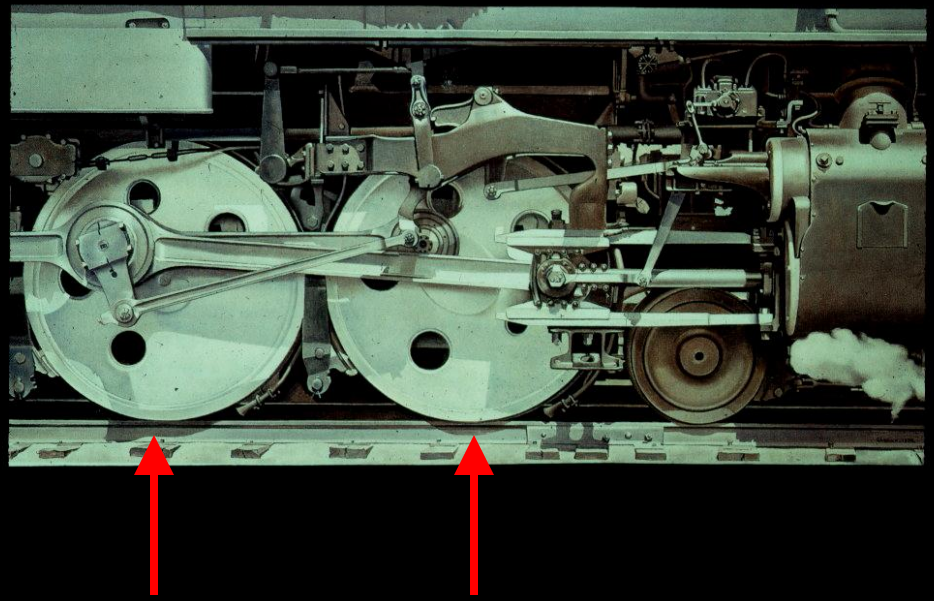




Charles Sheeler's "Rolling Power"

Leland Stanford

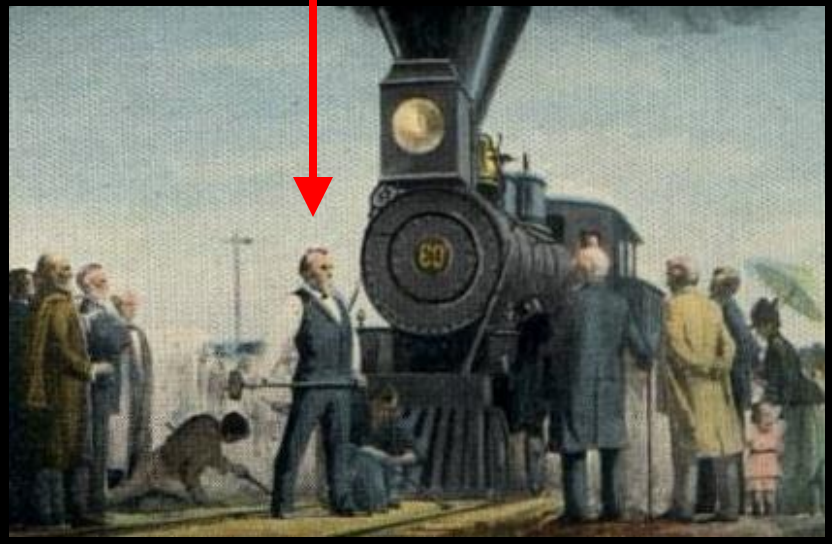


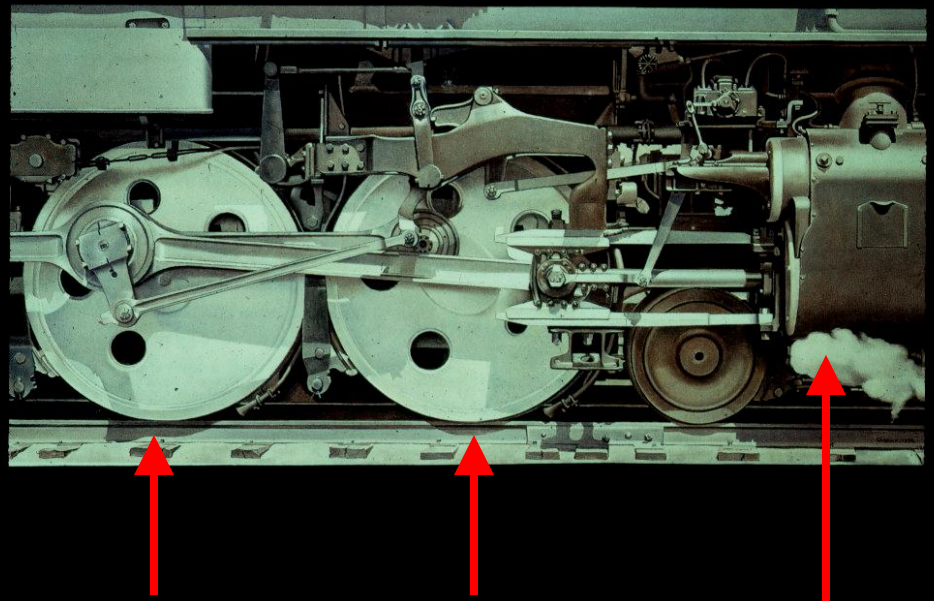


TRACTION = O.2 W_{LOCO}

Charles Sheeler's "Rolling Power"

Leland Stanford





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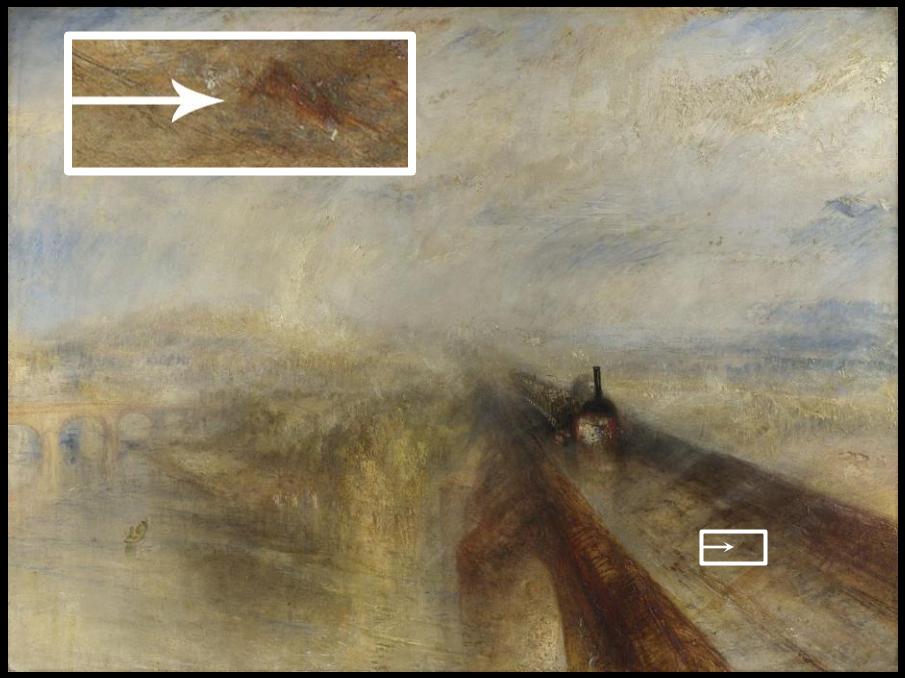
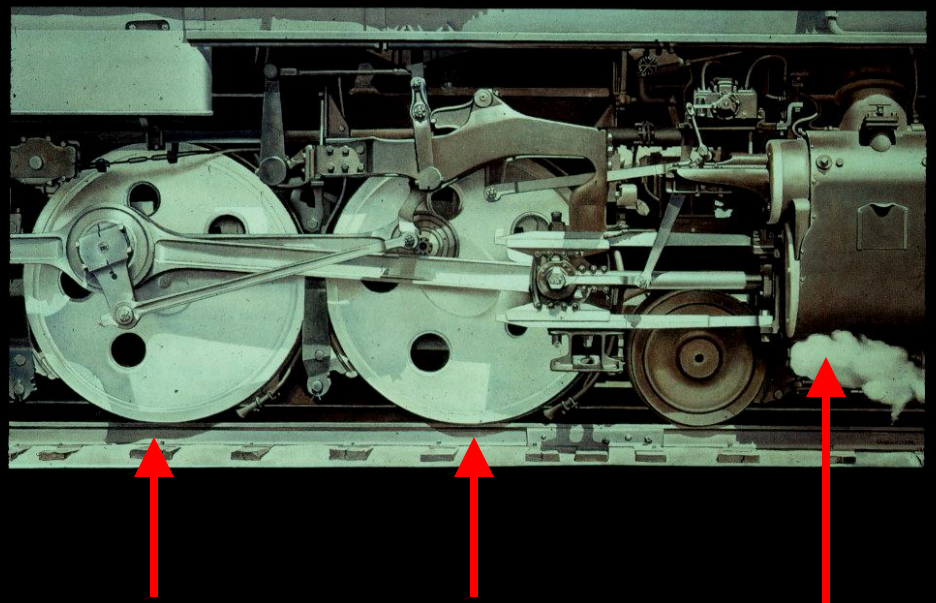


Turner's "Rain, Steam and Speed"
Locomotive replaces the hare



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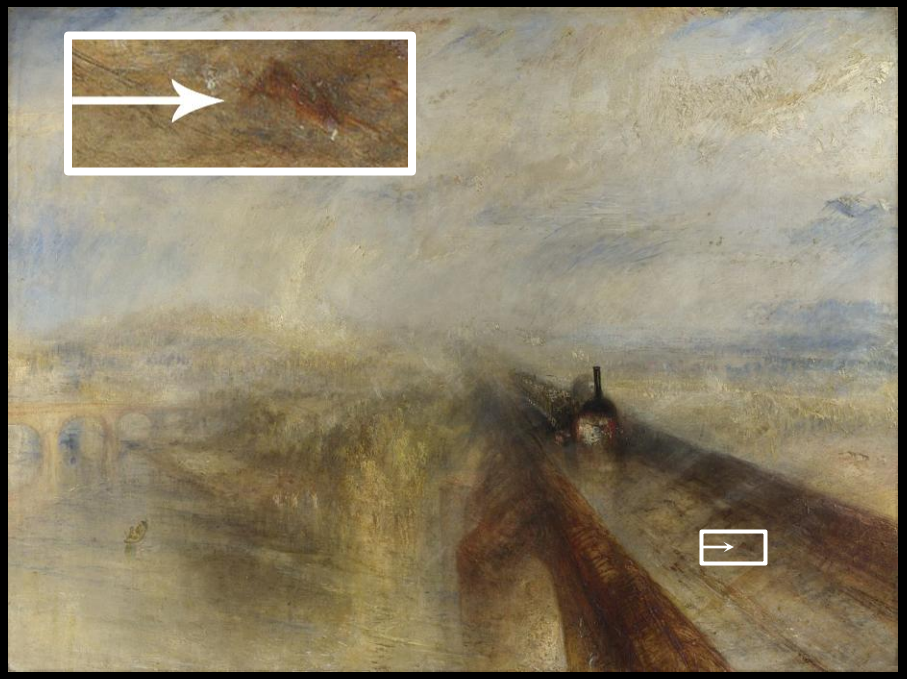

Turner’s “Rain, Steam and Speed”
Locomotive replaces the hare

Inness’s “Lackawanna Valley”
Restructuring of nature

Monet’s “Gare Saint Lazare”
Brings artist to landscape

Inness’s “Lackawanna Valley”
Restructuring of nature

Key Ideas

Monet's "Gare Saint Lazare"
Brings artist to landscape

Scientific:

- Traction and Power

Social:

- Public: Land Grants
- Private: First Big Business
- River to Rail

Symbolic:

- Railroads and Art