THE INDUSTRIAL REVOLUTION IN BRITAIN AND AMERICA TO 1900

SESSION 5 - COAL AND STEAM

1. INTRODUCTION; THE LATE MIDDLE AGES; VENICE (JANUARY 23)

2. AN EMPIRE OF MARKETS (JANUARY 30)

3. WHY BRITAIN? (FEBRUARY 6)

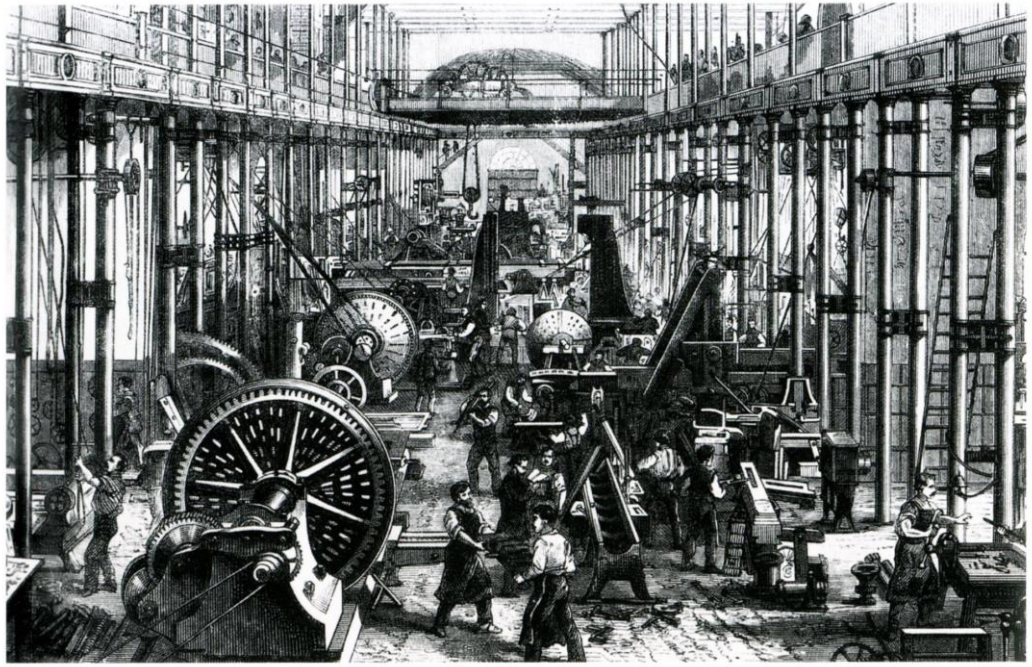
4. CITIES, TEXTILES AND METALS (FEBRUARY 13)

5. COAL AND STEAM (FEBRUARY 20)

6. THE BRITISH CONSUMER REVOLUTION; ADAM SMITH (FEBRUARY 27)

7. THE INDUSTRIAL REVOLUTION IN AMERICA – THE TYRANNY OF DISTANCE (1700 TO 1850) (MARCH 6)

8. THE INDUSTRIAL REVOLUTION IN AMERICA – THE ROBBER BARONS AND INDUSTRIAL EXPANSION (1850 TO 1900) (MARCH 13)



Exploiting Energy

All economies which developed in the wake of the neolithic food revolution may be termed organic.

- In organic economies, food and all other material products of use to man are from shallow earth
  - Think food, wood

- Production horizon for all organic economies was set in part by the annual cycle of plant growth.
  - This sets physical and biological limits to the possible scale of production (food, shelter, energy).

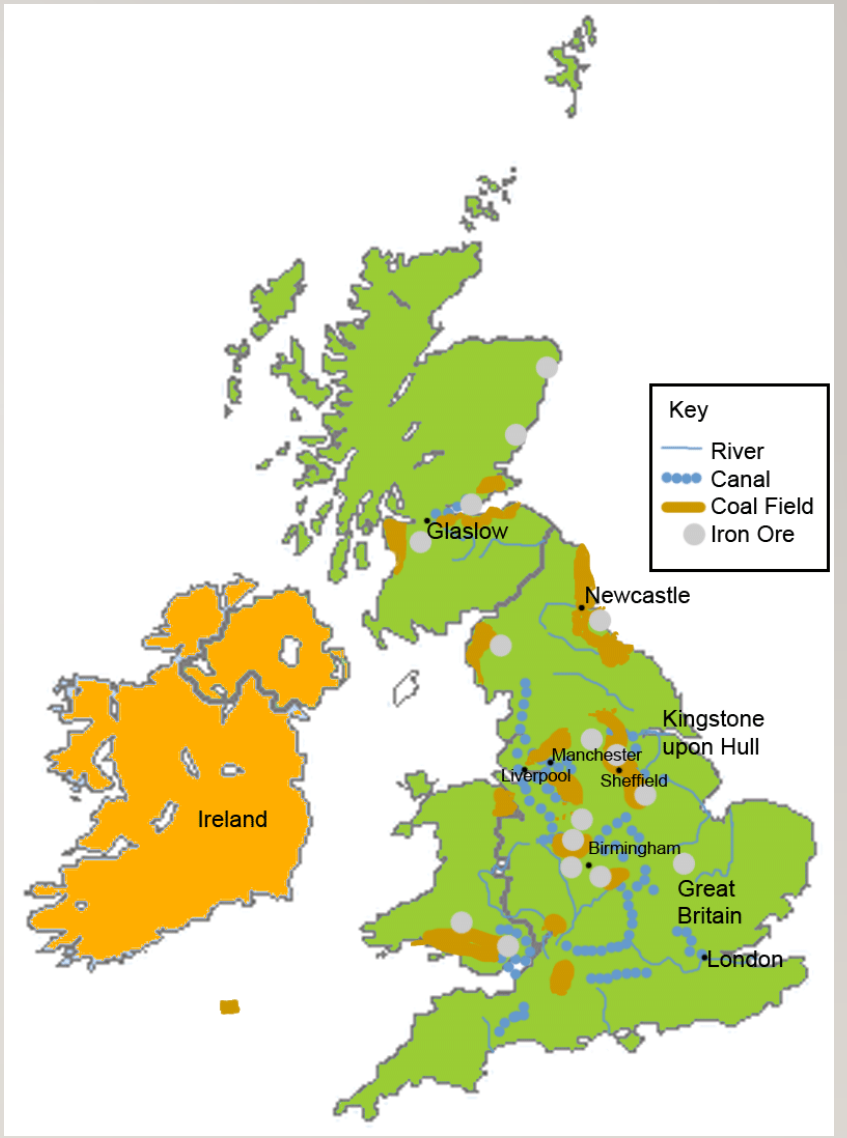
- Organic economies differed fundamentally from economies transformed by the Industrial Revolution since many of the industries which grew most rapidly made little or no use of organic raw materials.

- Above all, access to a mineral (coal and oil) rather than a vegetable energy expanded the production horizon decisively.

THE AMERICAN CENTENNIAL EXHIBITION — PRESIDENT GRANT AND THE EMPEROR OF BRAZIL STARTING THE "CORLISS" ENGINE IN THE MACHINERY HALL

England and Coal

- In parts of Britain, coal had been mined and quarried via shallow surface mining to a small extent since pre-Roman times.
    - Coal used in iron working along with charcoal.
    - Coal produces hotter fires and longer lasting heat than wood
    - Most coal intolerable for heating houses due to smoke; anthracite coal the exception
    - England and Scotland coal rich – a key
- Coal more and more a needed substitute for England's depleted wood supply.



- Improvements in mining technology in the 18th century along with rising demand for wood and coal, transformed coal mining into a large-scale capitalist enterprise and transformed Britain's economy from more energy.

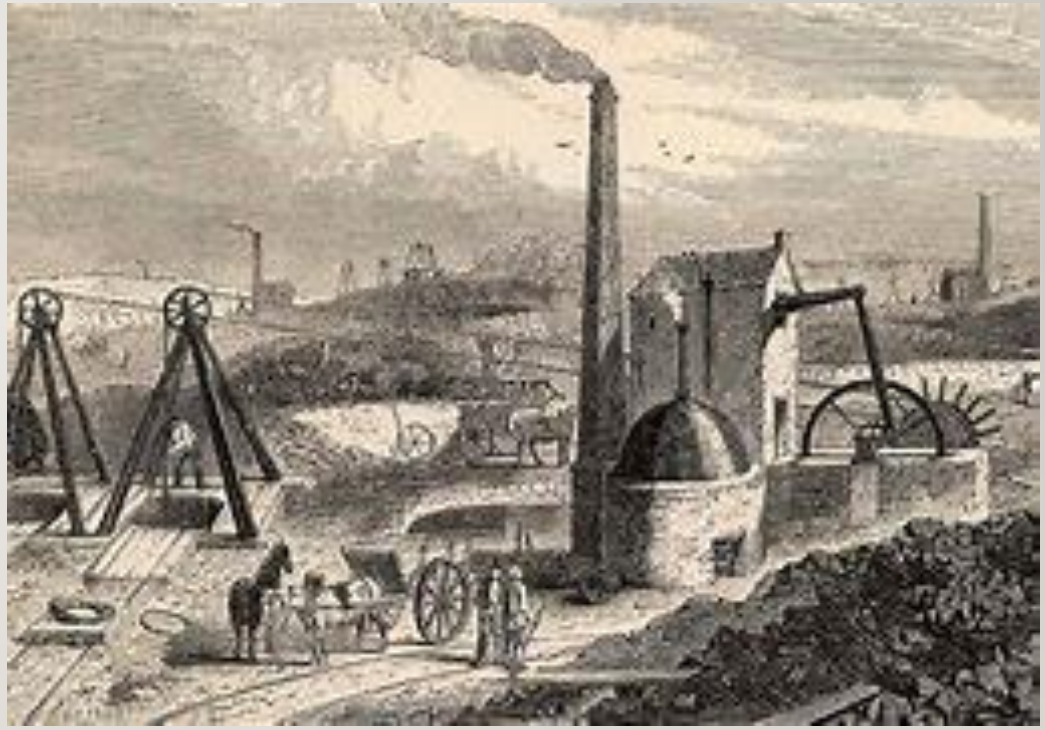
- Price was the brutal human conditions of coal mining

Often mining on lands of aristocrats looking to supplement income and amendable to the concept.

Deeper coal mines for more coal

- 17th century coal mining required deeper and deeper mines after strip mines were nonproductive.
- Environmental push and demand pull as cities began their growth.
- Before steam engine, mined coal often moved to removal shaft by horses and wagons
  - Wooden rails used to haul coal wagons to shaft
  - Coal was hauled up shaft in woven stick baskets by teams of horses on surface.
  - Horse feed and maintenance expensive

- Coal heads were often near rivers or oceans for transport of coal to final users
    - Coal from coal mines not near water hauled by wagon drawn horses to rivers, canals and harbors for distribution to London and other cities.
    - With invention of steam engine, stationary engine used to pull coal wagons to destination for off loading
    - Wagons hauled coal to towns over poor roads
- Deeper mines encountered more water
    - Surface horses worked pumps to pump water to surface, away from coal miners



Transporting coal

- Coal is high in bulk and relatively low in value “per unit”.

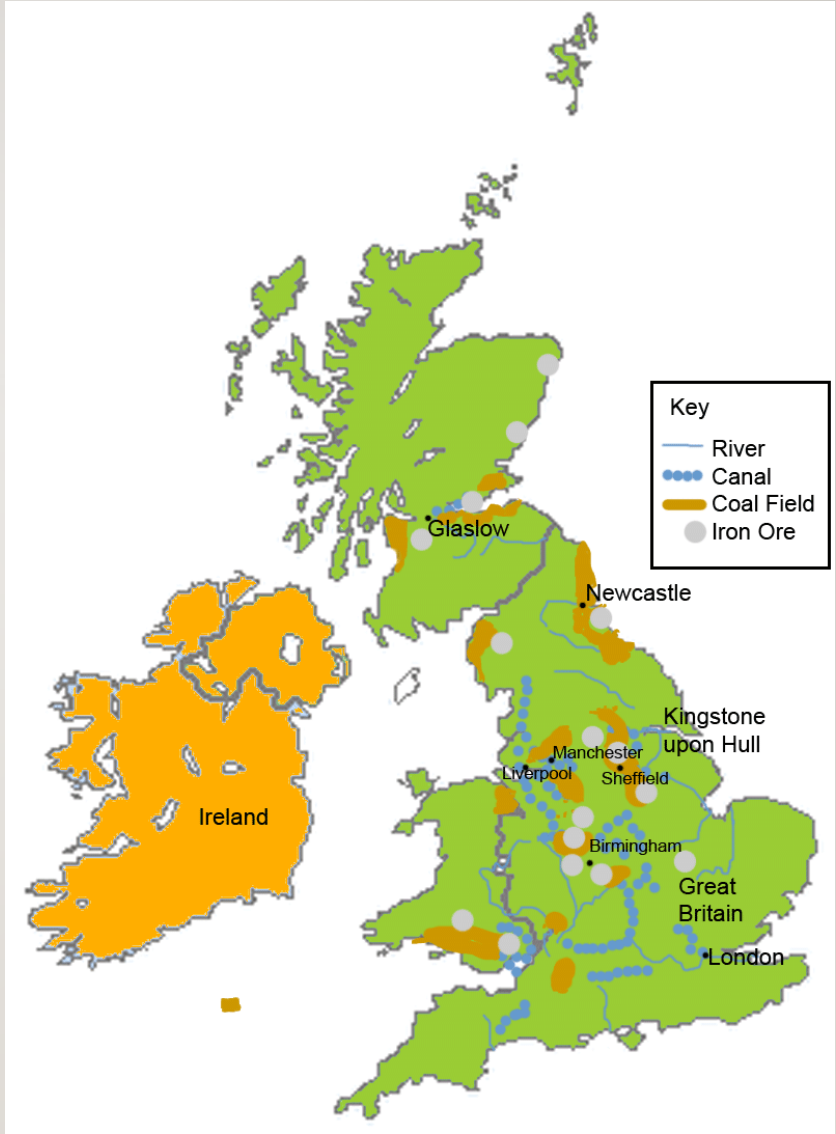
- Northwestern remote Newcastle developed partly because of its proximity to the River Tyne and the North Sea, which allowed transport by water to London and to the continent and coal fields.

- From these geographical resources, mining, steam engines, shipping, residential housing with all its products and other economic parts could develop

- If a mine was further inland, the cost of getting the coal to the coast for shipment was simply too high.

- Availability of coal throughout Britain (geography) was a major factor in its industrialization.
  - 18th century coal mines had to be near water for transportation purposes. When they were not, often times industrial facilities were built near coal mine heads.

  - Led to extensive development of canals in Britain connecting cities to rivers and seas
    - Canals privately financed with merchant capital and publicly financed



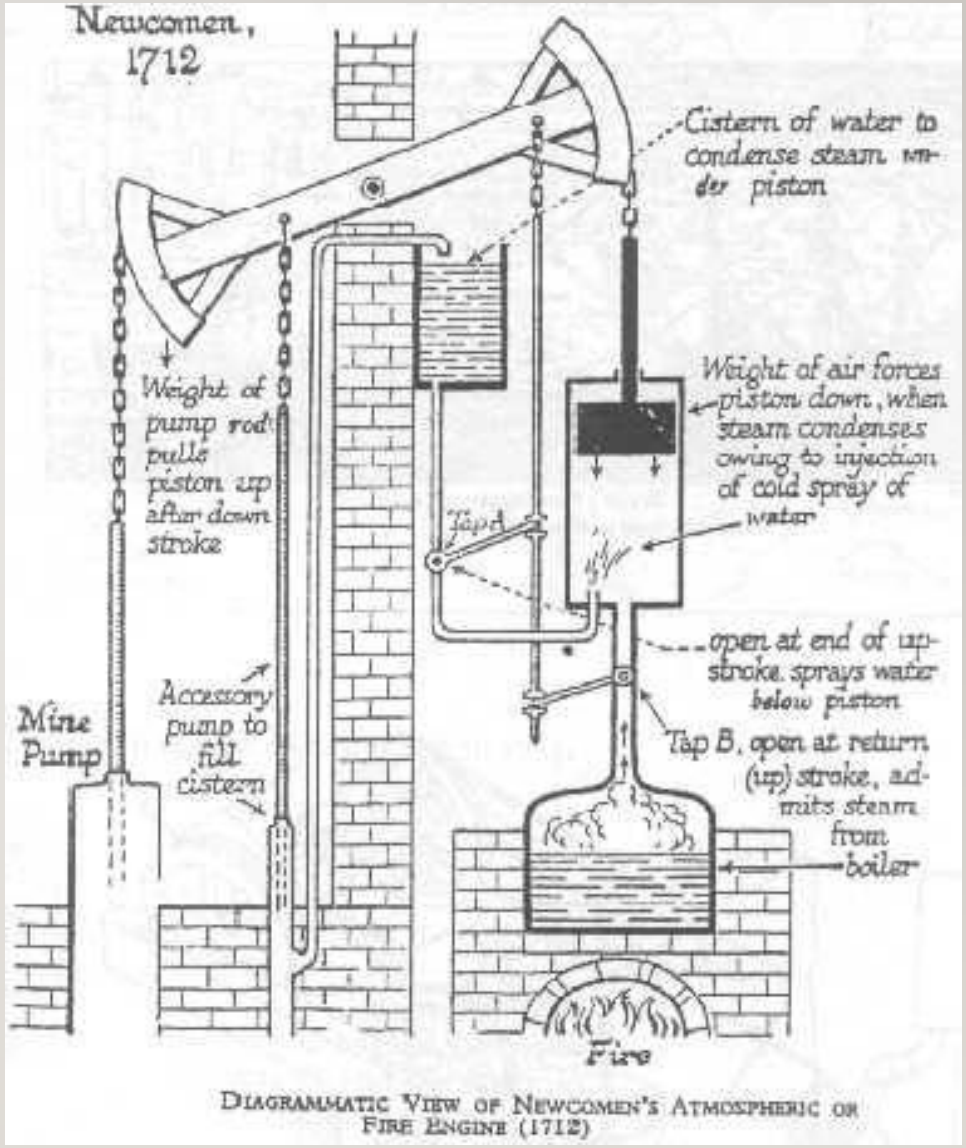
Solving the Mine Water Problem with Steam Engines

Water problem caused horse expense, increased labor expense and inefficiency, making coal more expensive

Steam engines were used since 1st century AD as a novelty entertainment device but not commercially exploited

Thomas Savery, an English military engineer, spent his free time with mechanical experiments (not a scientist in strict sense)

- Invented a primitive patented steam pump in 1696 that went into limited commercial use in mines in 1702
    - In 1702, Savery described his engine in his book *The Miner's Friend; or, An Engine to Raise Water by Fire* (communication). Savery claimed that the engine could pump water out of mines.



DIAGRAMMATIC VIEW OF NEWCOMEN'S ATMOSPHERIC OR FIRE ENGINE (1712)

- Savery partnered with Thomas Newcomen, an iron merchant, who improved Savery's design to a commercially viable steam engine beginning in 1712 that would pump water from mines into the 19th century.

- Newcomen installed 78 engines during the 20 years of his patent.

    - When the patent expired, others got into the business, installing 300 more in the next 40 years—nearly always as mine-pumping engines but occasionally to lift water into high ponds that fed waterwheels for rotary motion.

Thomas Savery with his wig Curly

Improving Newcomen*'s steam engine* (innovation)

- Newcomen's steam engine slow, with 2 to 3 strokes per minute
- James Watt would improve it and partner with Matthew Boulton to exploit commercially the improvements.

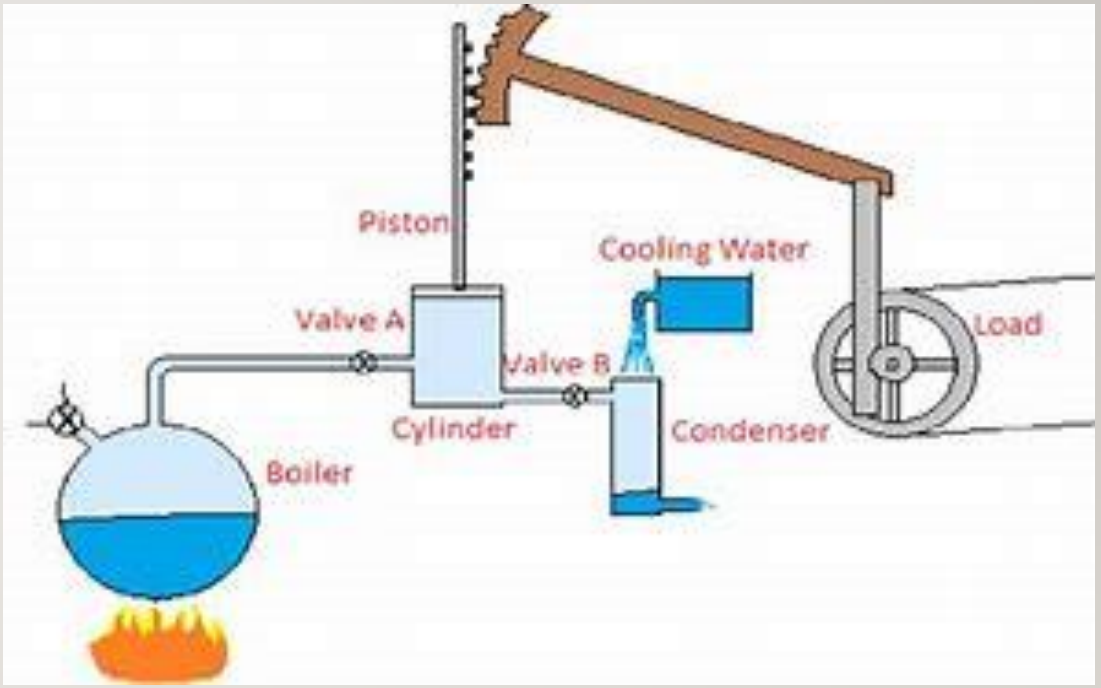
James Watt of Glasgow, Scotland (Watt a Glaswegian)

- Trained as a clockmaker in London and Glasgow

- Provided teaching display Newcomen engine upkeep services at University of Glasgow, a "dissenter university"
- Began in 1760s to tinker improving the resident Newcomen engine for more speed/power ("what if I do this" experimental method)

Matthew Boulton (1728-1809) and James Watt (1736 -1819)

- Watts improved engine for commercial use via efforts of business partner Boulton by 1780
    - Improvements included more precise iron pistons to decrease friction
    - Engaged Glaswegian iron workers to improve precision and iron pistons, cylinder strength and other engine parts resulting in greater durability and efficiency.
    - Ultimate improvement was a steam condenser to remove condensed steam in the cylinder to allow faster cooling and resulting in quicker downstroke of piston.

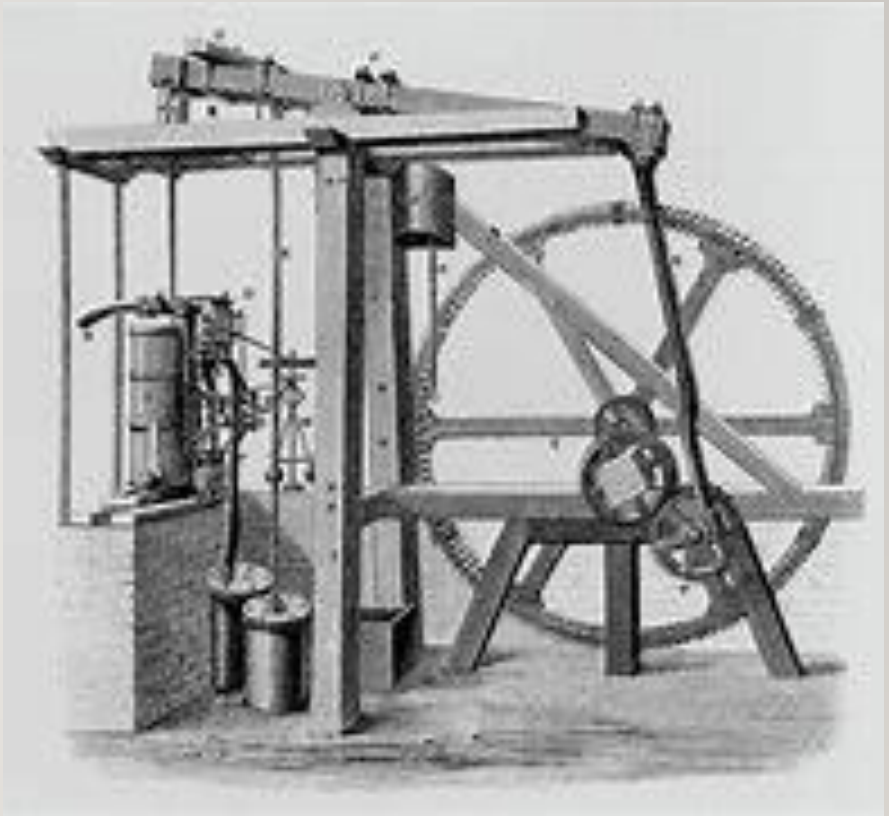


- Early uses of Watt steam engine
  - pumping water in coal and iron ore and copper mines, pulling coal wagons, driving shafts in paper mills, cotton mills, flour mills, iron mills, distilleries, lock gate power in canals

  - Later (1900s) others will install engines on boats and platforms attached to carriages (trains)

Ancillary inventions

- Watt iron workers improved iron strength and malleability for the use of iron in ship hauls, ship parts, textile machines



Why Glasgow? An Industrial City (geography)

- Glasgow is near low quality iron ore mines and home of iron workers as a result

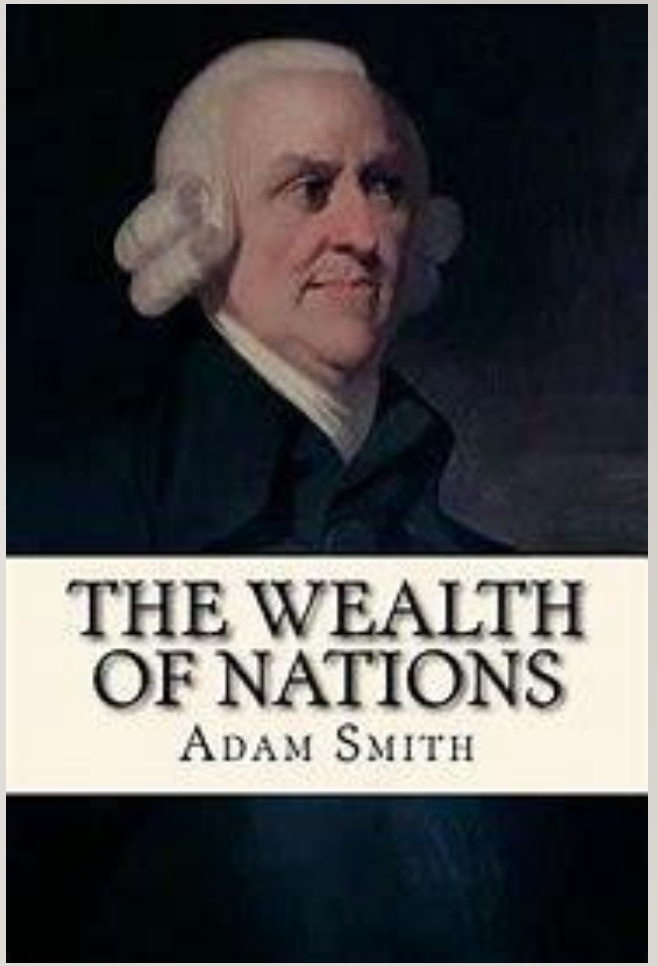
- Knowledge from steam engine iron working contributed to improving ships (hulls and engines eventually) and then in 19th century building high pressure steam locomotives to initiate transportation revolution.

- Glasgow became the home of multiple iron foundries and production facilities
  - With iron now so close, and the River Clyde fully dredged, Glasgow became a leading maker of iron ships later in the 19th century; would lead the world in ship tonnage produced each year until the early 20th century.
  - Dredging of the River Clyde was the key to increasing its depth at low tide from about 2 feet to 20 feet (infrastructure)

George's Square, Glasgow, Scotland today

- Glasgow began a banking industry to finance steam engine production. Investment funds from Glasgow, British and foreign investors.
- Glasgow steam engine expertise would be used to produce railroad train engines in Glasgow in the mid-19 century. Leading product of Glasgow and city became home to machinists and iron mongers.
- In Glasgow there was human capital as a number of talented technicians and entrepreneurs built upon each other skills and abilities.

- Adam Smith taught at the University of Glasgow for a time about moral sentiments and the threat of capitalism and free markets to an ordered society. But that's next week!



Next Week: THE BRITISH CONSUMER REVOLUTION; ADAM SMITH