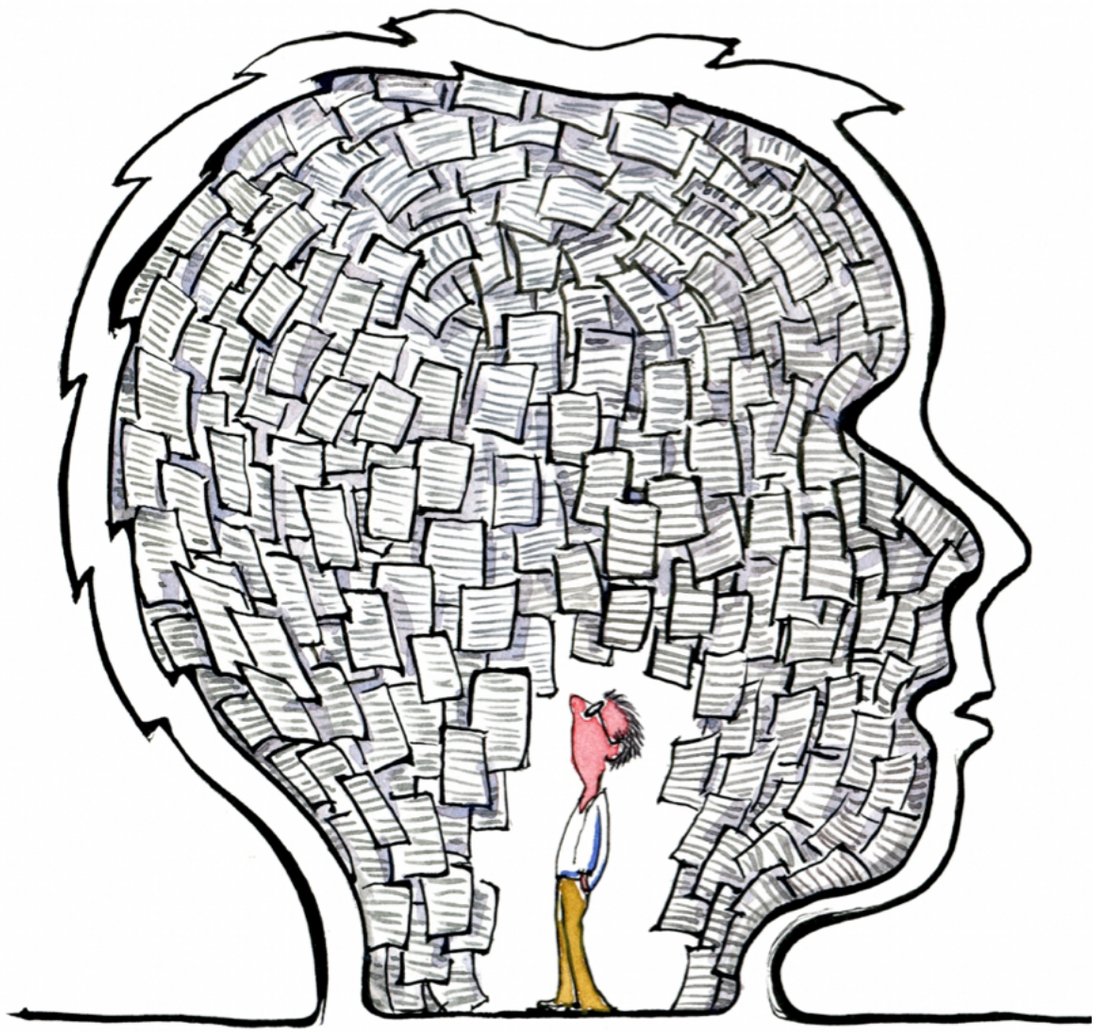
Theories of Work: Origins of the Design and Management of Work



By David Joyce

www.theoriesofwork.com

Image: Man in a head, Frits Ahlefeldt, Added: Apr 3, 2013, color illustration Copyright © 2013 HikingArtist, All Rights Reserved. www.hikingartist.net

Chapter One

Early Beginnings

Design and Management

__ Concepts __

- Craft Production.
- Industrialisation, Manufacturing Systems, Factories, and Assembly Lines.
- Centralised Authority.
- Cost Accounting.
- Payroll.
- Time and Materials.
- Piece-work.
- Production Quality.
- Standardisation.
- Interchangeability
- Mass Production, Make and Sell, and Batch Production.
- Economies of Scale.

The Emergence of management

How we design and manage work, what I call the prevailing theory of work, was not invented in one moment of time, its development has been emergent.[1]

To understand its roots we need to look far back into our history, look back at each of the main; protagonists, inventors, influencers and implementers of a collection of ideas: ideas that solved problems at different points in time, ideas that have become norms.[1]

[1] 540-A brief history of Western management thought, Copyright © Vanguard Consulting Limited

> "If you want to talk about the future, you have to look into the past.
>
> You can't know where you are going, until you find out where you have been, and how you got to where you are now. [168] "
>
> LLoyd Dobyns

[168] CC-M Productions, Inc. 7755 16th Street, NW Washington, DC 20012 ManagementWisdom.com (800) bob@cc-m.com

Image: **Lloyd Dobyns** CC-M Productions, Inc. 7755 16th Street, NW Washington, DC 20012 ManagementWisdom.com (800) bob@cc-m.com

The practice of management can be traced to 3000 b.c., to the first government organizations developed by the Sumerians and Egyptians, but the formal study of management is relatively recent.[79]

Management, as we would recognise it today, emerged during the eighteenth, nineteenth, and early twentieth centuries.

Therefore, our early beginnings start in this period, where technological advances led to the rise of larger industrial enterprises.[28]

Prior to the Industrial Revolution, businesses were small-scale, intimate affairs, consisting of a limited number of individuals.[28]

79 Daniel A. Wren, "Management History: Issues and Ideas for Teaching and Research," Journal of Management 13 (1987): 339–350.

28 We're not Japanese and we don't build cars, Richard Durnall, Agile Zone agile.dzone.com/articles/lean-development-benefits

Image: **Carpenter, 1425**, Transkription und weitere Informationen siehe www.nuernberger-hausbuecher.de/75-Amb-2-279-38-v/data Cloj (Klaus) Umblaff (Umlauf), stainetz (Steinmetz) Date: 1550, Source: Hausbuch der Landauerschen Zwölfbrüderstiftung, Band 1. Nürnberg 1511-1706. Stadtbibliothek Nürnberg, 279.2°, via ww.nuernberger-hausbuecher.de/

Image: **Shoemaker, 1535**, vlrich (Ulrich) fürnpach (Fürnpach; Fürnbach) , schuster (Schuster) Transkription und weitere Informationen siehe www.nuernberger-hausbuecher.de/75-Amb-2-317-154-r/data Date, 1535, Source: Hausbuch der Mendelschen Zwölfbrüderstiftung, Band 1. Nürnberg 1426–1549. Stadtbibliothek Nürnberg, Amb. 317.2°, via www.nuernberger-hausbuecher.de/

Image: **Stonemason, 1550**, Karl schreyner (Schreiner) , schreyner (Schreiner) Transkription und weitere Informationen siehe www.nuernberger-hausbuecher.de/75-Amb-2-317-21-r/ data Date: c. 1425, Source: Hausbuch der Mendelschen Zwölfbrüderstiftung, Band 1. Nürnberg 1426–1549. Stadtbibliothek Nürnberg, Amb. 317.2°, via www.nuernberger-hausbuecher.de/

Image: **Potter, 1605**, Hanß (Hans) Presser, Haffner (Hafner) Transkription und weitere Informationen siehe www.nuernberger-hausbuecher.de/75-Amb-2-317b-71-r/data Date: 1605, Source: Hausbuch der Mendelschen Zwölfbrüderstiftung, Band 2. Nürnberg 1550–1791. Stadtbibliothek Nürnberg, Amb. 317b.2°, via www.nuernberger-hausbuecher.de/

ALL Images: en.wikipedia.org/wiki/Artisan

The First Industrial Revolution, which began in the 18th century, merged into the Second Industrial Revolution around 1850, when technological and economic progress gained momentum with the development of steam-powered ships and railways, and later in the 19th century with the internal combustion engine and electric power generation.[29]

This led to innovations in industry; manufacturing, standardisation, quality, interchangeability and mass production, leading to bigger business, which in turn required innovations in organisation and supervision of labour.

In this chapter we shall discuss the former, in chapter two the latter.

[29] en.wikipedia.org/wiki/Modern_history

Many people believe innovations in industry that led to mass production, occurred either during the Industrial Revolution, or were invented by Henry Ford.

However, as we shall discuss, these innovations can be found prior to both Fordism and the Industrial Revolution.

Mass Production

Mass production is the manufacture of thousands of identical parts and their subsequent assembly into complete machines or consumer goods, whether or not on a formal "assembly line".[23]

It has occurred for centuries; there are examples of production methods that can best be defined as mass production that predate the Industrial Revolution.[4]

However, it has been widespread in human experience, and central to economics, only since the late 19th century.[4]

Human conflict spawns innovation as it has done for centuries. Such conflict led to innovation in mass production.

[23] The Puritan Gift: triumph, collapse and revival of an American dream, Kenneth Hopper and William Hopper, I. B. Tauris (April 3, 2007) p.58-59 By permission of Ken Hopper and Will Hopper

[4] en.wikipedia.org/wiki/Mass_production

Crossbows made of bronze were mass-produced in China during the Warring States Period. The Qin Emperor unified China at least in part by equipping large armies with these weapons, which were equipped with a sophisticated trigger mechanism made of interchangeable parts.[4 53]

Ships of war were mass-produced at a moderate cost by the Carthaginians in their excellent harbors, allowing them to efficiently maintain their control of the Mediterranean.[4]

Venice themselves also mass-produced ships using prefabricated parts and assembly lines many centuries later.[4]

[53] Mass-Produced Pre-Han Chinese Bronze Crossbow Triggers: Unparalleled Manufacturing Technology in the Ancient World. by David Williams. Arms & Armour, Volume 5, Number 2, October 2008 , pp. 142-153(12)

The Venetian Arsenal apparently produced nearly one ship every day, in what was effectively the world's first factory which, at its height, employed 16,000 people.[4]

Founded in 1104, the Venice Arsenal provides one of the first examples of a factory in the modern sense of the word.[19]

Image: **View of the entrance to the Arsenal, circa 1732**, Artist Canaletto (1697–1768). PD-Art en.wikipedia.org/wiki/File:View_of_the_entrance_to_the_Arsenal_by_Canaletto,_1732.jpg

Mass production in the publishing industry has been commonplace since the Gutenberg Bible was published using a printing press in the mid-15th century.[4]

In more recent times, in its earliest form, manufacturing was usually carried out by a single skilled artisan with assistants. Training was by apprenticeship. In much of the pre-industrial world the guild system protected the privileges and trade secrets of urban artisans.[157]

Before the Industrial Revolution, most manufacturing occurred in rural areas, where household-based manufacturing served as a supplemental subsistence strategy to agriculture.[157]

4 en.wikipedia.org/wiki/Mass_production

19 en.wikipedia.org/wiki/Factory

157 en.wikipedia.org/wiki/Manufacturing

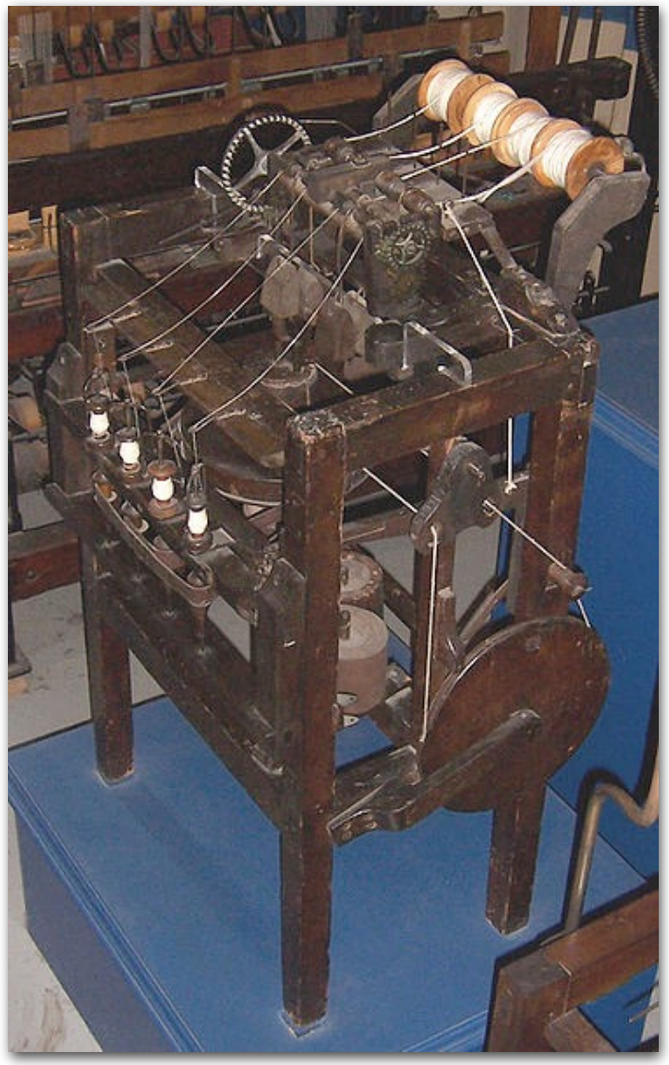
Manufacturing as the production of goods for use or sale using labor, machines and tools[157] required innovation.

In our exploration of the rise of industry, our first protagonist is an Englishman named Sir Richard Arkwright.

[157] en.wikipedia.org/wiki/Manufacturing

Image: Portrait of **Sir Richard Arkwright**, oil on canvas, by the American artist Mather Brown, 1790, Courtesy of the New Britain Museum of American Art. Charles F. Smith Fund, 1957.08, Public Domain, en.wikipedia.org/wiki/File:Sir_Richard_Arkwright_by_Mather_Brown_1790.jpeg

In 1769, he patented the water-frame, a machine that produced a strong twist for warps, substituting wooden and metal cylinders for human fingers.[17]



[17] en.wikipedia.org/wiki/Richard_Arkwright

Image: An example of **Arkwright's water frame** that was made in 1775 and acquired by the Manchester Museum of Science and Technology in 2006 with the assistance of the Heritage Lottery Fund and Prism Fund, CC-BY-3.0 en.wikipedia.org/wiki/File:Arkwright-water-frame.jpg

Arkwright's achievement was to combine power, machinery, semi-skilled labour and a new raw material (cotton) to create mass-produced yarn.[17]

About 30,000 people were employed in 1785, in factories using Arkwright's patents.[17]

His skills of organization made him, more than anyone else, the creator of the modern factory system, especially in his mill at Cromford.[17]

These factories allowed for the produce of goods at a larger scale, and at lower costs, than traditional cottage industries.[28]

Although factories had arisen, mass production had not.

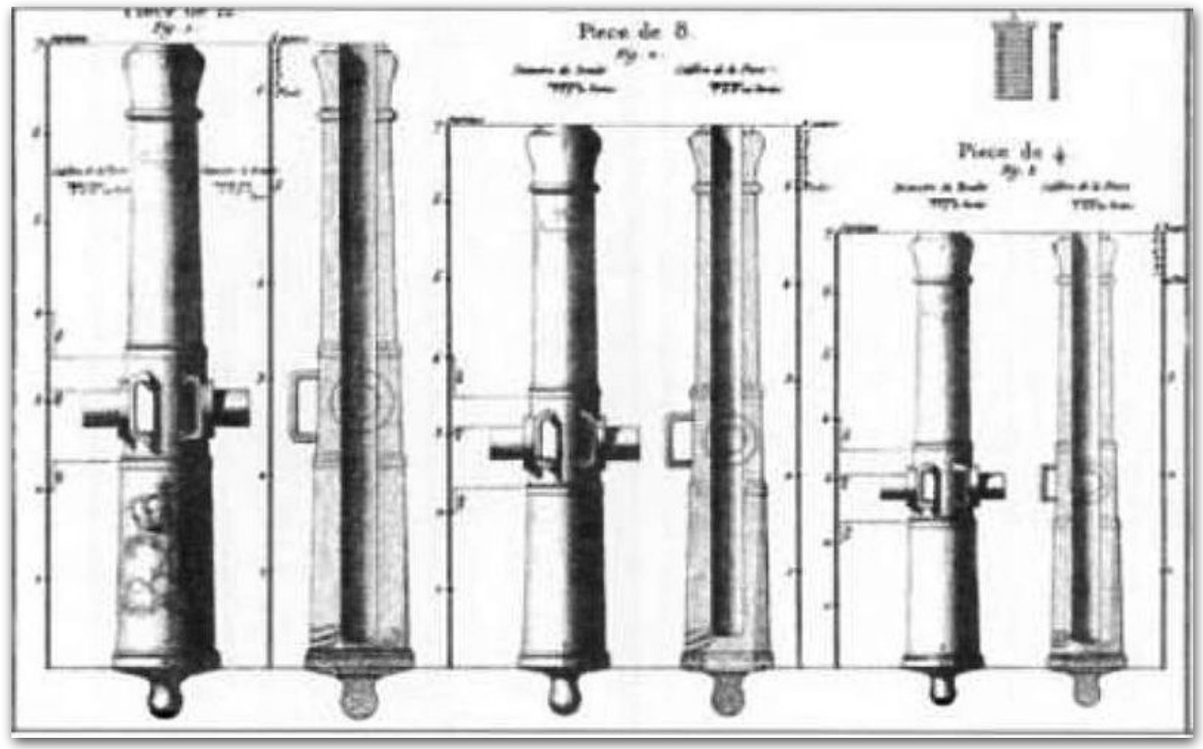
[17] en.wikipedia.org/wiki/Richard_Arkwright

[16] en.wikipedia.org/wiki/Interchangeable_parts

STANDARDIZED AND INTERCHANGEABLE PARTS

Mass production required standardized and interchangeable parts.

One of the earliest innovations in this area was in 1765.[16]



[28] We're not Japanese and we don't build cars, Richard Durnall, Agile Zone agile.dzone.com/articles/lean-development-benefits

Image: **L'Encyclopedie 1784, in Napoleon's Guns**, 1792-1815 [books.google.com/books?id=hb7DHfs8aZ4C&pg=PA4&dq=Maritz+Gribeauval&lr=#PPA4,M1], Author D'Alembert, Date 1784, Public Domain, en.wikipedia.org/wiki/File:Gribeauval_system_elements.jpg

General Jean-Baptiste de Gribeauval, inspector-general of artillery, had "sought to rationalize the French armaments by introducing standardized weapons with standardized parts".[5] [6]

In the late 18th century, Gribeauval promoted standardized weapons in what became known as the Système Gribeauval after it was issued as a royal order in 1765.[16]

[5] Hounshell, D.A., From the American System to Mass Production, 1800–1932: The Development of Manufacturing Technology in the United States, Johns Hopkins University Press, Baltimore, c. 1984, p. 25.

Gribeauval provided patronage to Honoré Blanc, who attempted to implement the Système Gribeauval at the musket level.[16]

By around 1778, Honoré Blanc began producing some of the first firearms with interchangeable flint locks, although they were carefully made by craftsmen.[16]

Blanc demonstrated in front of a committee of scientists that his muskets could be fitted with flint locks picked at random from a pile of parts.[16]

Thomas Jefferson, a friend of Blanc, promoted the new approach in the USA.[165]

[6] The Puritan Gift: triumph, collapse and revival of an American dream, Kenneth Hopper and William Hopper, I. B. Tauris (April 3, 2007) p.42. By permission of Ken Hopper and Will Hopper

[16] en.wikipedia.org/wiki/Interchangeable_parts

[165] Springer handbook of automation, Publisher: Springer; 2009 edition (August 27, 2009) Shimon Y. Nof (Editor) pp. 118-119

Image: **Jean Baptiste de Gribeauval**, famous French Artillery General of the 18th century. Attributed to the Nouveau Larousse illustré, dictionnaire universel encyclopédique of 1900. Public Domain, en.wikipedia.org/wiki/File:Gribeauval.jpg

Similarly the English system of manufacturing was an early system of industrial production that required skilled machinists who were required to produce parts from a design or model.[144]

But however skilled the machinist, parts were never absolutely identical, and each part had to be manufactured separately to fit its counterpart.[144]

This was almost always done by one person who produced the completed item from start to finish.[144]

The craftsman had to be highly skilled, there was no automation, and production was slow.[165]

[144] en.wikipedia.org/wiki/English_System_of_Manufacturing

[165] Springer handbook of automation, Publisher: Springer; 2009 edition (August 27, 2009) Shimon Y. Nof (Editor) pp. 118-119

By the end of the nineteenth century, however, the English system of manufacturing was supplanted by the American mass-production system that was pioneered by Eli Whitney.[166]

Whitney was an American inventor.[133]

Faced with a lack of access to English craftsmanship and precision tooling and the need to fulfill a contract to make muskets for the U.S. Treasury, Whitney devised a way to emulate the work of master smiths with a series of tasks that could be executed by ordinary workmen using specially designed machine tools.[166]

[133] en.wikipedia.org/wiki/Eli_Whitney

[166] An Enduring Quest: The Story of Purdue Industrial Engineers By Ferdinand F. Leimkuhler, Publisher: Purdue University Press (June 1, 2009) p.136.

Eli Whitney saw the potential benefit of developing “interchangeable parts” for the firearms of the United States military.[16] [66]

[16] en.wikipedia.org/wiki/Interchangeable_parts

[66] Van Dusen, Albert E. (2003). "Eli Whitney". Laptop Encyclopedia of Connecticut History. CTHeritage.org. Retrieved 2009-02-18..

In July 1801 he built ten guns, all containing the same exact parts and mechanisms, then disassembled them before the United States Congress.[16] [66]

He placed the parts in a mixed pile and, with help, reassembled all of the weapons right in front of Congress.[16] [66]

However, Whitney was never able to design a manufacturing process capable of producing guns with interchangeable parts.[16] [67]

[67] Fitch, Charles H. (1882), Extra Census Bulletin. Report on the manufacture of fire-arms and ammunition, Washington, DC, USA: United States Government Printing Office. P4.

Image: "**Eli Whitney**," portrait of the inventor, oil on canvas, by the American painter Samuel F. B. Morse. 35 7/8 in. x 27 3/4 in, 1822, Author Samuel Finley Breese Morse Courtesy of the Yale University Art Gallery, Yale University, New Haven, Conn.
en.wikipedia.org/wiki/File:Eli_Whitney_by_Samuel_Finley_Breese_Morse_1822.jpeg

Britain had become "the workshop of the world". Her Majesty's ships ruled the seven seas and ensured freedom for everyone's commerce. A combination of industrial might and martial skill had turned a medium-sized country into a Great Power.[22]

Mass production using interchangeable parts was first achieved in 1803 by Marc Isambard Brunel in cooperation with Henry Maudslay, and Simon Goodrich, under the management of (with contributions by) Brigadier-General Sir Samuel Bentham, the Inspector General of Naval Works at Portsmouth Block Mills at Portsmouth Dockyard, for the British Royal Navy during the Napoleonic War.[7 54 55 56 57 58 59 60 61 62]

7 en.wikipedia.org/wiki/American_system_of_manufacturing

60 Coad, Jonathan, The Royal Dockyards 1690-1850, Aldershot, 1989

22 The Puritan Gift: triumph, collapse and revival of an American dream, Kenneth Hopper and William Hopper, I. B. Tauris (April 3, 2007) p.57. By permission of Ken Hopper and Will Hopper

Image: Foto of a **pulley** taken in the city of nl:Kampen by user:GeeKaa
en.wikipedia.org/wiki/File:PulleyShip.JPG

By 1808 annual production had reached 130,000 sailing blocks.[7 54 55 56 57 58 59 60 61 62]

54 www.makingthemodernworld.org.uk/stories/enlightenment_and_measurement/05.ST.02/?scene=3&tv=true

55 www.portsmouthdockyard.org.uk/Page%206.htm

56 www.sciencemuseum.org.uk/collections/exhiblets/block/start.asp

57 Gilbert, K. R. The Portsmouth Block-making Machinery, London, 1965

58 Cooper, C. C. 'The Production Line at Portsmouth Block Mill', in Industrial Archaeology Review VI, 1982, 28-44

59 Cooper, C. C. 'The Portsmouth System of Manufacture', Technology and Culture, 25, 1984, 182-225

61 Coad, Jonathan, The Portsmouth Block Mills : Bentham, Brunel and the start of the Royal Navy's Industrial Revolution, 2005,ISBN 1-873592-87-6

62 Wilkin, Susan, The application of emerging new technologies by Portsmouth Dockyard, 1790-1815, The Open University PhD Thesis, 1999. (Copies available from the British Thesis service of the British Library)

This method of working did not catch on in general manufacturing in Britain for many decades, and when it did it was imported from America, and became known as the American System of Manufacturing, even though it originated in England.[7]

MECHANIZATION AND QUALITY

The American system of manufacturing was a set of manufacturing methods that evolved in the 19th century.[7]

The two notable features were extensive use of interchangeable parts and extensive use of mechanization to produce them, which resulted in more efficient use of labor compared to hand methods.[7]

7 en.wikipedia.org/wiki/American_system_of_manufacturing

The system was also known as armory practice because it was first fully developed in armories.[7]

The name “American system” came not from any aspect of the system that is unique to the American national character, but simply from the fact that for a time in the 19th century it was strongly associated with the American companies who first successfully implemented it, and how their methods contrasted (at that time) with those of British and continental European companies.[7]

Quality in manufacture was also important for industry to flourish.

E. I. du Pont de Nemours and Company, commonly referred to [today] as DuPont, was founded in July 1802 as a gunpowder mill by[31] E.I. du Pont (Éleuthère Irénée du Pont de Nemours) a French immigrant.[33]

[31] en.wikipedia.org/wiki/DuPont

Image: Portrait of **w:Eleuthère Irénée du Pont**, before 1923. Public Domain
en.wikipedia.org/wiki/File:Eleuthère_Irénée_du_Pont.png

Du Pont worked for Antoine Lavoisier at the Arsenal in Paris. It was from Lavoisier that he gained his expertise in nitrate extraction and manufacture.[32] [69]

Du Pont noticed that the industry in North America was lagging behind Europe.[31]

Du Pont brought an expertise in chemistry and gunpowder making, during a time when the quality of American-made gunpowder was very poor.[32]

What du Pont introduced [in 1804] to the American explosives industry was quality in manufacture.[33]

[32] en.wikipedia.org/wiki/Eleuthère_Irénée_du_Pont

[33] The Puritan Gift: triumph, collapse and revival of an American dream, Kenneth Hopper and William Hopper, I. B. Tauris (April 3, 2007) p.43-44 By permission of Ken Hopper and Will Hopper

[69] Wisniak, J. 2000. The History of Saltpeter Production with a Bit of Pyrotechnics and Lavoisier. Chem. Educator 5:205–209.

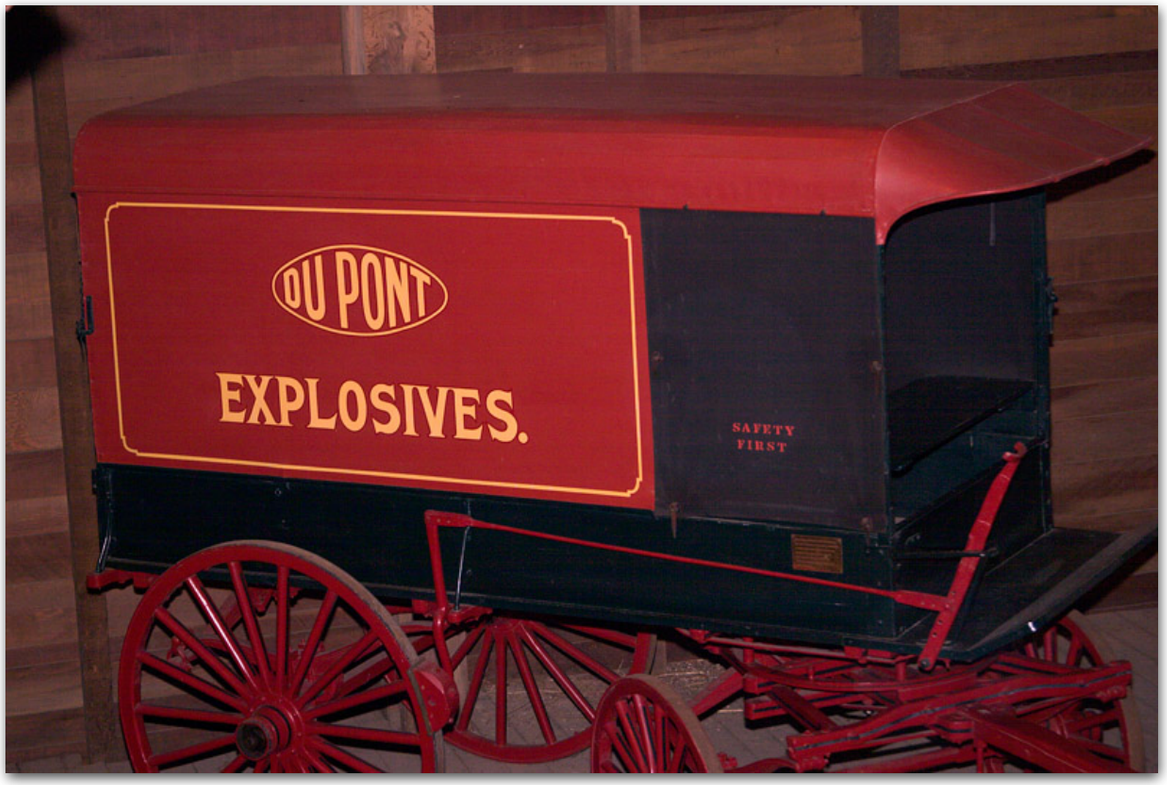
His gunpowder was reliable: it exploded when you wanted it to and did not explode when you did not want it to.[33]

The company grew quickly, and by the mid 19th century had become the largest supplier of gunpowder to the United States military, supplying half the powder used by the Union Army during the American Civil War.[31]

The company he founded would become one of the largest and most successful American corporations.[32] It is still one of the world's leading chemical companies.[33]

As we will learn in a chapter 5, the DuPont company also had a large influence on another organisation who will have a major part to play in what we treat today as design and management norms.

[33] The Puritan Gift: triumph, collapse and revival of an American dream, Kenneth Hopper and William Hopper, I. B. Tauris (April 3, 2007) p.43-44 By permission of Ken Hopper and Will Hopper



[31] en.wikipedia.org/wiki/DuPont

[32] en.wikipedia.org/wiki/Eleuthère_Irénée_du_Pont

Image: **Original DuPont gunpowder wagon** at Hagley Museum, Wilmington, Delaware, site of original DuPont gunpowder mills. Self-made, Date: 8/7/04 Author: User:Ukexpat
en.wikipedia.org/wiki/File:Hagley_DuPont_Wagon.jpg

THE ARMORY INFLUENCE

Col. Roswell Lee, superintendent of the federal armory at Springfield, Massachusetts (from 1815 until his death in 1833) transformed [the Armory] from a workshop of skilled craftsmen into a mechanized manufacturing plant, the first in the country [United States].[8] [9]

[8] Wren, D., The Evolution of Management Thought, Wiley, New York, 1994, p. 73.

[9] The Puritan Gift: triumph, collapse and revival of an American dream, Kenneth Hopper and William Hopper, I. B. Tauris (April 3, 2007) p.49. By permission of Ken Hopper and Will Hopper

It would be an exaggeration to say that Lee created an assembly line; it was less of an assembly line than the block mill that the British admiralty had established in Portsmouth, England in 1805, nevertheless, the key elements of the future lines were present – including specialized machine tools at a succession of distinct work stations, and a flow of parts and unfinished goods towards a single destination.[9]

The Springfield Armory also contributed to improved business management techniques.[10]

Colonel Roswell Lee, brought centralized authority, cost accounting for payroll, time, and materials, and increased discipline to a manufacturing environment—all business practices still in use today.[10]

[10] en.wikipedia.org/wiki/Springfield_Armory

Image: **Colonel Roswell Lee**, Hampden County Massachusetts © Laurel O'Donnell, 1999 - 2005, all rights reserved. Public Domain. www.hampdencountyhistory.com/springfield/christchurch/cc112.html

For example, in payroll, significantly, when new techniques were being tested, generous day rates would replace piece rates (which we will discuss later in this chapter), so that the workmen did not associate the introduction of new methods with a loss of pay.[11]

According to Pay Roll documents, workers were no longer referred to as "Armourers" and paid by the day, but were described by and paid for the number of individual musket parts they manufactured.[12]

Fueled by the Springfield Armory, the City of Springfield quickly became a national center for invention and development.[10]

[10] en.wikipedia.org/wiki/Springfield_Armory

[11] The Puritan Gift: triumph, collapse and revival of an American dream, Kenneth Hopper and William Hopper, I. B. Tauris (April 3, 2007) p.50. By permission of Ken Hopper and Will Hopper

[12] www.forgeofinnovation.org/Springfield_Armory_1812-1865/Themes/Craftsmen_to_Workers/Daily_Work/

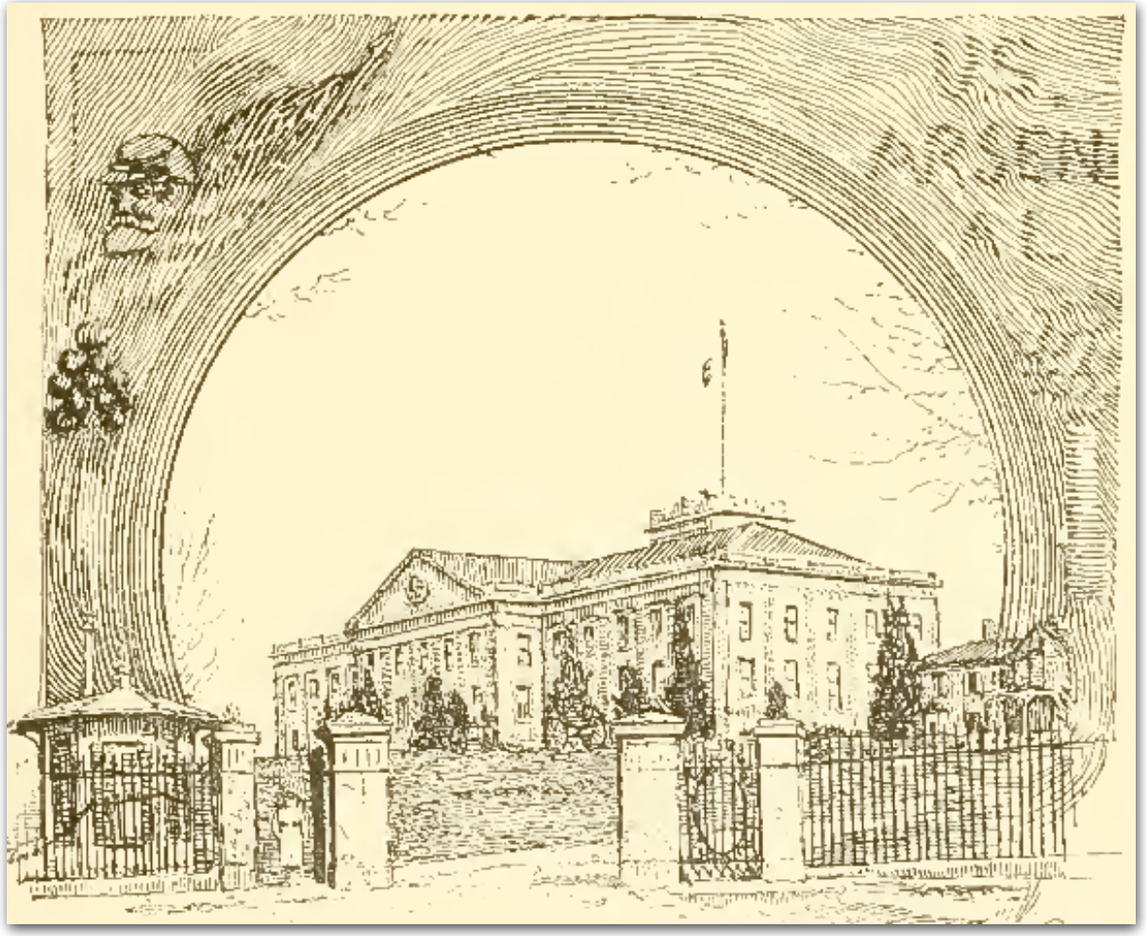
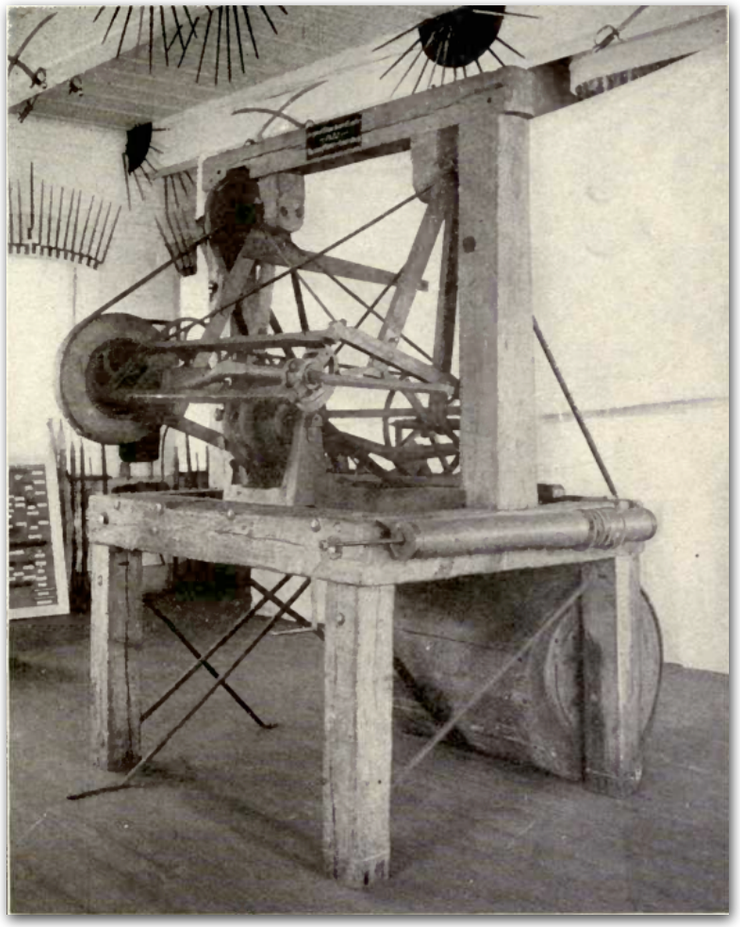


Image: **The Arsenal Building** and Gateway from State Street, Taken from Kings Handbook of Springfield, Massachusetts, Authors King, Moses, Clogston, William, 1884 Publisher James D. Gill,. Public Domain archive.org/details/kingshandbookofsooking

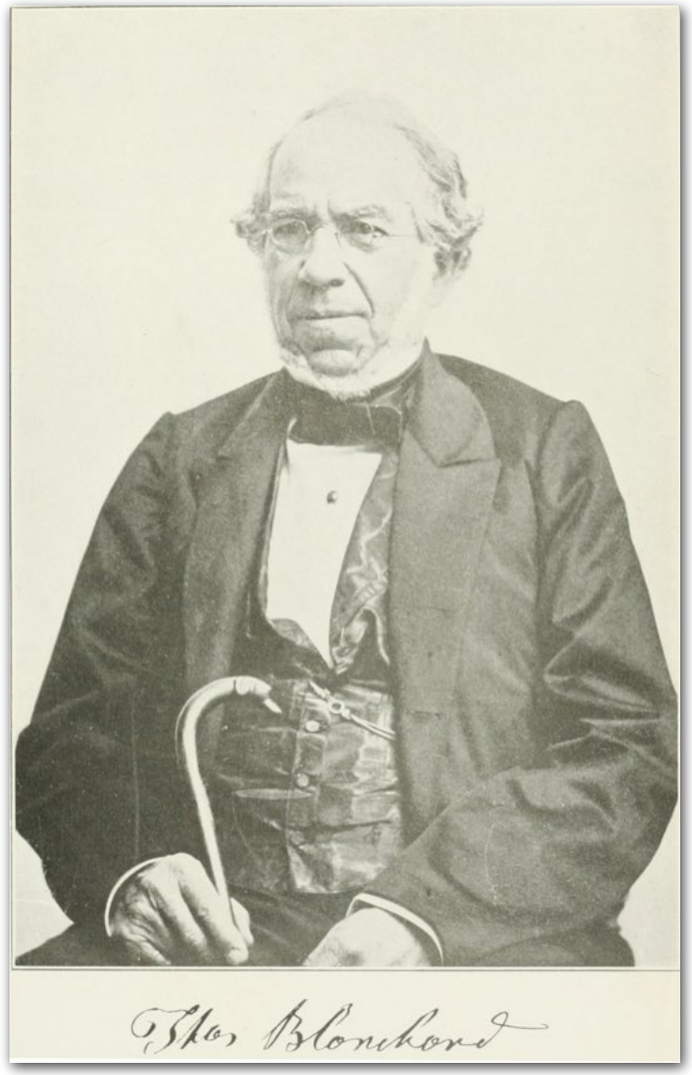
Thomas Blanchard worked at Springfield Armory for 5 years. In 1819 Blanchard developed a special lathe for the consistent mass production of rifle stocks. The lathe enabled an unskilled workman to quickly and easily turn out identical irregular shapes.[10]



[153] www.forgeofinnovation.org/Springfield_Armory_1812-1865/Chronology/nonFlash.html

Image: **Blanchard Lathe**. Below the image it says: "Original Blanchard Lathe, 1822, Museum, U.S. Armory, Springfield, Mass". Author George Iles, public-domain, book downloaded from archive.org. archive.org/details/leadingamericaniooilesrich

In 1825, Blanchard also invented America's first car, which he called a "horseless carriage", powered by steam.[152] [153]



[152] en.wikipedia.org/wiki/Thomas_Blanchard

[10] en.wikipedia.org/wiki/Springfield_Armory

Image: **Thomas Blanchard**, American inventor. Below the image it says: "From a portrait in the possession of F. S. Blanchard, Worcester, Mass." 1912. "Leading American Inventors", public-domain book downloaded from archive.org. Author George Iles en.wikipedia.org/wiki/File:Thomas_Blanchard.jpg

The Springfield Armory was largely involved in the growth and influence of the Industrial Revolution. Much of this grew out of the military's fascination with interchangeable parts, which was based on the theory that it would be easier to simply replace firearm parts than make battlefield repairs.[10]

The Springfield Model 1842 musket was the first small arm produced in the U.S. with fully interchangeable (machine-made) parts. Approximately 275,000 Model 1842 muskets were produced at the Springfield and Harper's Ferry armories between 1844 and 1855.[18]

> "The principles of manufacturing pioneered at the Springfield Armory provided the basis for the later manufacture of axes, shovels, sewing machines, clocks, locks, watches, steam engines, reapers, and other products.
>
> Mass production had not yet been perfected, but its antecedents were present. [14] "
>
> Daniel A. Wren Leading Business Historian

[10] en.wikipedia.org/wiki/Springfield_Armory

[14] Daniel Wren leading business historian
Wren, D., The Evolution of Management Thought, Wiley, New York, 1994, p. 74.

[18] en.wikipedia.org/wiki/Springfield_Model_1842

Image: **1842 Springfield Musket**, Source: United States National Park Service www.nps.gov/archive/peri/images/M1842%20(600).jpg Date: March 11th, 2008, Author: United States National Park Service Archive, Permission (Reusing this file) Public Domain en.wikipedia.org/wiki/File:M1842.jpg

STANDARDS AND TOLERANCES

Standards became highly important during the Industrial Revolution with the need to make interchangeable parts.[39]

Sir Joseph Whitworth was an English engineer. In Manchester in 1833 [he started] his own business manufacturing lathes and other machine tools, which became renowned for their high standard of workmanship.[37]

In 1841, Whitworth had a problem. He manufactured parts in a world where no two bolts would fit the same nut. Nearly every machine shop cut its own threads to suit the application.[48]

37 en.wikipedia.org/wiki/Joseph_Whitworth

39 en.wikipedia.org/wiki/Standardization

48 Watch out for the toolheads! Everything you need to know about lean manufacturing tools and why they won't work in service organisations, Vanguard Education, Copyright © Vanguard Consulting Limited

Whitworth devised a standard for screw threads with a fixed thread angle of 55° and having a standard pitch for a given diameter.[37]

Image: **Joseph Whitworth**, An engraving from a photograph made by Elliott and Fry, London in 1882. Public Domain.
en.wikipedia.org/wiki/File:Joseph_whitworth.jpg

This soon became the first nationally standardized system; its adoption by the railway companies, who until then had all used different screw threads, leading to its widespread acceptance.[37]

It later became a British Standard, "British Standard Whitworth", abbreviated to BSW and governed by BS 84:1956.[37]

The Whitworth thread was the world's first national screw thread standard.[36] [70]

Until then, the only standardization was what little had been done by individual people and companies, with some companies' in-house standards spreading a bit within their industries.[36]

[37] en.wikipedia.org/wiki/Joseph_Whitworth

[70] Gilbert, K. R., & Galloway, D. F., 1978, "Machine Tools". In C. Singer, et al., (Eds.), A history of technology. Oxford, Clarendon Press & Lee, S. (Ed.), 1900, Dictionary of national biography, Vol LXI. Smith Elder, London

His solution of a standard thread meant replacements parts could be sourced with minimum effort.[48]

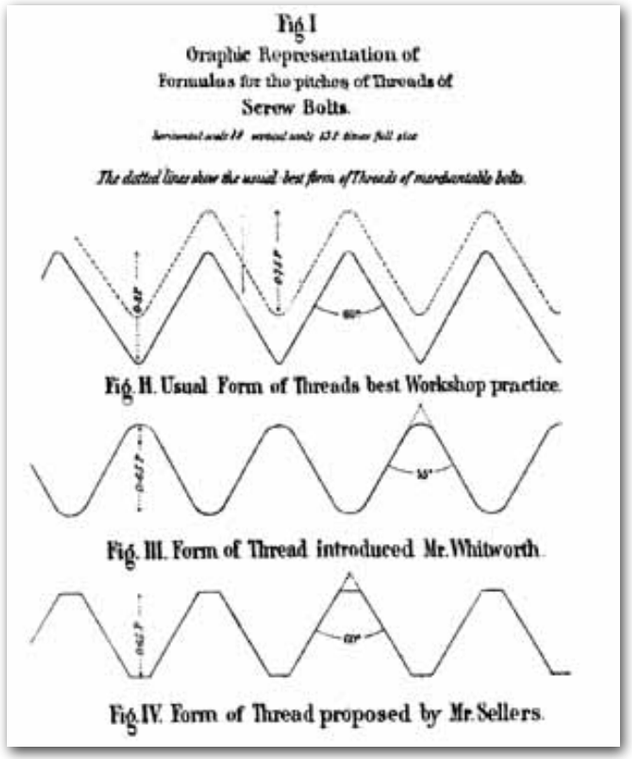


Fig I
Graphic Representation of
Formulas for the pitches of Threads of
Screw Bolts.
The dotted lines show the usual best form of Threads of marchantable bolts.
Fig. II. Usual Form of Threads best Workshop practice.
Fig. III. Form of Thread introduced Mr. Whitworth.
Fig. IV. Form of Thread proposed by Mr. Sellers.

[36] en.wikipedia.org/wiki/British_Standard_Whitworth

[48] Watch out for the toolheads! Everything you need to know about lean manufacturing tools and why they won't work in service organisations, Vanguard Education, Copyright © Vanguard Consulting Limited

Image: **Graphic representation of formulas for the pitches of threads of screw bolts, 1864**, from Franklin Institute, Author William Sellers. Public Domain. en.wikipedia.org/wiki/File:JFIScrewThread300.png

Whitworth is attributed with the introduction of the thou in 1844.[37] [71]

A thousandth of an inch is a derived unit of length. Equal to 0.001 inch, it is normally referred to as either a thou, a thousandth, or (particularly in the United States) a mil.[38]

> "... instead of our engineers and machinists thinking in eighths, sixteenths and thirty-seconds of an inch, it is desirable that they should think and speak in tenths, hundredths, and thousandths ... [38] [72]"
>
> Sir Joseph Whitworth, English Engineer

Bringing more metrology into machining increased the separation of concerns to make possible, for example, designing an assembly to the point of an engineering drawing, then having the mating parts made at different firms who did not have any contact with (or even awareness of) each other-yet still knowing with certainty that their products would have the desired fit.[38]

The Whitworth standards are still with us today.[48] A thou is commonly used in manufacturing dimensions and tolerances.[38]

[37] en.wikipedia.org/wiki/Joseph_Whitworth

[71] Edkins, Jo. "Small units". Imperial Measures of Length. Jo Edkins. Retrieved 2009-09-23.

[38] en.wikipedia.org/wiki/Thou_(length)

[72] "A Paper on Standard Decimal Measures of Length", Manchester, 1857

[48] Watch out for the toolheads! Everything you need to know about lean manufacturing tools and why they won't work in service organisations, Vanguard Education, Copyright © Vanguard Consulting Limited

Image: **Joseph Whitworth**, An engraving from a photograph made by Elliott and Fry, London in 1882. Public Domain. en.wikipedia.org/wiki/File:Joseph_whitworth.jpg

Whitworth also created the Whitworth rifle, often called the "sharpshooter" because of its accuracy and is considered one of the earliest examples of a sniper rifle.[37]

In 1860, the British National Rifle Association held its first annual meeting at Wimbledon. Queen Victoria fired the first shot from a Whitworth rifle on a machine rest at 400 yards, and struck the bull's-eye 1-1/4 inch from its center.[161] [162]

37 en.wikipedia.org/wiki/Joseph_Whitworth

161 en.wikipedia.org/wiki/Whitworth_rifle

162 "The gun and its development" By William Wellington Greener

Image: The Whitworth was a **British sharpshooting rifle** that was based off of the Enfield Model 1853, 11 March 2009, 12:36, Source: Whitworth, Author: Antique Military Rifles
en.wikipedia.org/wiki/File:Whitworth_rifle.jpg

INDUSTRIAL TECHNOLOGY AND DESIGN

"The Great Exhibition of the Works of Industry of all Nations" or "The Great Exhibition" was an international exhibition that took place in Hyde Park, London, from 1 May to 11 October 1851.[158]

It was the first in a series of World's Fair exhibitions of culture and industry that were to become a popular 19th-century feature.[158]

The Great Exhibition was organized by Henry Cole, Prince Albert, husband of the reigning monarch, Queen Victoria, and other members of the Royal Society for the Encouragement of Arts, Manufactures and Commerce as a celebration of modern industrial technology and design.[158]

158 en.wikipedia.org/wiki/The_Great_Exhibition

Its prime motive was for "Great Britain [to make] clear to the world its role as industrial leader." [158] [159]

Although the Great Exhibition was a platform on which countries from around the world could display their achievements, Great Britain sought to prove its own superiority.[158]

Six million people-equivalent to a third of the entire population of Britain at the time-visited the Great Exhibition.[158]

The official descriptive and illustrated catalogue of the event lists exhibitors not only from throughout Britain but also from its "Colonies and Dependencies" and 44 "Foreign States" in Europe and the Americas. Numbering 13,000 in total.[158]

[158] en.wikipedia.org/wiki/The_Great_Exhibition

[159] Kishlansky, Mark, Patrick Geary and Patricia O'Brien. Civilization in the West. 7th Edition. Vol. C. New York: Pearson Education, Inc., 2008.

Image: McNeven, J., The Foreign Department, viewed towards the transept, coloured lithograph, 1851, Ackermann (printer), V&A. **The interior of the Crystal Palace in London during the Great Exhibition of 1851**. collections.vam.ac.uk Author J. McNeven
en.wikipedia.org/wiki/File:Crystal_Palace_-_interior.jpg

From the Americas Alfred Charles Hobbs used the exhibition to demonstrate the inadequacy of several respected locks of the day. Firearms manufacturer Samuel Colt demonstrated his prototype for the 1851 Colt Navy and also his older Walker and Dragoon revolvers.[158]

One of the most popular American attractions at the Great Exhibition was the reaper manufactured by Cyrus McCormick.

On July 24, 1851, a contest was held at an English farm, and the McCormick reaper outperformed a reaper manufactured in Britain. McCormick's machine was awarded a medal and was written about in the newspapers.[160]

[158] en.wikipedia.org/wiki/The_Great_Exhibition

[160] Britain's Great Exhibition of 1851 Was a Milestone in Technology By Robert McNamara. history1800s.about.com/od/emergenceofindustry/ss/Great-Exhibition-1851_4.htm

The popularity of the American attractions made the British take note as described at the time:

> *"Our descendents on the other side of the water are every now and then administering to the mother country a wholesome filial lesson, and recently they have been "rubbing us up" with a severity which perhaps we merited for sneering at their shortcomings in the Exhibition."* [163] [164]

[163] en.wikipedia.org/wiki/Alfred_Charles_Hobbs

[164] "CABINET // National Insecurity". Cabinetmagazine.org. Retrieved 2012-08-15.

In 1853, Whitworth was appointed a British commissioner for the New-York International Exhibition.[37]

He toured around industrial sites of several American States, and the result was a report "The Industry of the United States in Machinery, Manufactures and Useful and Applied Arts, compiled from the Official Reports of Messrs Whitworth and Wallis, London, 1854".[37]

[37] en.wikipedia.org/wiki/Joseph_Whitworth

[7] en.wikipedia.org/wiki/American_system_of_manufacturing

In the report was written:

> *"The laboring classes are comparatively few in number, but this is counterbalanced by, and indeed, may be one of the causes of the eagerness by which they call in the use of machinery in almost every department of industry.*
>
> *Wherever it can be applied as a substitute for manual labor, it is universally and willingly resorted to .... It is this condition of the labor market, and this eager resort to machinery wherever it can be applied, to which, under the guidance of superior education and intelligence, the remarkable prosperity of the United States is due."* [7] [85]

[85] Roe, Joseph Wickham (1916), English and American Tool Builders, New Haven, Connecticut: Yale University Press, LCCN 16011753. Reprinted by McGraw-Hill, New York and London, 1926 (LCCN 27-24075); and by Lindsay Publications, Inc., Bradley, Illinois, (ISBN 978-0-917914-73-7). Report of the British Commissioners to the New York Industrial Exhibition, London 1854

Image: **New York Crystal Palace, Frontispiece to New York Crystal Palace**: illustrated description of the building by Geo. Carstensen & Chs. Gildemeister, architects of the building ; with an oil-color exterior view, and six large plates containing plans, elevations, sections, and details, from the working drawings of the architects (New York: Riker, Thorne & co., 1854), Date: 1854, Source: New York Crystal Palace at beinecke.library.yale.edu, Author: Karl Gildemeister 1820-1869), public domain (old) en.wikipedia.org/wiki/File:New_York_Crystal_Palace.jpg

In the Industrial Revolution simple mass production techniques were used to make clocks and watches, and to make small arms.[4]

In the 1850s Colt was the first to widely commercialize the total use of interchangeable parts throughout a product. It was a leader in assembly line practice. It was a major innovator and training ground in manufacturing technology.[15] [63]

At one exhibit Samuel Colt disassembled ten guns and reassembled ten guns using different parts from different guns.[15] [64]

As the world's leading proponent of mass production techniques, Colt went on to deliver a lecture on the subject to the Institute of Civil Engineers in London.[15] [64]

64 Houze, Herbert G. (2006). In Carolyn C. Cooper, Elizabeth Mankin Kornhauser. Samuel Colt: arms, art, and invention. Yale University Press. p. 84. ISBN 978-0-300-11133-0.

15 en.wikipedia.org/wiki/Colt's_Manufacturing_Company

147 Rosenberg, N., editor, The American System of Manufactures, Edinburgh University Press, Edinburgh, 1969, p.47.

When Colt was interviewed about his methods by a committee of the British House of Commons in 1854, he was asked: [146]

> *"When you made those 50,000 in a year, could any one part of one gun, for instance, be adapted to another gun; were they so accurately made that you might assemble the parts together, the locks and other parts, indiscriminately?"*

He replied not with an unambiguous "yes" but by saying,

> *"I should say that they would do that a great deal better than any arms made by hand,"*

adding that

> *"with 'a touch of a polishing machine' perhaps 95 per cent of the parts could be made to interchange."* [146] [147]

4 en.wikipedia.org/wiki/Mass_production

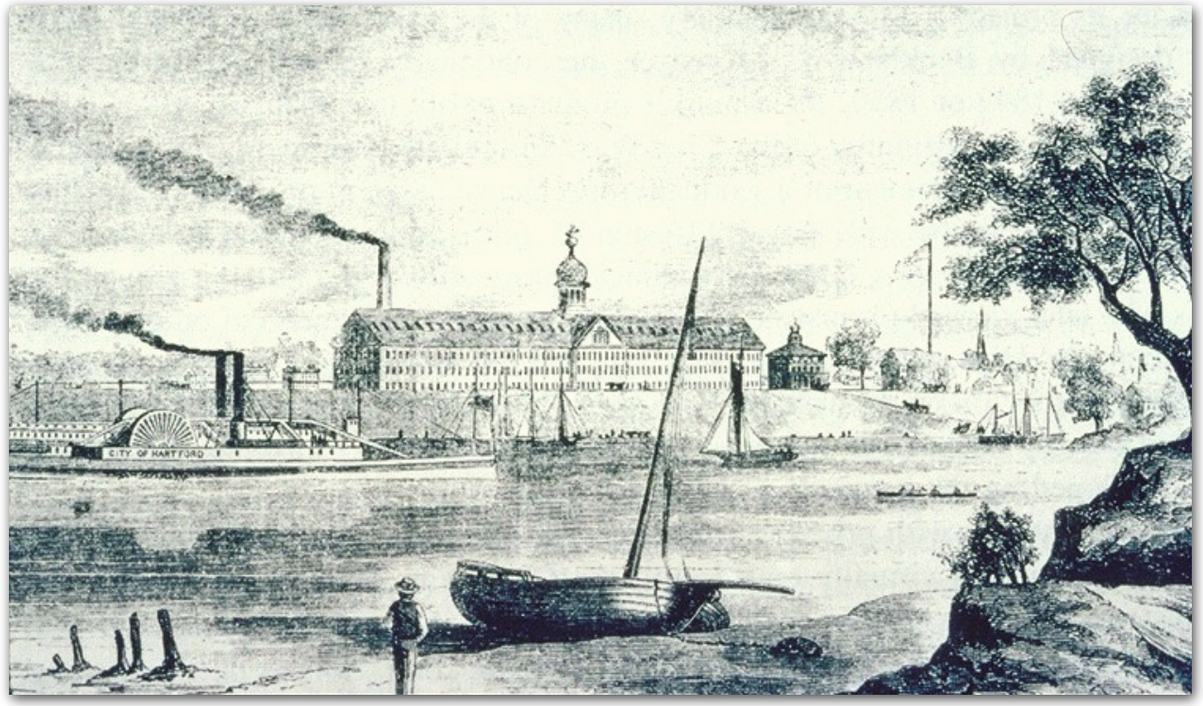
63 Roe, Joseph Wickham (1916), English and American Tool Builders, New Haven, Connecticut: Yale University Press, LCCN 16011753. Reprinted by McGraw-Hill, New York and London, 1926 (LCCN 27-24075); and by Lindsay Publications, Inc., Bradley, Illinois, (ISBN 978-0-917914-73-7).

146 The Puritan Gift: triumph, collapse and revival of an American dream, Kenneth Hopper and William Hopper, I. B. Tauris (April 3, 2007) p.53. By permission of Ken Hopper and Will Hopper

Uniformity in gun-work was then, as now, a comparative term; but then it meant within a thirty-second of an inch or more, where now it means within half a thousandth of an inch[145] (remember back to Whitworth's Thou).

Then interchangeability may have signified a great deal of filing and fitting, and an uneven joint when fitted, where now it signifies slipping in a piece, turning a screw-driver, and having a close, even fit.[145]

Most significant, the Colt factory's machines mass-produced interchangeable parts that could be easily and cheaply put together on assembly lines using standardized patterns and gauges by unskilled labor as opposed to England's top gunmakers.[15] [65]



15 en.wikipedia.org/wiki/Colt's_Manufacturing_Company

65 Great stories of American businessmen, from American heritage: the magazine of history. Madison, Wisconsin: American Heritage. 1972. p. 95.

145 C. H Fitch, Report on the Manufactures of Interchangeable Mechanism, Tenth Census of the United States, 1880, Vol. II p.5.

Image: Engraving of **Colt Armory, Hartford, Connecticut, USA**, as seen from the opposite bank of the Connecticut River. Contemporary engraving from 1857. This is the original East Armory building, constructed 1855, from Library of Congress Prints and Photographs Division, Washington, DC 20540. This image was originally published in United States Magazine in 1857 in a piece titled A Day at the Armory and was later reproduced in David Hounshell in, From the American System to Mass Production, 1984, page 46.
en.wikipedia.org/wiki/File:Colt_Armory_(1857).jpg

Returning back to the Springfield Armory, hundreds of thousands of Union troops carried the 1861 Springfield [musket] onto the battlefields of the Civil War, and untold numbers of Confederates captured the weapon and used it themselves.[68]

Between 1861 and 1865, the Springfield armory manufactured nearly 800,000 of the guns.[68]

The Minié ball, or Minie ball, was used in combination with the Springfield, and they too were mass produced.

Image: **The Springfield Model 1861 rifled musket**, Source: www.civilwar.si.edu/l_weapons_1861percussion.html, Author: Smithsonian, US Government. Public Domain en.wikipedia.org/wiki/File:Springfield_1861.jpg

68 Minie Ball - Facts, information and articles about the Minié Ball, a Civil War bullet, This article was written by Allan W. Howey and originally published in the October 1999 issue of Civil War Times Magazine. www.historynet.com/minie-ball

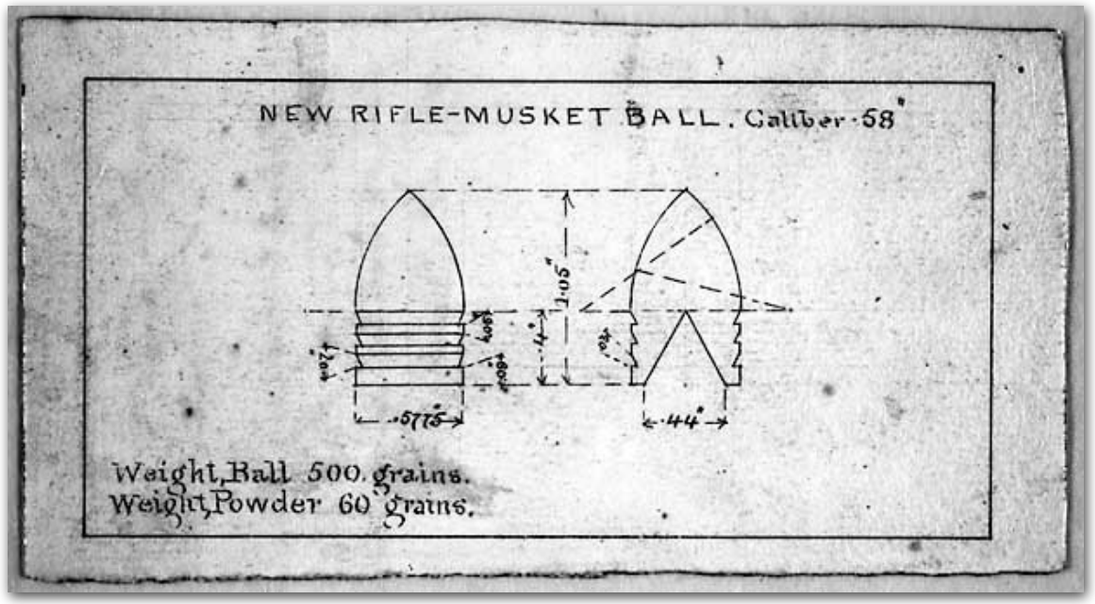


Image: **Minie Balls** - rifled musket bullets Source: US Wikipedia, Author: Mike Cumpston, Date: 3/08, Public Domain, en.wikipedia.org/wiki/File:Minie_Balls.jpg

Image: "**New rifle musket ball caliber 58-inch**. This final version of the Minie bullet resulted from experiments conducted by James H. Burton at the Harpers Ferry Armory during the early 1850s." Year: 1855. Image Credit: Smithsonian Neg. No. 91-10712; Harpers Ferry en.wikipedia.org/wiki/File:Minie_ball_design_harpers_ferry_burton.jpg

THE RISE OF THE FACTORY

As the Industrial Revolution gathered pace industry required dedicated facilities where labour could manufacture goods or operate machines processing one product into another.[186]

Giant water powered factories arose throughout the countryside.

However, water power varied with the seasons and was not available at times due to freezing, floods and dry spells.[21]

A new source of power was required.

James Watt was a Scottish inventor and mechanical engineer.[176] He has been described as one of the most influential figures in human history.[176] [170]

In 1759 Watt's friend, John Robison, called his attention to the use of steam as a source of motive power.[176] [171]

Watt began to experiment with steam though he had never seen an operating steam engine.[176]

Watt's critical insight, arrived at in May 1765,[176] [172] was to cause the steam to condense in a separate chamber apart from the piston, and to maintain the temperature of the cylinder at the same temperature as the injected steam.[176]

Watt had a working model later that same year.[176]

[186] en.wikipedia.org/wiki/Factory

176 en.wikipedia.org/wiki/James_Watt

[170] Hart, Michael H. (2000). The 100: A Ranking of the Most Influential Persons in History. New York: Citadel. ISBN 0-89104-175-3.

[21] en.wikipedia.org/wiki/Steam_power_during_the_Industrial_Revolution

[171] Muirhead, James Patrick (1858). The life of James Watt: with selections from his correspondence. J. Murray. pp. 74–83. Retrieved 17 August 2011.

[172] Dickinson, H. W. and Hugh Pembroke Vowles James Watt and the Industrial Revolution (published in 1943, new edition 1948 and reprinted in 1949. Also published in Spanish and Portuguese (1944) by the British Council)

The firm of Boulton & Watt was initially a partnership between Matthew Boulton and James Watt.[173]

The partnership was formed in 1775 to exploit Watt's patent for a steam engine with a separate condenser.[173] [174]

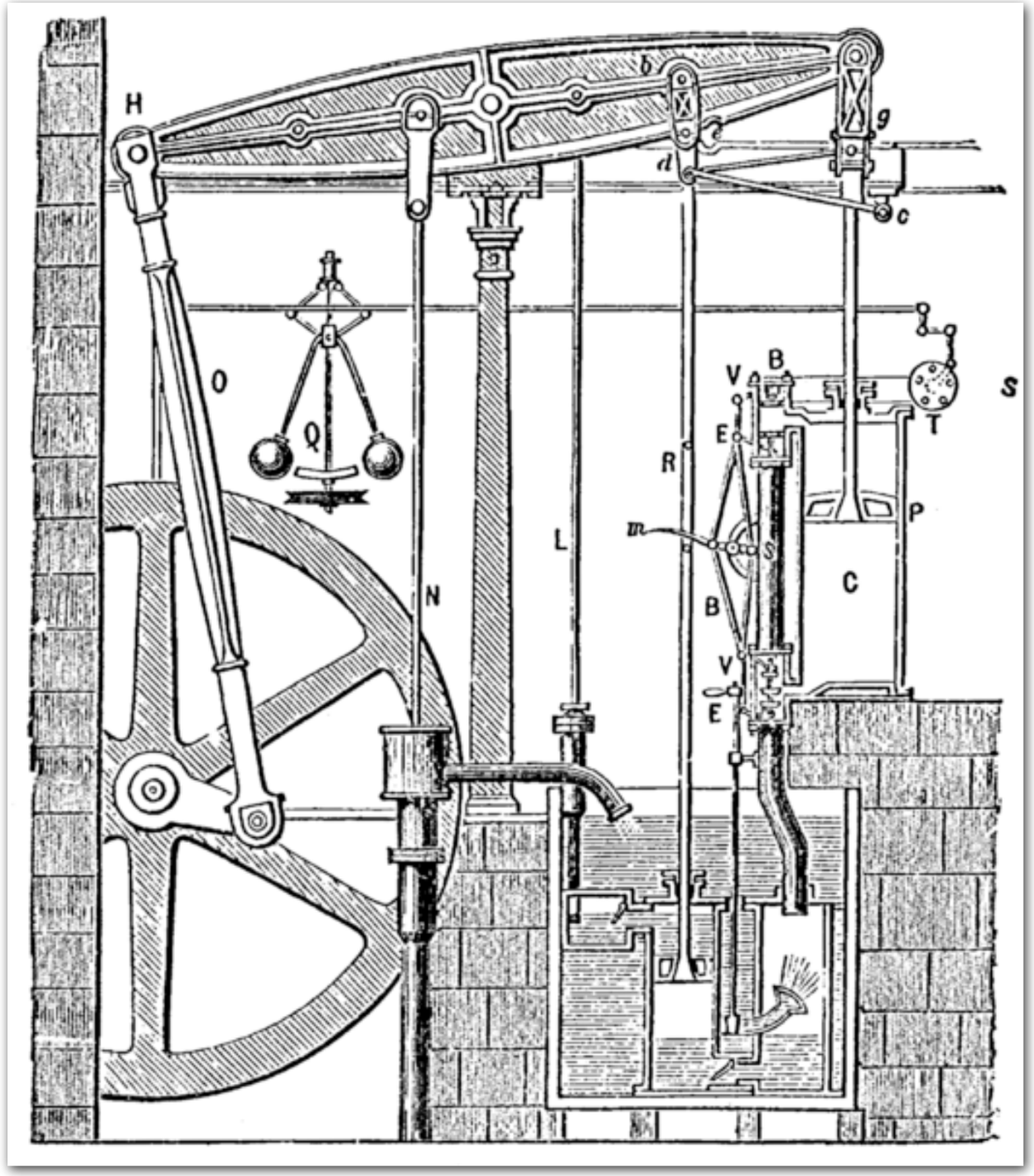
In 1776, the first engines were installed and working in commercial enterprises.[176]

These early engines were not manufactured by Boulton and Watt, but were made by others according to drawings made by Watt, who served in the role of consulting engineer.[176]

The partnership was passed to two of their sons in 1800[173] whom we shall meet in Chapter three.

[176] en.wikipedia.org/wiki/James_Watt

[174] Roll, Erich (1930). An Early Experiment in Industrial Organisation : being a History of the Firm of Boulton & Watt, 1775-1805. Longmans, Green and Co. p. 320.



[173] en.wikipedia.org/wiki/Boulton_and_Watt

Image: **Boulton & Watt Steam engine 1784** Source: Thurston, A History of the Growth of the Steam-Engine, Revised 4th edition, p. 199, Fig. 31. Date: 1902 Author: Robert Henry Thurston. Public Domain en.wikipedia.org/wiki/File:SteamEngine_Boulton%26Watt_1784.png

The partnership of Boulton the business man and Watt the inventor has gone down in the annals of British economic history as one of the highlights of the Industrial Revolution.[175]

This is mainly because the partnership gave to this country the steam engine which was to be the driving power of all industrial progress in the early nineteenth century.[175]

One can still easily see today the influence they had on British Industry.

On the back of a fifty-pound note there is a picture of Matthew Boulton with the words:

> *" I sell here, Sir, what all the world desires to have - POWER "*

and a picture of James Watt with the words:

> *" I can think of nothing else but this machine "*

The SI unit of power, the watt, was also named after him.[176]

[175] The Making Of Scientific Management Vol II, by L Urwick, Publisher Ulan Press (October 28, 2012) p.24.
archive.org/details/makingofscientifo29853mbp

[176] en.wikipedia.org/wiki/James_Watt

Image: Stock Photo - 50 pound sterling bank notes closeup view business background
www.canstockphoto.com/**50-pound-sterling-bank-notes**-closeup-10234092.html

Early mills had run successfully with water power, but by using a steam engine a factory could be located anywhere, not just close to water.[21]

Water power varied with the seasons and was not available at times due to freezing, floods and dry spells.[21]

Until steam power became available, factories had to be located in the more-remote places where water power was available.[20]

Steam was a game changer. Industry could now spread in ever larger dedicated factories, and could be located anywhere.

[21] en.wikipedia.org/wiki/Steam_power_during_the_Industrial_Revolution

[20] The Story of Us Humans, from Atoms to Today's Civilization By Robert Dalling, iUniverse, Inc. (March 24, 2006) P 401

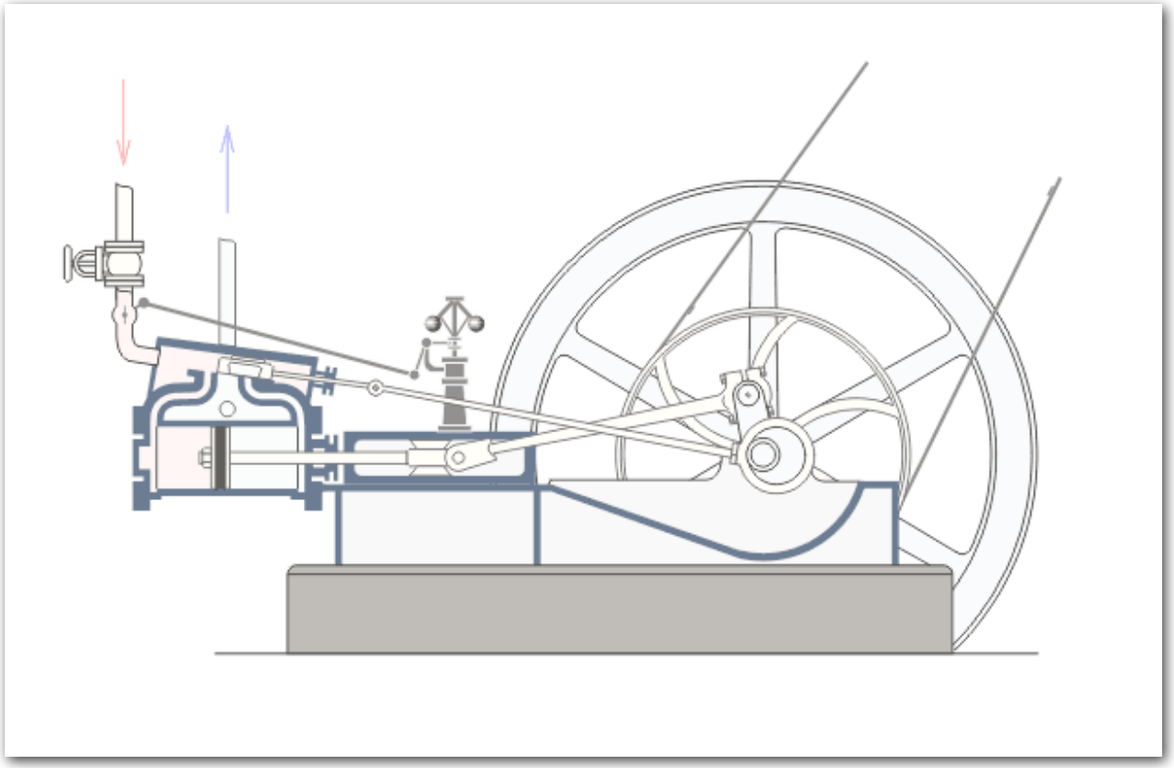


Image: **Steam engine in action** animation, Date: 14 August 2005, Source: Drawn by Panther using Corel Draw! & Image Ready, Author: Panther en.wikipedia.org/wiki/File:Steam_engine_in_action.gif GFDL

In the First Industrial Revolution, machinery had been constructed using traditional hand-operated tools, which lacked power and precision.[23]

The Americans had replaced them with machine tools – sometimes described as "machines for making machines" – powered by water or, later, steam and had also made extensive use of accurate gauges for measurement.[23]

Achieving interchangeability would have spectacular consequences for manufacturing – and ultimately for mankind as a whole. It became possible to create inventories of spare parts, which meant that the new machinery coming into use everywhere could be repaired without the intervention of a craftsman –

[23] The Puritan Gift: triumph, collapse and revival of an American dream, Kenneth Hopper and William Hopper, I. B. Tauris (April 3, 2007) p.58-59 By permission of Ken Hopper and Will Hopper

sometimes thousands of miles from the place where it had been made.[23]

Between 1820 and 1850, the non-mechanized factories supplanted the traditional artisan shops as the predominant form of manufacturing institution.[19]

The earliest factories (using the factory system) were in the cotton textile industry. Later generations of factories included mechanized shoe production and manufacturing of machinery, including machine tools.[19]

Factories that supplied the railroad industry included rolling mills, foundries and locomotive works. Agricultural equipment factories produced cast steel plows and reapers.[19]

[19] en.wikipedia.org/wiki/Factory

Bicycles were mass produced beginning in the 1880s.[19]

Though produced on a very small scale, Crimean War gunboat engines designed and assembled by John Penn of Greenwich (in 1854) are recorded as the first instance of the application of mass production techniques (though not necessarily the assembly-line method) to marine engineering.[4] [81]

In filling an Admiralty order for 90 sets to his high-pressure and high-revolution horizontal trunk engine design, Penn produced them all in 90 days.[4] [82]

He also used Whitworth Standard threads throughout.[4] [82]

[82] The Times. 24 January 1887.

[81] Osborn, G.A. (1965). "The Crimean War gunboats, part 1". The Mariner's Mirror, the Journal of the Society of Nautical Research 51: 103–116.

Interchangeability of parts was finally achieved by combining a number of innovations and improvements in machining operations and machine tools, which were developed primarily for making textile machinery.[7] [154]

Since the parts are interchangeable, it was also possible to separate manufacture from assembly, and assembly could be carried out by semi-skilled labor on an assembly line.[7]

[19] en.wikipedia.org/wiki/Factory

[4] en.wikipedia.org/wiki/Mass_production

[7] en.wikipedia.org/wiki/American_system_of_manufacturing

[154] Hounshell, David A. (1984), From the American System to Mass Production, 1800-1932: The Development of Manufacturing Technology in the United States, Baltimore, Maryland: Johns Hopkins University Press, ISBN 978-0-8018-2975-8, LCCN 83016269

The American System typically involved substituting specialized machinery to replace hand tools.[7]

These innovations included the invention of new machine tools and jigs (in both cases, for guiding the cutting tool), fixtures for holding the work in the proper position, and blocks and gauges to check the accuracy of the finished parts.[7] [154]

The American System involved semi-skilled labor using machine tools and jigs to make standardized, identical, interchangeable parts, manufactured to a tolerance, which could be assembled with a minimum of time and skill, requiring little to no fitting.[7]

7 en.wikipedia.org/wiki/American_system_of_manufacturing

154 Hounshell, David A. (1984), From the American System to Mass Production, 1800-1932: The Development of Manufacturing Technology in the United States, Baltimore, Maryland: Johns Hopkins University Press, ISBN 978-0-8018-2975-8, LCCN 83016269

Piece work (or piecework) is any type of employment in which a worker is paid a fixed piece rate for each unit produced or action performed[238] regardless of time.[237]

If quality is equal, piece rate rewards the more productive worker and offers less to those less productive.[237]

As a term and as a common form of labor, "piece work" had its origins in the guild system of work before the Industrial Revolution.[237]

Since the phrase "piece work" first appears in writing around the year 1549, it is likely that at about this time, the master craftsmen of the guild system began to assign their apprentices work on pieces which could be performed at home, rather than within the master's workshop.[237]

237 en.wikipedia.org/wiki/Piece_work

238 "The piece work principle in agriculture". Journal of the Statistical Society of London 28: 29–31. 1865.

Piece work took on new importance with the advent of machine tools made possible by the American System. Workers could truly make just a single part (but make many copies of it) for later assembly by others.[237]

In the mid-19th century, the practice of distributing garment assembly among lower-skilled and lower-paid workers came to be known in Britain as the sweating system and arose at about the same time that a practical (foot-powered) sewing machine, was developed.[237]

Factories that collected sweating system workers at a single location, working at individual machines, and being paid piece rates became pejoratively known as sweatshops.[237]

> "Finally, mass production would permit the creation of a mass market, which in turn necessitated, and depended on, distribution and advertising on a large scale.
>
> The decades immediately after 1880, when the System was in full swing, are referred to as the Second (or American) Industrial Revolution. [34] [23] "
>
> Chandler, A.D., Scale and Scope: The Dynamics of Industrial Capitalism

The American rise as an industrial power, and it's resulting influence of method on the rest of the world, had begun.

[237] en.wikipedia.org/wiki/Piece_work

[23] The Puritan Gift: triumph, collapse and revival of an American dream, Kenneth Hopper and William Hopper, I. B. Tauris (April 3, 2007) p.58-59 By permission of Ken Hopper and Will Hopper

[34] Chandler, A.D., Scale and Scope: The Dynamics of Industrial Capitalism, Harvard University Press, Cambridge, MA, 1990, p. 62.

Summary

Early Beginnings

In our story so far, technological advances led to the rise of larger industrial enterprises, comprising factories populated with machines (augmenting or replacing manual labour) and the assembly line.

This led to advances in; the manufacturing process, quality, and standardisation, which in turn resulted in; interchangeable parts, inventories of replacement parts, batch production and the separation of work across separate firms.

This gave rise to mass production, centralised authority, workers paid on either piece or day rates, economies of scale, and ultimately leading to mass markets.

Make and sell was born. A perfect invention for that time, where demand far outstripped supply.

What has this to do with the way we design and manage work today; the current dominant theory of work?

Well you may well recognise many of today's organisations still designing work in the form of a production line, a factory mentality; standardising work (including standard times, standard procedures, scripts etc), paying by a fixed piece rate, specialising work, and separating work across separate firms (through the use of third parties).

In today's organisations, people (or "resources" as they are often referred to) have become interchangeable.

The industrial age of "make and sell", building in batch, is the norm. Very few companies today are oriented towards "sell and make".

There is a belief in economies of scale, and that augmenting, or replacing workers with automation, or cheaper labour, are seen as a means for reducing costs, and as a source of competitive advantage.

All these notions of efficiency are rife and are born out of the norms discussed thus far.

As we will see in the coming chapters, much of what we have discussed in this chapter forms the bedrock for the other protagonists, inventors, influencers and implementers of a collection of ideas that form today's norms for the design and management of work.

Design and Management

__ Concepts __

- Craft Production.
- Industrialisation, Manufacturing Systems, Factories, and Assembly Lines.
- Centralised Authority.
- Cost Accounting.
- Payroll.
- Time and Materials.
- Piece-work.
- Production Quality.
- Standardisation.
- Interchangeability
- Mass Production, Make and Sell, and Batch Production.
- Economies of Scale.

In our next chapter we will look at the early beginnings of organisation and supervision of workers, discussing how work was organized and managerial power was delegated.[30]

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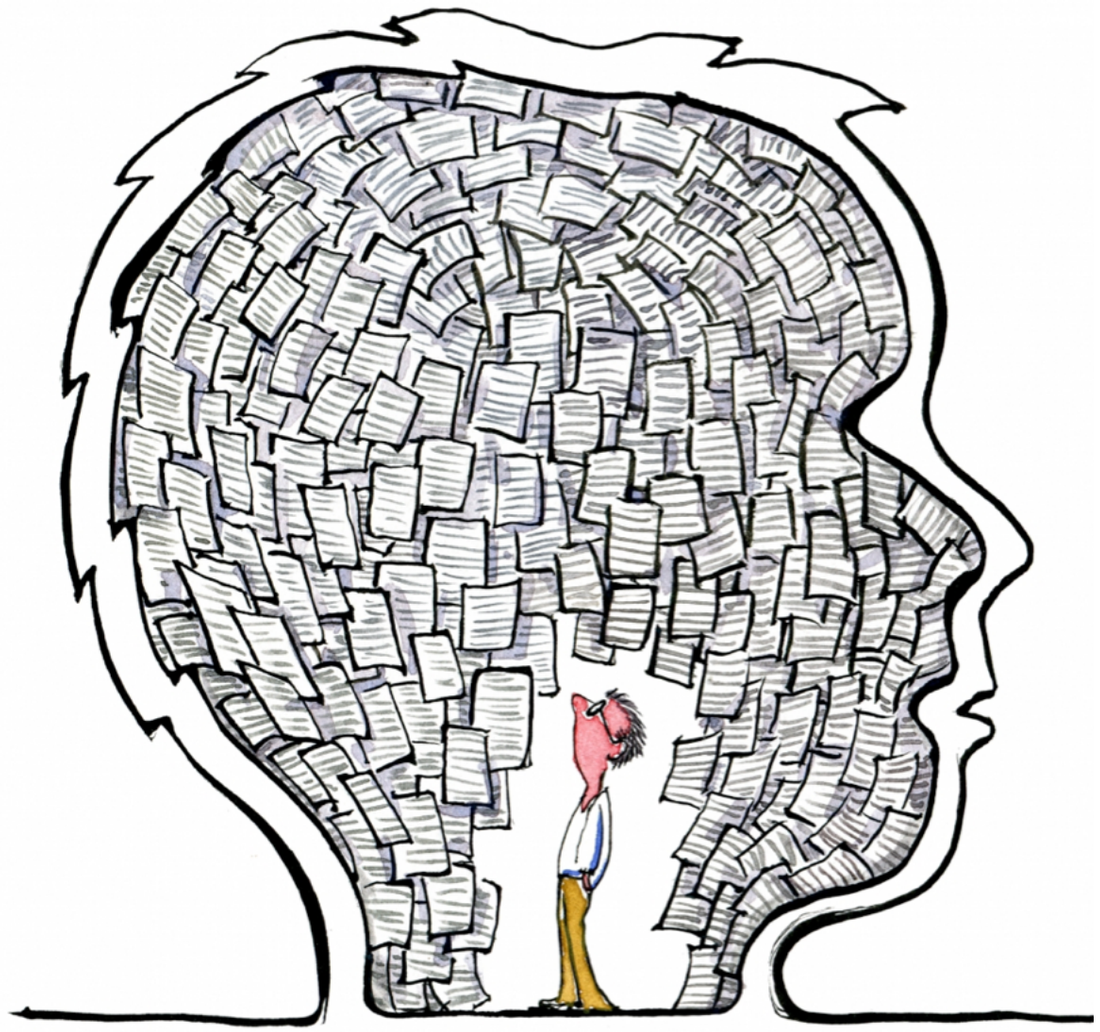
[30] Nelson, Daniel (1980) Frederick W. Taylor and the Rise of Scientific Management Madison Wisconsin, University of Wisconsin Press p 4

Chapter One:
Early Beginnings



By David Joyce

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6 The Puritan Gift: triumph, collapse and revival of an American dream, Kenneth Hopper and William Hopper, I. B. Tauris (April 3, 2007)
p.42. By permission of Ken Hopper and Will Hopper

7 en.wikipedia.org/wiki/American_system_of_manufacturing

8 Wren, D., The Evolution of Management Thought, Wiley, New York, 1994, p. 73.

9 The Puritan Gift: triumph, collapse and revival of an American dream, Kenneth Hopper and William Hopper, I. B. Tauris (April 3, 2007)
p.49. By permission of Ken Hopper and Will Hopper

10 en.wikipedia.org/wiki/Springfield_Armory

11 The Puritan Gift: triumph, collapse and revival of an American dream, Kenneth Hopper and William Hopper, I. B. Tauris (April 3, 2007)
p.50. By permission of Ken Hopper and Will Hopper

12 www.forgeofinnovation.org/Springfield_Armory_1812-1865/Themes/Craftsmen_to_Workers/Daily_Work/

14 Daniel Wren leading business historian Wren, D., The Evolution of Management Thought, Wiley, New York, 1994, p. 74.

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