

## AFD Ep 380 Links and Notes - 1IR: Interchangeable Parts [Bill/Rachel/Kelley] - Recording 6/6/21

- [Bill] Intro: This week we're going back further in time, to the First Industrial Revolution, to talk about the popularization of Interchangeable Parts, instead of custom-built piece work. This was a key breakthrough in manufacturing processes that allowed for the rise of the so-called "American system of manufacturing," broader mechanization of the emerging industrial economy, and eventually mass-production assembly lines. While the concept of interchangeable parts was not invented in the United States and has a lengthy history in ancient China and proto-industrial Europe, the nascent industrial capitalist class took to it with such enthusiasm in the United States that it became most closely associated with Americans during the First Industrial Revolution era. As we'll discuss today, this early drive to mechanize was partly a result of early American capitalists having a smaller labor pool to work with compared to European or Asian counterparts who could simply use craftsmen or grunt laborers like machines to ramp up industry. American employers also had to compete with the lure of landownership for men, which wasn't available in Europe. Interchangeability not only helps steer industry toward mechanization, but also the mechanization of manufacturing processes in turn allows for much more precise repetitive production and milling of component parts, promoting interchangeability in a feedback cycle. [On episode #349 in February 2021](#) (from our bonus feed on Patreon), Rachel and I examined the spread of the piecework putting-out system in the Massachusetts boot-making industry and the transformative effect that even this step had on the production of custom boots as piece work and the craftsmen who made them. But as we discussed then, that industry was much farther behind the curve relative to other industries in the United States and it did not become mechanized and mass-produced until later. In the meantime, other American industries were already rapidly pushing toward mechanization via interchangeable parts and indeed interchangeable finished products. As we will see today, the popularization of interchangeable parts is especially inseparable from the development of the American arms industry – like so many of the industrial developments we discuss on this show – and the phenomenon was sometimes called the "Armory Practice," due to extensive early use of interchangeable parts and standardized firearms production in US armories in Massachusetts and Virginia. As always, our notes and links will be available in a PDF posted with the episode at [Arsenalfordemocracy.com](http://Arsenalfordemocracy.com).
- [Kelley] The Arms Industry and precision machining for interchangeability: <https://www.history.com/topics/inventions/interchangeable-parts>
  - In the 18th century, gun making was a skilled craft and each gun was unique - it was not easy to repair a broken gun because you couldn't just replace the part. Process was time consuming and expensive.
  - In the mid 19th century gunsmith Honore LeBlanc came up with the idea to make guns from standardized patterns. Thomas Jefferson even went to his workshop and was impressed. The idea didn't quite catch on.
  - In 1797 Congress voted to prepare the nation for war with France. In 1798 Eli Whitney obtained a government contract for 10,000 muskets to be produced in 2 years - which was extraordinarily fast at the time.
  - *"By January 1801, Whitney had failed to produce a single one of the promised weapons, and was called to [Washington](#) to justify his use of Treasury funds before a group that included outgoing president [John Adams](#) and Jefferson, now the president-elect. As the story goes, Whitney put on a display for the group, assembling muskets before their eyes by choosing (seemingly at random) from a supply of parts he brought with him. The performance earned Whitney widespread renown and renewed federal support. It was later proven, however,*

*that Whitney's demonstration was a fake, and that he had marked the parts beforehand and they were not exactly interchangeable. Still, Whitney received credit for what Jefferson claimed was the dawn of the machine age."*

- Whitney did not finish making his 10,000 muskets for 8 years, but he was on to something and produced 15,000 more muskets within two years.
- [Rachel] Related - the Uniformity of Military Uniforms and then the broader clothing industry: From Dana Thomas's *Fashionopolis* (Penguin Press, 2019):
  - Francis Cabot Lowell brought the factory system to the US, copying from Richard Arkwright's Manchester cotton mills. He opened the Boston Manufacturing Company in 1813 on the Charles River in Waltham, Massachusetts, spinning and weaving cotton grown by slave labor.
  - Although the lockstitch sewing machine was invented in the 1830s, which allowed for ready-made garments, demand was low and most people made their own clothes. The Civil War created a demand for uniforms in standard sizes made quickly for both the Confederate and Union armies. Factories expanded to meet the demand. Post-war, the men liked the convenience of ready-made clothes so manufacturers started mass-producing menswear; womenswear came later.
- [https://en.wikipedia.org/wiki/Interchangeable\\_parts](https://en.wikipedia.org/wiki/Interchangeable_parts)
  - [Bill] Remarkably, the British even used mass production of interchangeable parts for their arms industry during the Napoleonic Wars and still didn't manage to get it to proliferate into the civilian industry for decades, unlike the Americans who were busy promoting it for both, often with close cooperation between military and civil industrialists.  
[https://en.wikipedia.org/wiki/American\\_system\\_of\\_manufacturing#History](https://en.wikipedia.org/wiki/American_system_of_manufacturing#History)
- [Rachel] Navy  
[https://en.wikipedia.org/wiki/Interchangeable\\_parts#Brunel's\\_sailing\\_blocks](https://en.wikipedia.org/wiki/Interchangeable_parts#Brunel's_sailing_blocks)
  - *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 (and with contributions by) Brigadier-General Sir [Samuel Bentham](#), the Inspector General of Naval Works at [Portsmouth Block Mills](#), [Portsmouth Dockyard](#), [Hampshire](#), England. At the time, the [Napoleonic War](#) was at its height, and the [Royal Navy](#) was in a state of expansion that required 100,000 [pulley blocks](#) to be manufactured a year.*
  - *Marc Brunel, a pioneering engineer, and Maudslay, a founding father of [machine tool](#) technology who had developed the first industrially practical [screw-cutting lathe](#) in 1800 which standardized [screw thread](#) sizes for the first time,<sup>[B]</sup> collaborated on plans to manufacture block-making machinery; the proposal was submitted to the [Admiralty](#) who agreed to commission his services. A total of 45 machines were required to perform 22 processes on the blocks, which could be made in three different sizes. The machines were almost entirely made of metal thus improving their accuracy and durability. The machines would make markings and indentations on the blocks to ensure alignment throughout the process ("Tab A into Slot B"). One of the many advantages of this new method was the increase in labour [productivity](#) due to the less labour-intensive requirements of managing the machinery. Richard Beamish, assistant to Brunel's son and engineer, [Isambard Kingdom Brunel](#), wrote:*

*So that ten men, by the aid of this machinery, can accomplish with uniformity, celerity and ease, what formerly required the uncertain labour of one hundred and ten.*

- By 1808, annual production had reached 130,000 blocks and some of the equipment was still in operation as late as the mid-twentieth century
- Listeners might recall Isambard Kingdom Brunel as the builder of the ship that laid the first permanent transatlantic cable, the SS Great Eastern ([ep #367](#))
- [Kelley] Wood parts: The first mass production of interchangeable parts in the US was Eli Terry's 1806 Porter Contract which required production of 4,000 clocks in three years. At the time the annual average was about a dozen. Terry used a milling machine and jigs and templates to produce uniform parts that could be assembled on an assembly line.
- [Kelley] Metal: Historians differ on whether Simmeon North or John Hall were the first to use milling machines to create metal pieces. By 1832 both were able to using milling machines to create metal parts, that could then be filed by and used in an assembly line process.
- [Bill] [https://en.wikipedia.org/wiki/American\\_system\\_of\\_manufacturing](https://en.wikipedia.org/wiki/American_system_of_manufacturing)
  - *"The [American] 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 [American capitalists] 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."* – Joseph Whitworth, English machine-tool maker and British commissioner for the NY International Exhibition, 1854
  - The British had brought workers under one roof with the factory system but many of the processes continued to be done by manual labor (why build an expensive machine that requires water or steam to move up and down when you can pay a huge guy to move that thing up and down instead?) and the early British factories often still had workers following the whole chain of production on an item, instead of just working on one piece of that item over and over. What separates this from the putting-out system is the capitalist owners having total ownership and constant supervision over the factory production and the materials and equipment necessary to produce goods, while the workers owned none of it and supplied none of it and were themselves basically interchangeable. The Americans took it a step further by breaking down the production process into more steps divided up among workers and standardizing everything, while also replacing more of their workers with machinery. Again, they didn't invent doing this – in fact the British did – but the Americans adopted it much, much faster than their counterparts in Britain and continental Europe.  
[https://en.wikipedia.org/wiki/Factory\\_system#Machine\\_tools\\_and\\_interchangeable\\_parts](https://en.wikipedia.org/wiki/Factory_system#Machine_tools_and_interchangeable_parts)
  - [Rachel] In 1774, [John Wilkinson](#) invented a method for boring cannon barrels that were straight and true every time. He adapted this method to bore piston cylinders in the [steam engines](#) [made by] [James Watt](#). This boring machine has been called the first machine tool.
- [Bill] Mechanization of more of the brute force manual labor parts of production allowed American capitalists to hire more women (or in fact young girls and boys)

to work in their factories because they could operate machinery without as much body strength. That being said, unmarried women and children also got hired in large numbers in American factories early on regardless of technological innovations in a specific industry, because they were simply much cheaper to hire than men, although women's wages rose in relative terms as industrialization progressed and demand for their labor shot up and businesses even had to start importing female factory workers from other regions or abroad. Eventually, women made up 30-40% of the pre-Civil War industrial workforce in the United States, with some businesses having a majority of women workers. Even without significant capital equipment upgrades, certain industries found themselves able to hire a cheaper, female workforce simply by breaking down and de-skilling the process of manual production into as many discrete, repetitive tasks as possible, which interchangeable parts and pieces played a role in once again. Some industries embraced this practice so thoroughly that they ended up dividing different parts of production over entirely different factories or even different businesses, knowing that they could sell an interchangeable manufactured input to another company to produce a finished good. It was easy to replace skilled craftsmen with unskilled women factory workers. (I read a paper titled "[Women, Children, and Industrialization in the Early Republic: Evidence from the Manufacturing Censuses](#)" by Claudia Goldin and Kenneth Sokoloff, The Journal of Economic History, Dec., 1982, Vol. 42, No. 4 (Dec., 1982), pp. 741-774) See also: [https://en.wikipedia.org/wiki/Factory\\_system#Societal\\_effects](https://en.wikipedia.org/wiki/Factory_system#Societal_effects)

- [Kelley] Reflections:
  - Assembly line technology is inseparable from the rise of consumerism and the downfall of the skilled craftsman.
  - Did efficiency of interchangeable parts and assembly lines lead to the end of child labor? (New England Labor Unions were among the first to condemn child labor in 1932 - <https://laborcenter.uiowa.edu/special-projects/child-labor-public-education-project/about-child-labor/child-labor-us-history>)
  - Given the evolution of technology and increase in efficiency in our current manufacturing processes it seems that a shrinking demand for labor is inevitable - who should we allow to exit the workforce? How can we structure a society that supports this exit?
  - [Rachel] Mechanics and machinists benefit from this industrialization/automation process. Fewer, but higher-quality jobs; especially applies to mass production of textiles.

[Bill] In some upcoming episodes we will talk more about later uses of interchangeable parts like in sewing machines. But listeners might also recall that we discussed mass production assembly lines for bicycles in [episode #332 in November 2020](#) and the huge proliferation of mechanized farm equipment in [episode #315 in July 2020](#), both toward the end of the 19th century.