The Engine that Moved the World

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Junior Division

Paper

Paper: 2,500 words

Process Paper:

500 words

Process Paper

Machines have always fascinated me, and the steam engine fits year's topic perfectly. The steam engine was a crucial part of the Industrial Revolution, which forever changed civilization, making the steam engine an enormous turning point.

I began researching general information as a foundation, leading to researching more specific topics that would provide depth to my paper. I put my research into paragraphs and did some additional research to fill the information gaps, then proofread and fixed errors.

After the competition, I saw that several parts of my paper were hindering me, mostly the bibliography and citations. I also had problems with my analysis and the historical impact, making my paper somewhat weak.

Upon rereading my paper, I began adding more primary sources, bringing with them lots of information. I then added several large sections about the impacts on farming and other people opposing it. I then turned to the more technical parts of my paper.

Despite my initial reluctance to incorporate footnotes, I decided that they would clean up my paper and give it a more professional look. I also added appendices to aid my explanations of the steam engine. The last step was fixing grammatical and logical errors, which was quick.

After the state contest, I saw that my hard work resulted in better judge reviews. However, there was still some room to work on. They still thought I could add more sources, as well as improving the clarity and content of the paper body.

I then found even more sources and filled in information gaps, adding depth, and to the word count. At the end, I was around three hundred words over the limit. I spent a couple of days redacting portions of my paper that were not necessary, and trying to trim down my paper so I could fit all the information I needed into it. Finally, I brought it down to the limit, but my quest was not over, as I continued to look for sources. They were a lot harder to find, and it took me some time to find them.

The steam engine had a significant impact on the growing society. In the pre 1700s world, industrialization was slowly advancing, as more efficient methods to produce goods were found. However, one problem was that the only ways to power machines in those days were by hand or animal labor, and wind or water. These were unreliable power sources, as laborers would tire, wind would stop blowing, and water would freeze. While the first steam engine could not be applied in such a setting, iterations created in the 1770s could. This new power source was a major cause of the Industrial Revolution. It went on to revolutionize transport and farming as well, with classic examples such as trains and tractors, as well as some more obscure ones like steam cars. This would go on to irreversibly change the way we live, and although steam engines are a rare sight nowadays, their impact is not.

Introduction

At the end of the First Industrial Revolution—around 1850—coal was 92.7% of England's power consumption, equal to 89 megajoules per capita[1]. This change wasn't happening solely in Britain, as work done with steam engines around the world doubled from 1840-1850, and then tripled from 1850-1860. Robert Thurston, steam engine specialist and author of *A History of the Growth of the Steam Engine*, said in 1896, "The steam-engine, and its inconceivable importance as an agent of civilization... the steam engine is, in modern times, the most important physical agent in that great work [civilizing the world]"[2]. The engine was pivotal in the 19th century, and its effects unsurpassed. It opened opportunities in many industries, providing higher production, growth, and profit. It became one of the greatest inventions and turning points in the industrial era because of how rapidly it improved civilization.

Before the steam engine, life was agriculturally focused. There were some factories powered by water or animals, but output was ridiculously low compared to early 1800's standards. A hindrance was the separation of the production elements. In the textile industry, for example, the wool, mills, and markets were all separated. That meant that products had to be transported and would take a long time to reach their destination[3]. Outside of the factories, manufacturing meant artisans in their homes. This system didn't have as much manufacturing potential, but wealth was distributed evenly among everyone. Additionally, households would have land, and manufacturers would grow crops and hold livestock, although in lesser amounts than agricultural workers. Essentials such as food were cheap, and despite having lower salaries,

[1] Tony Wrigley, Annual Energy Consumption per Head (megajoules) in England and Wales 1561-70 to 1850-9
[2] Henry Robert Thurston, A history of the Growth of the Steam Engine
[3] Heather Whipps, *How the Steam Engine Changed the World*, published in Live Science Magazine

laborers had more buying power. This system was a lot better than the industrial one, in terms of the laborer's experience[4].

The first steps to a more efficient system came when Britain's demand for coal skyrocketed. The inefficiency of using horses to drain flooded coal mines sparked research into better draining methods. In 1698, Thomas Savery patented an "engine to raise water by fire". It used steam to create a vacuum in a pipe, raising the water. It was improved by Thomas Newcomen, who added cylinders, and by James Watt, who improved efficiency, separating the condensation from the cylinder. It spread outside of mining circles, becoming a part of the factory system, and even transportation.

The Steam Engine's Evolution

The first useful design was simple, consisting of a boiler, water containers, and a pipe. Yet, it would forever change civilization. The boiler would produce steam, which is admitted into the containers via a valve. The increase in pressure causes the water inside the container to move into the pipe. It gets forced through a non-return valve, headed to the top of the pipe. The suction caused by the raising of the water and condensation of the steam lifts the floodwater through a lower non-return valve, and the process is repeated until the water is drained[5]. The simple engine proved to not function well in the mines, as the high-pressure steam wreaked havoc on the soldered joints, and frequent repair was required. It also needed to be close to the water, meaning

[4] Gibbins, Henry De Beltgens, *Industry in England*
[5] Savery, Thomas, *The Miner's Friend; Or, An Engine to Raise Water by Fire*

it had to be installed, operated, and repaired in the mines. It was applied to controlling water supply.

The next steam engine, the Newcomen engine, was more successful. Newcomen did away with the dangerous high-pressure steam, making the highest pressure in the system about atmospheric pressure, so it is called an atmospheric engine. It uses a piston to pull one end of a beam down, lifting the other end up. The second end is attached to a pump, which is used to pull water from a mineshaft. To make the beam go down, water from a reservoir is put into the cylinder, condensing the steam, and it stops pulling. That makes the pump side of the beam fall back to the starting location, and the process is repeated. The Newcomen engine replaced any Savery engines in use, and steam was finally effectively used to pump water from mines. Savery's patent was vague, and it covered any "engine to raise water by fire," so Newcomen was forced to establish a firm with Savery. The Newcomen engine was still inefficient, as energy was wasted heating and cooling the cylinder. It, however, was widely used and remained the best engine for 60 years.

The Newcomen engine was supplanted by the engine of James Watt, a Scottish instrument maker. He tinkered with a small Newcomen engine, changing materials, size, and injection amounts. Finally, he made the breakthrough, the cylinder should stay the same temperature the whole time, and the cooling should instead happen separately. In his own words, "On reflecting further I perceived that, in order to make the best use of steam, it was necessary first, that the cylinder should be maintained always as hot as the steam which entered it; and, secondly, that when the steam was condensed, the water of which it was composed, and the injection itself,

should be cooled down to 100°, or lower, where that was possible"[6]. By keeping the temperature the same, the efficiency of the engine could be increased. Watt engines became standard, and the invention of the rotary engine allowed it to replace other sources of power in factories, mills, and many other places. Its versatility and efficiency lead to its adoption in many industries and improving society at large, making it the most important steam engine.

How the Steam Engine Changed the World

It had an enormous impact on the growing industrial base, as factories were powered by water, so they could only be built next to rivers. Also, water could stop flowing when rivers froze or dried up. Although the steam engine was built for a simple reciprocating motion, Watt soon developed a mechanism that made a circular motion. Some benefits of using it in factories were that it didn't stop turning like water, it provided more power, and factories wouldn't be limited to fast-flowing rivers[7].

Another application was in transportation. However, the low-pressure designs of Watt and Newcomen couldn't build up enough speed to power a vehicle. Thankfully, advances in technology allowed high-pressure engines, like Trevithick's engine, to consistently work. The train is the most popular implementation. Richard Trevithick was the first person to create a steam locomotive, making its first run on a horsecar route in February of 1804. The first non-experimental steam locomotive to run on rails was Locomotion *1*, which ferried passengers from

[6] James Watt's *Invention of The Steam Engine*
[7] Catherine Reef, *The Factory System Emerges: 1733–1865*, American History Database

Stockton to Darlington, in northeast England. Trains soon became the primary form of travel, as they were faster than anything else, and had the capacity to haul heavy cargo.

Another form of transport was the steamboat, which was the primary form of transport before the train appeared. The first practical steamboat, *Charlotte Dundas*, was built by William Symington and assessed in the Forth and Clyde Canal in Scotland. The first successful steam passenger boat was built in 1807 by Robert Fulton, in the United States[8]. It ran against the current 150 miles from New York to Albany for 32 hours, an average speed of about five miles per hour. Steamboats ran on rivers and canals, arriving during the canal boom, making them primary forms of transportation. Even in their infancy, steamboats attracted a lot of attention, especially in America. Thomas Jefferson wrote, "I hear you are applying this same agent [the steam engine] in America to navigate boats, and I have little doubt but that it will be applied generally to machines, so as to supercede the use of water ponds, and of course to lay open all the streams for navigation. We know that steam is one of the most powerful engines we can employ"[9]. However, efficiency had to be improved for longer trips. In 1838, Isambard Kingdom Brunel's *SS Great Western* crossed the Atlantic in 10 days, three times faster than sail. Soon, more improvements were made, coming in the form of propulsion via propellers as opposed to paddlewheels[10].

Although ground transportation on rails was effective, transportation on common roads was trickier, leading to many different attempts to improve grip on the ground. This experimentation gave birth to a surprisingly important invention that would serve to radicalize a growing industry, farming. Although farming was around for tens of thousands of years, it was

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[8] Oriol Planas, *Transport Uses of Steam Engines*, en.demoter.net
[9] Thomas Jefferson, Letter to Charles Thompson
[10] Mark Cartwright, *The Steam Engine in the British Industrial Revolution*, World History Encyclopedia

growing, with farms getting larger, and techniques increasingly complicated. In the early 1870s, a man called Douw D. Williamson created the Williamson Steam Plow. He modified a Thomson Road Steamer, which had revolutionary wheel design. There was added rubber to the outside of the tires, as opposed to traction spikes. The weight of the vehicle would compress the rubber, increasing the surface area on the ground. This helped in two ways; it first increased the traction of the engine, and it also distributed the weight more which made it sink less on soft surfaces. Williams made the engine more reliable, and invented an attachable system that could plow a field[11]. This engine is an early iteration of the most widely known and used farming machines, a tractor.

People with a Different View

All this progress was progressing industrialization, making items more available, and growing the population. However, there was a group of people who were angry at these developments; they called themselves the Luddites. They got their name from their mythical leader Ned Ludd, who was said to live in the Sherwood Forest. There wasn't one single Luddite group, there were individual cells all over the country. They were mostly skilled laborers, such as handweavers, whose jobs were slowly being taken by the machines and unskilled machine operators. Even if they did manage to get jobs, they would get paid much less than they were before, often earning enough money in a week's wages as they did in a day. Machinery produced more product, but prices went up, "Wages were somewhat less in money value than at present,

[11] Douw D. Williamson, *Steam Plowing. Description of the Operations of the Williamson Road Steamer and Steam Plow, on the Seed Farms of Messrs. David Landreth & Son Bloomsdale, near Bristol, Pa.*

but, then, prices of food and rent were only about half what they are now."[12] Trade unions were banned, so they protested another way.

They sneaked into factories and destroyed machines, using hammers, setting fires, doing whatever they could to break them. They also threatened mill owners' private property and lives. Mill owners responded, fortifying their factories, sending spies, offering bounties, and lobbying the government. Parliament passed a bill stating anyone caught breaking a machine would be sentenced to death or deportation to a penal colony. The movement lost ground as the economy in Britain improved, lack of central authority weakened resolve, the government began to really crack down on Luddites, and that factories made more jobs than the traditional system. To this day, Luddite means someone who resists technological change and sticks in the past[13].

In addition to the Luddites, others also disagreed with the use of the steam engine, albeit for several reasons. Two chief concerns were the running costs and the difficult maintenance, coupled with the inherent fire risk that they pose. For example, "That a vessel for the conveyance of coal was to be worked from Newcastle to London by means of a steam engine. She consumed so much of the coal on her voyage, that by her arrival in the port of London, scarcely a cinder was left"[14]. This prohibitive cost of fuel made it only applicable if the large expense of fuel could be shrugged off e.g., coal mines, valuable mines, supplying water to a rich city, etc. The cost made many unwilling to use them. For example, the Philadelphia Counsel proposed a steam pump to supply water from the Schuylkill River in 1799, to be removed in 1822 because of the excessive fuel cost.

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[12] Gibbins, Henry De Beltgens, *Industry in England*
[13] Mark Cartwright, *Luddite*, World History Encyclopedia
[14] Article *Inland Navigation* in the Gazette of the United States, & Philadelphia Daily Advertiser

Malfunctions weren't unheard of, and one of the biggest issues was that they could cause large fires. For example, "December 12, 1797- and engine by Bolton and Watts, at Shadwell in London, raised at the rate of 903 gallons per minute, or 760,000 gallons per day of 14 hours;-it supplied a district, extending from the Tower to Limehouse Bridge and from the river to White-chapel, containing about 8000 houses and was burned down in less than 2 hours-The great inconvenience suddenly experienced by the inhabitants may readily be conceived"[15]. If the operator of the engine wasn't careful in his work, an explosion or other malfunction could occur, which would lead to such disastrous events. As if high expenses weren't enough, there was a risk of the very place you meant to help with a steam engine would get burned down by one. These issues caused many people to be set against it, until the rewards outgrew the risks.

Another large problem was the effects of the factory system on the working class. They lived such a squalid life, that it calls into question whether the steam engine had a positive impact. Families were packed into tiny homes, with unpaved streets, most without bathrooms, and all without sewage. They spend their days working from sunrise to sunset, with breaks for nutritionally sparce meals consisting of potatoes and oatmeal. Crime rates were high, disease spread like wildfire, and morale was nonexistent. Not utilizing child labor was a rarity, and infant mortality was at never-seen-before levels[16]. It was overall, such a wretched life, and it continued for a long time.

Before the Industrial Revolution, their wages weren't much lower than the Industrial Revolution standard, and all necessities were many times cheaper. As Henry Gibbins puts it, "For

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[15] Article *Inland Navigation* in the Gazette of the United States & Philadelphia Daily Advertiser

[16] James Phillips Kay, *The Moral and Physical Condition of the Working Class Employed in Cotton Manufacture in Manchester*

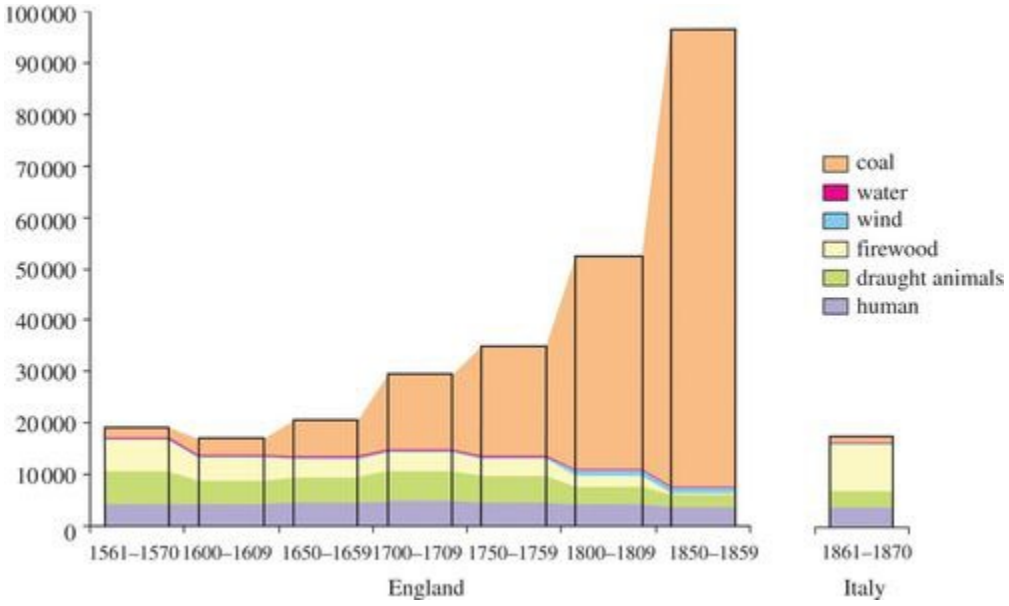
it is a significant fact that under the old domestic system, simple and cumbrous as it was, the manufacturing population was much better off than it was for some time after the Industrial Revolution."[17] Naturally, as their well-off lives were being threatened, they protested. The Luddites are a prime example of this, as well as being the most famous. At the end of the day, however, they couldn't compete with mass-produced products, and joined the industrial working class.

Conclusion

The steam engine revolutionized how society functioned, providing fast transportation, removing the need for most human and animal labor across many fields. It made most operations much more efficient, and it was possible to provide for a much larger population than previously. The increased efficiency made a whole swath of products cheaper and more available. Labor costs decreased noticeably, allowing for the companies and the economy to grow even further. It was also an enormous turning point from a cultural point of view, shifting our whole civilization from the agrarian form it had been in for thousands of years, to an urban and industrialized one. It is the greatest invention of the industrial era, and one of the most important to this day, because its impact on our society was one of great magnitude, leaving behind a changed civilization.

[17] Gibbins, Henry De Beltgens, *Industry in England*

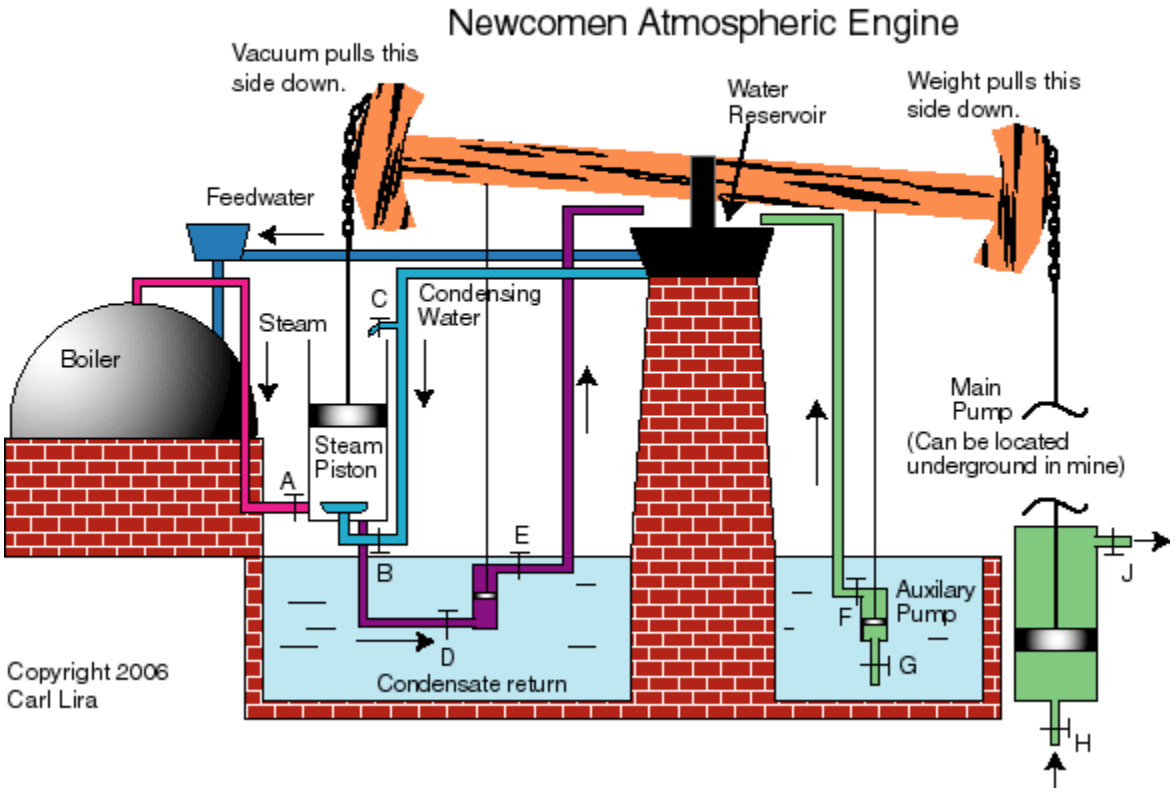
Appendix A



The chart demonstrates the rapid growth in the usage of coal in England, correlating steam engine's invention, which increased coal mining and consumption.

Wrigley, Tony. Annual Energy Consumption per Head (megajoules) in England and Wales 1561-70 to 1850-9. Aug. 2010. Cambridge Group for the History of Population, Cambridge U.

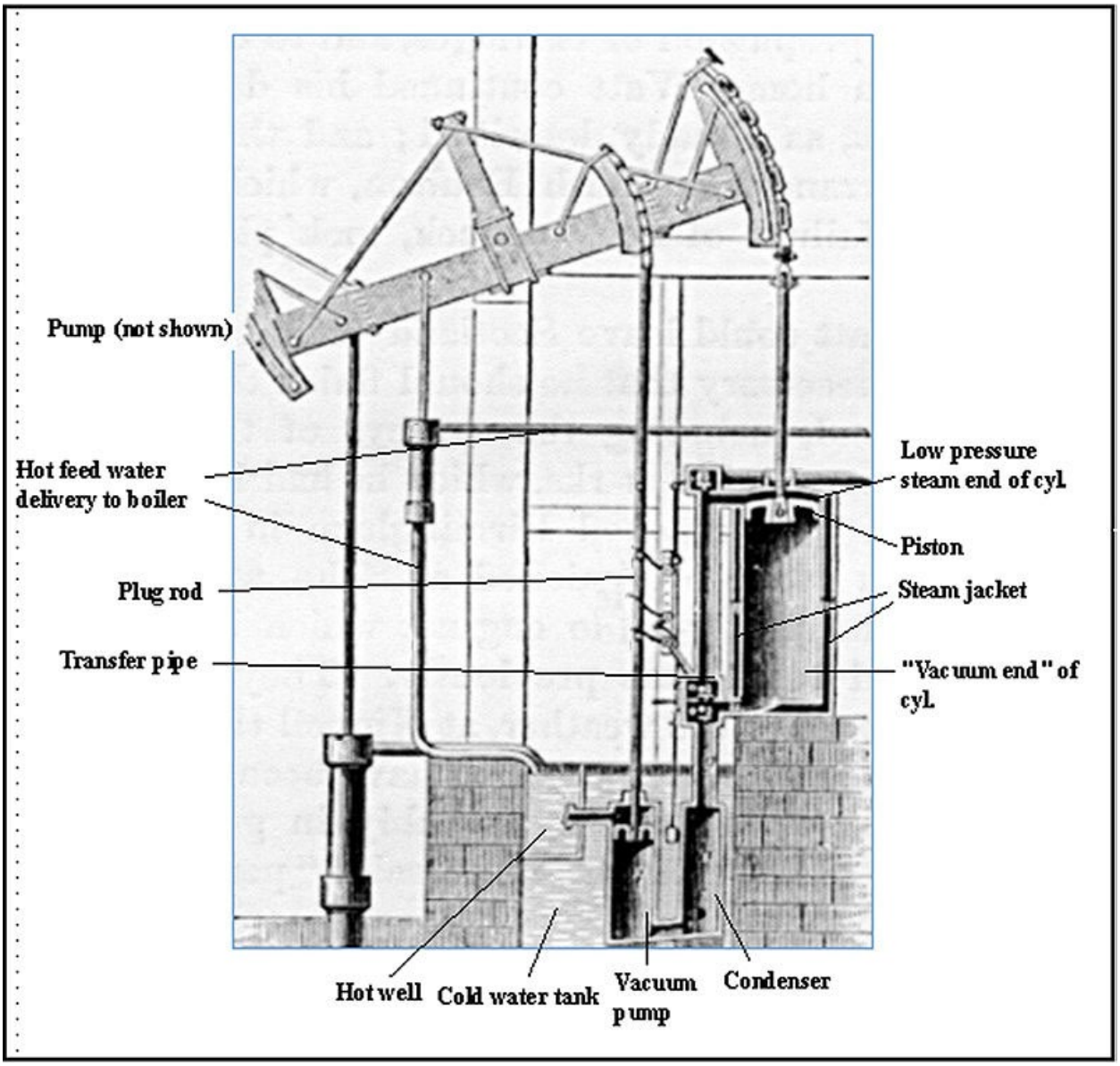
Appendix B



The diagram shows the parts, such as the piston, beam, reservoir, main water pipes, and water/steam movement in the engine.

---. Diagram of a Newcomen Steam Engine. 2006. Newcomen Atmospheric Engine Description, Michigan University College of Engineering, www.egr.msu.edu/~lira/supp/steam/. Accessed 19 Mar. 2024.

Appendix C



This image shows the Watt engine. Including the revolutionary separate condensing system.

Thurston, Robert H. The Major Components of a Watt Pumping Engine. 1896.

Annotated Bibliography

Primary Sources

Fulton, Robert. "To Joel Barlow, Philadelphia. New York, 22 Aug. 1807." *Aurora General Advertiser* [Philadelphia], 25 Aug. 1807. *Newspapers.com*, basic.newspapers.com/image/586582518/. Accessed 2 May 2024.

I used this source as a way to provide more information about the steamboat, in the form of a primary source.

Gibbins, Henry De Beltgens. *Industry in England*. New York City, C. Scribner's sons, 1897. *Library of Congress*, tile.loc.gov/storage-services/public/gdcmassbookdig/industryinenglan00gibb/industryinenglan00gibb.pdf. Accessed 2 May 2024.

I used this source to show that the steam engine was a catalyst for revolutionizing the British textile industry, the focal point of the industrial revolution. I also used it to compare how industrial methods varied from pre-industrial ones.

INVENTION OF THE STEAM ENGINE. *Bloomsbury*, media.bloomsbury.com/rep/files/Primary%20Source%2011.4%20-%20Watt.pdf. Accessed 14 Dec. 2023.

This source was very important to my research, as it is a primary source, a source type which is sparse in my topic. I used it to get information about how the Watt engine was made, and it helped me understand how advancements were made

with the steam engine and the downsides of the Newcomen engine, which helps give a fuller picture of it.

Jefferson, Thomas. Letter to Charles Thompson. Apr. 1786. *National Archives*, founders.archives.gov/documents/Jefferson/01-09-02-0353. Accessed 3 May 2024.

This source was used to address one of the blind spots of my paper, lack of input from contemporary voices. Thomas Jefferson was a very important and influential person, especially in the United States, which would become very involved in industrialization and the steam engine.

"On Inland Navigation." *Gazette of the United States, and Philadelphia Daily Advertiser* [Philadelphia], 1799, pp. 2-3. *Library of Congress*, www.loc.gov/resource/sn83025881/1799-03-26/ed-1/. Accessed 18 Mar. 2024.

I used this source to get information about the reasons people were opposed to steam engines. It helped expand my paper's content of alternative points of view.

Renwick, James. *Treatise on the Steam Engine*. New York City, G. & C. & H. Carvill, 1830. *Library of Congress*, tile.loc.gov/storage-services/public/gdcmassbookdig/treatiseonsteame02renw/treatiseonsteame02renw.pdf. Accessed 2 May 1830.

I used this source to obtain more information about steam road and rail transportation. My project didn't have much information about these topics, and this deepens the depth of knowledge in my paper.

Savery, Thomas. *The Miner's Friend; Or, An Engine to Raise Water by Fire*. London, 1702.

I used this source to obtain information about the Savery engine, and to help me get a description of the engine from the inventor. It helped me understand the topic because it explained the engine in depth, and it had some context for that period of time with the interview with a miner.

Sykes, John. Letter. Mar. 1812. *National Archives UK*, webarchive.nationalarchives.gov.uk/ukgwa/20180105040114/http://www.nationalarchives.gov.uk/education/politics/g3/source/g3s1b.htm. Accessed 11 May 2024.

This source showed me what an early Luddite attack would look like. It shows the underground and violent nature of the movement, which shows why many people were so opposed to it.

Thomas, John Jacob. *Farm Implements and Farm Machinery*. New York City, O. Judd, 1886. *Library of Congress*, tile.loc.gov/storage-services/public/gdcmassbookdig/farmimplementsfa01thom/farmimplementsfa01thom.pdf

Information from this book was useful in my paper to show other ways that steam was applied in farming other than the tractor. It also shows how large of an impact it had on the industry.

Thurston, Robert H. *The Major Components of a Watt Pumping Engine*. 1896.

This image helped me conceptualize how the Watt steam engine works and how it's different from the Newcomen engine.

Williamson, Douw D. *Steam Plowing. Description of the Operations of the Williamson Road Steamer and Steam Plow, on the Seed Farms of Messrs. David Landreth & Son Bloomsdale, near Bristol, Pa.* New York City, McDonald Bros, & Dillont, Printers and Stationers, 1873. *Library of Congress*, tile.loc.gov/storage-services/public/gdcmassbookdig/steamplowingdesc00will/steamplowingdesc00will.pdf. Accessed 18 Mar. 2024.

I used this source to get more information on how the steam engine was applied in an industry that it is often not connected with. This gave my paper a small amount of additional information on evolutions in steam transportation, and its specific impact on the very important industry of farming.

Secondary Sources

Annual Energy Consumption per Head (megajoules) in England and Wales 1561–70 to 1850–9 and in Italy 1861–70. 2010, Cambridge U. Infographic.

I used this source to show how much coal was used in Britain-the birthplace of the steam engine-around the time of the industrial revolution. It helped support my claim that the steam engine was a highly used and influential invention.

Augustyn, Adam, editor. "Steam Engine." *Encyclopaedia Britannica*, www.britannica.com/technology/steam-engine. Accessed 21 Sept. 23.

This source gives good starting, basic information about the steam engine. It provides information about advancements made in steam engine technology, as well as some basic information about how the steam engine works. The

information isn't hard to understand, and it gives a foundation for further research that gives more in-depth knowledge.

Cartwright, Mark. "Luddite." *World History Encyclopedia*, 3 Mar. 2023, www.worldhistory.org/Luddite/. Accessed 22 Jan. 2024.

I used this source to obtain information about the Luddites, who were the alternate point of view. It helped me understand my topic by showing the downsides of the engine, such as its negative effect on preindustrial economic sectors.

---. "The Steam Engine in the British Industrial Revolution." *World History Encyclopedia*, 8 Feb. 2023, www.worldhistory.org/article/2166/the-steam-engine-in-the-british-industrial-revolut/. Accessed 19 Jan. 2024.

I used this source in order to get information about steam transport, which I didn't have as much of before. It helped me understand my topic more because it added general information as well as specific information that deepened my understanding of the engine.

---. "Watt Steam Engine." *World History Encyclopedia*, 17 Apr. 2023, www.worldhistory.org/Watt_Steam_Engine/. Accessed 23 Mar. 2024.

I used this source to show more ways that the steam engine impacted society, showing that it was a real turning point.

Coman, Katharine, and Elizebeth Kendall. *The Growth of the English Nation*. Meadville, Flood and Vincent, 1894. *Library of Congress*, tile.loc.gov/storage-services/public/gdcmassbookdig/growthofenglishn00coma/growthofenglishn00coma.pdf. Accessed 11 May 2024.

This source gave me more information on how the steam engine impacted Britain and its growth. Since Britain used lots of steam engines, the effects can be translated to a larger level, on the world stage, showing just how powerful the engine was.

Henry, Thurston Robert. *A History of the Growth of the Steam Engine*. 4th ed., New York, Appleton, 1896.

This source provides information and a view that is more difficult to find otherwise. It is written by someone living during the heyday of the steam engine, and it has a lot of data that is only available to someone from that period. In addition, it contains a view of the steam engine that differs from modern views, as the steam engine had a very real impact on the author, as opposed to a modern view of an outdated invention.

Hodge, Paul Rapsey. *The Steam Engine, its Origin and Gradual Improvement, from the Time of Hero to the Present Day; as Adapted to Manufactures, Locomotion and Navigation.* New York City, D. Appleton & Co, 1840-41. *Library of Congress*, tile.loc.gov/storage-services/public/gdcmassbookdig/steamengine00hodg/steamengine00hodg.pdf. Accessed 11 May 2024.

This was a great source to consult about how the steam engine changed over time, and in what ways it was being used. It helped give a clearer picture of when and how advancements in technology happened.

Lira, Carl. "Brief History of the Steam Engine." *Steam Engine History - Michigan State University*, May 2013, www.egr.msu.edu/~lira/supp/steam/index.htm. Accessed 22 Jan. 2024.

This source provided specifics for every steam engine I covered, which helped me gain a technical understanding of how it works as well as its improvements over the previous one and its downsides. I used it to enhance my understanding of the engines, which is crucial to my topic and writing my paper.

---. Diagram of a Newcomen Steam Engine. 2006. *Newcomen Atmospheric Engine Description*, Michigan University College of Engineering, www.egr.msu.edu/~lira/supp/steam/. Accessed 19 Mar. 2024.

I used this image because it shows the separate parts of the engine, as well as what motion occurs in the system, which allowed me to understand how the engine works in practice.

Planas, Oriol. "Transport Uses of Steam Engines." *Demotor*, edited by Oriol Planas, 26 Mar. 2019, en.demotor.net/steam-engine/uses/transport. Accessed 19 Oct. 2023.

This source is more focused on one of the more widely known uses of the steam engine, in transport. It gives information about vehicles powered by steam, such

as trains, steamboats, and steam tractors. This source also provides some basic data with which to focus further research into steam transport.

Reef, Catherine. "The Factory System Emerges: 1733–1865." *Working in America*, Facts On File, 2007. *American History*, online.infobase.com/Auth/Index?aid=101192&itemid=WE52&articleId=204979. Accessed 27 Sept. 2023.

This source is focused on how industrialization affected the US economy. It points out one of the main advantages of the steam engine for industrialization, namely its ability to run almost anywhere. It also shows how widely it was accepted, and as early as around the dawn of the 1800's.

Whipps, Heather. "How the Steam Engine Changed the World." *Live Science*, June 2008, www.livescience.com/2612-steam-engine-changed-world.html. Accessed Oct. 2023.

This source links the steam engine to industrialization, which is a very important point in my project. It provides a little background on the history of industrialization, which is something rarely met. Additionally, it doesn't give specific data, but it illustrates how the steam engine revolutionized industry.