Imagine: you are on the writing staff of Scientific America Magazine. Your team is going to write an article titled "Technology that changed the world, the top six most important inventions of the Industrial Age" It has already been decided that Iron, Steam Engines, Rail Roads, Internal Combustion Engines, The Factory System and the Telegraph will be the six featured technologies, the question of how to rank them remains. They should be ranked from most profound and lasting to least. You must defend your assigned technology to the group with the information you recorded below. After an open debate, your group must come to a consensus by ranking the technologies and providing a written justification for the order.

Individual role:

Steam Engine:

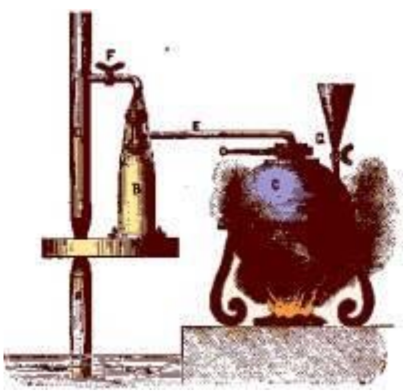
Prove: How did this technology have a lasting and profound impact on our lives.

Your argument:

Supporting evidence:

The History of Steam Engines

Inventors: Thomas Savery, Thomas Newcomen, James Watt



Thomas Savery (1650-1715)
Thomas Savery was an English military engineer and inventor who in 1698, patented the first crude steam engine, based on Denis Papin's Digester or pressure cooker of 1679.
Thomas Savery had been working on solving the problem of pumping water out of coal mines, his machine consisted of a closed vessel filled with water into which steam under pressure was introduced. This forced the water upwards and out of the mine shaft. Then a cold water sprinkler was used to condense the steam. This created a vacuum which sucked more water out of the mine shaft through a bottom valve.
Thomas Savery later worked with Thomas Newcomen on the atmospheric steam engine. Among Savery's other inventions was an odometer for ships, a device that measured distance traveled.

Thomas Newcomen (1663-1729)

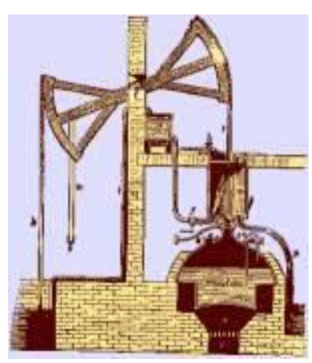


Illustration of Thomas Newcomen's Engine circa 1712
Thomas Newcomen was an English blacksmith, who invented the atmospheric steam engine, an improvement over Thomas Slavery's previous design.
The Newcomen steam engine used the force of atmospheric pressure to do the work. Thomas Newcomen's engine pumped steam into a cylinder. The steam was then condensed by cold water which created a vacuum on the inside of the cylinder. The resulting atmospheric pressure operated a piston, creating downward strokes. In Newcomen's engine the intensity of pressure was not limited by the pressure of the steam, unlike what Thomas Savery had patented in 1698.
In 1712, Thomas Newcomen together with John Calley built their first engine on top of a water filled mine shaft and used it to pump water out of the mine. The Newcomen engine was the predecessor to the Watt engine and it was one of the most interesting pieces of technology developed during the 1700's.

James Watt (1736-1819)
Engraving of James Watt

James Watt was a Scottish inventor and mechanical engineer, born in Greenock, who was renowned for his improvements of the steam engine. In 1765, James Watt while working for the University of Glasgow was assigned the task of repairing a Newcomen engine, which was deemed inefficient but the best steam engine of its time. That started the inventor to work on several improvements to Newcomen's design.

Most notable was Watt's 1769 patent for a separate condenser connected to a cylinder by a valve. Unlike Newcomen's engine, Watt's design had a condenser that could be cool while the cylinder was hot. Watt's engine soon became the dominant design for all modern steam engines and helped bring about the Industrial Revolution.

A unit of power called the Watt was named after James Watt. the Watt symbol is W, and it is equal to 1/746 of a horsepower, or one Volt times one Amp.

How it works

A steam engine is a device that converts the potential energy that exists as pressure in steam, and converts that to mechanical force. Early examples were the steam locomotive trains, and steamships that relied on these steam engines for movement. The Industrial Revolution came about primarily because of the steam engine. The thirty seconds or so required to develop pressure made steam less favored for automobiles, which are generally powered by internal combustion engines.

The first steam device was invented by Hero of Alexandria, a Greek, before 300BC, but never utilized as anything other than a toy. While designs had been created by varous people in the meanwhile, the first practical steam engine was patented by James Watt, a Scottish inventor, in 1769. Steam engines are of various types but most are reciprocal piston or turbine devices.

The strength of the steam engine for modern purposes is in its ability to convert raw heat into mechanical work. Unlike the internal combustion engine, the steam engine is not particular about the source of heat. Since the oxygen for combustion is unmetered, steam engines burn fuel cleanly and efficiently, with relatively little pollution.

One source of inefficiency is that the condenser causes losses by being somewhat hotter than the outside world. Thus any closed-cycle engine will always be somewhat less efficient than any open-cycle engine, because of condenser losses.

Most notably, without the use of a steam engine nuclear energy could not be harnessed for useful work, as a nuclear reactor does not directly generate either mechanical work or electrical energy - the reactor itself does nothing but sit there and get hot. It is the steam engine which converts that heat into useful work.*

In 1769, the Scotsman James Watt patented an improved version of the steam engine that ushered in the Industrial Revolution. The idea of using steam power to propel boats occurred to inventors soon after the potential of Watt's new engine became known.

The era of the steamboat began in America in 1787 when John Fitch (1743-1798) made the first successful trial of a forty-five-foot steamboat on the Delaware River on August 22, 1787, in the presence of members of the Constitutional Convention. Fitch later built a larger vessel that carried passengers and freight between Philadelphia and Burlington, New Jersey.

John Fitch was granted his first United States patent for a steamboat on August 26, 1791. However, he was granted his patent only after a battle with James Rumsey over claims to the same invention. Both men had similar designs.

Historical Significance of the Steam Engine:

The steam engine was central to the industrial revolution. Only through providing a convenient source of energy could major forms of transportation grow and prosper. Steamships and steam locomotives allowed for the quicker transportation of raw materials that could be used to produce finished goods.

Iron:

Prove: How did this technology have a lasting and profound impact on our lives.

Your argument:

Supporting evidence:

Creating Iron

The more advanced way to smelt iron is in a blast furnace. A blast furnace is charged with iron ore, charcoal or coke (coke is charcoal made from coal) and limestone ($CaCO_3$). Huge quantities of air blast in at the bottom of the furnace, and the calcium in the limestone combines with the silicates to form slag. Liquid iron collects at the bottom of the blast furnace, underneath a layer of slag. The blacksmith periodically lets the liquid iron flow out and cool.

At this point, the liquid iron typically flows through a channel and into a bed of sand. Once it cools, this metal is known as pig iron. To create a ton of pig iron, you start with 2 tons (1.8 metric tons) of ore, 1 ton of coke (0.9 metric tons) and a half ton (0.45 metric tons) of limestone. The fire consumes 5 tons (4.5 metric tons) of air. The temperature at the core of the blast furnace reaches nearly 3,000 degrees F (about 1,600 degrees C).

Pig iron contains 4 to 5 percent carbon and is so hard and brittle that it's almost useless. If you want to do anything with it, you have three options. First, you can melt it, mix it with slag and hammer it out to eliminate most of the carbon (down to 0.3 percent) and create strong, malleable wrought iron. The second option is to melt the pig iron and combine it with scrap iron, smelt out impurities and add alloys to form cast iron. This metal contains 2 to 4 percent carbon, along with quantities of silicon, manganese and trace impurities. Cast iron, as the name implies, is typically cast into molds to form a wide variety of parts and products.

The third option for pig iron is to push the refining process even further and create steel.

Iron and Steel Manufacture

The development of the railway stimulated the economy in two important ways. First, the advent of cheap and efficient transport lowered the carriage cost of goods. This meant that goods were cheaper in the shops and this increased the demand. The increase in demand led to the expansion of factories which required more energy. The prime energy source at the time was coal. As the Industrial Revolution began to speed up, the need for coal grew because it provided power for the factory engines, steam powered ships and steam locomotives. Second, the demand for iron increased. Iron was needed to make the railway tracks, steam locomotives and the giant Watt steam engines that pumped the mines and provided energy to run factory machinery. At a later stage, iron was needed to construct the steamships.

The developers of the early steam engines and steam railways would never have been so successful without parallel developments taking place in the iron industry. Without the ironmasters' expertise in creating new methods of iron casting and working iron, it would have been impossible to have produced steam power in the first place. All of these developments which drove the Industrial Revolution were dependent on each other for their success. New inventions in one field led to advancements in another. These, in turn, stimulated further research and development.

John Wilkinson (1728-1808)

John Wilkinson played an important role in the development of James Watt's rotary steam engine. In 1774, he patented a precision cannon borer which he manufactured at his father's Beisham factory at Denbigh in Wales. This boring machine was essential for the manufacture of Watt's engines since it allowed for the detailed measurements needed in the steam engine's design. Wilkinson was then able to use Watt's steam engines to power the bellows at his own wrought iron furnace at Broseley in Shropshire.

Wilkinson was called the "Great Staffordshire Ironmaster". He started his career as an industrialist in 1748 when he built his first iron furnace at Bilston in Staffordshire. One of his most famous achievements was the world's first iron bridge, which he built with the help of Abraham Darby III, and which was opened to traffic in 1781. This bridge was 100 feet (about 30 meters) in length and weighed a total of 378 tons. It was built one mile downstream from Coalbrookdale, and it spanned the River Severn at Broseley. The bridge was also notable because it used joints, pegs and keys in place of nuts, bolts and screws.

Wilkinson also built the world's first iron barge in 1787. He was also responsible for passing his cannon boring technique and expertise across the channel to France, and his factory cast all of the iron work needed for the Paris waterworks. Not surprisingly, Wilkinson was buried in a cast iron coffin which he designed himself!

Iron and Steel Manufacture

The iron industry began in forested areas since trees were necessary to make the fuel, charcoal. It was cheaper to move iron to the iron works than to move the vast amounts of charcoal needed. When ironworking and shipbuilding caused the forests to shrink rapidly, it became necessary to search for an alternative fuel. Iron was made by smelting iron ore or heating the ore up to melting point. The liquid iron was then cast into ingots, called pigs. The pig iron could then either be reheated until it was molten and cast into moulds, or heated and hammered into bars of wrought iron. Of the two, wrought iron was more malleable and less brittle. Attempts had been made to use coal in the smelting process, but the sulphur in the coal produced an iron which was too brittle for use.

In 1709, an ironmaster in Coalbrookdale, Abraham Darby I, succeeded in producing cast iron using coal. He discovered a process whereby coal was first turned into coke. When coal is turned into coke most of the sulphur is lost as sulphurous gases. The coke could then be used in the smelting process to produce iron. Darby kept his discovery a secret and passed it on only to the next generation of Darbys. His son, Abraham Darby II, and his grandson, Abraham Darby III, eventually perfected his method.

Because they kept the secret, the idea of smelting iron using coke did not become widespread until the second half of the 18th century. The Darby's method of producing iron could only be used for cast iron. The search was still on for a better and cheaper method of producing both wrought iron and steel. Until that time, steel had been very expensive to produce and its uses were limited.

It was Henry Cort who, in 1783, discovered an economic method of producing wrought iron. His 'puddling furnace' produced molten iron that could be rolled straight away, while it was still soft, into rails for railways, pipes, or even sheet iron for shipbuilding.

20th Century Iron and Steel Production

Iron is the fourth most common metal in the earth's crust. It makes up 5% of its weight. Iron occurs naturally in a variety of ores in sedimentary rocks:

Iron pyrites, or fool's gold, cannot be used to make iron because of its high sulphur content which makes the iron too brittle.

Although the early iron industry used "bog ore" to obtain iron, ironstone is the most common iron ore and it is extracted from open cast (surface) sites in England, from the River Humber to the River Severn.

To obtain iron from ironstone the ore is first roasted with coal. This process is called sintering. Sintering drives off impurities, such as water, carbon dioxide, sulphur dioxide and arsenic compounds. It leaves a sinter which is mainly granules of magnetite (an oxide of iron).

The magnetite is then reduced in the blast furnace. The sinter is mixed with high grade coke and limestone (calcium carbonate). Hot air at 2 atmospheres pressure, is blasted into the furnace, creating temperatures of up to 1900°C. The iron ore reacts with carbon monoxide in a reduction reaction producing iron and carbon dioxide. Any impurities fuse with the limestone to form a sludge which sinks to the bottom of the furnace. The molten iron, known as pig iron, lies on top of the sludge and can be run off. If the pig iron is re-melted and poured into moulds, it sets as cast iron.

Cast iron is brittle which makes it impractical for some uses. However, it does have a high compression strength and can be heated with air and hammered to produce wrought iron. Hammering cast iron into wrought iron was a long process.

To be converted into steel, the pig iron has to be melted in the presence of oxygen to remove any remaining impurities. Then an alloy of iron, manganese and carbon, is added. The result is a tremendous display of explosive sparks which shoot out of the converter. The carbon converts the iron into steel. High carbon steels are extremely strong and durable.

The History of Iron and Steel Manufacture

Iron was first extracted from its ores over 5000 years ago. Until the 18th century, charcoal was used as the reducing agent. By the early 18th century, charcoal was in short supply and had become expensive. It took 200 acres of forest to supply one iron works for one year, and iron was in demand.

Abraham Darby I

Abraham Darby I owned an iron works at Coalbrookdale in Shropshire. His iron works made everything from domestic pots to the huge iron cylinders needed for Newcomen's steam engine. In 1709, when he was 31 years old, Darby developed a new process for smelting iron. This new process made pig iron, and it used coke instead of charcoal. The demand for coke increased, as did the demand for Newcomen's steam engines since they were used to pump water out of coal mines. Although coke was the cheaper option, it took another 50 years before it completely replaced charcoal.

Benjamin Huntsman

Benjamin Huntsman, a 36 year old clockmaker, made steel, in small quantities, as early as 1740. He did not "discover" steel, however. In 334 B.C., Aristotle had described Damascus steel which had been used to make swords. Huntsman made steel by putting molten iron into earthenware crucibles and then heating it, while excluding air at the same time.

Matthew Boulton

In 1762, Matthew Boulton set up the Soho Manufactory in Birmingham. His factory made iron which was transformed into useful articles, such as buckles and bolts. What made Boulton's factory so special was that it was large and situated near the Midlands' coalfields. Most of the other iron works at that time were small affairs and built close to forests, since they still depended on charcoal.

Henry Cort

Henry Cort was from Lancaster in Lancashire. His work for the Navy took him to Plymouth. In 1775, after ten years in the west country, he retired from his naval job and bought a small ironworks just outside the city. His innovations in the iron industry earned him the name "Father of the Iron Trade". Cort invented a new process to make wrought iron. His method was called the "puddling process". He also developed a rolling mill to produce wrought iron bars. He patented his inventions in 1783. In Cort's process, the melted pig iron was heated with air and iron ore. The resulting pasty metal was then hammered to remove some of the impurities (or slag). To make iron bars, the molten metal was passed through grooved rollers. As a result of Cort's method, wrought iron production increased by 400% over the next twenty years. Unfortunately, Cort lost his patent when his business partner was discovered to have financed the project using stolen money. Cort went bankrupt and lived the rest of his life on a small pension.

Sir Henry Bessemer

Henry Bessemer was a self-educated man who came from Hertfordshire in England. In 1856, he developed a "basic oxygen converter" to change pig iron into steel. In 1879, Bessemer received a knighthood and a fellowship in the Royal Society for his contribution to the iron and steel industries. Bessemer's process was only suitable for British iron ore, since the ore did not contain much phosphorous. It was not until 1879, that the more advanced Percy Gilchrist and S.G.Thomas method, which was suitable for phosphoric ores as found in Europe, was adopted by the continental steel makers, such as Alfred Krupp in Germany.

Production of pig iron in Britain during the 18th century.

Year	Pig iron production (tons)
1740	17350
1788	68300
1796	125079

After 1770, iron (and later, steel), replaced wood as the material for making industrial machines and tools. In 1806, the annual production of pig iron had reached 272000 tons, which was a 200% increase over 18 years.

Railroad:

Prove: How did this technology have a lasting and profound impact on our lives.

Your argument:

Supporting evidence:

The Railroad

The steel highway improved the lives of millions of city dwellers. By the 1890s, the United States was becoming an urban nation, and railroads supplied cities and towns with food, fuel, building materials, and access to markets. The simple presence of railroads could bring a city economic prosperity. Railroads even helped shape the physical growth of cities and towns, as steam railroads and then electric street railways facilitated growth along their lines and made suburban living feasible.

Mail, sorted enroute aboard Railway Post Office (RPO) Cars, permitted reliable and rapid communication. Railway express and the rise of mail-order merchants permitted people in the most remote rural areas to enjoy inexpensive consumer goods. Telegraphy and railroading had been inseparable since the beginning, and virtually everywhere there was a railroad, there was a telegraph wire.

In 1893, the United States celebrated the 400th anniversary of the "discovery" of the New World with a spectacular fair in Chicago. The Transportation Building at the "World's Columbian Exposition" featured railroad exhibits and equipment from around the world, but the most lavish displays were from Baldwin Locomotive Works, the Pullman Palace Car Company, and other American companies. The B&O erected a huge exhibit tracing the entire history of the railroad, while the Pennsylvania and New York Central railroads had separate exhibit buildings.

The world's fair marks the high point of the railroad in American life. By the mid-1890s, almost the entire North American transport network was oriented around the 200,000 miles of track extending from the Atlantic to the Pacific and also connecting with substantial networks in the neighboring countries of Canada and Mexico.

By then, New York Central's Empire State Express had exceeded 100 miles per hour on its runs to Chicago, leaving no doubt about rail travel's potential for speed. As for comfort, Pullman cars of the day rivaled the finest hotels for the level of service and creature comforts provided. Railroads offered convenience, taking travelers across the continent in less than a week-or down branch lines to the most remote Appalachian hamlet in a matter of days.

On the flanks of almost every steam locomotive, a plaque provided the engine's pedigree. This was its "birth certificate." This plaque was from the 2,475th locomotive built by the Brooks Locomotive Works.

Sanderson Photography, Inc.

In the West, railroads helped open new territory to economic exploitation, and then played a large part in the creation of the first national parks. They also pioneered modern forms of hotels, resorts, and restaurants. As the nineteenth century ebbed, every aspect of society and culture was reflected in the railroad. When the Supreme Court ruled that racial segregation was legal, railroads in the South responded with "Jim Crow" cars having "separate, but equal," accommodations. There also were special Temperance Movement trains, as well as excursions promoting the vote for women.

Americans celebrated the railroad in song, literature, and art. The fledgling motion-picture industry turned its hand-cranked cameras on speeding trains because they were the most exciting things on wheels. Virtually every form of entertainment traveled by rail, from the latest popular magazines to touring circuses and New York theater companies.

By 1900, the people of Canada, Mexico, and the United States had settled a vast continent that the best minds of Thomas Jefferson's day thought would take a thousand years to occupy. Largely because of railroads, it took only a few decades.

Historians argue over the fact whether railroads determined the pace of economic development in nineteenth-century America. Robert Fogel, among others, tried to measure the impact of transportation innovations on American development using tools of new economic history, and concluded that the contribution of railroads was not as crucial as some had maintained[92]. The issue is a controversial one, but the fact remains that the railroads came, saw, and conquered nineteenth century America in more ways than one.

They were liberating - increasing mobility and speed across the continent - as well as confining: they held the power of economic life and death over many communities, often abusing that power. The railroads played an important role in developing new concepts of management and brought forth giant corporations, but usually accompanied by obscure financial practices and greed. They provided employment for thousands and thousands of workers, but the conditions under which these laborers had to work and live made them revolt and informed the nation of the hardships of the working class. The railroads were also to a great extent responsible for the settlement of the West, but simultaneously helped extinguish the Native American population. They were a prize to be won for each part of the divided nation in the volatile years before the Civil War, yet linked the nation together with the first transcontinental railroad in 1869. They were born and raised on government money, yet eventually became the first and most heavily regulated segment of the private sector[93].

The importance of solving the question whether or not the railroads were the prime stimulus for American economic development fades when focusing on the effect they had on society as a whole. One cannot help but wonder how different America would have looked and functioned had it not been for the railroads.

Telegraph:

Prove: How did this technology have a lasting and profound impact on our lives.

Your argument:

Supporting evidence:

The telegraph

The electric telegraph is a now outdated communication system that transmitted electric signals over wires from location to location that translated into a message.

The non-electric telegraph was invented by Claude Chappe in 1794. This system was visual and used semaphore, a flag-based alphabet, and depended on a line of sight for communication. The optical telegraph was replaced by the electric telegraph, the focus of this article.

In 1809, a crude telegraph was invented in Bavaria by Samuel Soemmering. He used 35 wires with gold electrodes in water and at the receiving end 2000 feet the message was read by the amount of gas caused by electrolysis. In 1828, the first telegraph in the USA. was invented by Harrison Dyar who sent electrical sparks through chemically treated paper tape to burn dots and dashes.

Electromagnet

In 1825, British inventor William Sturgeon (1783-1850) revealed an invention that laid the foundations for a large scale evolution in electronic communications: the electromagnet. Sturgeon displayed the power of the electromagnet by lifting nine pounds with a seven-ounce piece of iron wrapped with wires through which the current of a single cell battery was sent. However, the true power of the electromagnet was its role in the creation of countless inventions to come.

Three Telegraph Systems Emerge Based on the Electromagnet

In 1830, an American, Joseph Henry (1797-1878), demonstrated the potential of William Sturgeon's electromagnet for long distance communication by sending an electronic current over one mile of wire to activate an electromagnet which caused a bell to strike.

In 1837, British physicists, William Cooke and Charles Wheatstone patented the Cooke and Wheatstone telegraph using the same principle of electromagnetism.

However, it was Samuel Morse (1791-1872) that successfully exploited the electromagnet and bettered Joseph Henry's invention. Morse made sketches of a "magnetized magnet" based on Henry's work. Morse invented a telegraph system that was a practical and commercial success.

Samuel Morse

While a professor of arts and design at New York University in 1835, Samuel Morse proved that signals could be transmitted by wire. He used pulses of current to deflect an electromagnet, which moved a marker to produce written codes on a strip of paper - the invention of Morse Code. The following year, the device was modified to emboss the paper with dots and dashes. He gave a public demonstration in 1838, but it was not until five years later that Congress (reflecting public apathy) funded $30,000 to construct an experimental telegraph line from Washington to Baltimore, a distance of 40 miles.

Six years later, members of Congress witnessed the sending and receiving of messages over part of the telegraph line. Before the line had reached Baltimore, the Whig party held its national convention there, and on May 1, 1844, nominated Henry Clay. This news was hand-carried to Annapolis Junction (between Washington and Baltimore) where Morse's partner, Alfred Vail, wired it to the Capitol. This was the first news dispatched by electric telegraph.

What Hath God Wrought?

The message, "What hath God wrought?" sent later by "Morse Code" from the old Supreme Court chamber in the United States Capitol to his partner in Baltimore, officially opened the completed line of May 24, 1844. Morse allowed Annie Ellsworth, the young daughter of a friend, to choose the words of the message, and she selected a verse from Numbers XXIII, 23: "What hath God wrought?", which was recorded onto paper tape. Morse's early system produced a paper copy with raised dots and dashes, which were translated later by an operator.

The Telegraph Spreads

Samuel Morse and his associates obtained private funds to extend their line to Philadelphia and New York. Small telegraph companies, meanwhile began functioning in the East, South, and Midwest. Dispatching trains by telegraph started in 1851, the same year Western Union began business. Western Union built its first transcontinental telegraph line in 1861, mainly along railroad rights-of-way.

In 1881, the Postal Telegraph System entered the field for economic reasons, and merged with Western Union in 1943.

The original Morse telegraph printed code on tape. However, in the United States the operation developed into sending by key and receiving by ear. A trained Morse operator could transmit 40 to 50 words per minute. Automatic transmission, introduced in 1914, handled more than twice that number. Canadian, Fredick Creed invented a way to convert Morse code to text in 1900 called the Creed Telegraph System.

Multiplex Telegraph, Teleprinters, & Other Advancements

In 1913 Western Union developed multiplexing, which it made possible to transmit eight messages simultaneously over a single wire (four in each direction). Teleprinter machines came into use about 1925. Varioplex, introduced in 1936, enabled a single wire to carry 72 transmissions at the same time (36 in each direction). Two years later Western Union introduced the first of its automatic facsimile devices. In 1959 Western Union inaugurated TELEX, which enables subscribers to the teleprinter service to dial each other directly.

Telephone Rivals the Telegraph

Until 1877, all rapid long-distance communication depended upon the telegraph. That year, a rival technology developed that would again change the face of communication -- the telephone. By 1879, patent litigation between Western Union and the infant telephone system was ended in an agreement that largely separated the two services.

Samuel Morse is best known as the inventor of the telegraph, but he is also esteemed for his contributions to American portraiture. His painting is characterized by delicate technique and vigorous honesty and insight into the character of his subjects.

"The Industrial Revolution occurred in the mid-eighteenth century in Britain" (Kishlansky). "The Industrial Revolution was a continuing period of economic growth and change which were caused by technological innovations in the process of manufacturing" (Kishlansky). One of the greatest inventions during the Industrial Revolution was the telegraph. "Samuel Morse in 1832 was assisted by Alfred Vail who created the idea for an electromechanical telegraph, which he called the "Recording Telegraph" (History Wired). In 1837 the telegraph began to get remodeled into a working mechanical form by Morse, Vail, and a colleague, Leonard Gale. "Joseph Henry provided electricity in 1836 with his "intensity batteries," which were sent over a wire" (History Wired). The electric flow in the wire was disrupted for some short and long periods by pressing down on the device. In 1838 Morse put together a corporation and made Vail and Gale his partners. Morse began receiving funds from Congress to start an illustration where the line would be between Washington and Baltimore. Morse was not a businessman so naturally he had no plan to put together a line. This led to Morse switching to a construction of telegraph poles which was much more successful. "In 1845 Morse hired Amos Kendall as his agent to locate potential buyers. Kendall had no problem for convincing others of the profit and had a small group of investors that put up $15,000. The investors form the Magnetic Telegraph Company" (History Wired). The competition for a telegraph began heading up and there were over 50 telegraph companies competing in the United States. "Judge Samuel L. Selden had the House telegraph patent suggested that they should acquire all of the companies west of Buffalo and unite them to a single system" (History Wired). This led to the creation of a company called "New York and Mississippi Valley Printing Telegraph Company" which later became the Western Union Telegraph Company. "In 1870 William Vanderbilt tried to get control of the major telephone patents and the new telephone industry" (History Wired). "Through the remainder of the 1800s, the telegraph became one of the most significant factors in the development of social and commercial life of America. Two new inventions, the telephone (1800s) and the radio (1900) began to replace the telegraph as the leader of communication" (History Wired). "In 1908, AT&T got control of Western Union which helped Western Union because it allowed the companies to share lines when needed, but then AT&T separated itself to prevent the government from invoking antitrust laws" (History Wired). Even with all the ups and downs Western Union survived and was one of the first communication empires. Western Union to some was the considered to beginning of what Americans should expect in the future of communication.

"The first advancement of the telegraph occurred during the 1850's when operators realized that the clicks of the recording instrument portrayed a sound pattern which was understandable by the operators as dots and dashes. This led for the operator to be able to hear the message by ear and simultaneously write it down" (History Wired). These advancements were only some that altered the telegraph into a quick and accessible system. Another huge advancement was the invention of Duplex Telegraphy that let two messages be delivered over a wire at the same time, one in each direction. "Thomas Edison created the Quadruplex which let four messages be transferred over the same wire at the same time" (History Wired). One more improvement was "Buckingham's Machine Telegraph that was improvement to the House System. It printed received messages in plain Roman letters quickly and legibly on a blank message that was ready for delivery" (History Wired). Historically, it's obvious that the telegraph was such an important invention during the Industrial Revolution. The telegraph changed communication and allowed people from all over the world to connect with one another.

One of the greatest technological advances was from the telegraph to the telephone. "The telephone came as a result of Alexander Graham Bell's direct result of his attempts to improve the telegraph" (Bellis). Bell started working with electrical signals. When Bell began working the telegraph had already been a highly successful system for over 30 years. "One downfall to the telegraph was it was limited to sending and receiving one message at a time" (Bellis). With Bell's understanding of music it allowed him to communicate multiple messages over the wire at the same time. Bell later on began to work with electricity allowed him to put work on his "harmonic telegraph". Bell began to work with Thomas Watson which led for them to prove that the electric strength of an electric current in a wire could vary based on different tones. This led to them creating a working transmitter that could allow a receiver and electronic currents to replicate the variation in frequencies. "Bell's greatest success was achieved on March 10, 1876 marked not only the birth of the telephone but the death of the multiple telegraph" (Bellis). One of the big improvements of the telephone over the telegraph was that anyone could use the telephone. In order to use the telegraph you would have to understand the Morse code or have to travel to a nearby office. Another improvement was the telephone allowed people from all over the world to communicate with one another. The telephone was a very orchestral in a business setting which allowed them to communicate with their salesmen and customers. The telephone and telegraph were a huge boast in the economy during the Industrial Revolution. “The telephone and telegraph also helped society, business, and the military which would suffer if we were still using methods such as the Pony Express and steamboats to communicate” (Bellis). The telephone and telegraph were such great inventions because they allowed people to communicate with one another and changed the speed in which people were able to communicate. This is why the telephone and telegraph changed communication and allowed for people all over the world to connect with one another.

The telegraph was the main reason for the improvement of communication during the Industrial Revolution. The improvement of communication in the world led to regional and local areas being merged into larger national ones. “In some areas, small firms grew, merged, and vertically integrated into large, multifunctional firms coordinating various functions or stages of economic activity internally” (Yates 149). The telegraph helped businesses economically by reducing the time and cost for communication of long distance which led to the emergence of efficient and large markets. Yates argues that “ the telegraph encouraged the growth and vertical integration of firms by forwarding the emergence of national market areas to absorb local and regional market areas” (Yates 150). This allows for the big markets to get new quicker and easier. “The telegraph expanded the area within which goods could be bought and sold under the influence of market forces” (Yates 151). This permitted people to almost instantaneously get information and produce transactions. The increased production of telegraphs led to postal rates dropping and led to communication being less expensive. Another important economic impact was with the increase in demand of telegraphs led to more jobs being available. These are all reasons why the telegraph had a huge economic impact on the economy.

The political effect the telegraph had was with arrival of sound broadcast. The government was required because of there resources to purchase the radio transmitters. “While owning the transmitting stations they could then be used for national propaganda purposes” (Marconi). One of the first to see how important the radio was was the military. The first to actively use radiotelegraph equipment in 1903 were the British naval ships. The use of the radio in the military was very slow at first because it was inefficient. The first time Marconi wireless telegraphy was used in battle was in the Boer war. A later improvement of antenna performance allowed for a later development of radio use in battle. The aforementioned instances in history are the reasons the telegraph had such a great political effect.

I believe where the telegraph had its greatest impact was on its social effect. First off the telegraph promoted the growth of monopoly capitalism and imperialism. Another thing the telegraph did was separate communication from transportation. Until the telegraph was invented communication was something that was hard to come by. Since the telegraph was created, it allowed for messages to be relayed on to other people. The telegraph also led to the creation of the telephone. Both the telephone and telegraph changed communication in the world today. The communication let people from everywhere be able to receive and send messages. These reasons show why the telegraph had a big social impact on the economy.

As you can see the telegraph had a big effect during the Industrial Revolution. The telegraph changed communication and allowed for people all over the world to connect with one another. I believe that its clear to see why the improvement of the telegraph into the telephone had such a big impact.

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Internal Combustion Engine:

Prove: How did this technology have a lasting and profound impact on our lives.

Your argument:

Supporting evidence:

Internal Combustion

The principle behind any reciprocating internal combustion engine: If you put a tiny amount of high-energy fuel (like gasoline) in a small, enclosed space and ignite it, an incredible amount of energy is released in the form of expanding gas. You can use that energy to propel a potato 500 feet. In this case, the energy is translated into potato motion. You can also use it for more interesting purposes. For example, if you can create a cycle that allows you to set off explosions like this hundreds of times per minute, and if you can harness that energy in a useful way, what you have is the core of a car engine!

Almost all cars currently use what is called a **four-stroke combustion cycle** to convert gasoline into motion. The four-stroke approach is also known as the **Otto cycle**, in honor of Nikolaus Otto, who invented it in 1867. The four strokes are illustrated in **Figure 1**. They are:

- Intake stroke
- Compression stroke
- Combustion stroke
- Exhaust stroke

Figure 1

You can see in the figure that a device called a **piston** replaces the potato in the potato cannon. The piston is connected to the **crankshaft** by a **connecting rod**. As the crankshaft revolves, it has the effect of "resetting the cannon." Here's what happens as the engine goes through its cycle:

1. The piston starts at the top, the intake valve opens, and the piston moves down to let the engine take in a cylinder-full of air and gasoline. This is the **intake stroke**. Only the tiniest drop of gasoline needs to be mixed into the air for this to work. (Part 1 of the figure)
2. Then the piston moves back up to compress this fuel/air mixture. **Compression** makes the explosion more powerful. (Part 2 of the figure)
3. When the piston reaches the top of its stroke, the spark plug emits a spark to ignite the gasoline. The gasoline charge in the cylinder **explodes**, driving the piston down. (Part 3 of the figure)

4. Once the piston hits the bottom of its stroke, the exhaust valve opens and the **exhaust** leaves the cylinder to go out the tailpipe. (Part 4 of the figure)

Now the engine is ready for the next cycle, so it intakes another charge of air and gas.

Notice that the motion that comes out of an internal combustion engine is **rotational**, while the motion produced by a potato cannon is **linear** (straight line). In an engine the linear motion of the pistons is converted into rotational motion by the crankshaft. The rotational motion is nice because we plan to turn (rotate) the car's wheels with it anyway.

Now let's look at all the parts that work together to make this happen, starting with the cylinders.

Internal combustion engines are most commonly used for mobile propulsion in vehicles and portable machinery. In mobile equipment, internal combustion is advantageous since it can provide high power-to-weight ratios together with excellent fuel energy density. Generally using fossil fuel (mainly petroleum), these engines have appeared in transport in almost all vehicles (automobiles, trucks, motorcycles, boats, and in a wide variety of aircraft and locomotives).

Where very high power-to-weight ratios are required, internal combustion engines appear in the form of gas turbines. These applications include jet aircraft, helicopters, large ships and electric generators.

The internal combustion engine was invnented by Jean Joseph Etienne Lenoir (Belgian Born). Lenoir made the first internal combustion engine that provides a reliable and continuous source of power, which was the gas engine using coal gas, in 1860, in France.

The creation of the rocket made by the Chinese people is considered to be the simplest kind of internal combustion engine. Also previous pioneers who also worked on the internal combustion engine but failed, also helped in the development of the internal combustion engine.

The first practical internal combustion engine based heavily on experience from the production of steam engines. The engine had a horizontal cylinder; slide valves were used to draw in the fuel-air mixture; and it was double acting, the mixture being fed into the cylinder alternately at either end of the piston. Once it is in the cylinder the mixture was ignited by electric sparks generated at spark plugs by a coil and a battery. This ignition system, a primitive ancestor of modern electric ignition, was unreliable.

Because the first internal combustion engine was unreliable, many later pioneers made improvements of the first internal combustion engine. As a result many new engines were made. Such engines were the two and four stroke engine and the petrol engine. Siegfried Marcus in Austria in 1864 was able to create an engine that uses petrol as a fuel. The first internal combustion engine is the basic form for modern car engines.

The invention of the internal combustion engine made some of man's most cherished dreams become reality: the aircraft, the motor car, the submarine, the tank and many other inventions before they could be born in there practical form. Nowadays the internal combustion engine is for effective and economical than ever, with reduced gas emissions and lower fuel consumption

Factory System:

Prove: How did this technology have a lasting and profound impact on our lives.

Your argument:

Supporting evidence:

The Factory System

WHAT WAS THE FACTORY SYSTEM AND WHY DID IT DEVELOP? WHAT WERE ITS EFFECTS?

The factory system was a new way of organizing labor made necessary by the development of machines which were too large to house in a worker's cottage. Furthermore, the efficient use of the new machines required that many of them be installed together where they could all be driven by the
same power source.

Therefore, workers' homes became separately located from their place of work. All brought together under one roof, it was considerably easier for the factory owner to supervise and closely regulate their workers.

Ruthless competition between owners (capitalists) motivated them to reduce costs and maximize productivity in every way. That meant imposing long hours, low wages, and unsatisfactory, even dangerous working conditions upon the workers. It also meant employing child labor and women's labor because the wages were lower and the work to be done often required little skill.

Working hours were as long as they had been for the farmer, that is, from dawn to dusk, six days per week. Hours were regulated with precision by the factory clock to ensure that a full measure of work was performed. Wages were so low that entire families; father, mother, and children had to work in order that the family might survive at a bare subsistence level. The cruelest form of employment was that of children taken from orphanges or otherwise abandoned. For these unfortunates had no adult to afford them some degree protection from exploitation. The work performed was monotonous and often dangerous. Children employed in coal mines, pushing or pulling coal carts, grew up stunted in growth, and died at an early age, usually by their twentieth year.

While capitalists were gaining increased political power as a result of the liberal revolution, the workers had no political power or influence. When workers tried to organize into the first labor unions, these were often outlawed by a government controlled by capitalists. These circumstances encouraged the development of the socialist ideology.

It also led to the English reform movement.

factory system, system of manufacturing that began in the 18th century and is based on the concentration of industry into specialized—and often large—establishments. The system arose in the course of the Industrial Revolution.

The factory system replaced the domestic system, in which individual workers used hand tools or simple machinery to fabricate goods in their own homes or in workshops attached to their homes. The use of waterpower and then the steam engine to mechanize processes such as cloth weaving in England in the second half of the 18th century marked the beginning of the factory system. This system was enhanced at the end of the 18th century by the introduction of interchangeable parts in the manufacture of muskets and, subsequently, other types of goods. Prior to this, each part of a musket (or anything else assembled from multiple components) had been individually shaped by a workman to fit with the other parts. In the new system, the musket parts were machined to such precise specifications that a part of any musket could be replaced by the same part from any other musket of the same design. This advance signaled the onset of mass production, in which standardized parts could be assembled by relatively unskilled workmen into complete finished products.

The resulting system, in which work was organized to utilize power-driven machinery and produce goods on a large scale, had important social consequences: formerly, workers had been independent craftsmen who owned their own tools and designated their own working hours, but in the factory system, the employer owned the tools and raw materials and set the hours and other conditions under which the workers laboured. The location of work also changed. Whereas many workers had inhabited rural areas under the domestic system, the factory system concentrated workers in cities and towns, because the new factories had to be located near waterpower and transportation (alongside waterways, roads, or railways). The movement toward industrialization often led to crowded, substandard housing and poor sanitary conditions for the workers. Moreover, many of the new unskilled jobs could be performed equally well by women, men, or children, thus tending to drive down factory wages to subsistence levels. Factories tended to be poorly lit, cluttered, and unsafe places where workers put in long hours for low pay. These harsh conditions gave rise in the second half of the 19th century to the trade-union movement, in which workers organized in an attempt to improve their lot through collective action. (*See* organized labour.)

Two major advances in the factory system occurred in the early 20th century with the introduction of management science and the assembly line. Scientific management, such as time-and-motion studies, helped rationalize production processes by reducing or eliminating unnecessary and repetitious tasks performed by individual workers. The old system in which workers carried their parts to a stationary assembly point was replaced by the assembly line, in which the product being assembled would pass on a mechanized conveyor from one stationary worker to the next until it was completely assembled.

By the second half of the 20th century, enormous increases in worker productivity—fostered by mechanization and the factory system—had yielded unprecedentedly high standards of living in industrialized nations. Ideally, the modern factory was a well-lit, well-ventilated building that was designed to ensure safe and healthy working conditions mandated by government regulations. The main advance in the factory system in the latter part of the century was that of automation, in which machines were integrated into systems governed by automatic controls, thereby eliminating the need for manual labour while attaining greater consistency and quality in the finished product. Factory production became increasingly globalized, with parts for products originating in different countries and being shipped to their point of assembly. As labour costs in the developed countries continued to rise, many companies in labour-intensive industries relocated their factories to developing nations, where both overhead and labour were cheaper.

Group work:

Debate: You must defend your assigned technology to the group with the information you recorded below in an open debate.

Consensus and Justification: come to a consensus by ranking the technologies and providing a written justification for the order.