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The Steam Engine and Industrialization

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Iron, Coal and Steam: The Building Blocks of the Industrial Revolution

Many staples of our modern day society from bridges and sewers to factories and steel plants are results of the industrial revolution in 18th and 19th century Europe. In England; iron, coal and steam really pushed the revolution forward. The steam engine, in particular was an essential part in the revolutionary machine. The revolution blossomed out from the steam engine. For example, the mining of coal, factories, and machines such as the steam locomotive are direct results of it. As the brain child of Thomas Newcomen and James Watt, the steam engine fueled the fires of the English Industrial Revolution which spread all over the world.

Background:

The steam engine was a machine that could be applied in many different areas. It was used in everything from pumping water out of mines to transporting people great distances. In England, one of the oldest steam engines has been in service since 1813 and still is to this day. Located in Wiltshire, the number 42B steam engine at the Crofton Pump Station, pumps several tons of water a minute into locks along the Kennet and Avon Canal. The engine is very complex due to all the gears, axles, crankshafts and connecting rods moving about. However the main force producing the engines power is due to the piston and cylinder system. Steam pressure is built up inside a boiler, flows into the cylinder and pushes up against the piston head. As the

piston reaches the bottom of the cylinder, a vacuum inside the cylinder causes the piston to move back up the cylinder towards it original starting position.

This pressure and vacuum idea was developed over many centuries of scientific discovery and thought. Many scientists and philosophers have fiddled with the idea of air pressure and vacuum. Around the first century A.D., Heron of Alexandria showed the expansive power of steam pressure. He constructed a simple device called an aeolipile. It was a metal sphere with two bent tubes located at either end. This was on an axle that carried steam from a boiler into the sphere. As steam would enter the sphere it would exit the bent tubes and cause it to rotate. Heron's aeolipile showed how steam pressure could cause mechanical rotation. However, steam pressure is not the only contributor to the number 42B engine's power. A vacuum is needed to bring the piston back to the top of the cylinder. Otto Gericke, born in Germany, showed how the absence of air, a vacuum, held two metal hemispheres together despite thousands of pounds of force attempting to pull them apart.

Gericke constructed two copper hemispheres which came to be known as the Magdeburg hemispheres. He fitted these spheres together, pumped out the air and amazed crowds because teams of horses could not pull the objects apart. The atmospheric pressure on the outside of the spheres was what held them together. This is what completes the cycle for the number 42B engine. Steam pressure pushes down on the piston and then atmospheric pressure pushes up on the piston because of the vacuum inside the cylinder. Thomas Newcomen and James Watt put these ideas together to produce the steam engines which influenced the Industrial Revolution.

Ancient Romans had used piston and cylinder pumps to remove water from mines for centuries. In 1712, Thomas Newcomen created an engine based off the early Roman idea. He constructed an engine that consisted of boiler, a piston and cylinder system and a water jet. The boiler would create steam which flowed into the cylinder, moving the piston. The water jet, located inside the cylinder would condense the steam and create a vacuum. The atmosphere would push down on the piston returning it to its original position. This up and down motion was harnessed in removing massive quantities of water from mines. The engine ran much like a modern day oil well, removing liquid with each stroke. However, it was slow and demanded huge quantities of coal. Nevertheless, Newcomen created an engine that saw immediate profitability. Coal mines, for example, could be excavated at deeper depths than ever before. His engine replaced huge teams of horses and men. "By 1769, there were 120 Newcomen engines in use at coal mines" (Bland 18). Bland indicates that by 1769—only 57 years after the creation of the engine—120 were already in use at coal mines. Newcomen's engine revolutionized coal production in a relatively short time. It was the first engine that ignited the English Industrial Revolution.

Newcomen's engine was outstanding. It changed how coal would be mined and it was faster and much more profitable than men and horses. However, it was not very fast and huge amounts of heat were lost in between each stroke. James Watt saw these inefficiencies and sought out to solve them. Watt made some minor but effective changes that cut down on fuel by 75 percent. In 1769, he added an air pump which further improved the power of the engine. By 1787, safety gauges for steam pressure and temperature were added as well as a cast iron working beam, replacing the old wooden one. Matthew Boulton, Watt's business partner, further

influenced Watt's engine by adding a flywheel. The flywheel stored up energy and allowed the engine to operate with less coal. Boulton & Watt, the company started by Matthew Boulton and James Watt, created engines that were more universal than Newcomen's engine and were applied to more forms of industry. Textile mills, saw mills and iron furnaces were steam powered and became much more productive. Practically everything was powered by a Boulton and Watt engine. In fact, the number 42B engine at the Crofton Pump Station was one such engine. Due to Watt's innovativeness, engines like the number 42B could pump tons of water a minute. These engines, successful in many areas, raised production levels in England greatly. Textiles were produced at enormous rates, saw mills were steam powered instead of water powered, and coal was mined at great amounts. Watt's engine expanded the reach of steam power to other forms of industry.

Locomotives propelled the Industrial Revolution forward. They carried goods hundreds of miles across continents and moved people at high velocities. However, early steam engines were not as powerful or complex as today's high speed trains. The first steam locomotive, the *Rocket,* was built in England by George and Robert Stephenson. Constructed in 1829, the *Rocket* was like the *Saturn V* rocket of the 19th century. It had a six foot long boiler, complex linkages, and flanged wheels. The idea of the steam locomotive was simple; it could transport goods at high speeds from place to place. In fact, the *Rocket* would travel from Manchester to Liverpool, transporting cotton. Compared to the great steam locomotives of the 20th century, the *Rocket* does not stand up much. However in 1829, it was revolutionary. It ushered in an era of railroading that continues to this day.

The development of technology in 17th and 18th century England pushed the Industrial revolution forward. Many scholars have pondered the causes of the revolution in England. Some argue that the laws of England promoted industrial growth. Or perhaps England's access to coal started the Industrial Revolution. These all had a part in the revolution. William Rosen indicates that, "the Industrial Revolution was, first and foremost, a revolution in *invention*" (xix). Rosen shows that invention was the force behind the revolution. For instance, the steam engine was invented and utilized to remove water from coal mines. In the years following the Industrial revolution many great engineering works like the Brooklyn Bridge, London Sewers, Transcontinental Railroad and the Panama Canal were created.

The Panama Canal, constructed in the late 19th and early 20th century, was a massive undertaking. The canal is nearly 50 miles long and passes through the harsh terrain of Panama. Started by the French in 1881, it did not reach completion until America finished it in 1914. Construction on the canal was difficult due to disease, rain and mudslides. The ground was soaked with water which made it hard to excavate. However, the use of steam shovels, dynamite and trains helped with excavation and construction. Machines invented during the Industrial Revolution including the steam engine helped with the creation of the Panama Canal.

The process of invention and innovation helped bring the aeolipile to the huge steam engines of the Titanic. The need for more coal and harder steel is one of the causes of the Industrial Revolution. Thomas Newcomen constructed an engine to remove water from coal mines. From this the steam engine blossomed out to factories, mills, and even locomotive

technology. This allowed England to produce more goods and to transport them quicker. England therefore, became the leader of the Industrial Revolution.

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