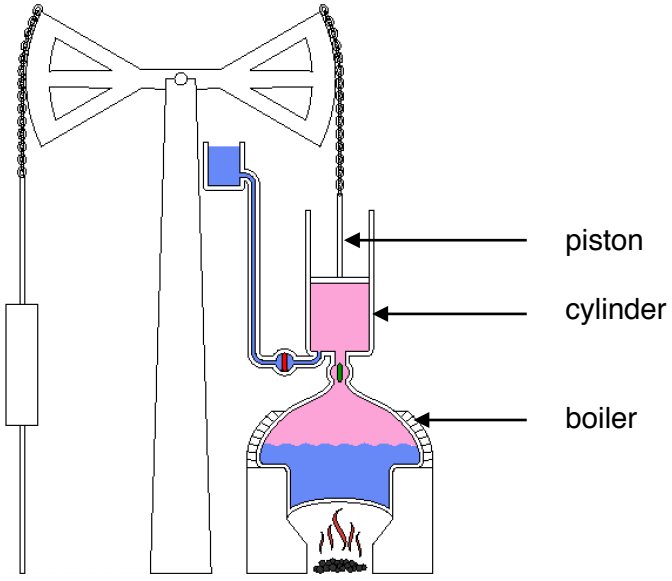
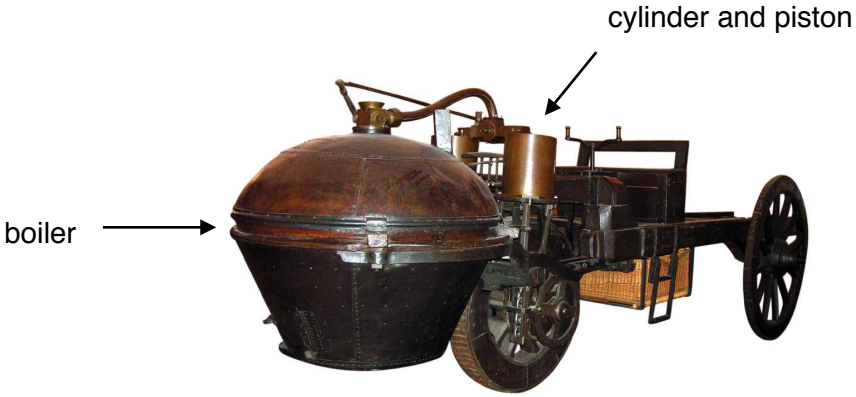
F. The Second Power Revolution, Part 1: Oil

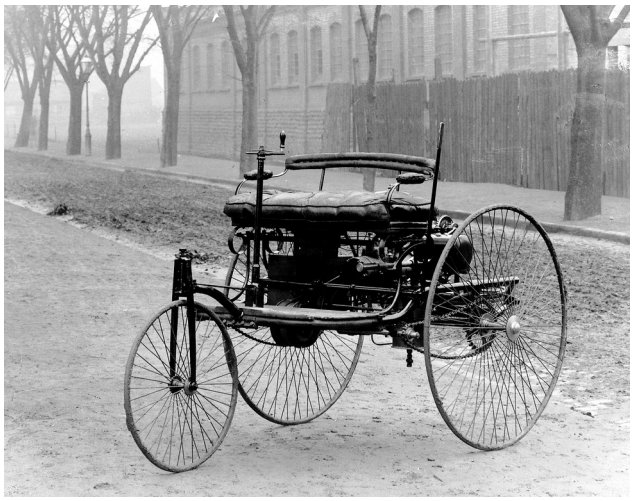
1. The formation of the Standard Oil company of John D. Rockefeller in **1870** is one way to capture the transition to truly industrial technology. Oil (refined into gasoline) is the fuel that makes possible kinds of engines used in automobiles and airplanes.
2. Steam engines could never have been used in cars and planes for the simple reason that they are too large and heavy. A steam engine gets its power from a vessel called a "boiler" in which water is boiled to create steam, usually by burning coal. The pressure created by that steam then enters the "engine"—a cylinder in which pressure changes move a piston, as in the diagram of a simple steam engine below.



3. Steam engines are sometimes called "external combustion engines," because the burning of of the fuel is done outside the engine itself, in the boiler. If a car had such an engine, it would look something like this:

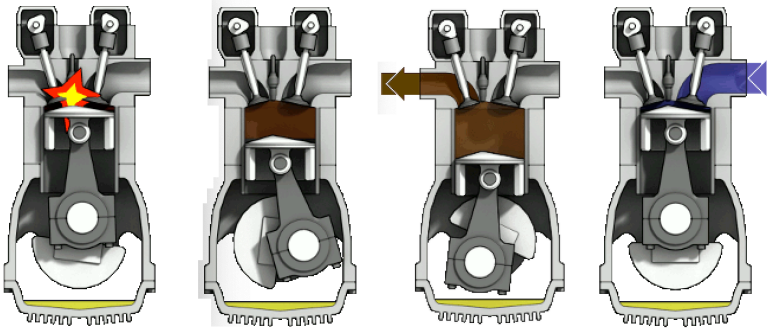


4. By contrast, "internal combustion engines" are much smaller and lighter.



The first Mercedes Benz - 1885!

5. The ability to burn gasoline inside the engine is why motors of this kind are called "internal combustion engines." As per the diagram below, in such an engine a mixture of fuel and air are pumped into the cylinder, and then exploded! The explosion creates the pressure to move the piston and create a mechanical force.



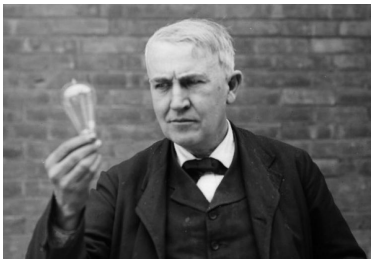
A fuel-air mixture explodes thanks to a spark plug, driving the piston down, cranking the axle that turns the wheels of the vehicle, and pumping the exhaust out, permitting the entry of new fuel. This process occurs perhaps 30-50 times per *second* in your family car as it travels down the road!

6. Small and light engines were needed for the first airplane, flown by the Wright Brothers in **1903**, and then in mass-produced automobiles like the Ford Model-T, which began production in **1908**.

7. Meanwhile, a parallel power revolution was transforming other aspects of industrial life such as the livability of our shelters, our ability to communicate at great distances, and our ability to produce and distribute food…

G. The Second Power Revolution, Part 2: Electricity

1. The Industrial phase of the history of technology is also called the *"Industrial Revolution,"* because so many inventions were created so quickly, from cars and planes to lightbulbs, refrigerators and televisions.
2. Many of these inventions are based on the science of "electro-magnetism," which has to do with electricity and magnets, and how they work together.
3. The first useful communication device based on electro-magnetism was the telegraph of **c.1837** by Samuel Morse (after whom "Morse code" is named). Telegraphs were powered by batteries that sent an electric signal down a wire, which could be changed by a Morse key to create a message.
4. As batteries improved, other uses for electricity were imagined by amazing inventors, such as Alexander Graham Bell, who invented the telephone **c.1876** and Thomas Edison, who invented the light bulb **c.1879.**
5. When the ability to generate electricity using motors called "turbines" with water falling from a great height (such as at Niagara falls) became possible **c.1882**, it was possible to create great amounts of electricity—enough to light the cities and homes of the world!
6. Who can even begin to calculate what new wonders were created because inventors could work through the night in well-lit laboratories and offices from that point onward?!

Alexander Graham Bell makes his first famous public telephone call in **1876** (left) and Thomas Edison shows off his lightbulb in **1879.**