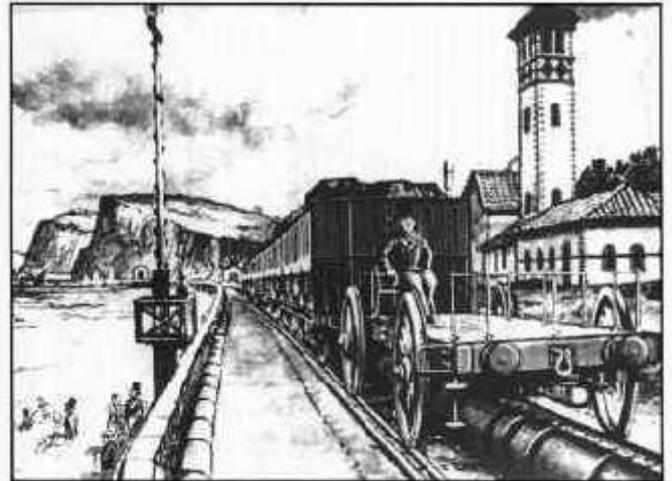


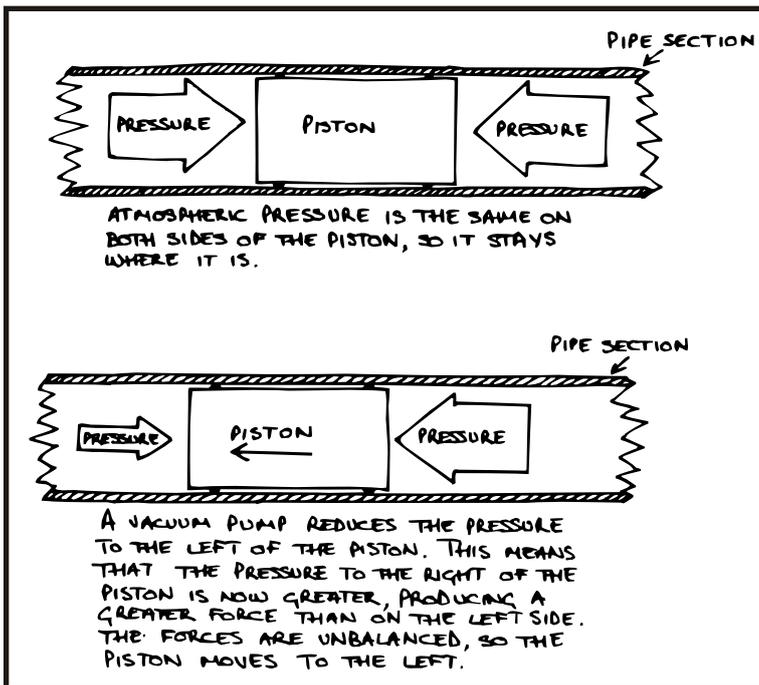
The Atmospheric Railway

The Atmospheric System for propelling railway carriages was patented in 1839 by Samuel Clegg and Jacob and Joseph Samuda.

It was used to run the first Atmospheric Railway in 1844, in Dublin, Ireland. The trains literally ran on air - a close fitting piston was placed inside a pipe and a vacuum pump was used to remove the air from in front of the piston. As the air was removed and the pressure dropped, the force with which it pushed back on the front end of the piston became less than the force pushing the piston forwards. The forces acting on the piston were therefore unbalanced, causing the piston to move.



The Atmospheric Railway in operation between Exeter and Teignmouth



The difficult part was connecting the piston to the train carriages. To do this, the pipe containing the piston had a slot running along the top which was sealed with a hinged leather flap.

A connecting rod could then run from the piston to the carriage as the pipe was laid between the tracks of a railway line.

Steam-powered engine houses were built at intervals along the track and extracted air from the pipe in front of the piston, so that the air pressure behind pushed it and the train along. A series of small wheels beneath the piston carriage opened and closed the leather flap as the train passed.

The people of Dublin, used to being covered in smoke and soot from conventional steam locomotives, were delighted and flocked to travel on this silent, smokeless marvel.

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The Atmospheric Railway

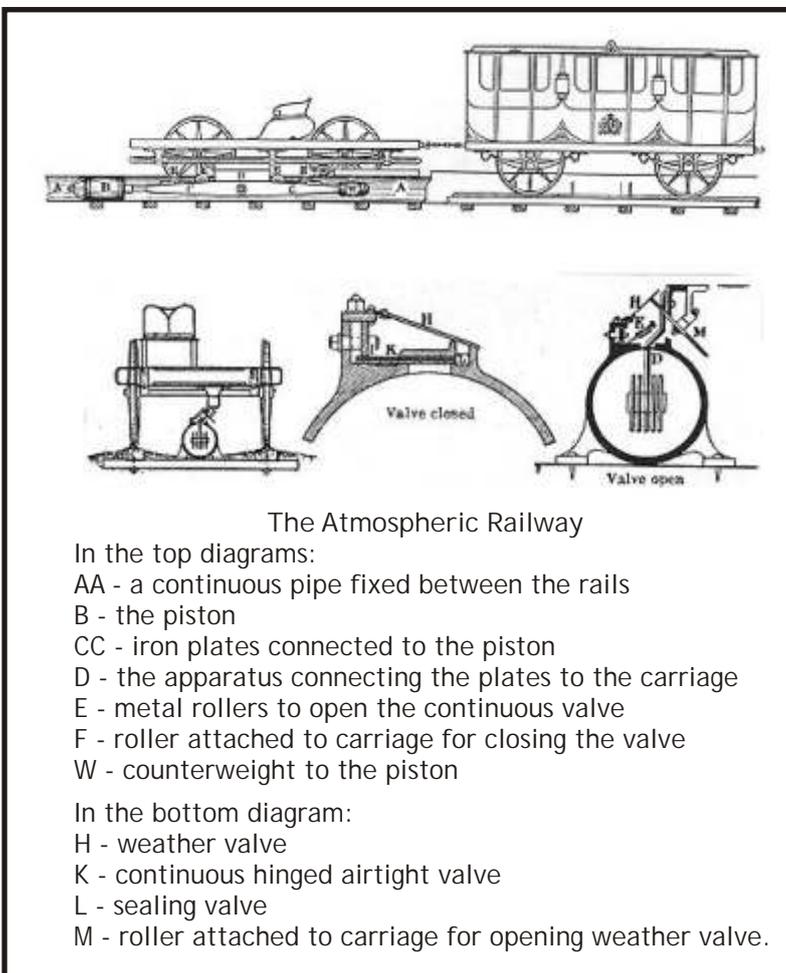
In the mid to late 1840s other Atmospheric Railways were run as far and wide as Croydon and Paris. However, the most ambitious project was Brunel's plan to run an Atmospheric Railway 52 miles (83km) from Plymouth to Exeter.

Almost from the start it was known as the 'atmospheric caper' and was plagued with difficulties. The original 12 inch (30 cm) pipe was found to be too small to cope with the steep hills in that area of the country and had to be replaced with a 15 inch (38 cm) pipe. Unfortunately, the pumping stations had already been built along the first stretch of the line and they had to work much harder than planned because of the change in pipe size. As a result they often broke down. The pipes themselves were too roughly cast and there were great difficulties with the leather flap sealing the slot on top of the pipe. It often cracked and had to be kept greased with tallow to try

to prevent this from happening but unfortunately rats were attracted to the tallow and also ate the leather.

The first atmospheric passenger trains ran in September 1847 and it soon became popular with passengers who very much appreciated the smooth, quiet ride, if not the frequent breakdowns when third class passengers were obliged to get out and push! During the spring and summer of 1848 nine trains a day were running between Exeter and Teignmouth.

These trains reached average speeds of 64 miles per hour (103 kilometres per hour) and weighed over 30 tons each. However, when it was realised that the whole leather flap system was going to need replacing after just one year of service at a cost of £25,000 it was decided to abandon the project. By this time the line had been completed from Exeter to Newton Abbott and the last atmospheric passenger train ran from Exeter to Newton Abbott in September 1848. After this the line was taken over by steam locomotives.



Although the project ultimately failed it gives an insight into what made Isambard Kingdom Brunel a truly great engineer; he was never afraid to try new ideas.



Build your own Vacuum Cannon

The vacuum cannon works on exactly the same principle as Brunel's Atmospheric Railway. It uses atmospheric pressure to provide a force which pushes an object along a tube containing a vacuum.

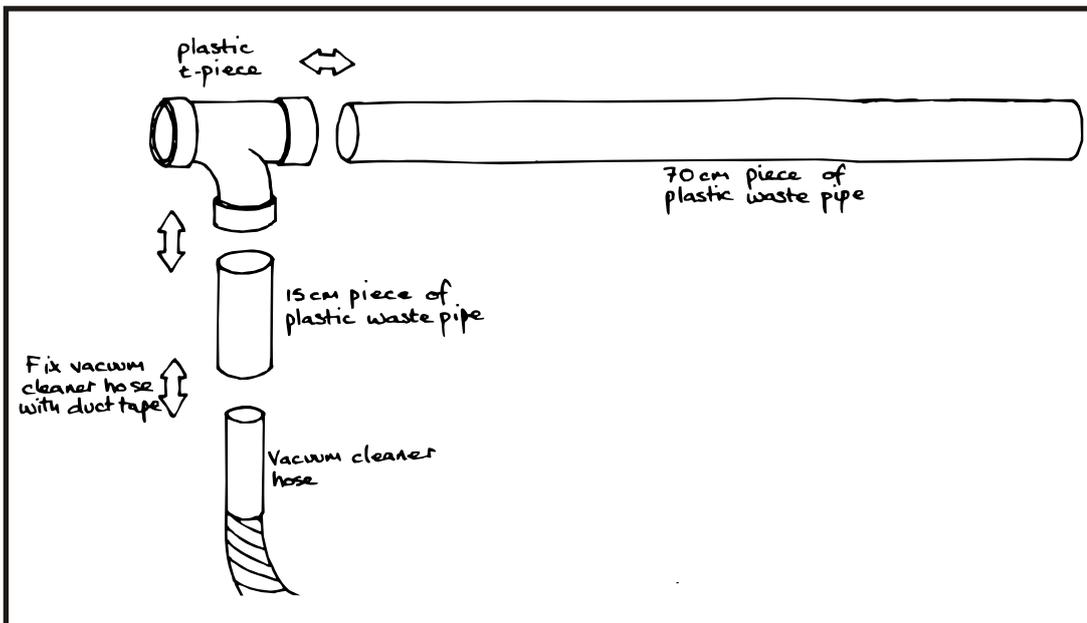
What you will need

- Duct tape
- Two pieces of 40 mm diameter plastic waste pipe, one approximately 70 cm long, the other approximately 15 cm long
- A t-piece to fit the waste pipe
- A vacuum cleaner
- A piece of paper
- A hot glue gun
- A plastic container from inside a chocolate egg
- Some garden twine or other string

Making the cannon

Fit the t-piece onto one end of the 70 cm length of pipe. It is important that there are no obstructions inside the pipe or t-piece to stop your projectile. If there are any protruding plastic tabs inside the t-piece, these will need to be removed. Make sure that the pipe and t-piece are fitted together firmly.

Next, fit the shorter length of pipe to the other arm of the t-piece. The vacuum cleaner will attach to this section so there is no need to remove any plastic tabs that may be present in this section.



Connect the vacuum cleaner to this section of pipe using duct tape to give a good seal.

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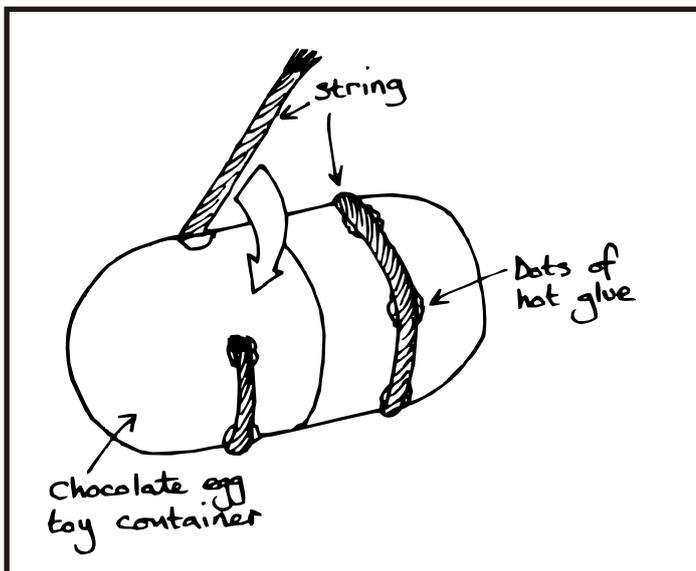


Build your own Vacuum Cannon

Making the projectile

The trickiest part about making the cannon is making the projectile which it will fire. The key to making your cannon work well is making sure that the projectile it is going to fire fits in the barrel with a good air-tight seal. However, the fit must not be too tight or friction between the projectile and the barrel will slow down the projectile and stop it shooting the barrel.

There are a number of different ways to build the projectile but possibly the easiest is to use one of the plastic containers used for holding toys inside certain types of chocolate egg. These are lozenge shaped and snap together in two halves. They are slightly smaller than the inside diameter of the plastic pipe, which allows room to fit a seal around them.



The seal is made by wrapping two pieces of string around the container as shown in the diagram below and carefully fixing them in position with dots of hot glue. The string needs to be trimmed to just the right length so the two ends meet up with no gap, giving as airtight a seal as possible.

When using a hot glue gun take care not to get the glue on your hands as it can be hot enough to make skin blister.

It is important to make sure that the dots of hot glue are not too big or they will rub on the barrel and increase friction between the projectile and the barrel, which will slow the projectile down and decrease the distance it will fly.

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Build your own Vacuum Cannon

Firing your vacuum cannon safely Requires adult supervision

Firing the vacuum cannon is easier with two people. One person can hold and aim the cannon, while the other can release the projectile.

Your cannon should fire its projectile up to about 15 metres, depending on how airtight and friction free the seal on the projectile is, so ensure that you have at least this amount of clear space in front of your cannon. To fire the cannon safely use the following procedure. Read the steps through before you actually do them.

1. Ensure that your partner is holding the cannon in a stable position. The best way of doing this is for them to hold it over their shoulder the way a soldier might hold a bazooka.
2. Check there are no people or other obstructions in front of you.
3. Switch on your vacuum cleaner.
4. Hold the back end of your projectile tightly and place it into the back end of the barrel. Make sure that at least one of the seals is inside the barrel. **KEEP HOLDING THE PROJECTILE TIGHTLY AGAINST THE FORCE PUSHING IT DOWN THE BARREL.**
5. Place a small sheet of paper over the front end of the barrel. This sheet need be only slightly larger than the barrel opening. At the same time the force on the projectile at the back end of the barrel will increase dramatically. Make sure you are ready for this so that the projectile does not slip out of your fingers.
6. Check again that there are no people or other obstructions in front of the cannon. If the coast is clear release the projectile.

Your cannon is surprisingly powerful and on no account must it be deliberately aimed at anyone.

