Heron's Aeolipile

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Science Fair Experiment

Probably the most famous invention of the great Heron of Alexandria (10 CE – 70 CE) was his aeolipile, a steam engine that worked on exactly the same principle as the great machines of the industrial revolution and many modern electricity-generating turbines.

Aeolipile, Daniel Hopton

His machine consisted of a water reservoir with a heat source located underneath, and copper tubing extended upwards from this, acting as the pivot for a rotating sphere. To the outside of the sphere, two nozzles were created from tubing bent out from the surface of this sphere, making an L-shape.

The principle behind the machine relied upon steam from the heated water rising through the copper tubing into the sphere. This steam escaped through the nozzles at high speed, generating thrust according to Newton's 2nd and 3rd laws of motion, causing the sphere to rotate on its axis.

Simpler versions of Heron's aeolipile dispensed with the boiler and simply heated the water in the sphere; this was much easier to build but would not operate for long before the water boiled away.

Replicate Heron’s Aeolipile

Unless you have access to a metalworking shop and the ability to shape and braze copper, building an exact replica of Heron’s aeolipile is impossible. However, you can build a device that works upon exactly the same principle, generating thrust and allowing a vessel to rotate. We have two options, one using liquid and one using steam, both fairly easy to build with everyday items.

Using the Power of Water

A safe way to replicate the work of heron of Alexandria is to take a drinks carton or aluminum can, and use water instead of steam. The principles are exactly the same, although the effect a lot less dramatic!

This experiment is best performed outside if you don’t want to get into trouble for making the floor wet. Otherwise, use a large basin to collect the worst of the water and have a couple of old towels handy.

For this experiment, you need:

- A milk carton
- String
- A frame to hang the apparatus from, or you can hold it if you don’t mind getting wet
- Scissors, knife or a bradawl for making holes in the carton
- Waterproof tape
- A basin, or somewhere to perform the experiment where it doesn’t matter if the floor gets wet

To recreate a version of Heron’s aeolipile:

1. Poke a hole in all four faces of the drinks carton, making sure that they are all near the bottom left corner.
2. Make a hole in the top of the carton and suspend the carton from the string, over the bowl, making sure that it can rotate freely
3. Place a piece of tape over the holes
4. Half fill the carton with water
5. Remove the tape
6. Watch what happens.

You can also do this experiment with an aluminium drink can. Make four holes near the bottom with a nail and, in each case, lay the nail over, so the water will squirt sideways. Cut the top off the can carefully with scissors or a knife (ADULT SUPERVISION REQUIRED) and hang the can, using fishing line and a fishing swivel, under a flow of water.

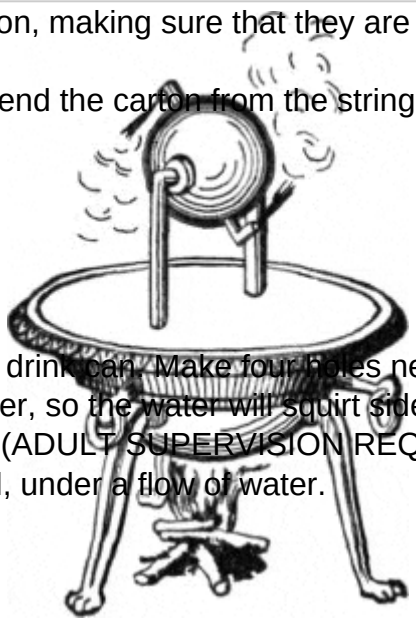


Illustration of the Aeolipile (Public Domain)

How does it Work?

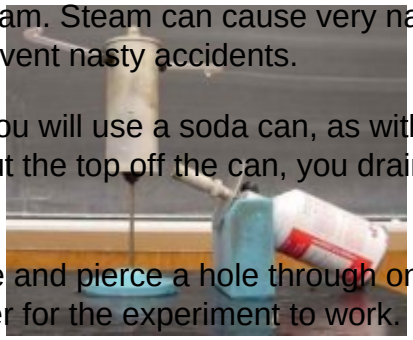
This experiment shows one on the basic principles of physics, that for every action, there must be an equal and opposite action, and this simple principle lies at the root of modern

society. Combustion engines, turbines, lawn sprinklers, and rockets are just some of the machines relying upon the principles shown by Heron.

Newton's Third Law states that every action has an equal and opposite reaction and, as water shoots out of the holes, it pushes back on the carton with equal force. A turbine is formed as the energy of the moving liquid is converted into rotational energy. This principle was well known to Heron of Alexandria [1] (also known to us as Hero of Alexandria).

Advanced Experiment

This experiment uses a heat source and steam. Steam can cause very nasty scalding, so this experiment requires adult supervision to prevent nasty accidents.



Heron's Engine Blowtorch (Creative Commons [2])

To perform this version of the experiment, you will use a soda can, as with the water-based version of the experiment but, rather than cut the top off the can, you drain the drink through the holes.

1. Lay the unopened soda can on its side and pierce a hole through one side, near the top, with a nail. This hole must be off-center for the experiment to work.
2. Flip the can over, allowing the drink to start draining, and pierce again, in the opposite place to the first hole.
3. Force the rest of the drink out of the can, blowing into the hole gently, if required.
4. Submerge the can and ¼ fill with water
5. Turn the ringpull of the can through 180 degrees, covering the part of the can that usually opens, and connect the twine, either by tying it directly with a paper clip, or preferably with a fishing swivel.
6. Hang the apparatus from a wooden frame or scientific clamp, with the stove or Bunsen burner beneath
7. Light the stove and watch what happens as the water heats ands releases steam.

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These experiments are a great way to explore the sophisticated knowledge of Heron and the other Greek thinkers of the time. Their work lies at the foundation of much of our modern knowledge and, by emulating the work of Heron; you are paying homage to a truly great inventor and mathematician.

Soda Can Aeolipile

Links
[1] https://explorable.com/heron-of-alexandria
[2] http://en.wikipedia.org/wiki/User:Finn-Zoltan