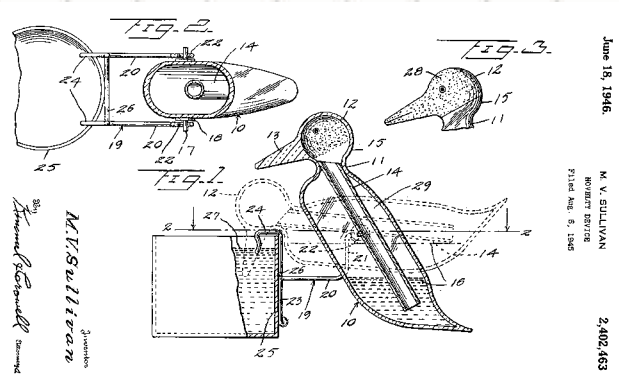


The DRINKING BIRD - A simple heat engine in action



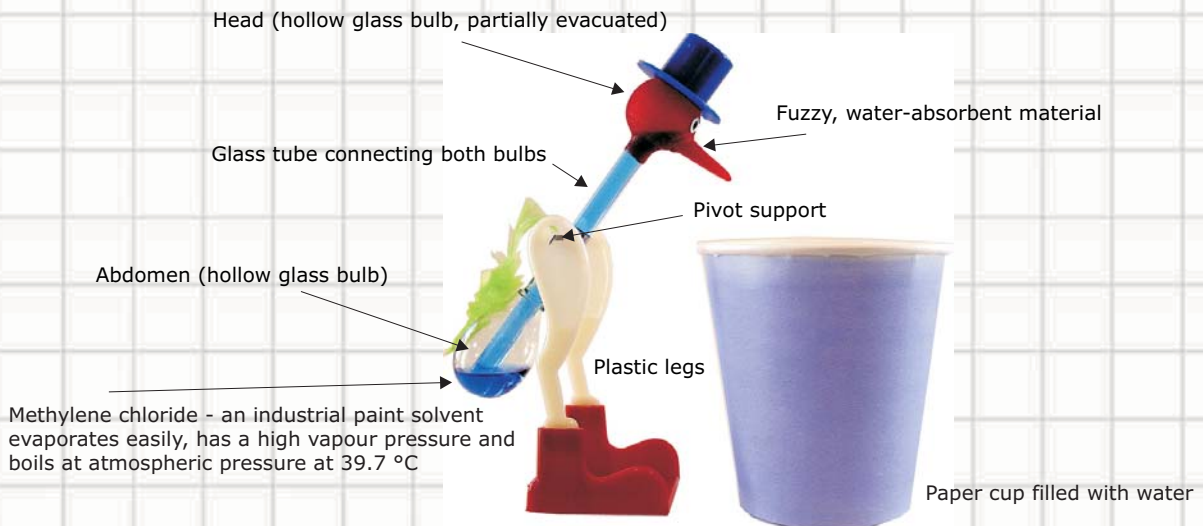
The amazing drinking bird, one of the best known 'classical scientific toys', seems to defy scientific laws by demonstrating the impossible - perpetual motion. Or does it? Without any external energy provided - no electricity or winding - it seems to go indefinitely, dipping its head time and again.

Patented in 1946 by M V Sullivan (U.S. Patent No 2,402,463) this amazing item has been produced by numerous manufacturers over the years and has gained several identities in the process. Some of these being: Dippy Bird, Magic Bird, Thirsty Bird, Bobbing Bird, Drinking Duck and Dunking Bird.



An extract from the first drinking bird patent filed in the USA in 1946.

The parts of the Bird



How does the Drinking Bird function?

1. The head with its water-absorbent felt, is wetted with water. As the water evaporates the head cools down. The bottom bulb is still at room temperature.
2. Methylene chloride evaporates rapidly at room temperature. As the abdomen bulb is at higher temperature, the vaporization tempo is higher than that in the head. This causes a higher vapour pressure in the abdomen bulb.
3. The greater vapour pressure in the abdomen forces liquid up through the neck to the head.
4. As fluid enters the head, the centre of gravity is raised, the bird becomes top-heavy and it tips around the fulcrum.
5. The bird's beak dips into the water and the evaporated water is replaced on the felt head because of capillary action. Note: The bird does not "drink" water - only wets its head.
6. As it dips, a clear passage is opened between the head and the abdomen, allowing the pressures to equalize and the liquid to freely drain to the abdomen.
7. The bird gets bottom-heavy, tips back to the upright position and the process repeats itself.

In short: The drinking bird is an example of a crude heat engine as it converts a difference in temperature (between the cooled head and the abdomen at room temperature) into cyclical motion. The small temperature difference is the driving force and makes it a low efficiency heat engine.

Is it a perpetual motion device?

No, this can never happen. It only appears to be the case but in actual fact, the room's surroundings provide external energy by raising the beak's water molecules' internal energy to evaporation level.

CONCEPTS

Evaporation: The change of a liquid to a gas below the boiling point of the liquid. Some high-energy particles at a liquid's surface vibrate fast enough to escape and form a gas (called a vapour). Their escape energy comes from the particles left behind, therefore decreasing the temperature of the liquid. **Evaporation thus is a cooling process.** We all know that humans are cooled when their skin perspires. (You will never be able to cool a wall, table or tree with a fan!)

Condensation: The change of a gas to a liquid. As a gas cools, its particles move more slowly and the forces between them grow stronger.

Vapour pressure: Molecules at the surface of a liquid escape and exert a pressure on the surrounding atmosphere known as the vapour pressure. When this pressure is the same as the air pressure, the liquid is said to boil. The vapour pressure of water is 3 kPa at room temperature and that of methylene chloride, 46 kPa.

Centre of gravity (CG): The point at which the whole weight of an object acts.

Fulcrum: A point on which a lever turns or is supported.

Capillary action: The process in which the effect of surface tension causes liquid to rise in a small tube.

Volatile liquid: The molecules aren't attracted to each other that strong, so the liquid evaporates much quicker. Ether is a very volatile liquid - this is the smell you sometimes get when entering a hospital.

Specific latent heat of evaporation: The amount of heat needed to change a liquid to a gas. A liquid has to impart energy to the molecules that leave as a vapour.

Further classroom investigation

How can one make the bird operate without wetting its head?

Paint the abdomen black. It is essential to get the head cooler than the abdomen. By painting the abdomen black and exposing the bird to a hot lamp or sunlight, the abdomen will become warmer than the head. The object is to create a temperature difference between the two bulbs.

How can one increase the bobbing rate?

1. Replace the water in the glass with alcohol, eg. surgical alcohol or methylated spirits. (*Prof Bunsen* has tried this and has found that alcohol makes the bird bob every 19 seconds and water every 1,5 minutes. A typical real life situation!!) Compared to water, alcohol is more volatile, has a lower specific latent heat and has a much lower specific heat capacity than water. These facts will ensure that the evaporation and the cooling process happen much faster. Thus alcohol will cool the bird much quicker than water.
2. Expose the bird to a working fan. Better air circulation accelerates the evaporation process on the head.
3. Heat the abdomen with a warm hand. The methylene chloride's evaporation rate increases, increasing the vapour pressure.
4. Can you or the students think of more ways?

How can one decrease the bobbing rate?

Prevent evaporation by placing the bird in a large jar or covered aquarium. After a while the bird stops bobbing as the atmosphere gets saturated with water vapour.

Can one use the bird to indicate the relative humidity - functioning as a hygrometer?

You will need a hygrometer to calibrate the bird. A sealed aquarium will create a range of humidity conditions. Count the number of cycles per 5 minute period under different humidity conditions and let the students graph the results. The lower the humidity, the higher the bobbing rate.

Drinking Bird Snippets

- ☺ An amateur scientist, Don Rathjen, has measured the output of his bird by making it to raise paper clips. He managed to extract one nano horsepower (a microwatt) of work from it.
- ☺ The bird's biggest enemy is - cats! They just can't resist the motion and just have to relieve the bird from its monotonous existence.
- ☺ Earlier versions of the drinking bird contained freon-11, a chemical used to cool fridges and freezers. This is now replaced by methylene chloride as freon gases have a negative effect on the ozone in the upper atmosphere.

Want to read more about the Drinking Bird?

- Journal of Chemical Education 50(3), 213 (March 1973) "Physical chemistry of the drinking duck" Wagner R E
- The Physics Teacher 31, 126-7 (Feb 1993) "The drinking bird - the little heat engine that could" Mentzer R
- The Science Teacher 34-5 (Sept 1977) "Energy is for the birds, too!" Spooner W E

