06-6838 Drinking Bird

Construction

The drinking bird consists of two glass bulbs joined by a glass tube (the bird's neck). The tube extends nearly all the way into the bottom bulb and attaches to the top bulb but does not extend into it. The space inside the bird contains a coloured, volatile fluid.

Air is removed from the apparatus during manufacture, so the space inside the body is filled by vapour evaporated from the fluid. The upper bulb has a 'beak' attached, which, along with the head, is covered in an absorbent material. The whole device pivots on a crosspiece attached to the legs.

Heat engine operation

The drinking bird is a heat engine that exploits a temperature difference to convert heat energy to a pressure difference within the device, and performs mechanical work. Like all heat engines, the drinking bird works through a thermodynamic cycle. The initial state of the system is a bird with a wet head oriented vertically.

The process operates as follows:

1. The water evaporates from the material on the beak and head.
2. Evaporation lowers the temperature of the glass head (heat of vaporization).
3. The temperature decrease causes some of the vapour in the head to condense.
4. The lower temperature and condensation together cause the pressure to drop in the head (by the ideal gas law).
5. The higher vapour pressure in the warmer base pushes the liquid up the neck.
6. As the liquid rises, the bird becomes top-heavy and tips over.
7. When the bird tips over, the bottom end of the neck tube rises above the surface of the liquid.
8. A bubble of warm vapour rises up the tube through this gap, displacing liquid as it goes.
9. Liquid flows back to the bottom bulb (the device is designed so that when it has tipped over the neck's tilt allows this). Pressure equalizes between top and bottom bulbs.
10. The weight of the liquid in the bottom bulb restores the bird to its vertical position
11. The liquid in the bottom bulb is heated by ambient air, which is at a temperature slightly higher than the temperature of the bird's head.

If a glass of water is placed so that the beak dips into it on its descent, the bird will continue to absorb water and the cycle will continue as long as there is enough water in the glass to keep the head wet. However, the bird will continue to dip even without a source of water, as long as the head is wet, or as long as a temperature differential is maintained between the head and body.

This differential can be generated without evaporative cooling in the head; for instance, a heat source directed at the bottom bulb will create a pressure differential between top and bottom that will drive the engine. The ultimate source of energy is the temperature gradient between the bird's head and base.