# Maxwell's Demon

In 1867 James Clerk Maxwell ( The same Maxwell of Maxwell's equations on electromagnetism) conceived a **thought experiment** contradictory to the **2nd Law of Thermodynamics** to demonstrate that this law applies only in terms of statistical certainty," The experiment involves a theoretical container divided into two parts by a door that can be opened and closed by a single entity. The entity was later named "Maxwell's Demon" by Lord Kelvin, who elaborated on Maxwell's experiment. This entity would somehow be clever enough to open the door at the right time to permit only high energy gas molecules to enter one compartment, leaving a higher number of lower energy molecules in the other. Thus the compartment with the higher energy molecules would tend to get hot and the other compartment cold.

Our experience demonstrates that Maxwell's demon is not likely to be found in our everyday life. We know that (in the absence of air conditioning) that the temperature of any room we occupy eventually reaches the same temperature – throughout the room. The second law however tells us that there is a slim chance – actually a negligible chance that one end of the room will be freezing and the other end hot. But then there is the invention of the vortex tube.

The vortex tube is a mechanical device that separates a compressed gas into hot and cold streams – thus realizing Maxwell's demon. It was invented in 1933 by French physicist Georges J. Ranque, but the plans were intercepted by invading forces and German physicist Rudolf Hilsch improved the design and published a widely read paper in 1947 on the device,

The Vortex tube has no moving parts. Pressurized gas is injected tangentially into a swirl chamber and accelerates to a high rate of rotation. Due to the conical nozzle at the end of the tube, only the outer shell of the compressed gas is allowed to escape. The inner shell of gases are forced to return as a counter vortex within the outer vortex – this is at least the most accepted theory.

In any event the Vortex tube has become a popular physics demonstration on the property of **entropy** in that it appears to violate the 2$^{nd}$ law of thermodynamics. But in reality the "isolated system" with decreasing entropy comes with a large cost. Appended to this system is a large source of energy to achieve this separation. The vortex tube has a voracious appetite for compressed air. Thus when this external input of energy is considered, the entropy of the system as a whole increases and so the 2$^{nd}$ law remains unviolated.

Definitions

**Equilibrium** The state of a system in which competing influences become balanced

**Entropy** The measure of the state of disorder in an isolated system

**Thought Experiment** Any experiment conducted by pure imagination that leads to hypothetical conclusions – as contrasted to physical experiments conducted in a laboratory which result in real measurements.

**Second law of Thermodynamics** The entropy of an isolated system which is not in equilibrium will tend to increase over time, approaching a maximum value at equilibrium. In other words entropy tends to increase.