SHORT FEATURE

Einstein's Refrigerator

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Einstein and Szilard

The idea that had been gathering dust for 70 years was resurrected recently when Andy Delano started research into Albert Einstein's work and produced some chilling results.

WE know Albert Einstein as a theoretical physicist, whose name is synonymous with the Theory of relativity, $E=mc^2$, Photoelectric emission, Brownian motion, and so on. There is a story about Einstein that once he was asked by a reporter why he has not been associated with a famous research lab. In reply Einstein pulled out his notebook and said, "With this, my pencil and my brain, I have all the laboratory I need."

The reply shows his keen interest in theoretical physics, but how many of us know that he also worked on many more everyday tasks, like developing an energy-efficient refrigerator. Let's go down the bylanes of history and take a look at this story.

History behind Einstein's Refrigerator

In 1921, Einstein was awarded the Nobel Prize in Physics for his explanation of the photoelectric effect. From 1926 to 1933 Einstein and Leo Szilard, considered by many to be the father of the nuclear age, dedicated themselves to improving home refrigeration technology. So, why did a man with a Nobel Prize, worldwide fame, and genius intellect waste his valuable time working on such a mundane project like refrigerators.

For Einstein this was a very important project. According to most accounts, while Einstein was in Germany one day in the early 1920s he came across a newspaper article that described the death of an entire family – mother, father, and their children. Apparently, they had been killed in their sleep by a poisonous coolant that had leaked out of their refrigerator.

All of the coolants available in those days of refrigeration (ammonia, sulfur dioxide, and methyl chloride) were very toxic and would kill if they leaked out into the home. People were afraid to use a refrigerator. Einstein knew that there had to be a better way. So he took that challenge.

Szilard was just starting his career at that time. These two great scientific minds came together and concluded that the problem with refrigeration was not just limited to the poisonous coolant. The mechanical parts of the refrigerators were the real culprit. Anyone with even the slightest mechanical experience knows that moving parts cause wear and tear on any system. Eliminate the moving parts and the system will probably never leak.

As great physicists, these two men realized that they could use their knowledge of thermodynamics to produce a cooling system that did not involve any type of mechanical motion. And finally, they came up with a refrigerator without any moving parts, which was a unique piece of work.

Now let's see how a refrigerator works. The main principle behind a refrigerator is based on the second law of thermodynamics according to which without any external work heat cannot flow from a lower temperature to a higher temperature. Here refrigeration cycle is the reverse of the Carnot cycle. Carnot cycle is the heat engine which takes heat from higher temperature (source), converts some portion of this heat to work and releases the rest to the sink. Refrigeration cycle is also a heat engine which takes the heat from a lower temperature (source) to higher temperatures (sink) and for this external work is required.

On the basis of this external work, refrigerator system is of two types – Vapor Compression Type and Vapor Absorption Type.

In compression type the input energy is electricity and the energy consuming element is the compressor. On the other hand, in the absorption type refrigerator the input energy is low-grade energy like heat. Here compressor is absent, a pump acts as the energy-consuming element.

In both cases two types of working pressure are being created. In the evaporator the pressure becomes very low, as a result liquid transforms to gas by absorbing latent heat which creates the refrigeration effect. When it moves to the compressor the pressure increases and the gas loses heat to its surroundings and becomes liquid. This liquid comes again to the expansion device through the throttle valve. In this way it works in a cyclic order. This is the working principle of a refrigerator.

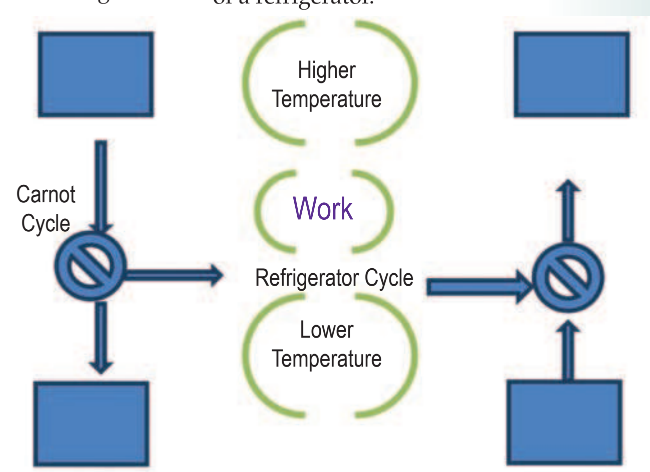
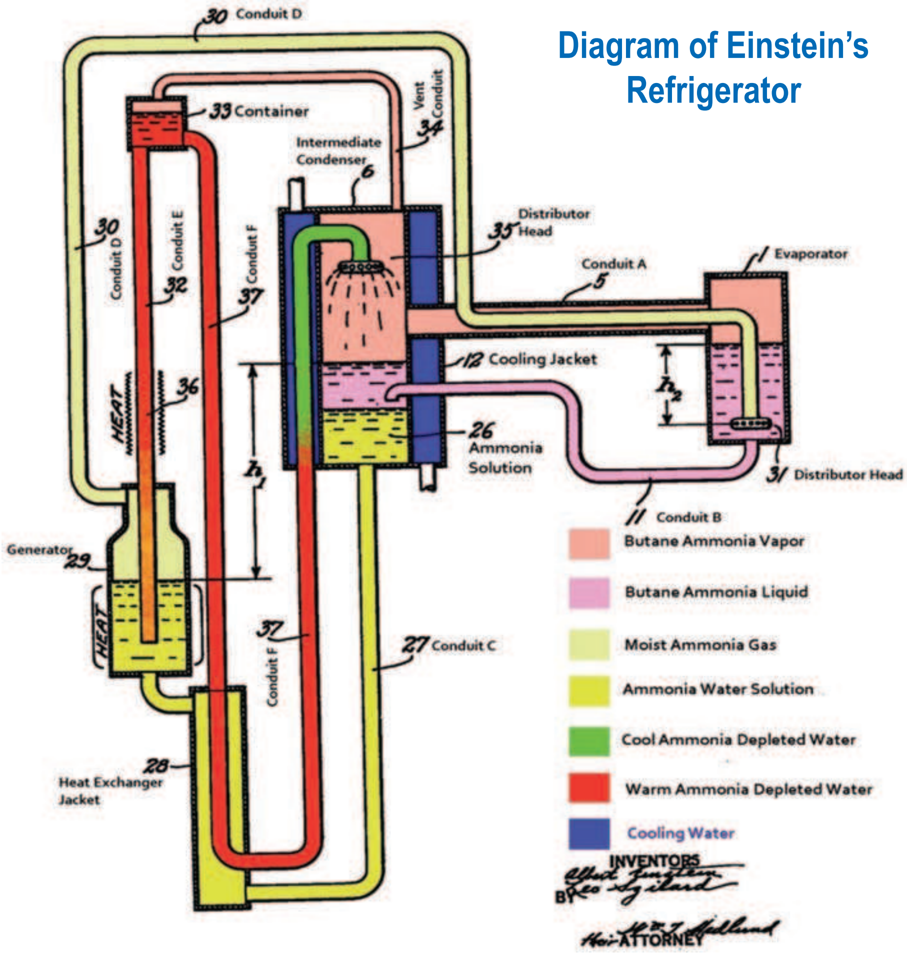


Diagram of Einstein's Refrigerator



Science Behind Einstein's Refrigerator

It is a single pressure absorption type refrigerator. Here butane is used as refrigerant, ammonia as pressure controlling agent and water as absorbing fluid. In any absorbing refrigerator, two fluids are required, one for refrigerant and another as absorbent. For example, in the ammonia-water cycle, ammonia is the refrigerant and water is the absorbent.

In Einstein's refrigerator, Einstein and Leo Szilard used two flow loops (ammonia flow loop and water flow loop) and three fluids (ammonia, water and butane) and successfully avoided the moving parts by applying their knowledge of physics. With the standard working fluids, a water-flow loop serves as an ammonia pump, and the ammonia-flow loop serves as a butane pump. Ammonia and water are suitable choices because ammonia is highly soluble in water and its solubility declines steeply with increasing temperature. Butane is a suitable choice for the refrigerant because it has a suitably low boiling point and is virtually insoluble in water.

In conventional refrigerators, two operating pressures work. A refrigerant evaporates at a temperature-dependent pressure. Evaporation absorbs heat from whatever is being cooled, and the vapor flows to a compressor. In Einstein's refrigerator, in the evaporator they used a mixture of ammonia and butane. Let the pressure of the system is Ps, and partial pressure of ammonia be Pa and butane be Pb. Then P=Pa+Pb. Here butane changes its phase (from liquid to gas) due to its own partial pressure Pb and creates the cooling effect and ammonia act ass pressure equalizer. The expansion of butane (liquid state to a gaseous state) acts as a pump and helps to flow the moist ammonia to another loop.

In the condenser the ammonia gets dissolved in water, as a result the partial pressure of butane increases, which helps to change its phase (gaseous to liquid). As it is insoluble in water, it floats over it and ammonia will act as a pump to move it to the other loop.

On the other hand, the mixture of ammonia water will move into the ammonia generator chamber and will be heated by the external heat (the input of this system). This ammonia will mix again to form a butane ammonia mixture. In this way the cycle will go on.

What happened to the Einstein-Szilard Refrigerator?

Einstein and Szilard had to overcome many challenges. Some of the designs were too noisy, some not as efficient as they would have liked. Still, they received 45 patents in six countries for refrigeration technology.

Yet none of their inventions ever reached the customers. The project was dropped for a number of reasons. The worldwide depression certainly didn't help things. But the 1930 invention of Freon was the real killer of the Einstein-Szilard refrigerator. Freon was a non-toxic refrigerant, so the danger of leaking was eliminated. There was no longer a need to redesign the refrigerator.

Though the commercial production of this refrigerator stopped, the pump was later incorporated into the cooling systems of nuclear breeder reactors.

Is the Einstein-Szilard refrigerator relevant today only from the historical point of view? Times have changed. A refrigerator that lasts 100 years and uses less energy looks highly attractive today as we are trying to discover ways to live with more efficient, less disposable things. Besides, the coolant Freon is now recognized as a serious environmental hazard. So, are there any chances that Einstein's refrigerator may come back in some modified way?

It just might be. Actually, The idea that had been gathering dust for 70 years was resurrected recently when Andy Delano, a Georgia Tech graduate, started research into Albert Einstein's work and produced some chilling results. In 2008, "Time" honored scientists at Oxford University – led by engineer Dr. Malcolm McCulloch – with a "best invention" award for new research based on the Einstein-Szilárd designs.

Although it's more than 80 years old, the Einstein refrigerator could be one example of an idea that is relevant today.

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