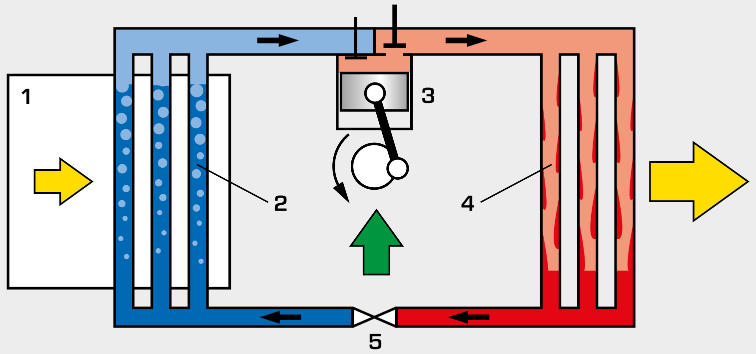
Basic knowledge

Principles of cold production

Refrigeration describes the removal of heat from a space which is to be cooled. Thermal energy is transferred from the warmer to the colder medium due to a temperature difference. There are various principles, presented here, on the technical implementation of heat transport.

Compression refrigeration systems are the most common cooling systems found in practice. In a compression refrigeration system a refrigerant flows through the refrigerant circuit and is subject to different changes of state. The compression refrigeration system is based on the physical effect that thermal energy is required during the transition from the liquid to the gaseous state. The evaporator **2** extracts thermal energy from the room **1** to be cooled. Different pressures during evaporation and condensation allow the temperature levels to be set so that heat is transferred from the cold side to the warm side. The thermal energy is released again by condensation **4** of the refrigerant.

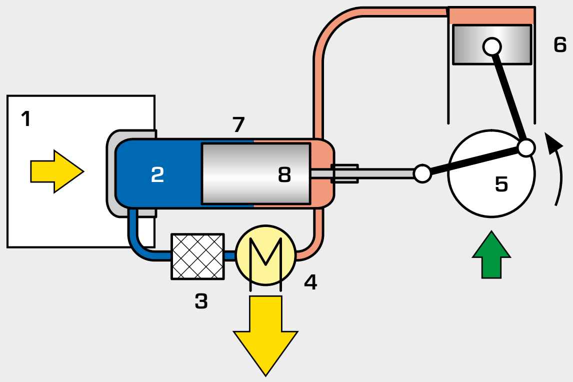
To increase the pressure, screw, scroll, turbo or vapour jet compressors can be used instead of the piston compressor **3** shown.



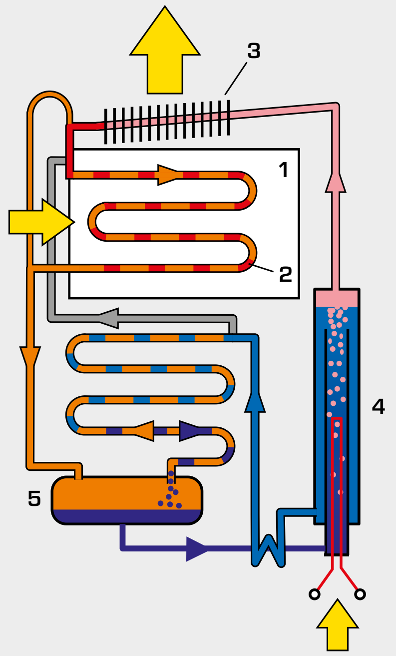
1 room to be cooled or process cooling, **2** evaporator, **3** compressor, **4** condenser, **5** expansion valve;
HP gaseous refrigerant, HP liquid refrigerant, LP liquid refrigerant, LP gaseous refrigerant, heat, mechanical work

The **Stirling refrigerator** is an absolute niche solution in practical application. It works according to the same principle as the Stirling engine, but with reverse direction of rotation. The Stirling refrigerator makes it possible to achieve very low temperatures, for example, to cool infrared cameras or to condense gases.

The Stirling refrigerator consists of a working cylinder **6** and a displacement cylinder **7**. A working gas is alternately compressed and expanded in the working cylinder. The compressed, hot gas releases its heat in the heat exchanger **4**. During expansion, the working gas cools down and absorbs heat on the cold side **2** of the displacement cylinder from the room **1** being cooled. Displacement piston **8** and working piston **6** are moved correspondingly phase-shifted via a crank mechanism **5**.



1 room being cooled or process cooling, **2** cold cylinder side,
3 recuperator, **4** heat exchanger, **5** crank mechanism,
6 working cylinder, **7** displacement cylinder, **8** displacement piston;
cold exhaust gas, hot exhaust gas,
heat, mechanical work



In contrast to the compression refrigeration system, an **absorption refrigeration system** uses two working media, one refrigerant and one solvent. The two working media are separated from each other in the generator **4** where thermal energy is added. The expelled refrigerant vapour flows into condenser **3** and is condensed. The refrigerant then evaporates at low pressure in the evaporator **2** and dissipates heat. The resulting refrigerant vapour flows into the absorber **5**, where it is absorbed by the solvent. The solution of refrigerant and solvent is pumped back into the generator.

The use of absorption refrigeration systems makes sense if thermal energy, e.g. waste heat, is available. In this case, cooling can be achieved by using waste heat.

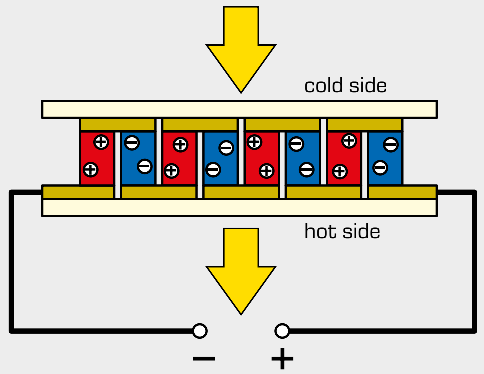
Illustration using the combination of ammonia and water as an example

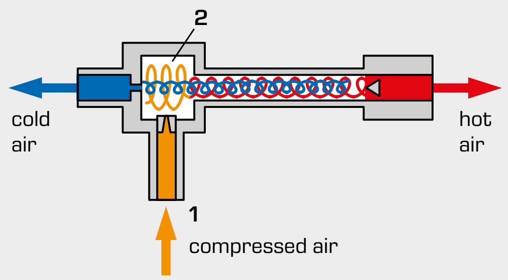
1 room to be cooled or process cooling, **2** evaporator,
3 condenser, **4** generator, **5** absorber;
ammonia vapour, liquid ammonia,
low ammonia solution, rich ammonia solution,
hydrogen, hydrogen and ammonia vapour, heat

Thermoelectric refrigeration plants are based on the Peltier effect. A Peltier element generates a temperature difference in an electrical current flow and can be used for heating or cooling, depending on the direction of flow.

Current is conducted through a thermoelectric element. One electrical contact heats up and the other one cools down. In order to increase the power, several thermoelectric elements are connected in series, arranged in such a way that cooling and heating contacts are each connected to a cover plate. During current flow, one of the plates extracts heat and transfers it to the other. The cold plate corresponds to the useful side of the thermoelectric refrigeration plant.

Peltier elements can generate very low temperatures. However, the efficiency decreases as the temperature difference increases. Peltier elements are easy to adjust, have no moving parts and no toxic fuels.





1 inlet opening, **2** vortex chamber

The **vortex cold generator** has an exceptional operating principle. Compressed air is introduced into the inlet opening **1**. The compressed air is introduced tangentially into a vortex chamber **2** and is set in rotation. A cold air flow forms in the centre of this vortex, while the outer layer of the vortex heats up. The cold air flow is diverted from the centre of the vortex and used for cooling.

The advantage of a vortex cold generator is its particularly simple design, which has no moving components and does not require toxic fuels or power supply. The low efficiency is a disadvantage