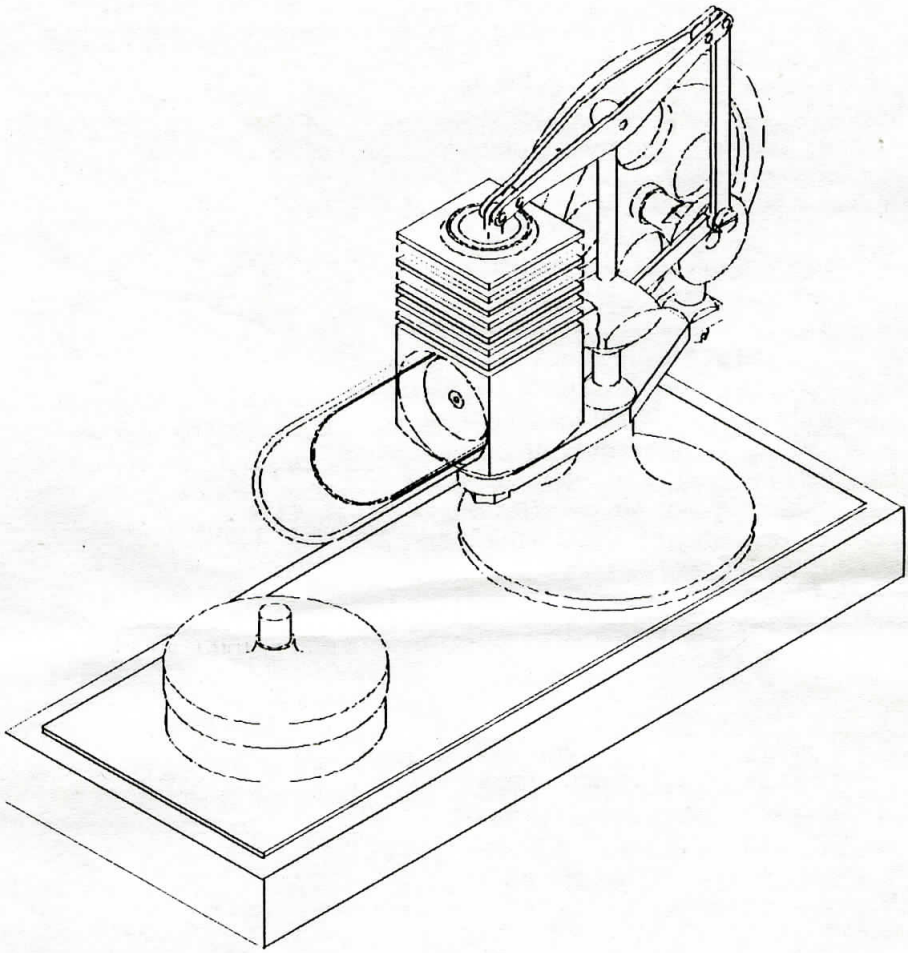


# MICRO-Stirling

**Hot air engines and their development**

In 1816 Robert Stirling invented an engine which is externally heated and which internally carries a captive quantity of ordinary air repeatedly through a closed cycle of compression, heating, expansion and cooling. Engines based on this principle and the improvements that he and his brother introduced were produced in many sizes and forms until just after the turn of the century. These engines, called hot air engines at the time, were very popular because they were simple and safe to operate, ran almost silently on any combustible fuel, and were clean and efficient compared to contemporary alternatives. Although they had low power for their size and their weight, these engines excelled as water pumps, fans and light machinery as sewing machines, laboratory centrifuges and mixers, air pumps, gramophones and window display turntables. The first era of the Stirling hot air engine was terminated by the invention of the internal combustion engine and electric motors.

The second era of the Stirling engine opened around 1937 with the work of the Philips company in Holland on updating the Stirling to drive a generator to operate electronic equipment that they produced. The research team at Philips had newer materials to work with such as stainless steel and had a much better understanding of thermal and fluid physics than their predecessors of the first era. With their small „102C" engine of 1952 they had increased the specific power of the old Stirling engines by a factor of 30. Their spectacular success captured the attention and the interest of scientists and engineers and inspired a great variety of Stirling research and development projects for applications in busses, trucks, cars, power stations and space stations and even within the human body for powering artificial hearts with stored heat.

**The MICRO-Stirling**

The MICRO STIRLING is a model without a specific predecessor. The design utilises a glass cylinder, which permits good insight to the cycle process. Thus the MICRO STIRLING is an ideal object for demonstration of the Stirling cycle. The attractive design and the elegant shape of this little engine makes it a gem.

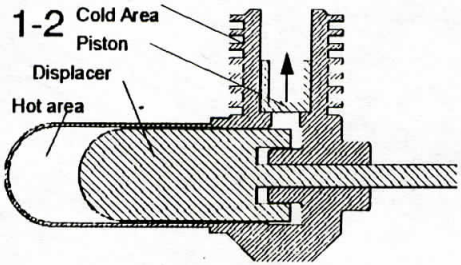
The MICRO STIRLING most probably is the smallest Stirling engine which is produced in series.

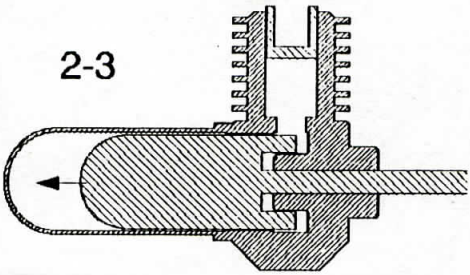
The piston and the bearing of the piston rod of the displacer is made of special material, which is self lubricating. Freedom of maintenance thus is connected to a high life durance. NOTE: The working piston and the piston rod of the displacer must not be lubricated!

**The Stirling cycle at the MICRO-Stirling**

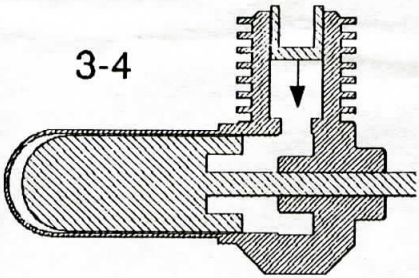
The principle of the Stirling engine is based on interaction of hot air which is expanding and cooler air, which has a smaller volume.

In the first Phase the displacer is in the rear end position and the working piston in the inner end position. The air in the hot area of the engine is heated up, which causes the internal pressure in the engine to rise. The resulting pressure is transmitted to the area of the working piston and causes it to be pressed outward. Thus work is extracted.

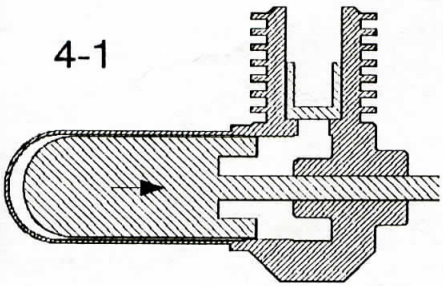


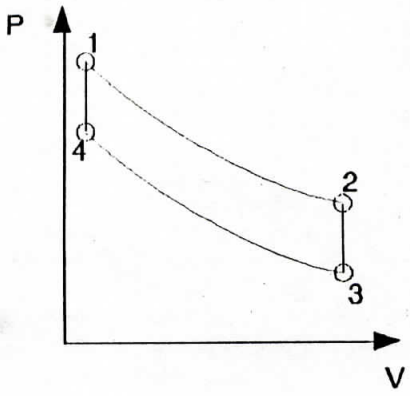

In the second phase the working piston has been pushed outwards thus giving the air a bigger volume and reducing the pressure in comparison to the first phase.




In the third phase the displacer is moved to the front end position causing the hot air to be displaced from the hot area of the motor towards the cold end of the motor. In the cold area and at the walls of the displacer heat is transferred from the air which causes the air to be cooled down and reducing the pressure inside the engine.




In the fourth phase the piston is moved into the inner end position, which has been made possible by the reduced internal pressure. Simultaneously the air is compressed, the required energy is supplied by the flywheel. Then the diplacer is moved again into the inner end position causing the air to be transferred from the cold area to the hot area, terminating the cycle and restarting the next one.




A graph of the pressure and volume of the ideal Stirling cycle is shown to the left. Process 1-2 is the isothermal expansion, where mechanical work is extracted. Process 2-3 represents the constant volume cooling. Process 3-4 is the isothermal compression of the working medium, process 4-1 is the constant volume heating, which completes the cycle.

**Operation of the engine**

Fill the burner up to approx. 2/3 with heating alcohol. Ignite the burner and adjust the flame by pushing in the thread such, that the flame is just reaching the glass cylinder of the engine. After a couple of seconds of heating up, the engine can be startet by rotating the flywheel away from the cylinder. The MICRO STIRLING has been sized for continuous operation and should cool down only to avoid burns during refilling the burner.

**Operation temperature**

If the engines are operated at very cold temperatures, the combination of cylinder and piston may have a tendency to stall, due to different coefficients of thermal expansion of graphite and brass. The fit between piston and cylinder has to be very tight because of efficiency reasons, so very small changes in diameters may have an impact on the operation. Thus the engine should only be operated, if it has normal room temperature.

## NOTE: The operation of this engine requires the same safety precautions as with open flames!

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