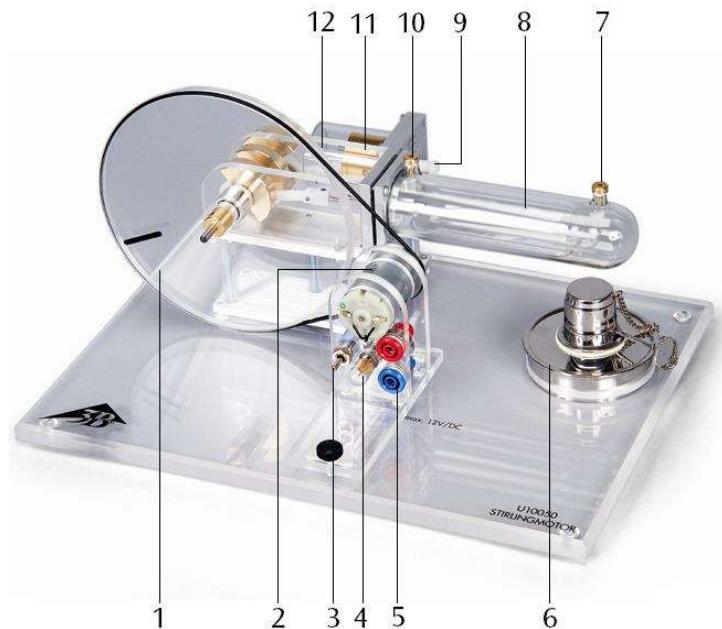


## Stirling Engine G 1002594

### Instruction Sheet

10/23 ALF/UD



- 1 Flywheel with marking for speed determination
- 2 Motor-generator unit with 2-stage pulley
- 3 Switch
- 4 Bulb
- 5 4-mm safety plugs
- 6 Alcohol burner
- 7 Temperature measurement connector 1
- 8 Displacement piston
- 9 Capped hose connection for pressure measurements
- 10 Temperature measurement connector 2
- 11 Working piston
- 12 Threaded rod M3 (connected with the working piston)

### 1. Safety instructions

- Pour the fuel alcohol carefully into the alcoholburner, making sure that none of it is spilt.
- Never fill the alcoholburner as long the wick is still smoldering or another open flame is in close proximity.
- Immediately close the fuel container after use.
- Keep away from the open flame.
- Caution! Only extinguish the flame by fitting the cover provided for this purpose.

The Stirling engine becomes hot when it is operated with an open flame.

- Do not touch the displacement cylinder during or immediately after operation of the Stirling motor.
- Allow the Stirling engine to cool before putting it away.

### 2. Description

The Stirling engine can be used for qualitative and quantitative investigations of the Stirling cycle and can be operated in three different modes: heat engine, heat pump and refrigerator.

The displacement cylinder and piston are made of heat-resistant glass; the working cylinder, flywheel and transmission covers are made of acrylic glass. This allows a very clear observation of the individual motion sequences at all times. The crankshafts are equipped with ball bearings and made of hardened steel. The connecting rods consist of wear-resistant plastic.

The integrated motor-generator unit with a 2-stage pulley allows the generated mechanical energy to be converted into electrical energy. A switchover mechanism permits operation of an integrated lamp or external loads, as well as a feeding of electrical energy in order to simulate a heat pump or refrigerator.

By attaching the thin cord supplied with the apparatus to the threaded rod on the work piston, the stroke length can be measured.

### 3. Technical data

Motor-generator unit:	max. 12 V DC
2-stage pulley:	30 mm dia., 19 mm dia.
Working piston:	25 mm dia.
Path of working piston:	24 mm
Volumetric change:	24 mm $\left(\frac{25\text{ mm}}{2}\right) \cdot \pi = 12\text{ cm}^3$
Minimum volume:	32 cm <sup>3</sup>
Maximum volume:	44 cm <sup>3</sup>
Power of the Stirling motor:	1 W approx.
Dimensions:	300x220x160 mm <sup>3</sup> approx.
Weight:	1.65 kg approx.

### 4. Functioning principle

An ideal Stirling cycle has 4 phases (refer to Fig. 1):

- Phase 1: Isothermal change of state, during which the air expands at constant temperature.
- Phase 2: Isochoric change of state, during which the air cools at constant volume in the regenerator.
- Phase 3: Isothermal change of state, during which the air is compressed at constant temperature.
- Phase 4: Isochoric change of state, during which the air in the regenerator is heated back to its initial temperature.

The process that takes place in the Stirling engine only approximates to such an ideal cycle because in fact the four phases overlap. Gas changes from hot to cold while the expansion is still taking place and not all the air will yet be in the colder part of the engine while the compression phase is occurring.

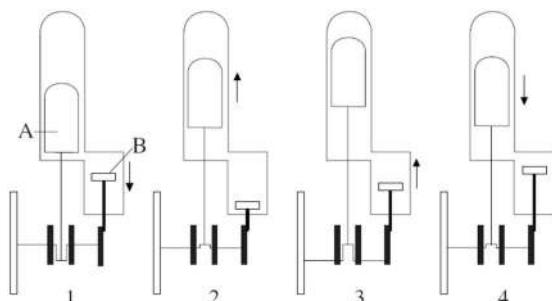


Fig. 1 Functioning principle  
(A: Displacement piston, B: Working piston)

### 5. Operation

#### 5.1 The Stirling Engine as a heat engine

- Fill the methylated-spirit burner, place it in the recess in the base-plate, twist out about 1-2 mm of the wick, and ignite it.
- Move the displacer piston to its farthest-back position, and after a short heating-up time (about 1-2 minutes) push the flywheel gently in the clockwise direction (as seen from the motor-generator unit) to set it turning (see Fig. 2).
- If necessary, adjust the tension of the drive belt by moving the motor-generator unit.
- Turn on the filament lamp by moving the switch to the "up" position.
- Alternatively, connect an external load through the 4 mm sockets and drive it by moving the switch to the "down" position.

Speed without a load: 1000 rpm approx.

Speed with a generator as the load: 650 rpm approx.

Generator voltage: 6 V DC approx.

Pressure difference: +250 hPa / -150 hPa

#### 5.2 The Stirling motor as a heat pump or refrigerator

Additional instruments needed:

1 DC Power supply, 0 - 20 V, 0 - 5 A @ 230 V  
1003312

or

1 DC Power supply, 0 - 20 V, 0 - 5 A @ 115 V  
1003311

Digital thermometer 1002794

- Insert temperature sensors into the thermometer sockets and connect them to a measuring instrument (see fig. 3).
- Connect a DC voltage source through the 4 mm sockets.
- Adjust the voltage (maximum 12 V) and operate the Stirling engine with the switch in the "down" position.
- Observe the increase or reduction in temperature.

In the refrigerator mode of operation, the flywheel rotates in the clockwise direction (as seen from the motor-generator unit), whereas in the heat pump mode it rotates in the anticlockwise direction.

- To switch between the two modes of operation, reverse the polarity of the connections.

Pressure difference:	+250 hPa / -150 hPa
Motor voltage:	9 V
Speed:	600 rpm
Temperature difference (with respect to 21° C):	
Refrigerator:	-4 K (reservoir: +6 K)
Heat pump:	+13 K (reservoir: -1 K)

### 5.3 Plotting a graph of pressure against volume when the Stirling engine is being used as a heat pump

Additional instruments needed:

1 DC Power supply, 0 - 20 V, 0 - 5 A @ 230 V  
1003312

or

1 DC Power supply, 0 - 20 V, 0 - 5 A @ 115 V  
1003311

1 Sensor Holder for Stirling Engine G 1008500

1 Relative Pressure Sensor FW  $\pm 1000\text{hPa}$   
1021533

1 Displacement Sensor FW 1021534

2 Sensor Cables 1021514

1 Data logger

1 Software

More information about digital measurement can be found on the product's webpage in the 3B Webshop.

- Attach the holder for the sensor to the base plate of the Stirling engine.
- Fit the relative pressure sensor to the bottom of the sensor holder and the displacement sensor at the top with the printed sides of the sensors both facing upwards.

- Connect the nozzle marked "+" on the relative pressure sensor to the nozzle on the working cylinder of the Stirling engine by means of the hose included with the sensor holder (1008500).
- Screw the cap nut attached to the string (supplied with the sensor holder) onto the thread of the working piston, thread the string around the displacement sensor pulley and attach a coil spring to the threaded rod (a detailed description of how to attach the sensor to the sensor holder is included in the instruction manual for the sensor holder 1008500).
- Connect the relative pressure sensor and the displacement sensor to the data logger.
- Connect a DC voltage source via the 4 mm sockets.
- Adjust the voltage (maximum 12 V) and operate the Stirling engine with the switch in the "down" position.
- Start the software and record the pressure-volume diagram.

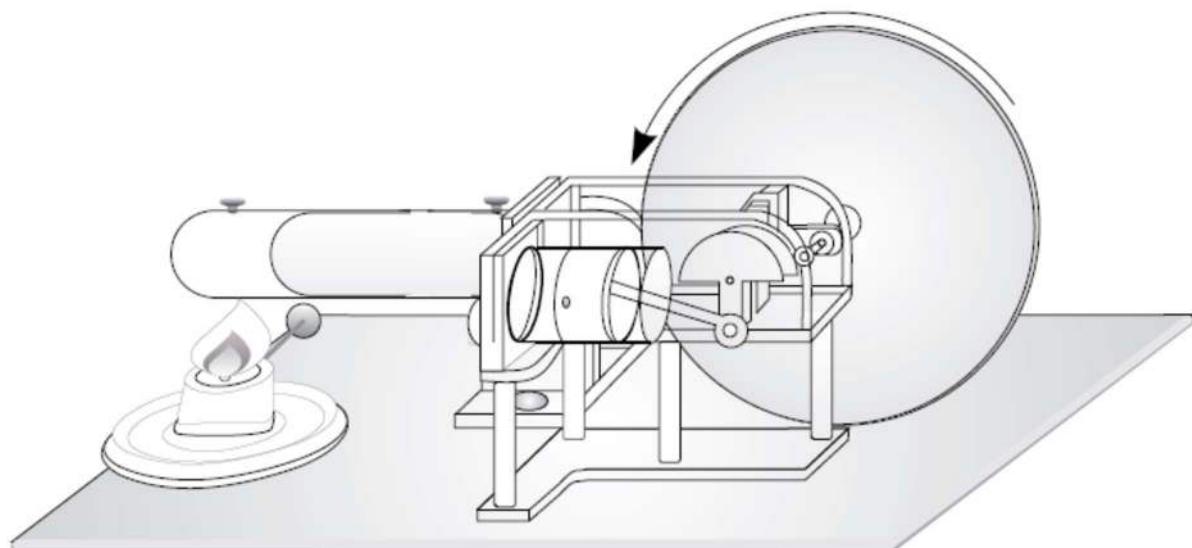


Fig.2 The Stirling motor as a heat engine

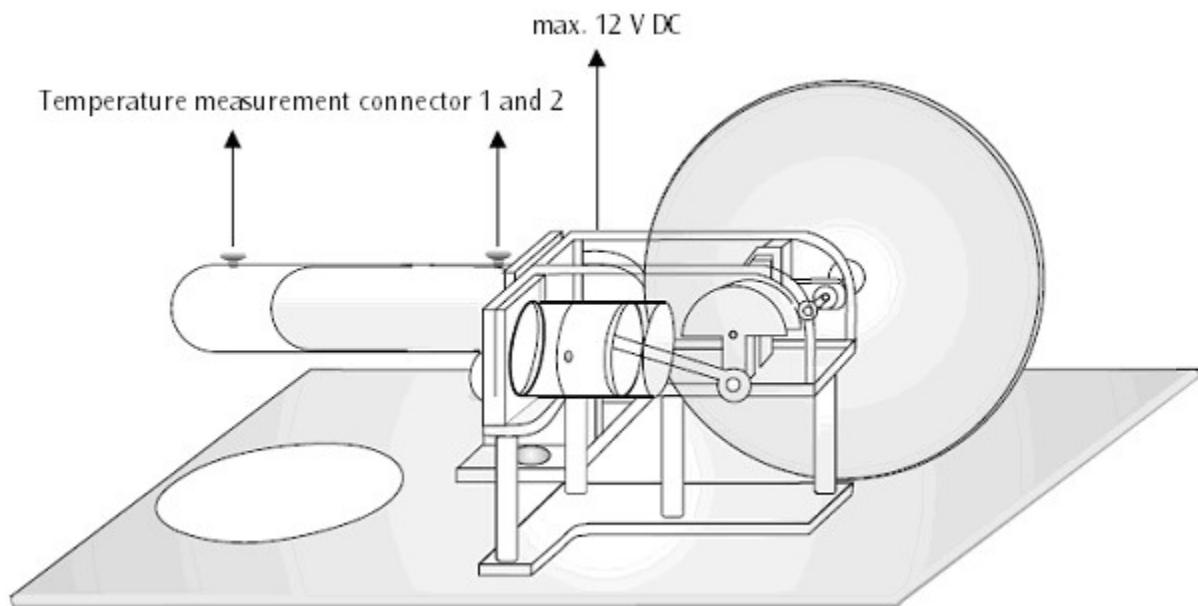


Fig. 3 The Stirling motor as a heat pump or refrigerator

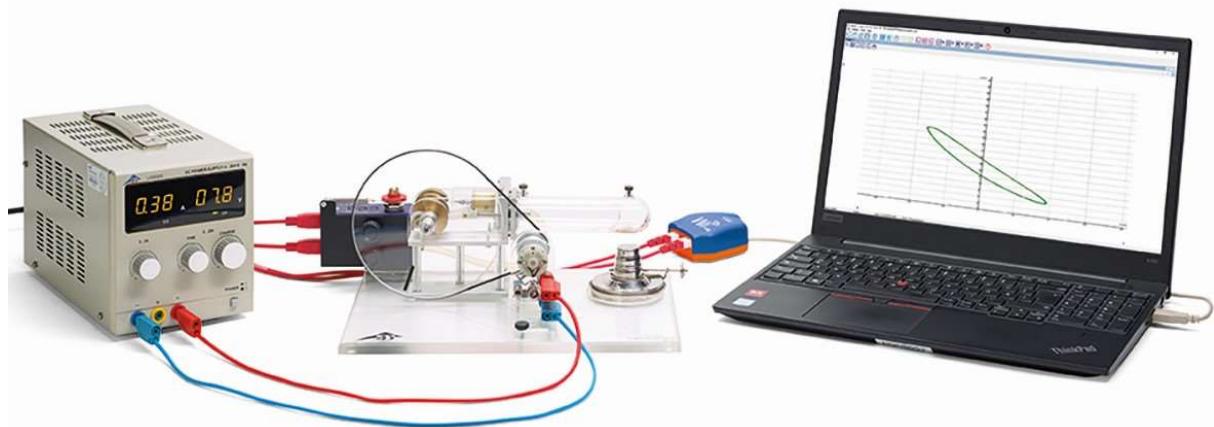


Fig. 4 Recording the pressure-volume diagram