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Operating instructions



Fig. 1: Stirling Motor, transparent 04372-00

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1 SAEFTY PRECAUTIONS



Attention!

- Carefully read these operating instructions completely before operating this instrument. This is necessary to avoid damage to it, as well as for user-safety.
- Do not operate if there are visible signs of damage to the unit
- Only use the instrument for the purpose for which it was designed.

2 PURPOSE AND DESCRIPTION

A Stirling motor (hot-air motor) converts heat energy into mechanical energy. When driven mechanically it acts as a heat pump or refrigerating machine and therefore impressively demonstrates the reversibility of thermodynamic processes. The operating principle of the Stirling motor is explained in Fig. 2. The main and displacement pistons are mounted in a 90° V- type configuration. The main piston (A) is made of metal and fits exactly in the glass tube. The glass displacement piston (V) also provides the regenerator function which is important for the operation of the Stirling motor. It cools the hot gas which flows past it, stores its energy and passes the energy on to the returning cold gas.

The mechanical energy produced by the Stirling motor is converted into electrical energy in the form of light with the aid of a motor/generator unit. The Stirling motor can therefore also be mechanically driven.

The Stirling motor can be loaded with a certain torque using the torque meter. If the speed is also measured, the mechanical power produced can be computed.

3 FUNCTIONAL AND OPERATING ELEMENTS

3.1 Stirling Motor 04372-00

Supplied items:

- 1 Stirling motor
- 1 blue base plate
- 1 spirit burner
- 1 Allen key
- 4 knurled screws
- (2 in base plate, 2 on Stirling motor)

The Stirling motor is placed on the base plate and firmly screwed from the bottom with two knurled screws. Two other knurled screws on top of the base plate are used to attach the motor/generator unit or the torque meter scale. The flywheel normally remains fastened to the shaft. It can be loosened with the aid of the Allen key. After the flywheel has been remounted, the shaft should be pulled slightly outwards and only a small air gap the thickness of a sheet of paper should be present between the flywheel and the motor housing, so that the shaft does not have too much play when in operation.

Two temperature measuring points are situated in the displacement cylinder. The holes in the metal sleeves have a diameter of 0.6mm for accepting sheathed NiCr/Ni thermocouples (Order no. 13615-01).

3.2 Motor/Generator unit 04372-01

Supplied items:

- 1 motor/generator on mounting bracket
- 1 belt
- 1 filament lamp 4 V / 40 mA

The M/G unit has two pulleys of different size with which the influence of the transmission ratio on the power and speed of the Stirling motor can be demonstrated. A belt links the flywheel to the motor.

The motor and generator operating modes are selected with a switch.

In the generator mode the filament lamp lights. Two output sockets are wired in parallel to the lamp socket, enabling a variable resistance to be connected. The generator is unloaded with the switch in position „0“. For operation as a motor a DC voltage is applied to the input sockets.

3.3 Torque Meter 04372-02

Supplied items:

- 1 pointer
- 1 scale

The inner metal part of the pointer (Prony brake with inclination weight) is fastened to the shaft of the Stirling motor in front of the flywheel using the Allen key. The friction between the metal part and the pointer can be changed with the adjustment screw on the pointer.

When the Stirling motor runs, the pointer is carefully pushed onto the shaft. The friction should then be slowly increased; it should not be so high that motor comes to rest. The set torque is indicated on the scale.

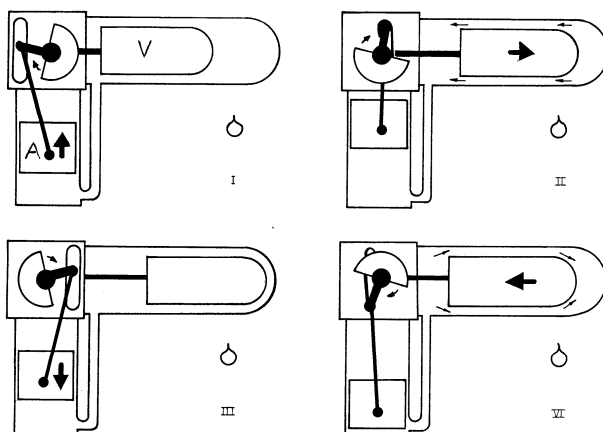
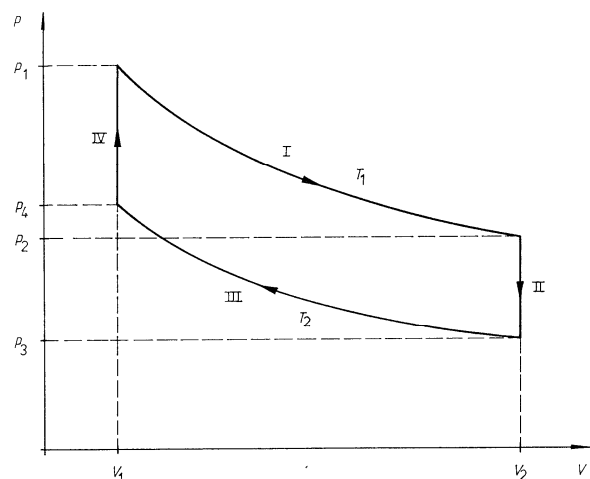


Fig. 2: Operating principle of the Stirling motor

- 1) Isothermal expansion, heat absorbed, work done
- 2) Isochoric heat emission, no work transferred
- 3) Isothermal compression, heat emission, work absorbed
- 4) Isochoric heat absorption, no work transferred



$V_1 \rightarrow V_2$ $p_1 \rightarrow p_2$ and $T_1 = \text{constant}$.

$T_1 \rightarrow T_2$ $p_2 \rightarrow p_3$ and $V_2 = \text{constant}$.

$V_2 \rightarrow V_1$ $p_3 \rightarrow p_4$ and $T_2 = \text{constant}$.

$T_2 \rightarrow T_1$ $p_4 \rightarrow p_1$ and $V_1 = \text{constant}$.

4 IMPORTANT INFORMATION

The main piston should not be oiled. It has been fitted exactly to the glass cylinder. Oil would lead to increased friction and the motor power would be reduced. The displacement cylinder has been mounted such that a uniform air gap occurs between it and the displacement piston, optimising the motor power. The fastening screws should not therefore be altered. The piston rod should be lubricated with a drop of thin machine oil if the power of the Stirling motor drops. This is best done using a syringe (Order no. 02593-03) with a hollow needle (Order no. 02597-04), so that no oil drops onto the main piston.

5 TECHNICAL DATA

Stirling motor

No-load speed at least 800 rpm
max. power approx. 1 W

M/G unit

Motor voltage max. 12 V
Filament lamp 4 V / 40 mA
Belt diameter 150 mm

Torque meter

Measurement range $25 \cdot 10^{-3}$ Nm
Resolution $1 \cdot 10^{-3}$ Nm

6 LIST OF EQUIPMENT

Stirling Motor, transparent	04372-00
Motor/Generator Unit	04372-01
Torque Meter	04372-02
Chimney for Stirling motor	04372-04
Sensor Unit pVn	04371-00
$pVnT$ Instrument	04371-97
Thermocouple, NiCr-Ni, sheathed (2x)	13615-01
Oscilloscope, 20 MHz, 2-channel	11454-93
Screened Lead, BNC (2x)	07542-11
Rheostat, 330 Ω	06116-02
Connecting cords	

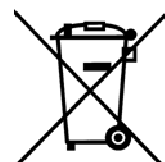
7 EXPERIMENTS

The supplementary devices which are matched to the Stirling motor enable a large variety of qualitative and quantitative experiments to be undertaken.

- Conversion: heat - mech. energy – light
- Operation as heat pump or refrigeration machine
- Mech. power in relation to speed (Fig. 3)
- Electr. power in relation to speed (Fig. 3)
- Temperature measurement
- Recording of the pV curve

8 WASTE DISPOSAL

The packaging mainly consists of environmentally-friendly materials that should be returned to the local recycling stations.



Do not dispose of this product with normal household waste. If this unit needs to be disposed of, please return it to the address that is stated below for proper disposal.

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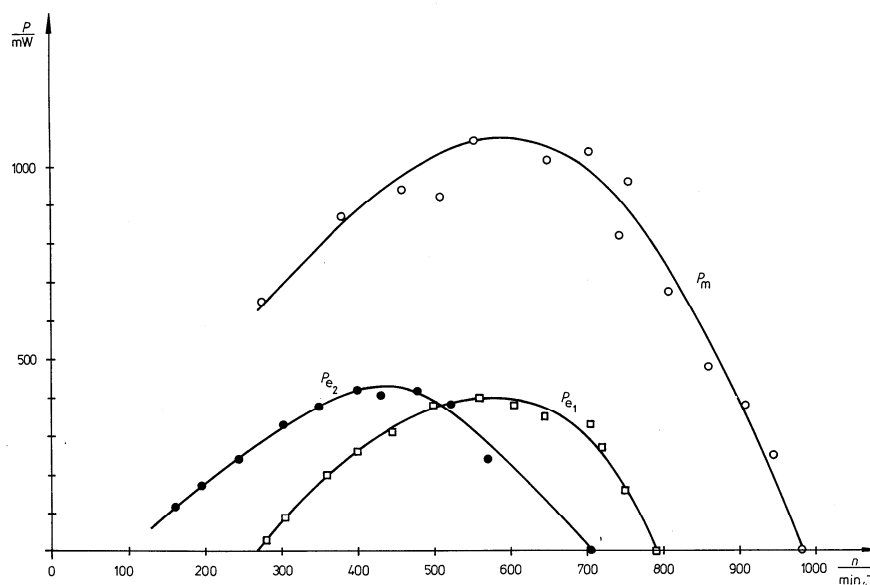


Abb. 3: Mechanical power P_m and electrical power P_e in relationship to the speed (P_{e1} = large pulley, P_{e2} = small pulley)