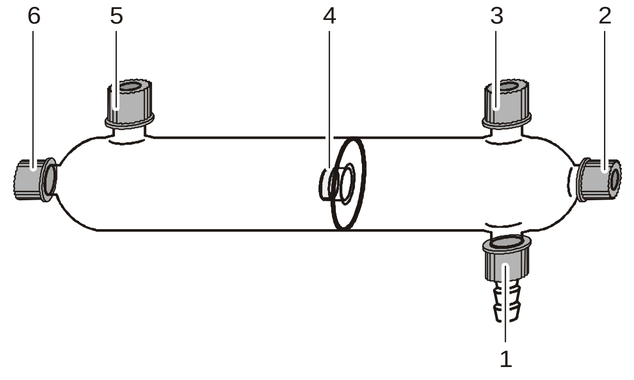
Lehr– und Didaktiksysteme
LD Didactic GmbH
Leyboldstrasse 1 · D-50354 Huerth

06/05-W97-Hke



1 Gas inlet
2 Connection of thermocouple 1
3 Connection of pressure sensor
4 Separating wall
5 Gas outlet
6 Connection of thermocouple 2

Instruction sheet 371 56

Joule-Thomson Apparatus (371 56)

1 Description

The Joule-Thomson apparatus serves to study the Joule-Thomson effect quantitatively and to determine the Joule-Thomson coefficients of various gases. The apparatus consists of a glass cylinder which is subdivided into two chambers by a separating wall. When a gas flows through the fritted-glass filter, which acts as a throttle, a pressure difference between the two sides arises, whereby the gas cools off on the side where the pressure is lower.

The pressure sensor and the thermocouples are connected to the apparatus via GL screw connections with gaskets. The gas inlet and outlet can be made gastight via GL screw connections as well. Therefore measurements are possible involving critical gases that must not be admixed to the air in the room.

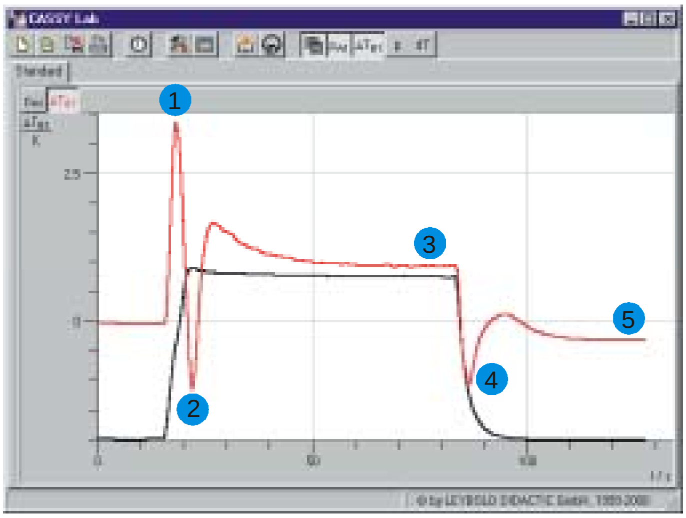
2 Technical data

Length:	240 mm
Diameter:	35 mm
Max. overpressure:	1000 hPa
Diameter of fritted-glass filter:	10 mm
Connection of thermocouples:	2 GL14 screw connections
Gas inlet:	GL14 screw connection
Gas outlet:	GL18 screw connection
Connection of pressure sensor:	GL18 screw connection

3 List of required apparatus

1 Joule-Thomson apparatus	371 56
2 thermocouples NiCr-Ni	666 216
1 pressure sensor	529 038
1 Sensor CASSY	524 010
1 CASSY Lab	524 200
1 temperature box	524 045
1 B box	524 038
1 PC with Windows 95 / NT or higher version	
1 pressure cylinder carbon dioxide	661 012
or	
1 pressure cylinder nitrogen	661 013
1 vacuum tubing 2 m	307 68
1 pressure-reducing valve	661 018
1 set of 10 hose clamps	667 184

4 Principle of operation:

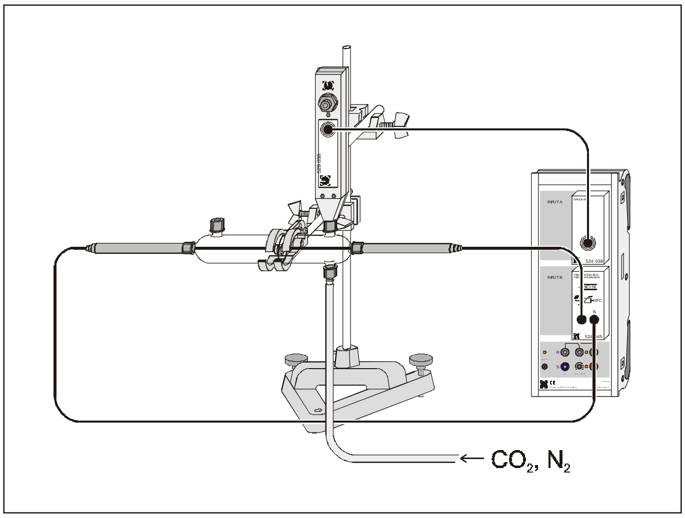


When a gas flows into the pressure chamber of the Joule-Thomson apparatus, the temperature difference between the two chambers increases quickly because of adiabatic compression in the pressure chamber (1). As cool gas continues flowing in, the process of warming up already slows down in the pressure chamber while the warm gas reaches the expansion chamber. Therefore the temperature in the expansion chamber is higher than that in the pressure chamber for a short period (2). If the gas flow is uniform, a constant temperature difference ΔT is observed after a certain time (3).

After the gas flow has been switched off, there is once more a strong adiabatic change in temperature, this time due to expansion (4), and after a certain time, the temperature difference $\Delta T'$ (5), which is slightly different from zero, remains constant again. For the evaluation, the difference between the two temperature differences that occur while the gas is flowing and after the gas flow has been switched off has to be determined.

The temperatures are measured with two very thin, quick NiCr-Ni thermocouples (666 216) in a differential measurement. Therefore it is possible to observe the adiabatic temperature changes that occur during the pressure increase and drop in the pressure chamber, and the gas need not be kept at a specified temperature. If the measuring values are recorded with a computer, it can easily be seen when the process has reached an equilibrium. Nevertheless, the measurements should be made in thermally stable surroundings.

5 Putting the apparatus into operation



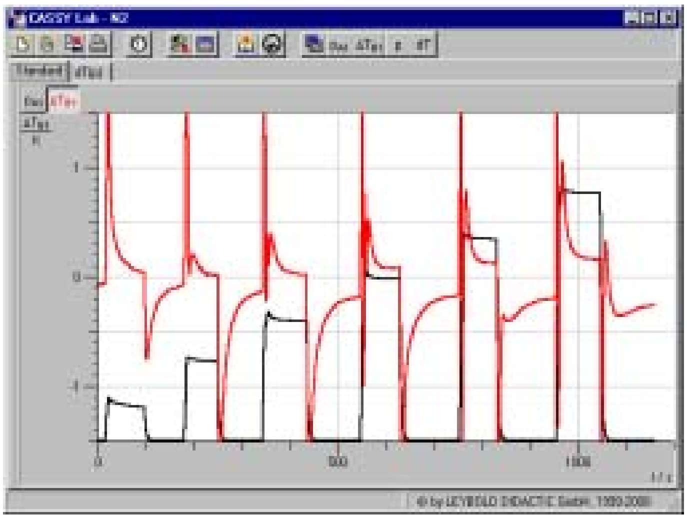
- Equip Sensor CASSY with the temperature box and the B box.
- Mount the NiCr-Ni thermocouples in the GL screw connections with gaskets so that they are both close to the centre of the fritted-glass filter. Connect the thermocouples to the temperature box.
- Mount the pressure sensor without tubing, again using a gasket, fix it with stand material, and connect it to the B box.
- Connect the pressure cylinder via the vacuum tubing.

6 Carrying out the experiment

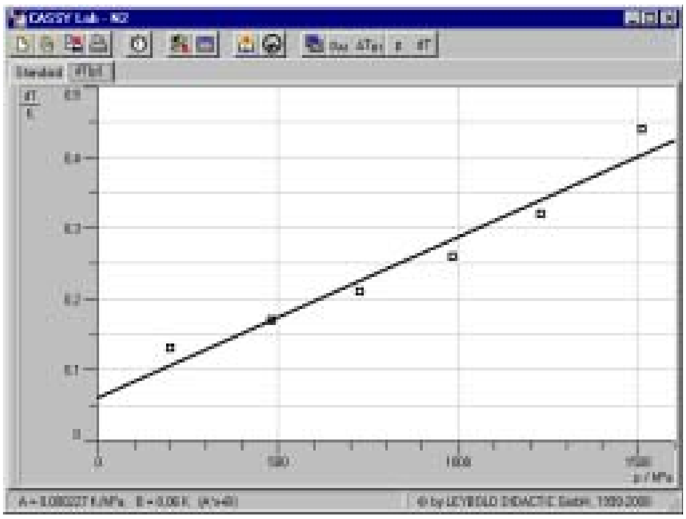
- Wait some minutes until a thermal equilibrium is established.
- Get CASSY Lab started, and choose automatic recording with time interval 200 ms or 500 ms.
- Open the pressure cylinder; adjust the desired gas pressure *p* (read the pressure display of the pressure sensor) with the pressure-reducing valve and, if necessary, with the low-pressure stop valve.
- Wait until the temperature difference $\Delta T = T_2 - T_1$ remains constant.
- Switch the gas flow of, and wait until the temperature difference remains constant again.
- Take the two temperature differences ΔT and $\Delta T'$ down, and calculate the difference between them.
- Repeat the measurement at another gas pressure *p*.

7 Results

7.1 Nitrogen:



Pressure difference Δp and temperature difference ΔT (as functions of time)



ΔT-Δp diagram of the equilibrium values

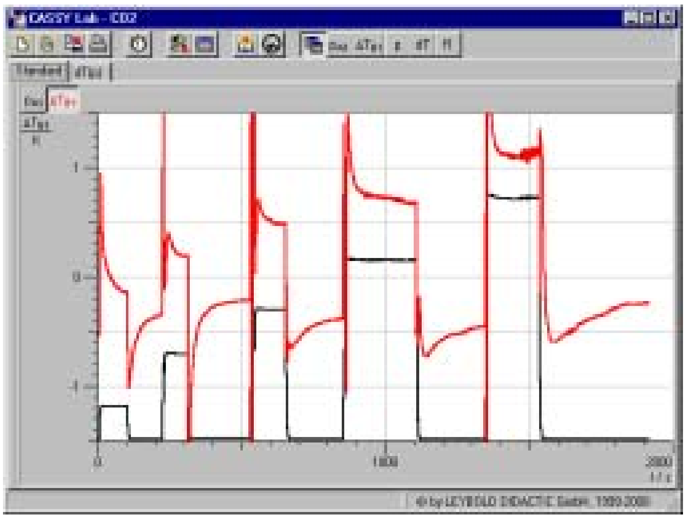
Joule-Thomson coefficient

Experimental value determined by a linear fit:

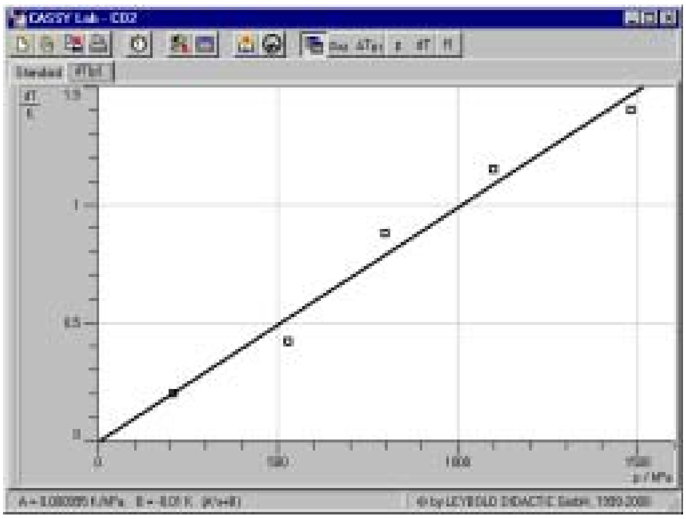
$$\frac{\Delta T}{\Delta p} = 0.00023 \frac{\text{K}}{\text{hPa}}$$

Value quoted in the literature: $\frac{\Delta T}{\Delta p} = 0.00023 \frac{\text{K}}{\text{hPa}}$

7.2 Carbon dioxide:



Pressure difference Δp and temperature difference ΔT (as functions of time)



ΔT-Δp diagram of the equilibrium values

Joule-Thomson coefficient

Experimental value determined by a linear fit:

$$\frac{\Delta T}{\Delta p} = 0.00100 \frac{\text{K}}{\text{hPa}}$$

Value quoted in the literature: $\frac{\Delta T}{\Delta p} = 0.00109 \frac{\text{K}}{\text{hPa}}$

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