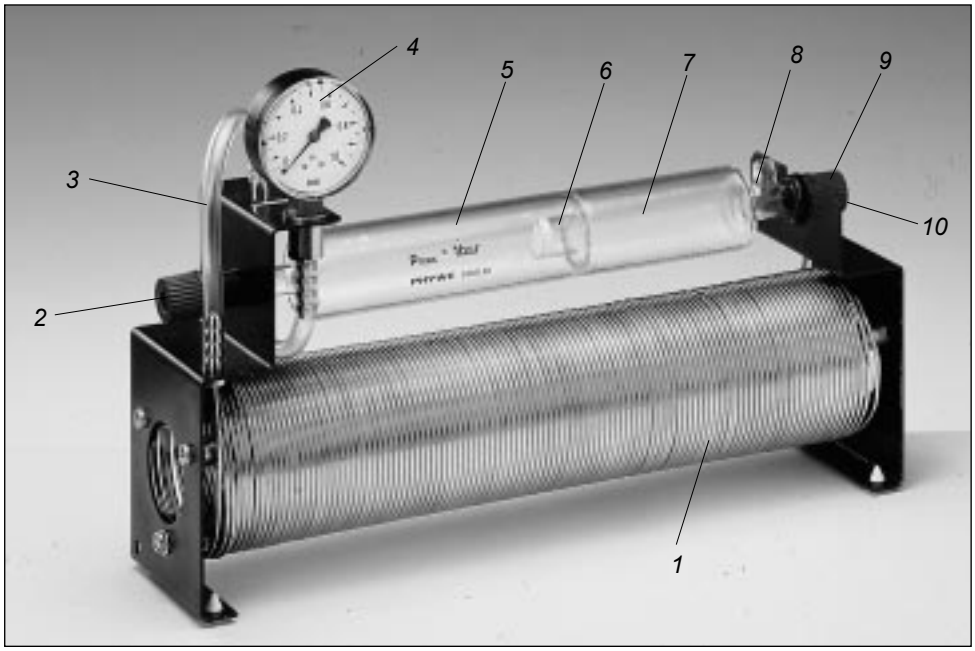
Joule-Thomson apparatus

04361.00

Operating Instructions



1. PURPOSE

The Joule-Thomson apparatus (fig. 1) is a unit meant for demonstrations and for laboratory work and is used to determine the Joule-Thomson coefficient. The Joule-Thomson apparatus is equipped with a heat exchanger. This is used to heat the gas, which has been cooled at the pressure reducing valve of the gas pressure cylinder, back to ambient temperature, and thus to system temperature. To measure the Joule-Thomson coefficient, the gas is expanded over a frit from the overpressure displayed by the manometer to ambient pressure. The glass part of the unit is enclosed in a transparent plastic case, as a protection against glass splinters. The Joule-Thomson apparatus works in an overpressure range of up to 1 bar and is basically used at room temperature.

2. THE JOULE-THOMSON EFFECT

If an ideal gas expands without performing any work, it cannot cool down. A real gas, however, also cools down in this case, because in the real gas, forces act between the molecules, which is not the case in ideal gases. During expansion, work must always be performed against these forces. The gas thus cools down during expansion, if no exchange of heat can take place with the environment.

3. DESCRIPTION

The gas which is to be investigated is brought into the air heat exchanger *1* of the Joule-Thomson apparatus over the olive shaped hose coupling *10*. From the air heat exchanger, the gas flows through the PVC hose *3* and over the manometer *4* into the pressure vessel *5*. The latter is connected over a frit with a vessel *7* which is at ambient pressure. The two screw caps *9* and *2* are used to hold two temperature measurement probes.

4. HANDLING

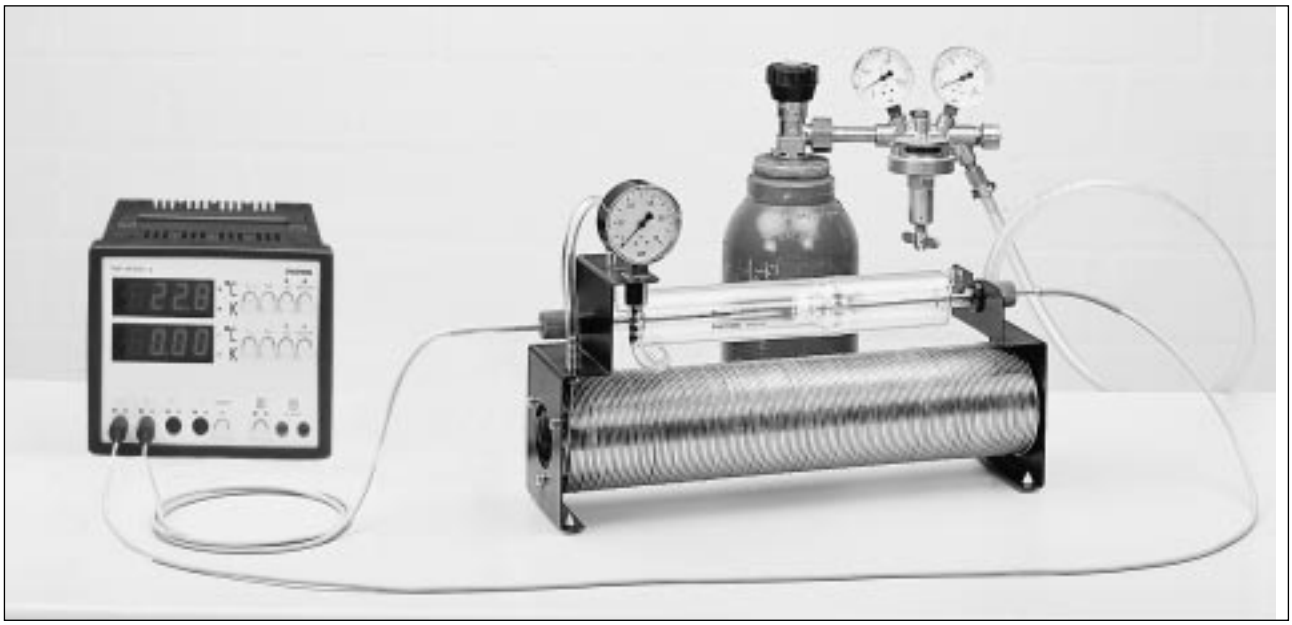
A complete experimental set-up is shown in fig. 2. The fourfold digital temperature measurement device (13616.93) is particularly suitable to measure temperatures, because it shows the difference of temperatures between two probes with a precision of 0.01 K when operated in the difference measurement mode. Immersion probes Pt100 (11759.01) are used. They are fixed in screw caps *2* and *9* in such a way that their tips are at a distance of 2 - 5 mm from the frit.

The input of the unit (olive shaped hose coupling *10*) is connected to the pressure reducing valve of the gas pressure cylinder (pressure hose and 2 hose clamps are provided). When adjusting pressure, please take into account that, due to the pressure drop in the heat exchanger, pressure displayed by the pressure reducing valve is several bar higher than the overpressure displayed by manometer *4*. The latter may not exceed the maximum admissible pressure of 1 bar for the Joule-Thomson tube. The gas outlet orifice *8* may thus never be closed during operation of the unit.

In the course of the experiment, different pairs of pressure-temperature difference values are measured (it is recommended to go from higher to lower pressures), which are then plotted in a graph. The slope of the obtained straight line is the Joule-Thomson coefficient of the measured gas.

Hints concerning the experiment

- The complete device must remain at least one hour in the room, in which the experiment will be carried out, to make sure all parts will have the same temperature.
- The apparatus can only work correctly if the pressure displayed before the heat exchanger at the pressure reducing valve is of a few bar.



- The digital temperature measuring instrument should be switched on at least half an hour before beginning measurements, to make sure display drift will remain negligible during measurements. (This is particularly important when measuring nitrogen, because in this case the maximum temperature difference which can be reached is 0.3 K).
- The gas should flow for about 1.5 minutes at constant pressure, so that a temperature equilibrium may be reached. The value of D*t* should be observed 10 to 15 seconds and averaged before being recorded.
- The Joule-Thomson coefficient is determined from the slope D*t*(D*p*). Normally this straight line does not intersect the D*t* axis, as expected theoretically, at D*t* = 0. The point of intersection may be different for every measurement series. Cause: zero compensation is carried out with the gas resting, which is no advantageous condition for a temperature equalisation between the points of measurement. As a result, the points of measurement usually have different temperatures for the display D*t* = 0. This error causes a shift of the measurement straight line in the direction of y, but has no influence on its slope.

5. EXPERIMENTING LITERATURE

Versuchseinheiten Physik
Thermodynamik 2, Ideale Gase und Dämpfe 26300.11
University laboratory experiments 00067.72

6. LIST OF ACCESSORIES

Joule-Thomson apparatus
(with pressure hose and 2 hose clamps) 04361.00
Temperature measuring instrument with 0.01 K display resolution when used in differential measuring mode:
digital temperature measuring instrument 4-4 13616.93
Immersion probes Pt 100 (2x) 11759.01
Gas sources with accessories:
Steel pressure cylinder CO_2, 10 l 41761.00
Pressure reducing valve for CO_2 33481.00
Steel pressure cylinder for N2, 10 l 41763.00
Pressure reducing valve for N_2 33483.00
Spanner for steel pressure cylinders 40322.00