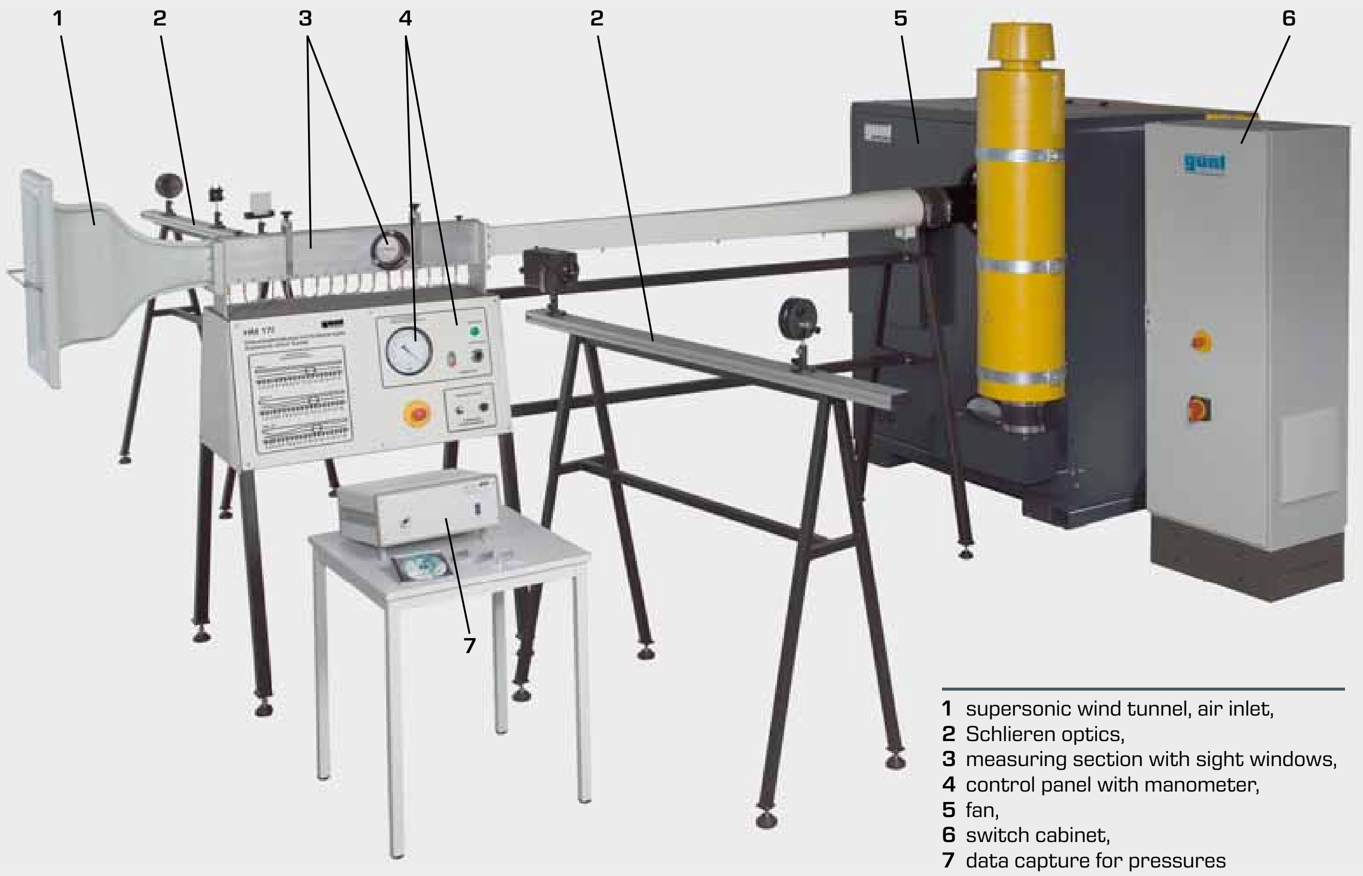
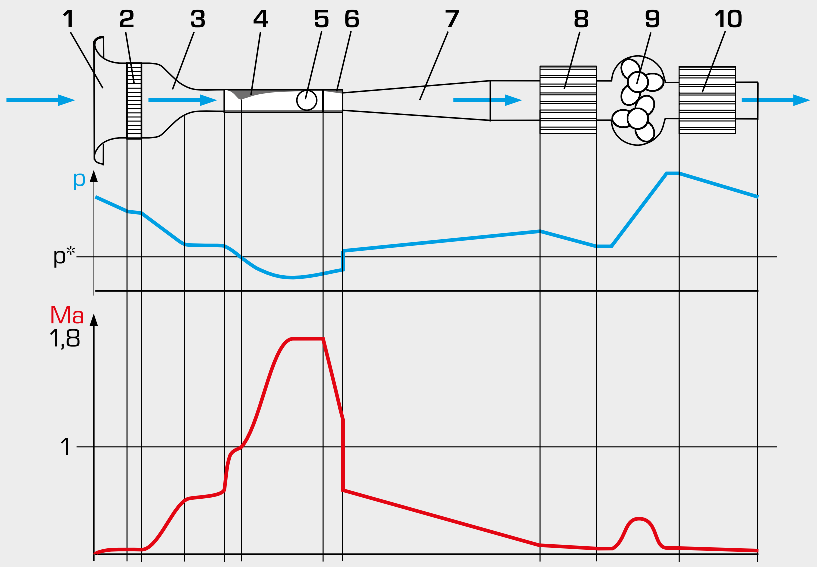
HM 172
Supersonic wind tunnel with visualisation of flow



1 supersonic wind tunnel, air inlet,
2 Schlieren optics,
3 measuring section with sight windows,
4 control panel with manometer,
5 fan,
6 switch cabinet,
7 data capture for pressures

How the supersonic wind tunnel works



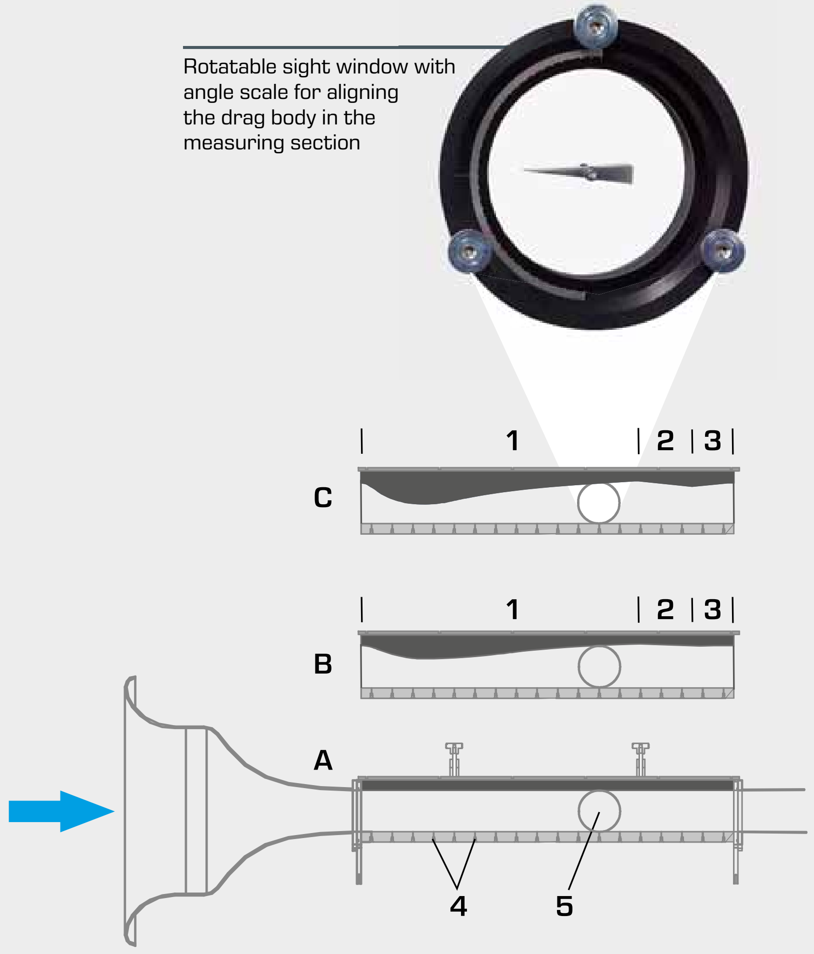
p* critical pressure ratio, **Ma** Mach number
pressure curve, velocity curve

The open supersonic wind tunnel operates continuously. A fan draws air in from the environment through the air inlet **1**, designed to be favourable to flow. The air drawn in flows through a flow straightener **2**, whereby transverse turbulence can be smoothed. The air is accelerated in the subsonic nozzle **3**. In the closed measuring section **4** an interchangeable wall with de Laval contour is used as supersonic nozzle in which air is accelerated to velocities up to Ma 1,8. The flow is observed using Schlieren optics through the sight window **5**, which is made of optical special-purpose glass. Supersonic and subsonic diffusers, **6**, **7** slow down the air flow in the rest of the supersonic wind tunnel. The air enters the fan **9** via the intake filter **8** and is compressed. The air is emitted back into the environment at the air outlet with sound damper **10**.

Complete experimental set-up

- dimensions, set up: 6,1x4,5m
- powerful fan allows continuous operation
- fan with effective soundproofing. Thus it is possible to set up in the laboratory.
- sight windows in the measuring section for using Schlieren optics to observe flow around bodies at supersonic speeds
- subsonic, transonic and supersonic flow up to Ma 1,8

Interchangeable walls for generating velocities up to Mach 1,8 in the measuring section



A straight contour: subsonic Ma < 1
B de Laval contour: supersonic Ma < 1,4
C de Laval contour: supersonic Ma 1,8

1 supersonic nozzle,
2 supersonic diffuser,
3 subsonic diffuser,
4 pressure measuring point,
5 sight window

The closed measuring section with two opposite windows is a central component of the supersonic wind tunnel. Different drag bodies are inserted in the measuring section. The sight window on the operator side can be rotated and fitted with an angular scale, so that the drag body can be reproducibly aligned in the measuring section.

The pressure is recorded at 16 measuring points in the measuring section. The measuring points are evenly distributed over the length.

Interchangeable walls, inserted in the measuring section, are used to generate different velocities. The floor of the measuring section is flat, so that only the contour of the interchangeable wall determines the cross-section profile.

A straight contour for producing subsonic speeds. **B** and **C** de Laval contours are used as supersonic nozzles. The customised shape results in supersonic flow in the area of the sight window. Further down the measuring section, the interchangeable wall is designed as a supersonic diffuser, in which the flow is decelerated by an oblique and a normal shock wave in the subsonic range.

HM 172
Visualiation and pressure profile of supersonic flow

1 concave mirror,
2 lens aperture,
3 screen,
4 light source

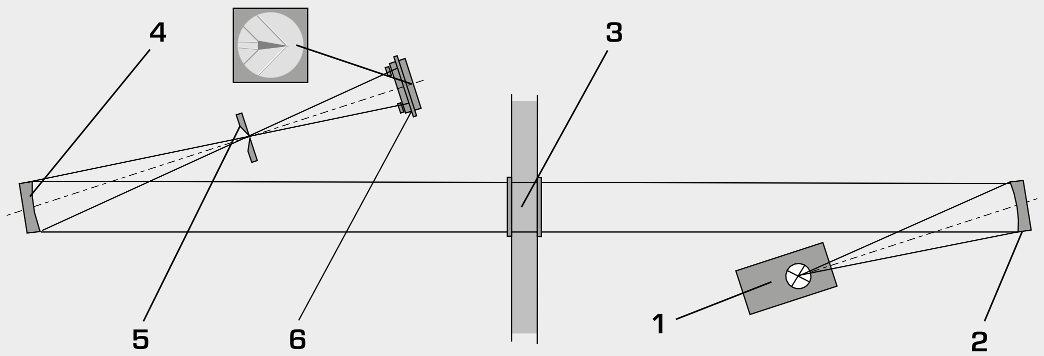
Layout and function of the Schlieren optics

Schlieren optics are used to visualise shock fronts and Mach lines that occur in shock waves.

Shock waves result in sudden increases in pressure and therefore changes in density. The Schlieren optics make the differences in density visible in the air.

To do so, a parallel light beam is sent through the measuring section, across the direction of flow. There are two sight windows in the measuring section for this purpose. Differences in density partially deflect the light due to the altered refractive index. After the light beam is focussed, deflected parts of the light beam are eliminated by a single-sided lens aperture. Thus transitions from light to dark are visible. Further down the path of the beam is a screen, onto which is projected an image of the density distribution in the measuring section – this is the Schlieren image.

The elements of the Schlieren optics are arranged on two optical benches on both sides of the measuring section. The set-up being separate from the wind tunnel prevents vibrations from transferring to the sensitive optics.

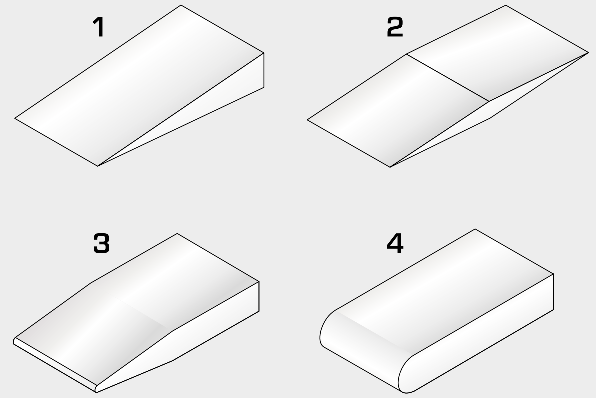


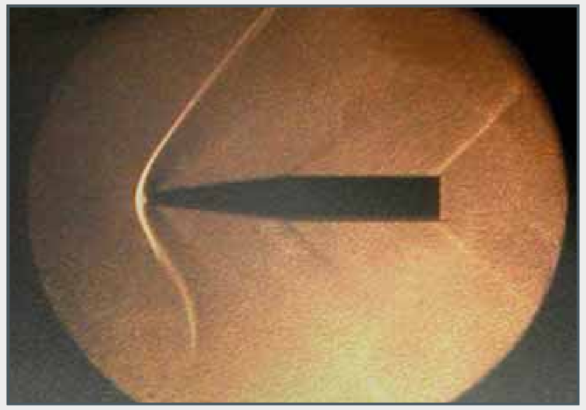
The Schlieren optics contain the following optical elements in the beam path:

1 dot-shaped light source, **2** concave mirror parallelises the light beam,
3 measuring section with two sight windows made of optical special-purpose glass, **4** concave mirror focuses the light beam,
5 single-sided aperture filters out deflected parts of the beam, **6** screen displays the Schlieren image

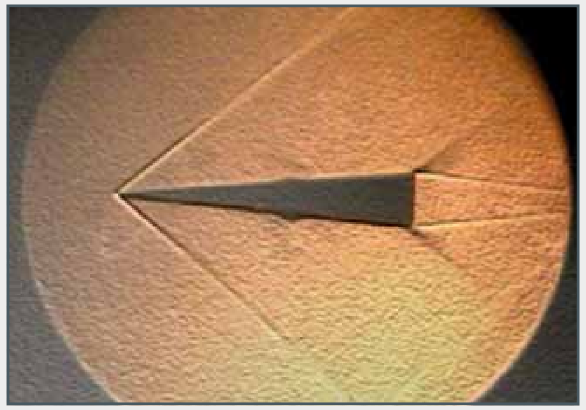
Interchangeable drag body

- angle of attack of the drag body can be adjusted
- the drag bodies **1** wedge and **2** double wedge represent supersonic aerofoils
- the drag bodies **3** rocket and **4** projectile are used to demonstrate a detached circular arc shaped shock wave





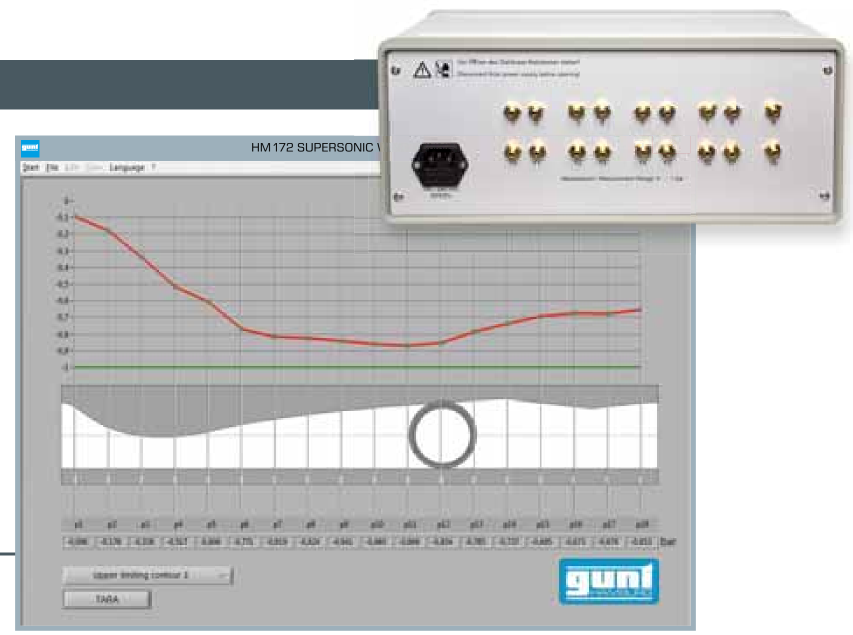
The shot of a Schlieren image shows a detached shock front on the rocket drag body typical of blunt bodies



The shot of a Schlieren image shows an adjacent shock front on the wedge drag body typical of pointed bodies

Software for data acquisition

- GUNT software included
- graphical representation of the pressure curves
- evaluation of measurement data in a spreadsheet programme (MS Excel, OO Calc)
- transfer of measurement data to a PC via USB interface



The display shows the pressures and positions of individual pressure measuring points in the measuring section