

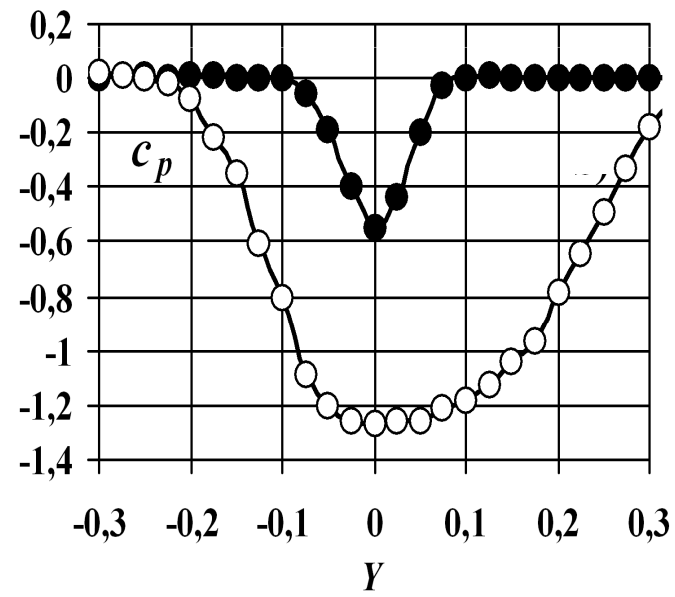
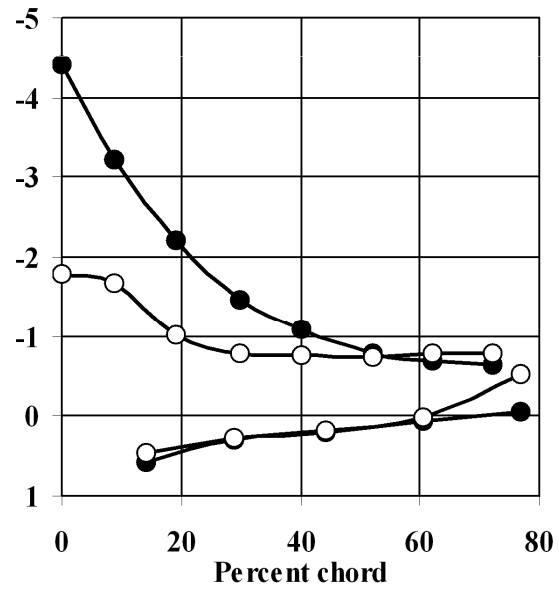
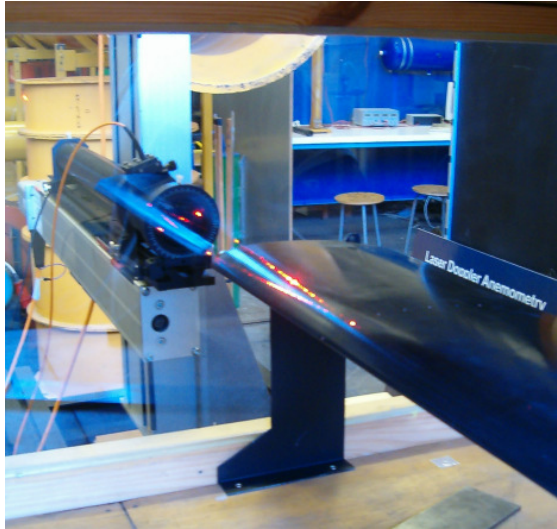
2. SZONDÁK ÉS ÉRZÉKELŐK AZ IDŐBELI ÁTLAGNYOMÁS MÉRÉSÉRE

2.1. Statikus nyomás

A zavartalan közeg nyomása

2.1.1. Gyakorlati alkalmazások: példák

- Áramlási veszteségek megítélése
- K+F



- A dinamikus nyomás meghatározásához

$$p_{dynamic} = \rho \frac{v^2}{2} = p_t - p$$

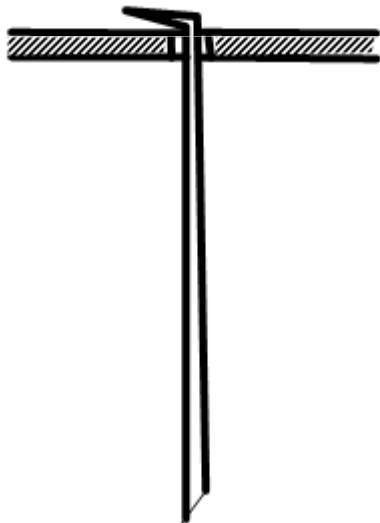
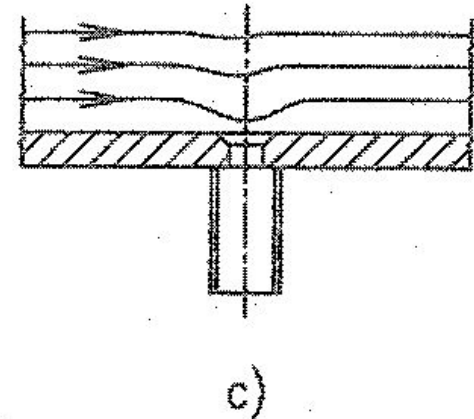
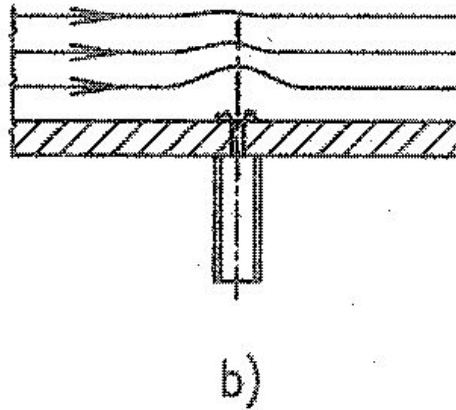
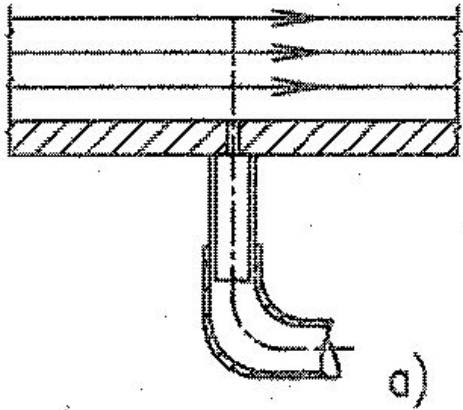
2.1.2. Mérési elv

Az Euler egyenlet normális komponens egyenlete:

$$\rho \frac{v^2}{R} = \frac{\partial p}{\partial n}$$

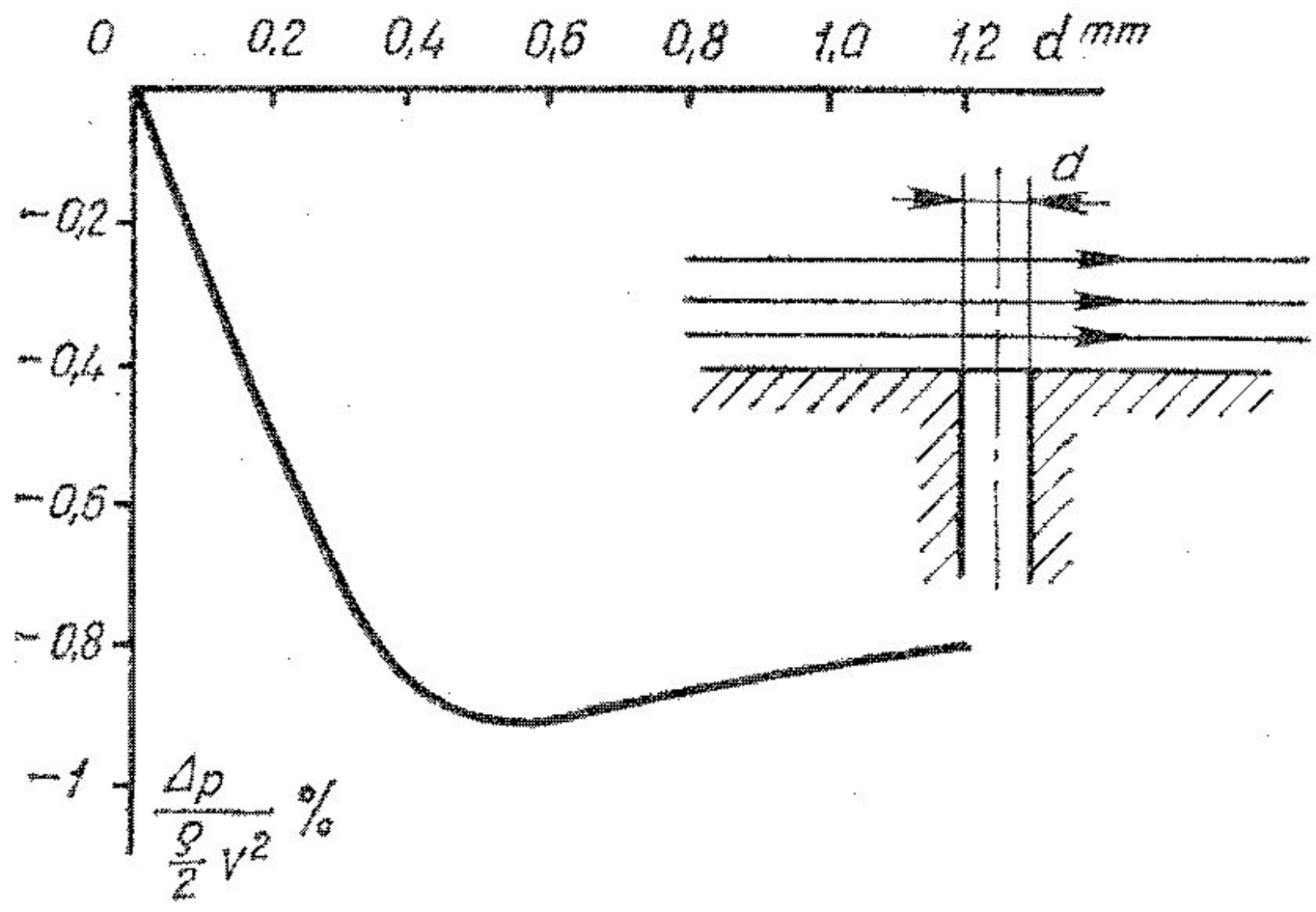
2.1.3. Példák mérési konfigurációkra és eszközökre

- Belső statikus nyomás megcsapolása fali furaton keresztül

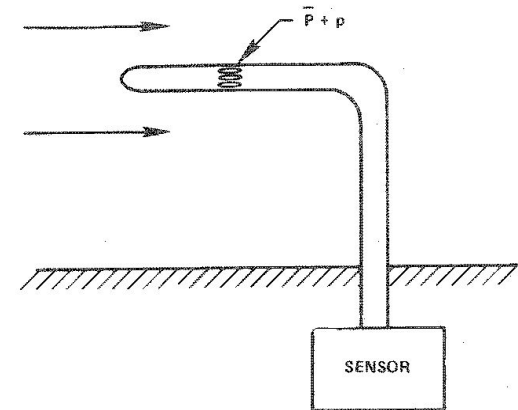
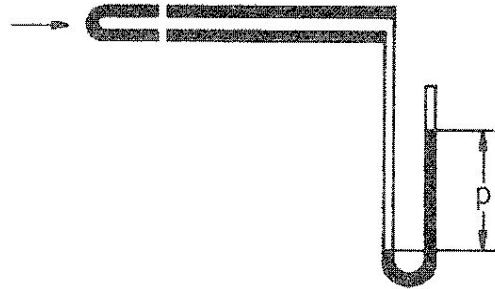
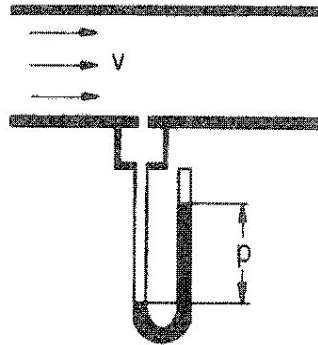


Az áramvonal-görbületi hatás elhanyagolható, ha:

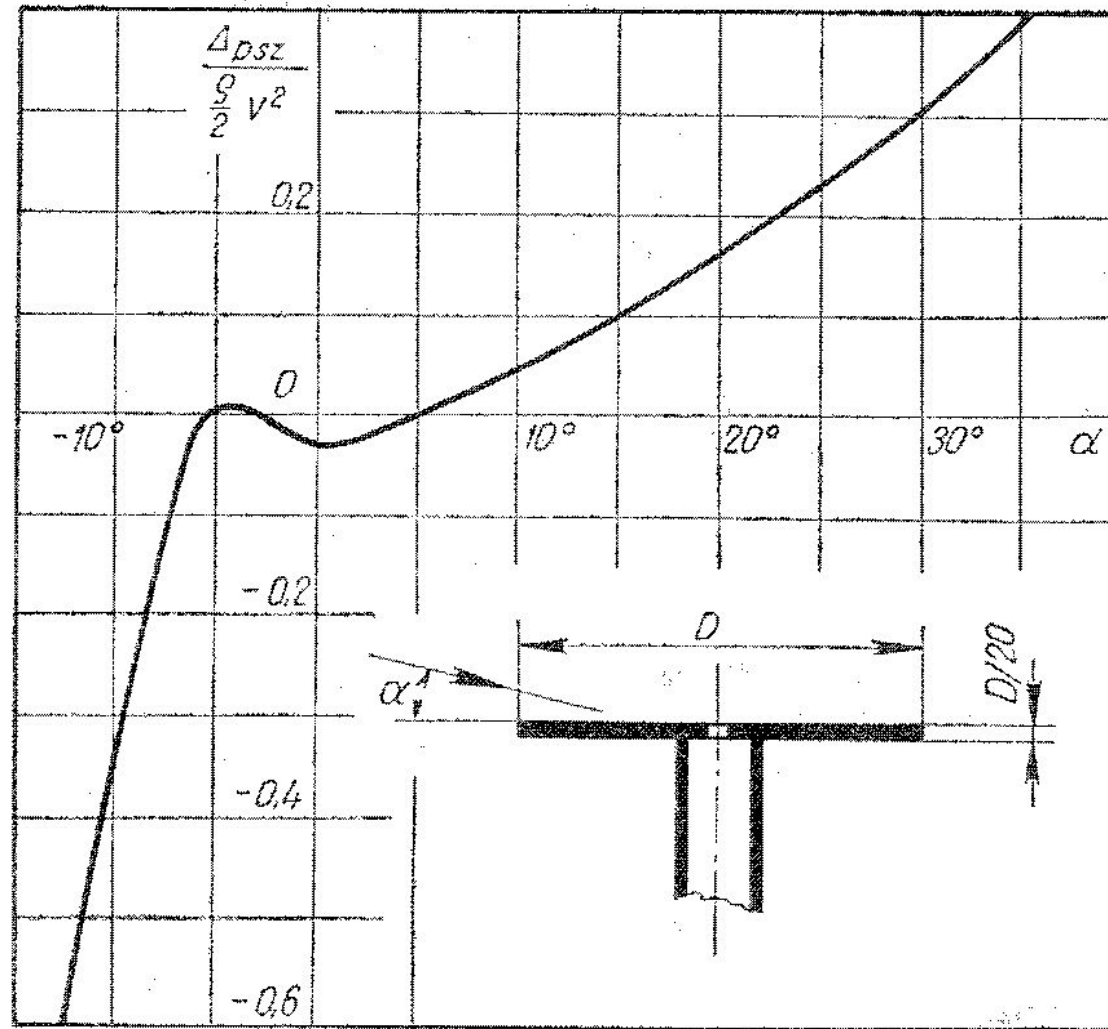
$$\rho \frac{v^2}{2} < 0.02 |p - p_{ref}|_{measured}$$



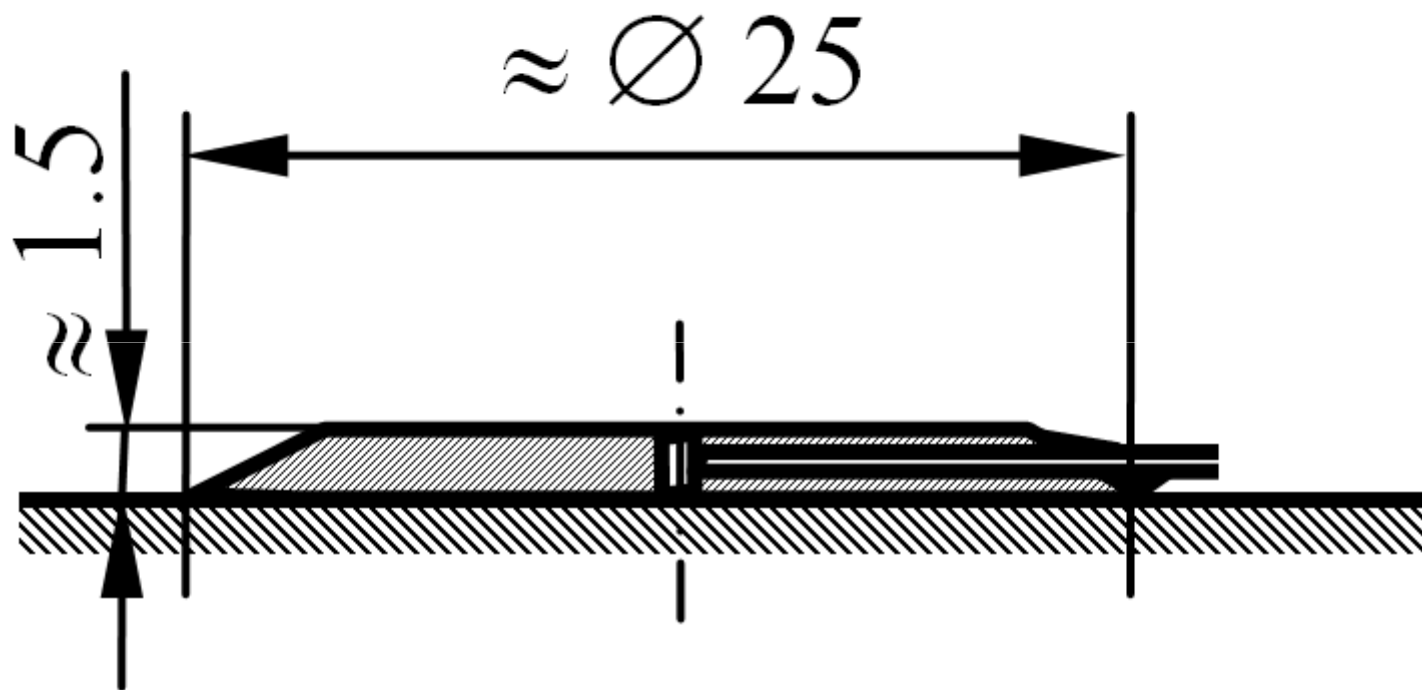
- Statikus nyomásmérő



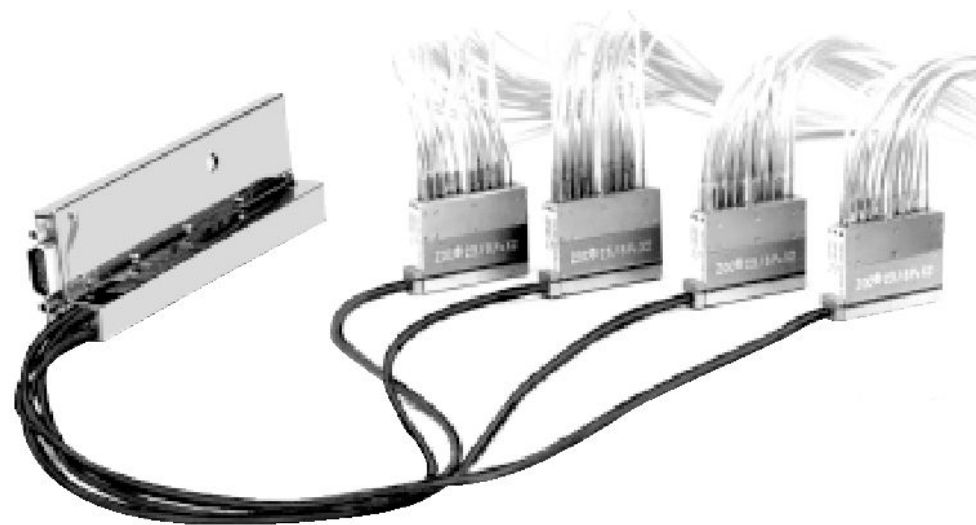
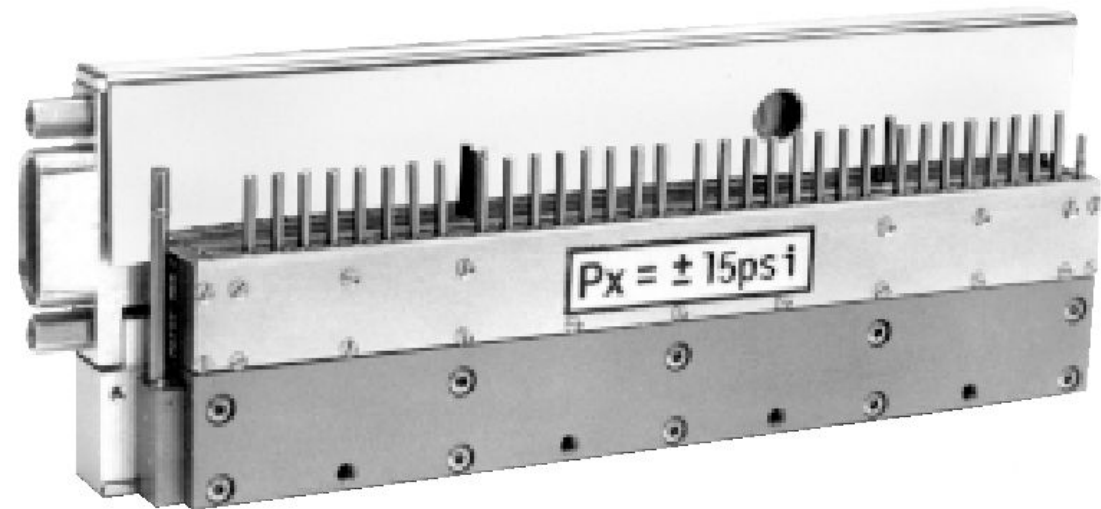
•Ser-tárcsa



•Érmeszonda



- Nyomásmultiplexer

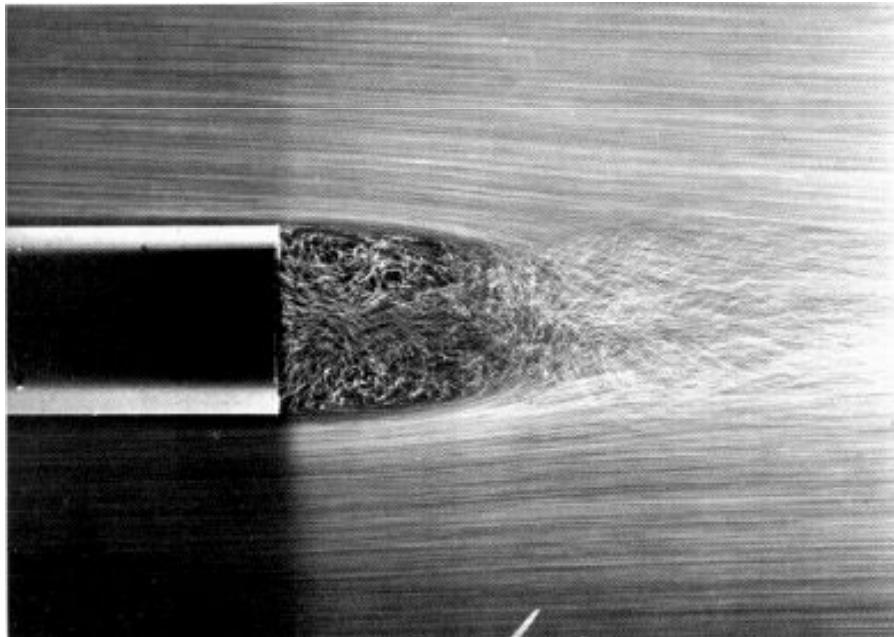


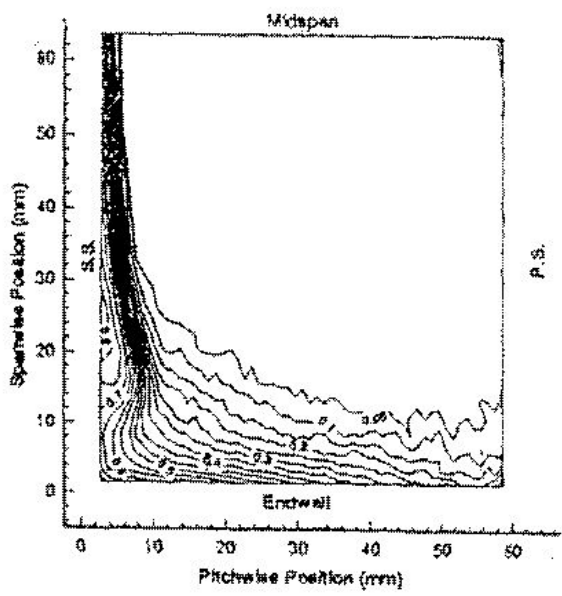
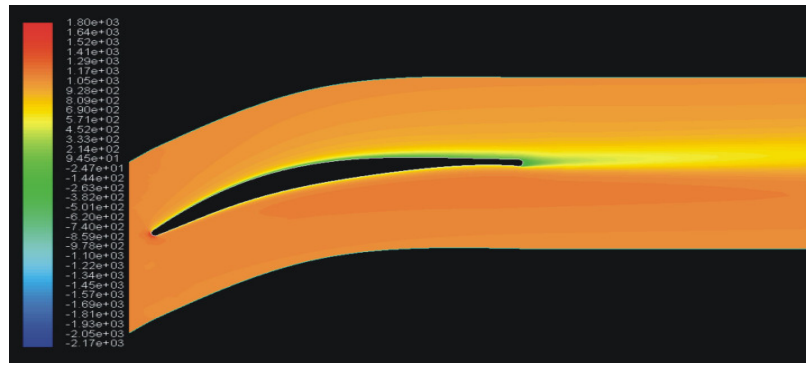
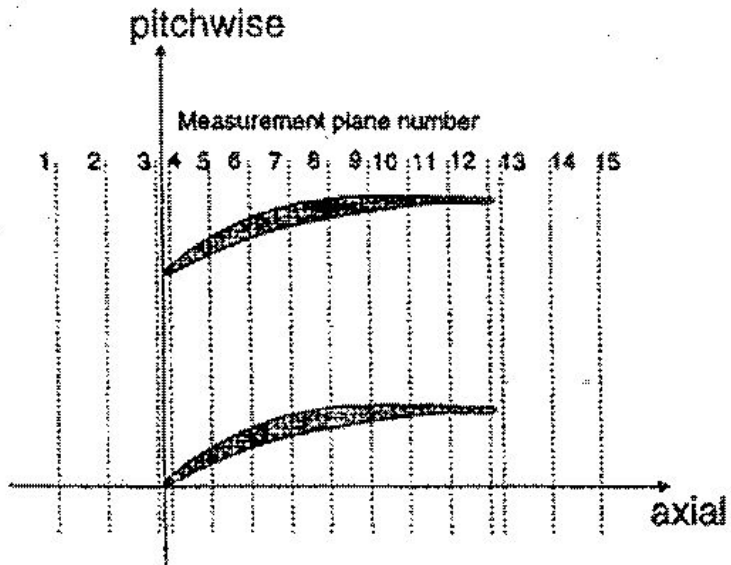
2.2. Össznyomás

A megállított közeg nyomása (torlóponti nyomás)

2.2.1. *Gyakorlati alkalmazások: példák*

- Áramlási veszteségek megítélése



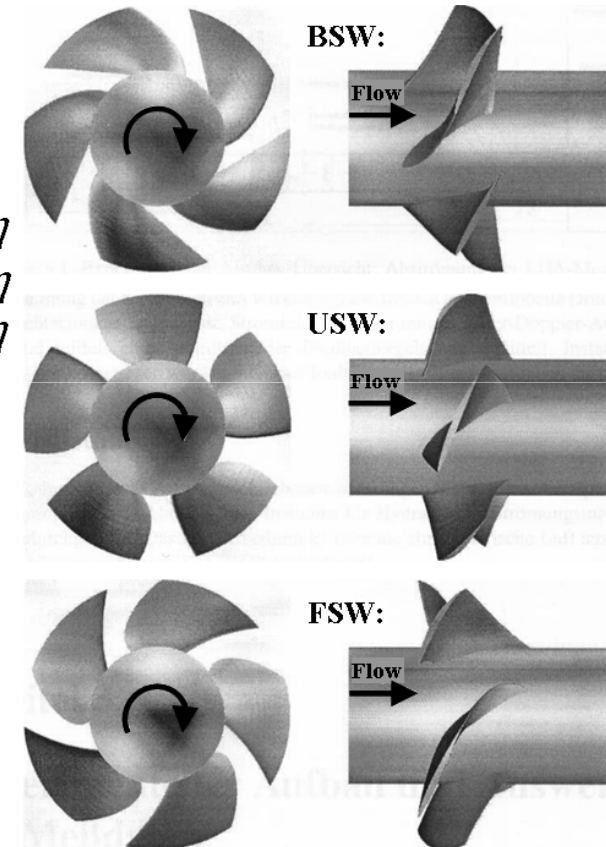
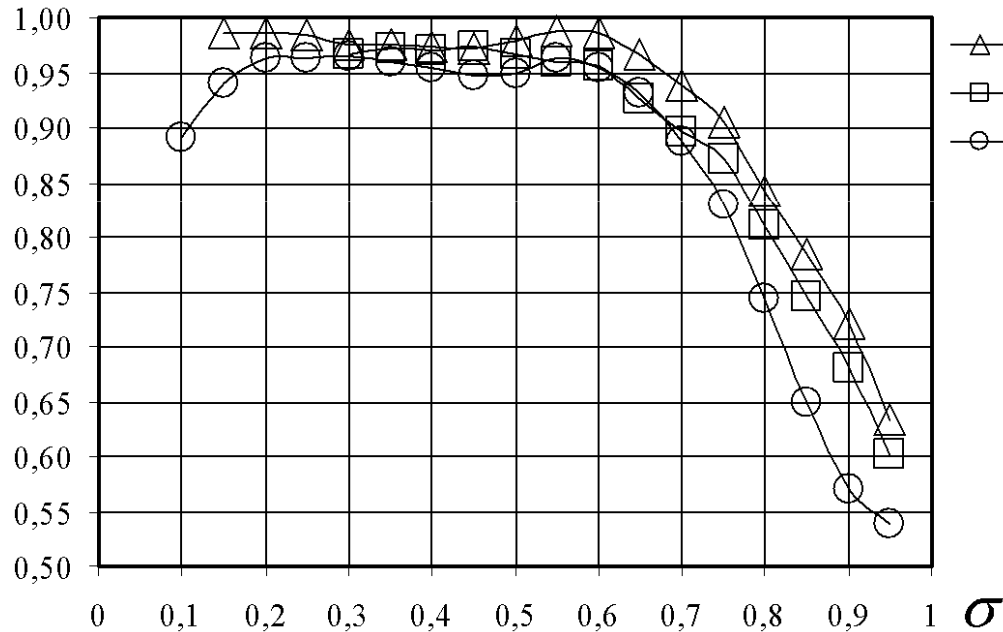


- Forgógépek teljesítményének és hatásfokának megítélése

Euler-turbinaegyenlet:

$$\Delta p_{tid} = \rho(\underline{v}_2 \underline{u}_2 - \underline{v}_1 \underline{u}_1) = \rho(v_{2u} u_2 - v_{1u} u_1)$$

$$\eta_t = \frac{\Delta p_t}{\Delta p_{tid}}$$



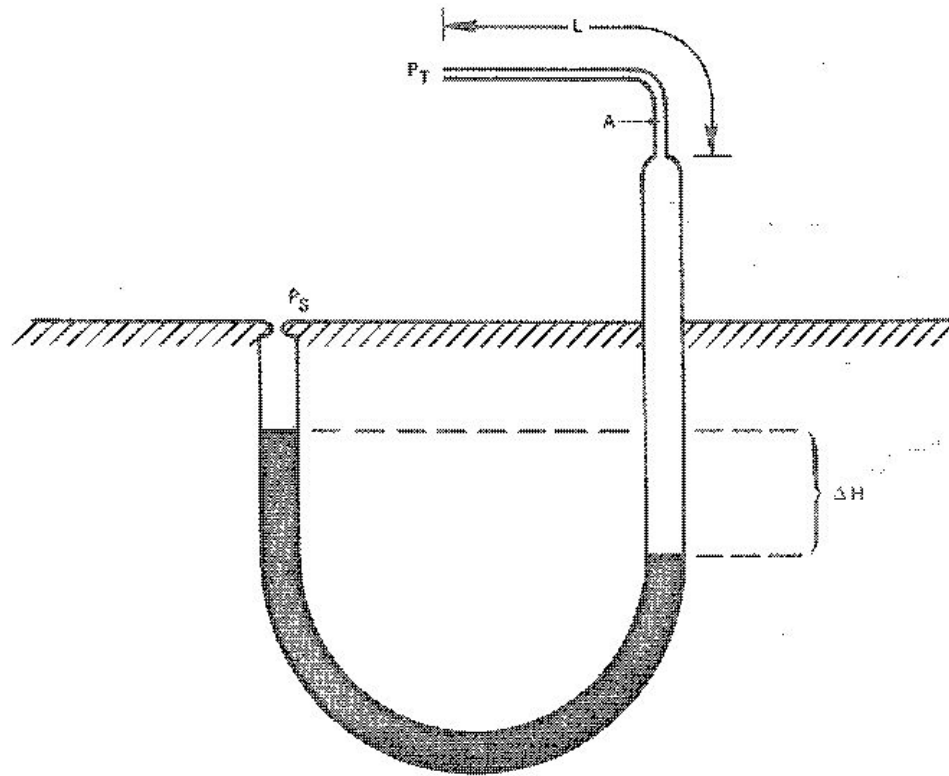
- Dinamikus nyomás meghatározásához

2.2.2. *Mérési elv*

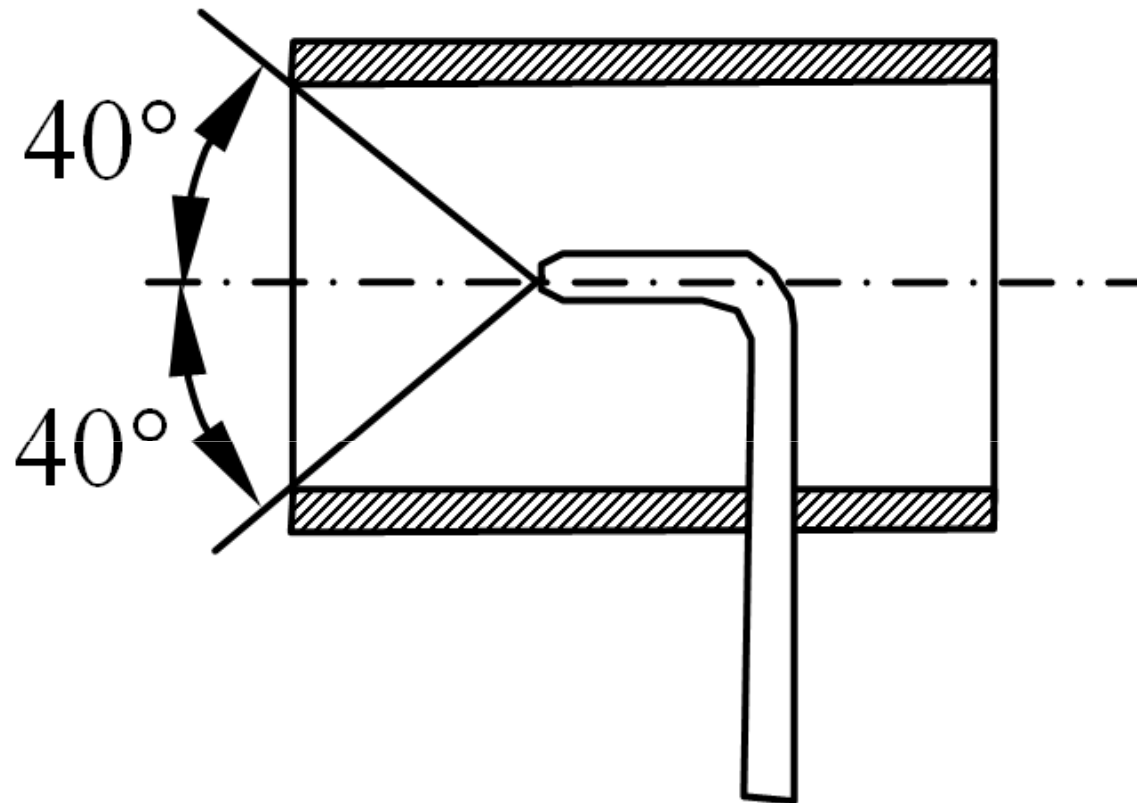
A közeget meg kell állítani a mérőeszközzel.

2.2.3. *Példák mérési konfigurációkra és eszközökre*

- Pitot-cső



•Kiel szonda



•Íránymérő szondák

2.3. Dinamikus nyomás

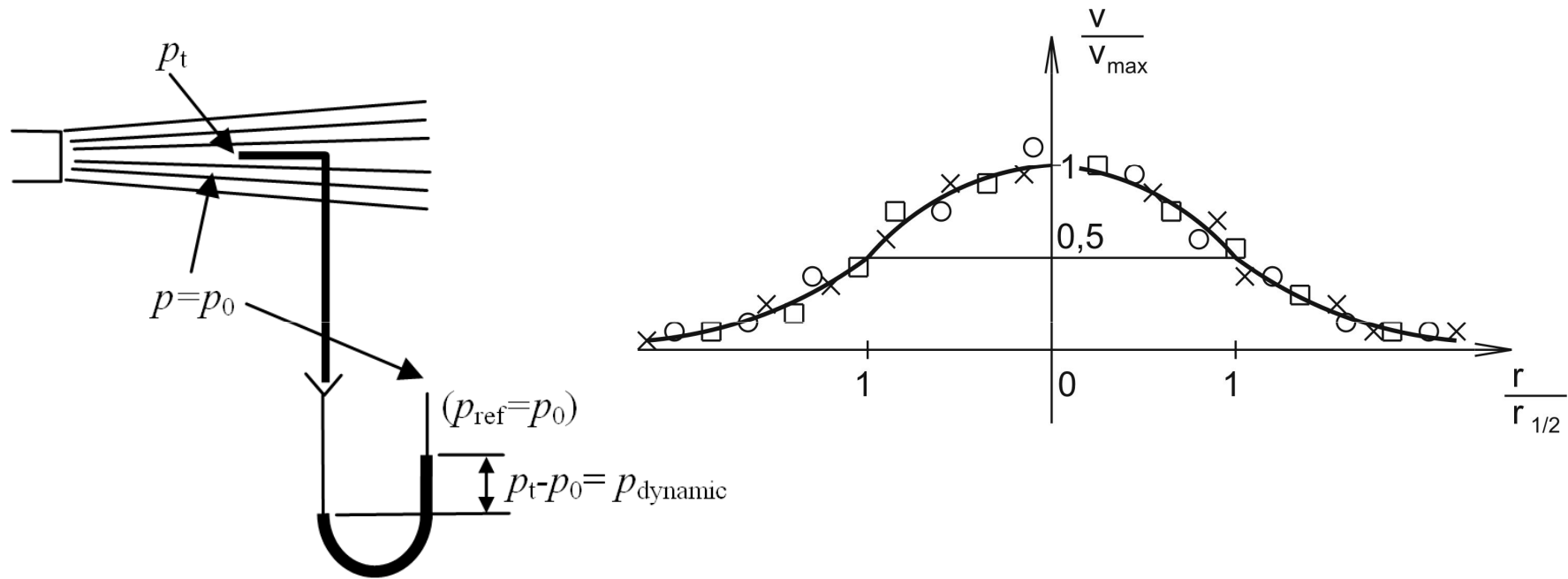
2.3.1. Gyakorlati alkalmazások:példák

$$v = \sqrt{\frac{2}{\rho} (p_{dynamic})} = \sqrt{\frac{2}{\rho} (p_t - p)} \quad \rho = \frac{p}{RT}$$

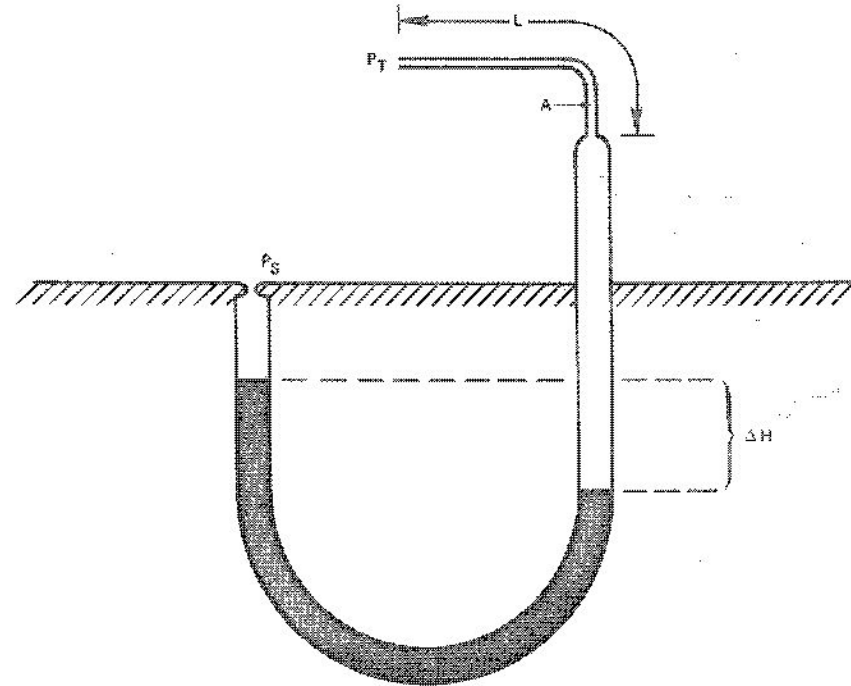
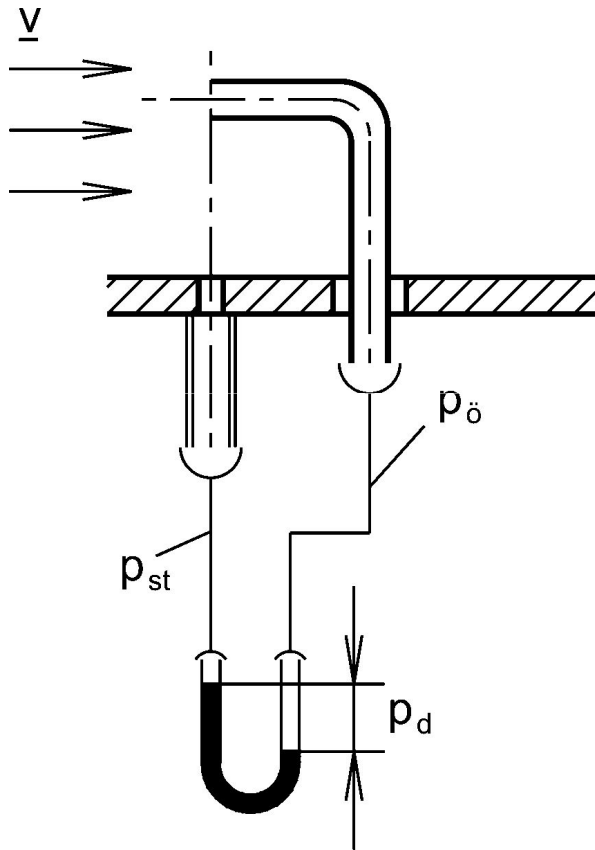
2.3.2. Mérési elv

2.3.3. Példák mérési konfigurációkra és eszközökre

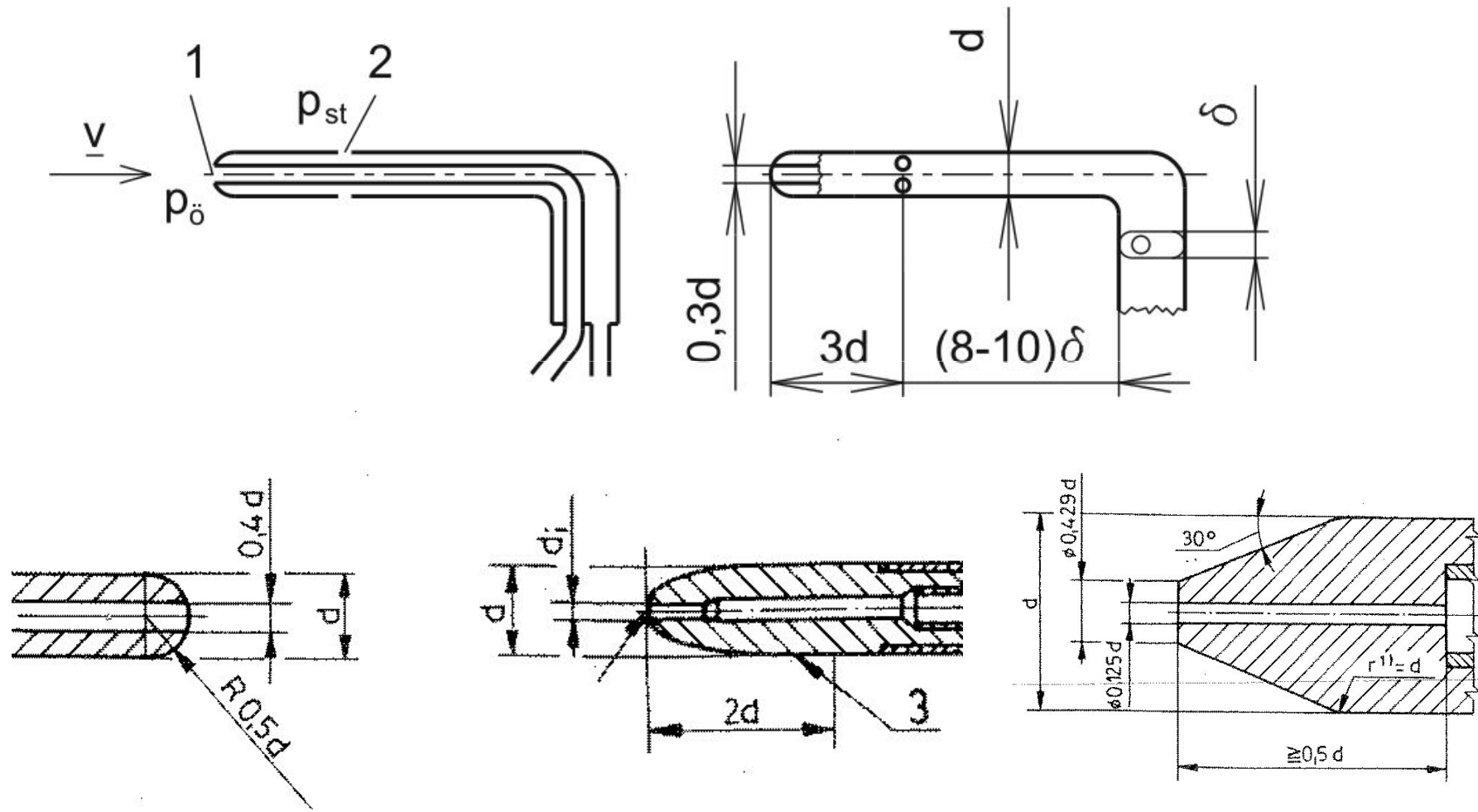
- Egyetlen Pitot-csővel



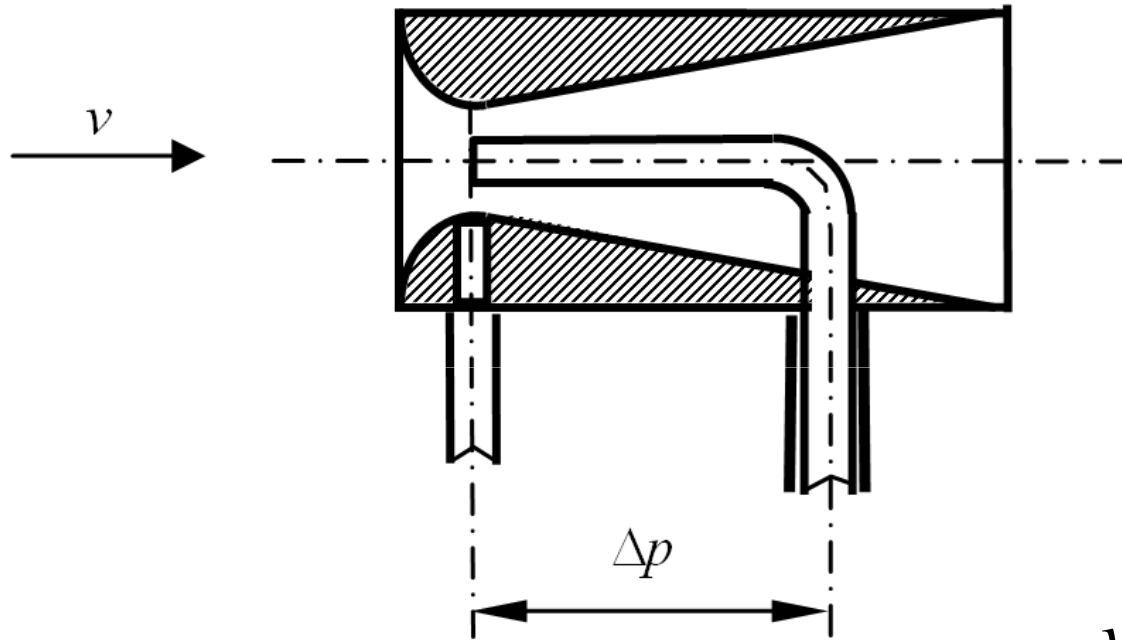
- Pitot-csővel és fali statikus nyomásmegcsapolással



•Pitot-statikus szonda (Prandtl-cső)

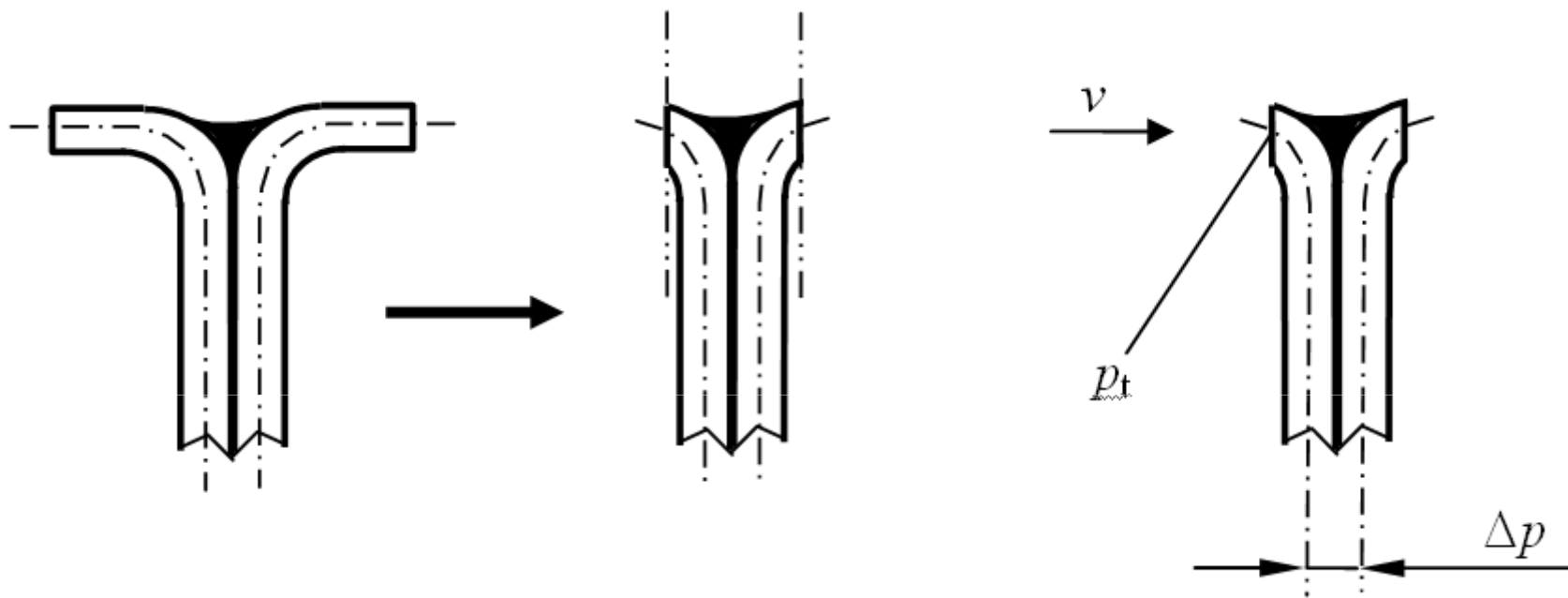


•Venturi szonda (dinamikus nyomás-sokszorozó)



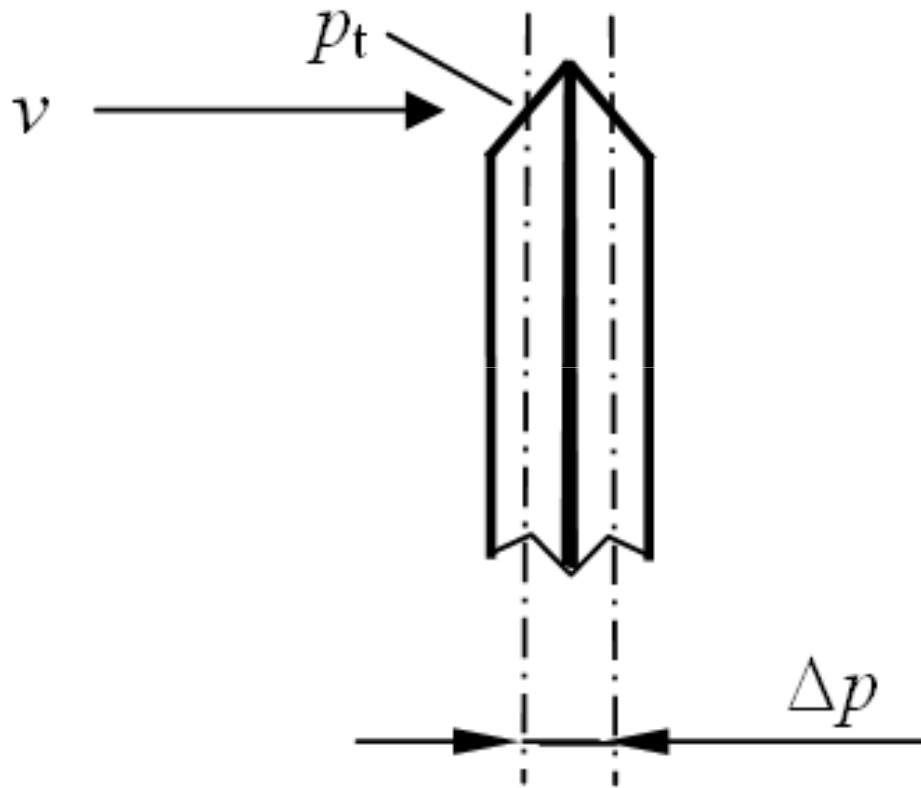
$$v = k \sqrt{\frac{2}{\rho} \Delta p}$$

•S-szonda



$$v = k \sqrt{\frac{2}{\rho} \Delta p}$$

•Spitz-szonda



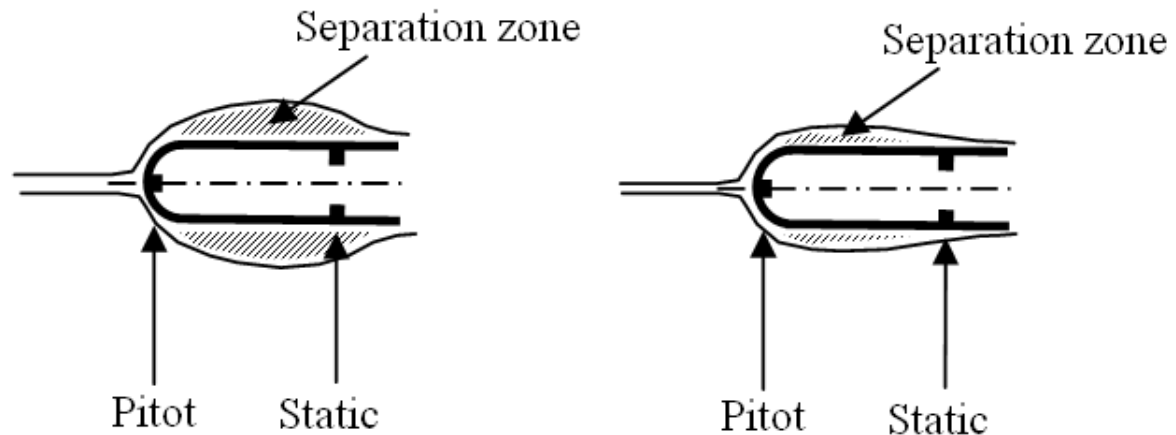
2.3.4. Nyomásmérő szondák: megjegyzések

1/ Reynolds-szám hatás

$$\text{Re}_{D/2} = \frac{v D/2}{\nu} \quad p_{dynamic} = \rho \frac{v^2}{2} = \frac{P_{dynamic meas}}{C}$$

$$C = 1 + \frac{3}{\text{Re}_{D/2}}$$

$$\text{Re}_d = \frac{v d}{\nu}$$

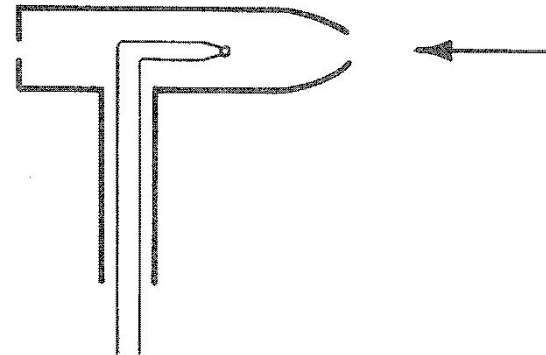


2/ Összenyomhatóság hatása

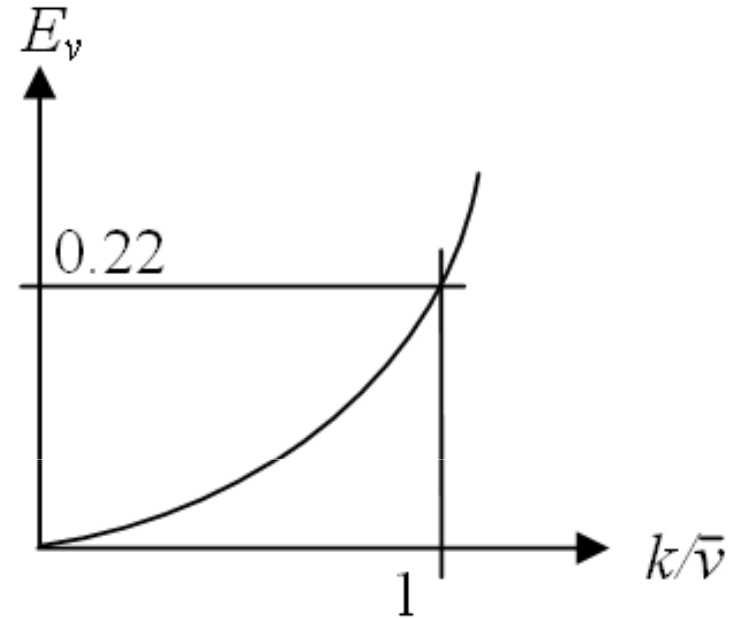
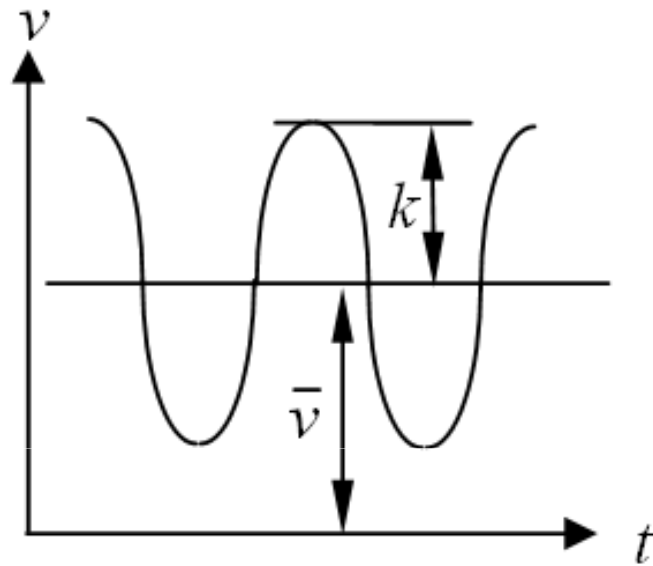
$$a = \sqrt{\kappa RT} \quad Ma = \frac{v}{a}$$

Ha $Ma > 0.3$:

$$v = \sqrt{\frac{2\kappa}{\kappa-1} \frac{p_t}{\rho_t} \left[1 - \left(\frac{p}{p_t} \right)^{\frac{\kappa-1}{\kappa}} \right]} \quad \frac{p_t}{\rho_t} = RT_t$$



3/ Ingadozó sebesség hatása



$$\overline{p}_{dyn\ meas} = \frac{\rho}{2} \overline{v^2} > \frac{\rho}{2} \overline{v}^2 \quad \sqrt{\frac{2}{\rho} \overline{p}_{dyn\ meas}} = \overline{v^2} > \overline{v}^2$$

$$E_v = \frac{\overline{v}_{meas} - \overline{v}}{\overline{v}} = \sqrt{1 + \frac{1}{2} \left(\frac{k}{\overline{v}} \right)^2} - 1$$

Turbulens ingadozások:

$$k/\bar{v} := Tu$$

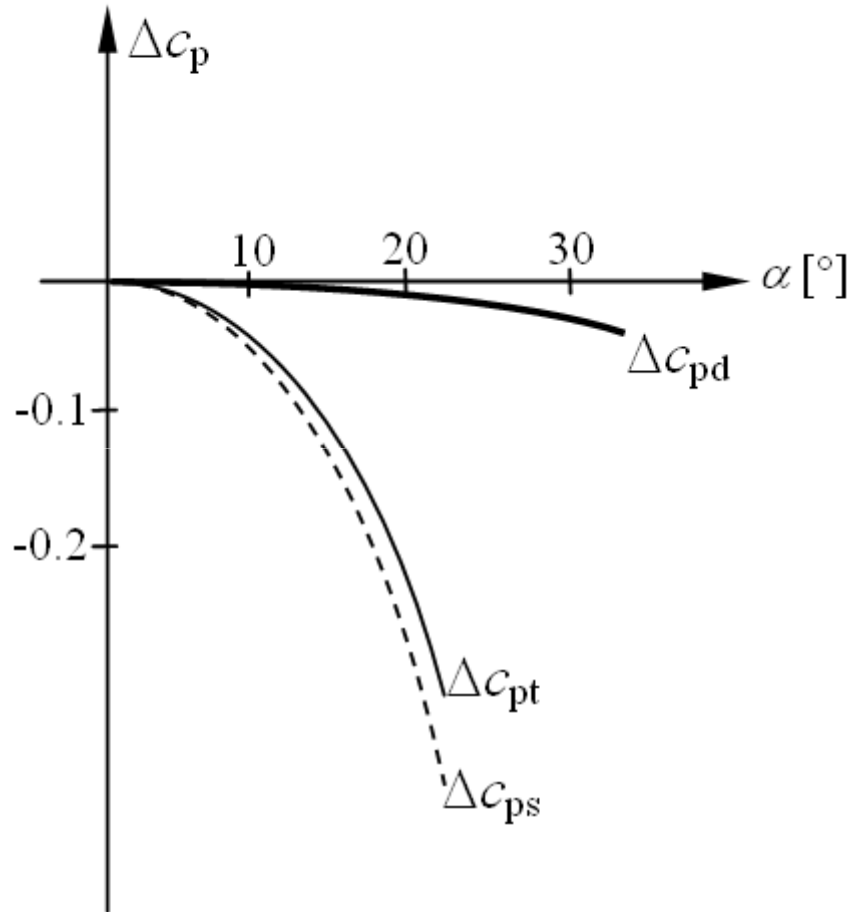
$$Tu = \frac{1}{|\bar{v}|} \sqrt{\frac{1}{3} \left(\overline{v_x'^2} + \overline{v_y'^2} + \overline{v_z'^2} \right)}$$

Áramvonalas testek körül: $Tu \approx 0.03$,

Atmoszférikus áramlás: $Tu \approx 0.3$, de magasságfüggő,

Belső áramlás: $Tu \approx 0.05 \div 0.1$.

4/ Áramlási irány hatása



$$\Delta c_{ps} = \frac{p_{meas \alpha} - p_{meas 0^\circ}}{\frac{\rho}{2} v^2}$$

$$q_V = \int_{A_{duct}} \underline{v} \, dA \approx \sum_{i=1}^n v_{\perp i} \Delta A_i$$

5/ Szilárd fázis jelenlétének hatása

- Szilárd fázis (pl. por) koncentrációja: c_S
- Folyadékfázis koncentrációja: c_F

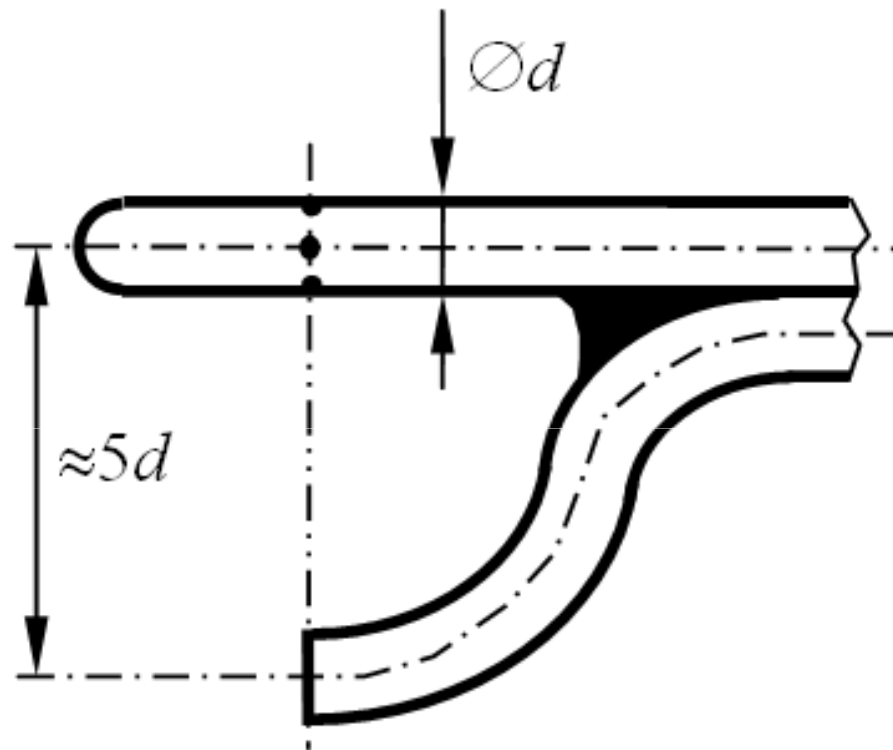
$$v = \sqrt{\frac{2}{c_F + Kc_S} P_{dyn\ measured}}$$

Részecskeátmérő: d_p

Ha $d_p \geq D$, $K \rightarrow 0$

Ha $d_p \ll D$, $K \rightarrow 1$

6/ Nem-szabványos geometria



$$v = k \sqrt{\frac{2}{\rho} \Delta p}$$

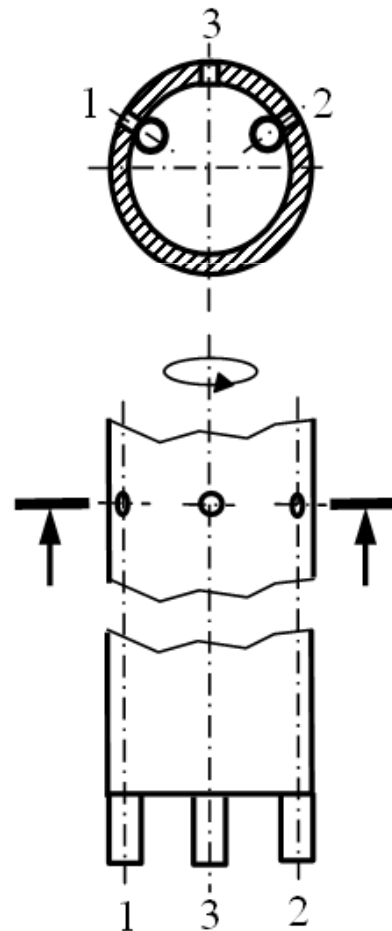
7/ A fal közelségének és a szivárgásnak a hatása

8/ Folyadéktömörség

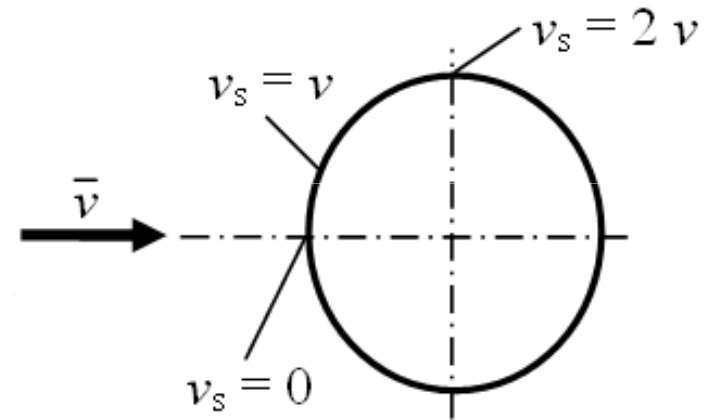
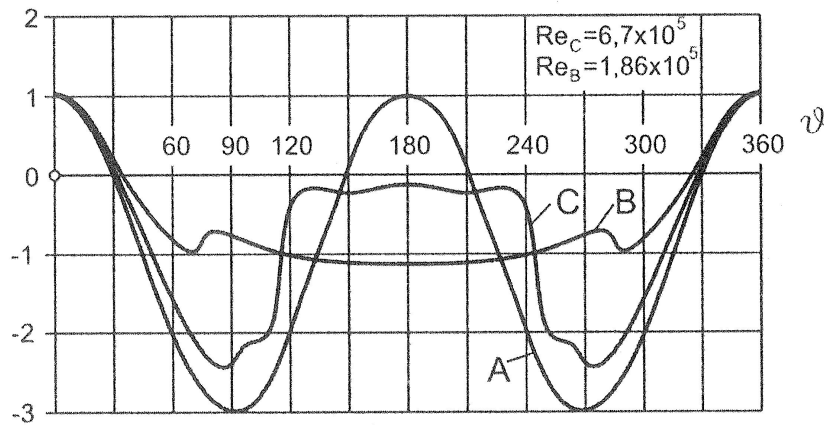
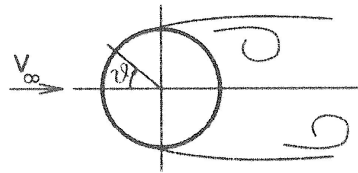
2.4. Sebesség-nagyság és irány mérése nyomásmérésre visszavezetve

•Hengerszonda

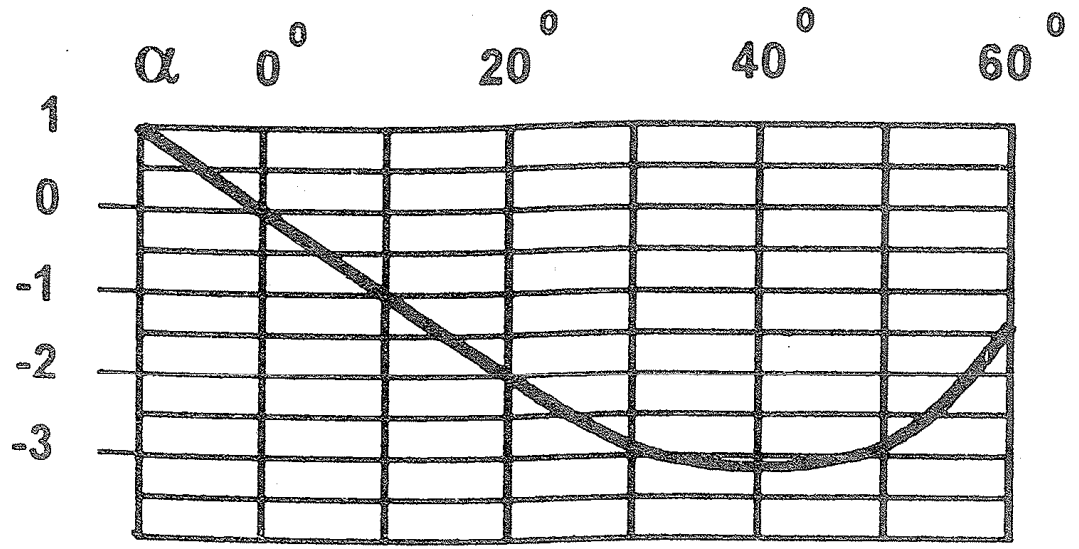
$$v = k \sqrt{\frac{2}{\rho} (p_3 - p_2)}$$



$$c_p = \frac{p_s - p}{\rho v^2 / 2} \quad p_t = p + \frac{\rho}{2} v^2 = p_s + \frac{\rho}{2} v_s^2$$

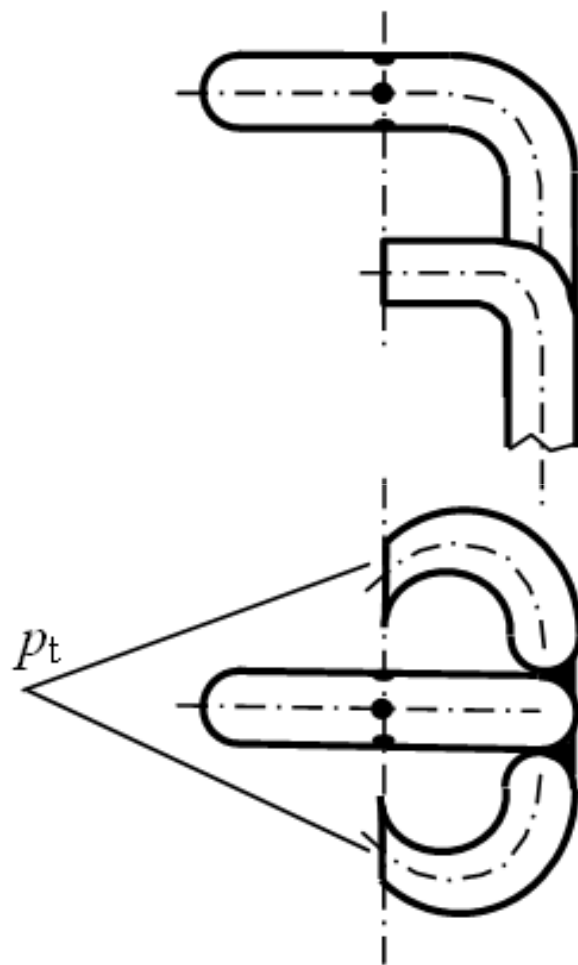


Inviscid case

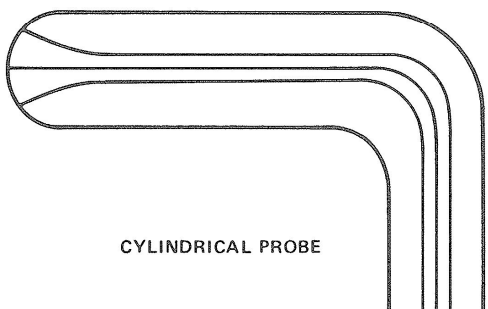
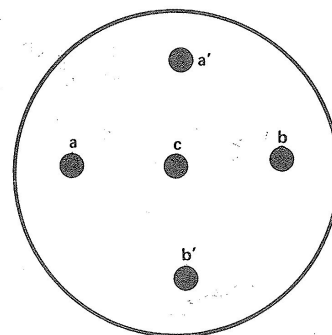
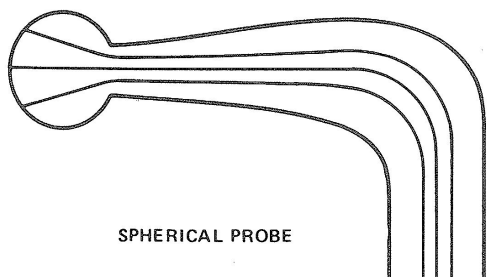


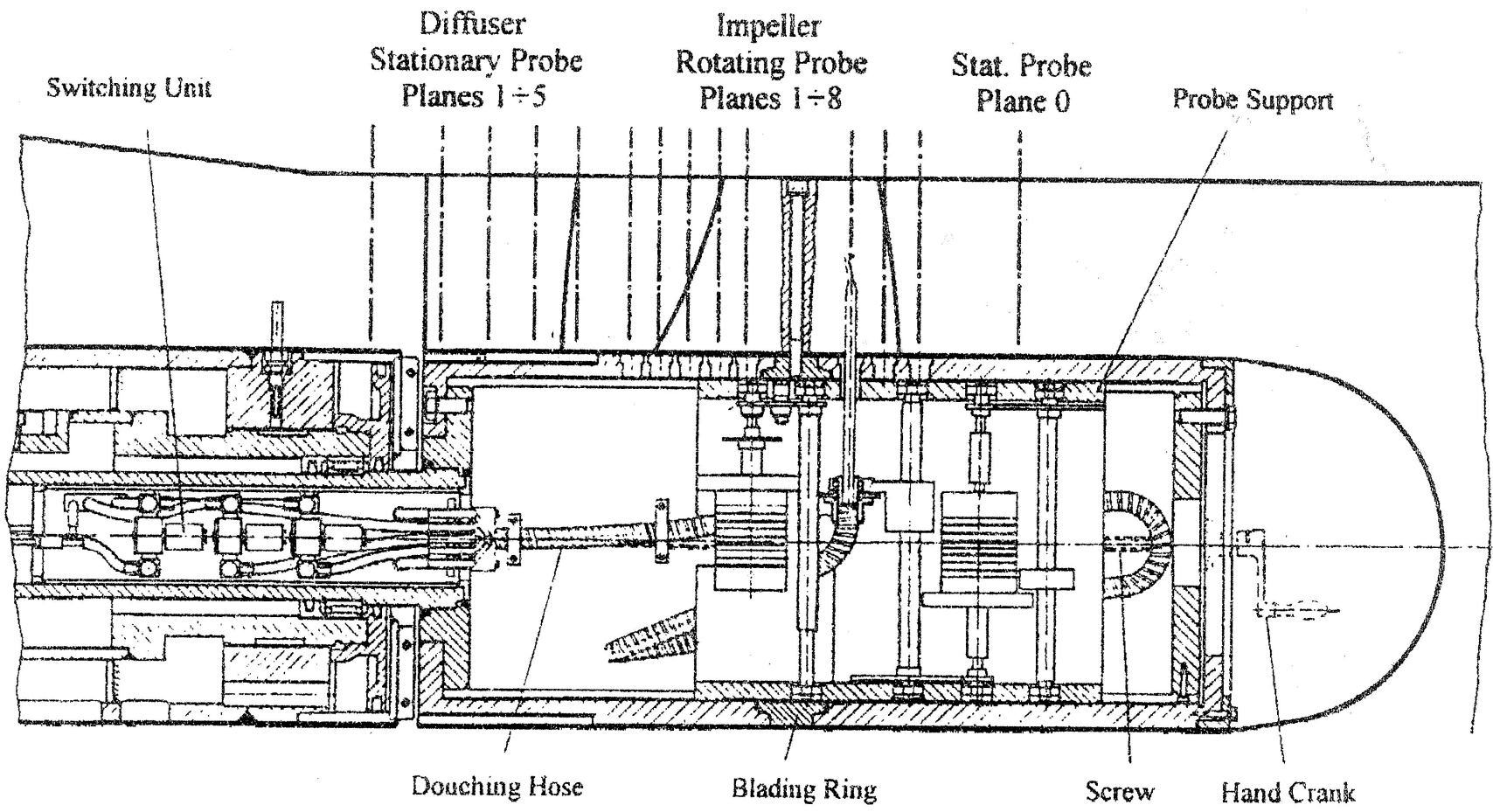
$$\frac{p_1 - p_2}{\frac{\rho}{2} c^2}$$

•Ujjszonda



•Ötlyukú szondák (ötlyukú Pitot-csövek)





Switching Unit

Diffuser
Stationary Probe
Planes 1-5

Impeller
Rotating Probe
Planes 1-8

Stat. Probe
Plane 0

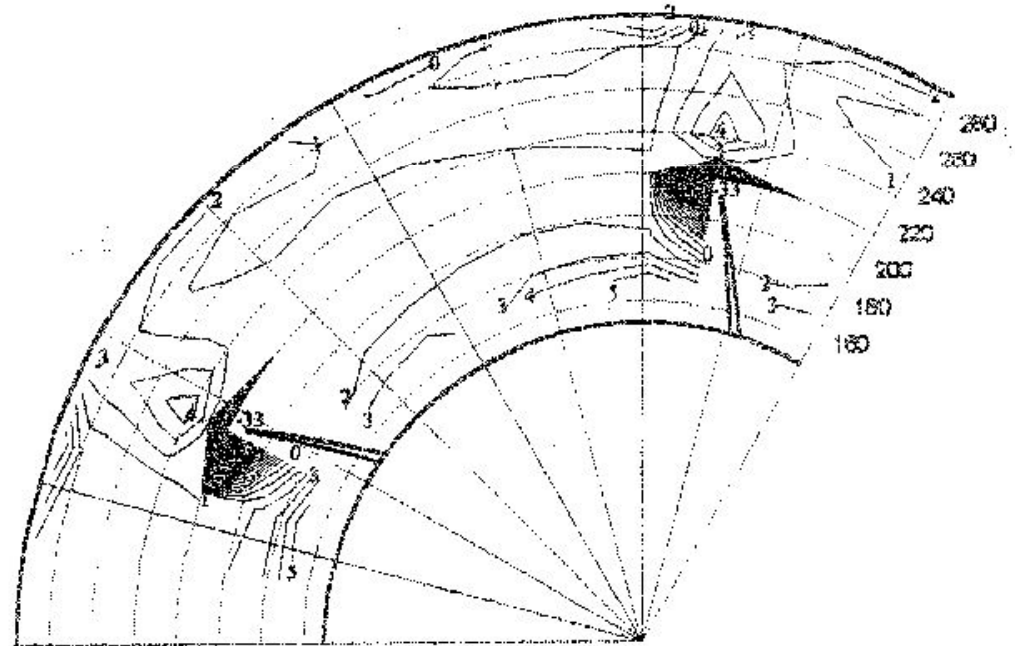
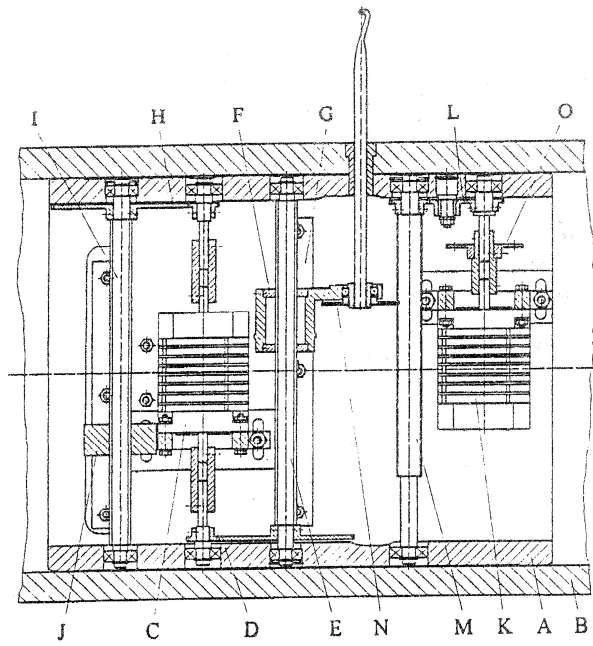
Probe Support

Douching Hose

Blading Ring

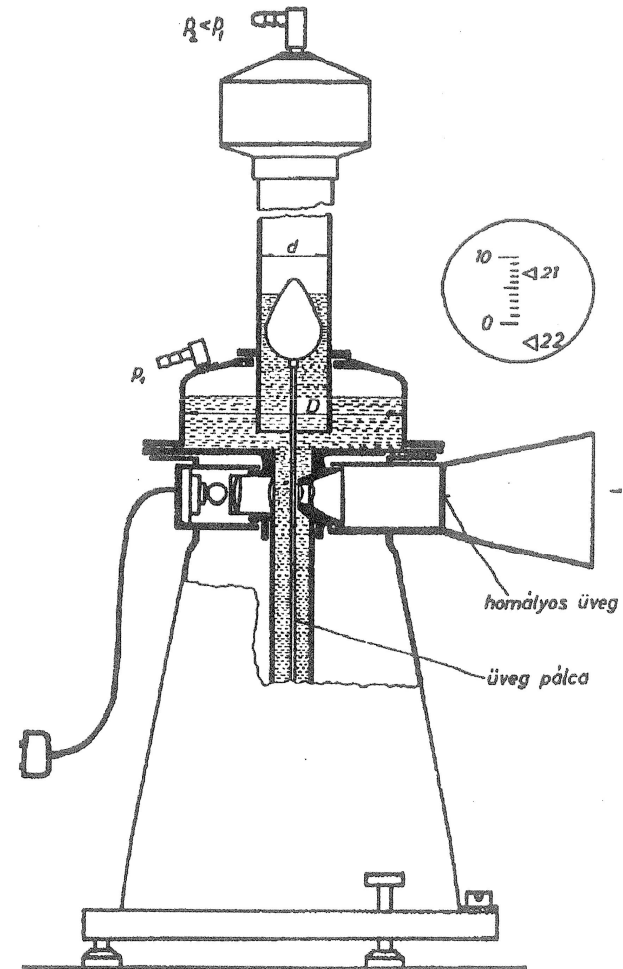
Screw

Hand Crank



2.5. Nyomáskülönbség-távadók (nyomáásszenzorok, manométerek)

- Folyadékös mikromanométerek

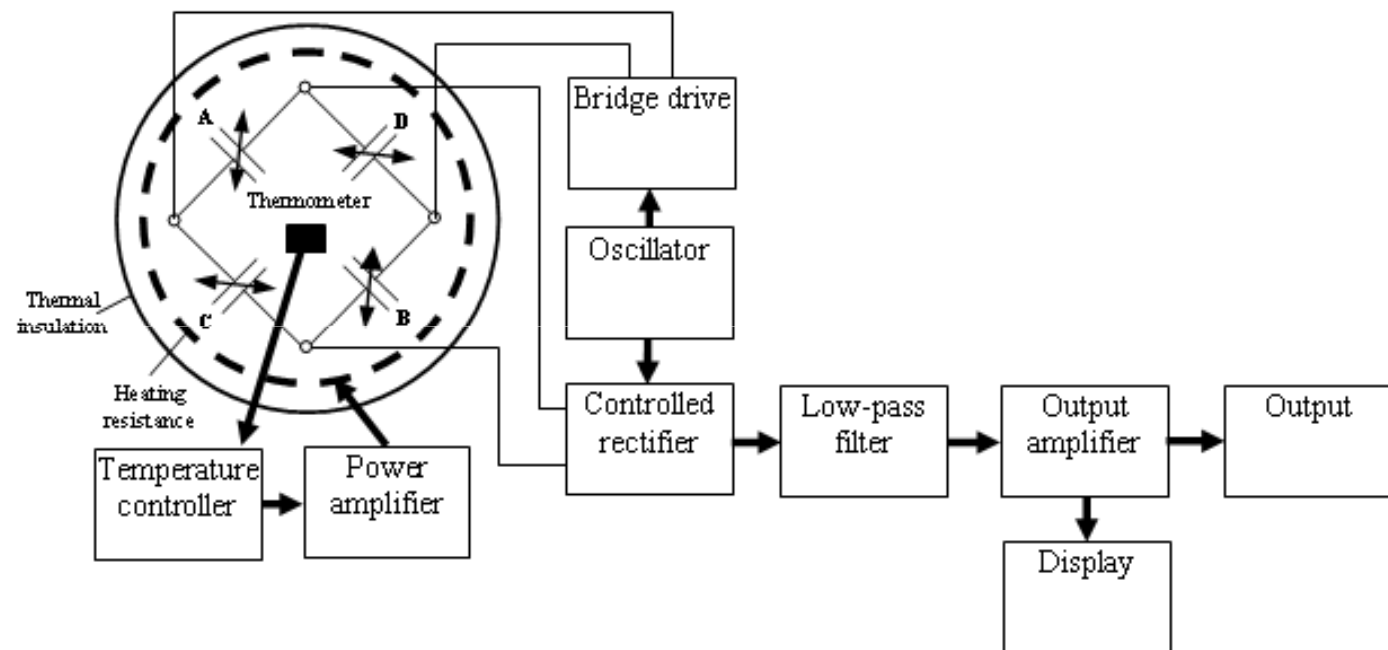
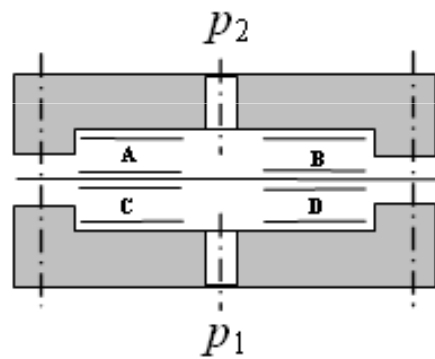


Betz manométer

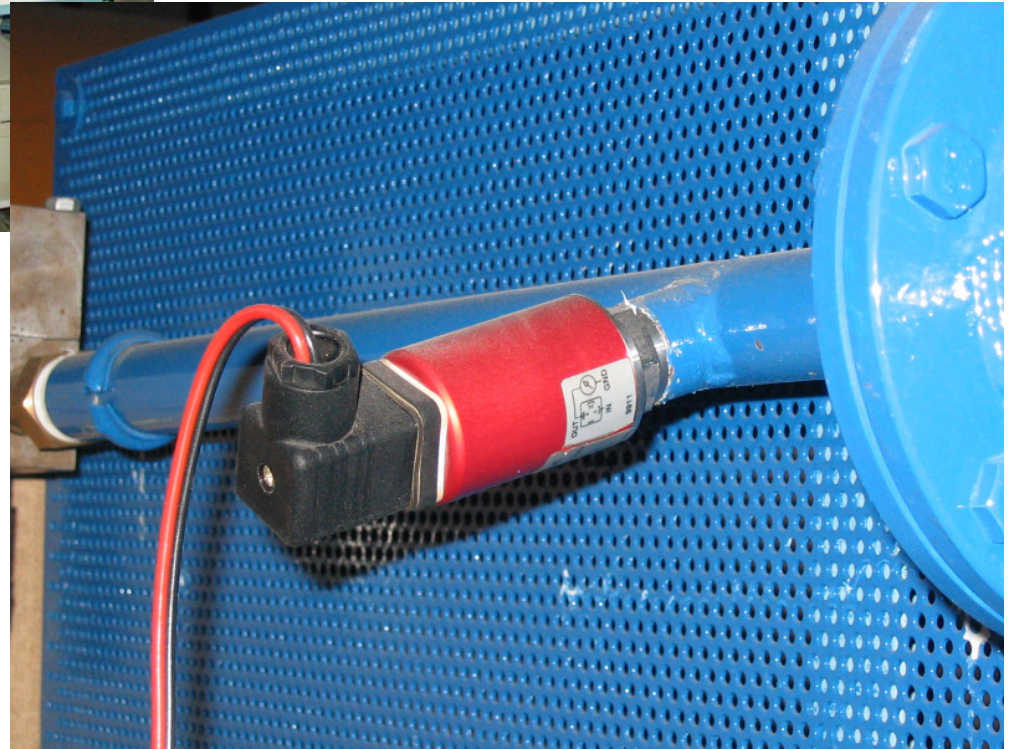
- Membrános manométerek

Villamos kapacitás-elv











100 MPa
DIGITAL
manometer

STANDARD

DM120
No: 0415