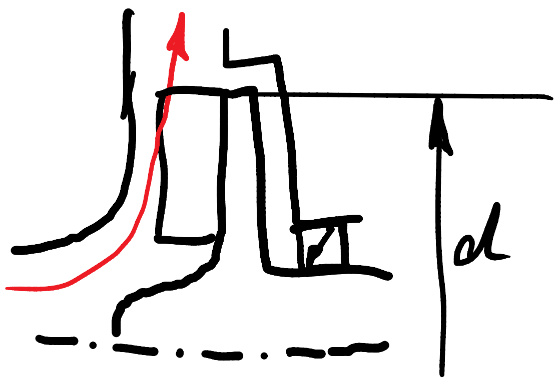
Fluidenergiemaschinen

Modul

Turbomaschinen

hydrodynamisch



$$dM_z = d\dot m\,(r_2 c_{u2} - r_1 c_{u1})$$

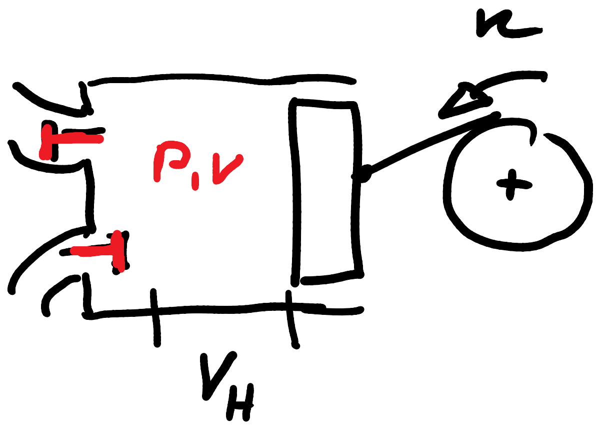
$$\frac{\partial}{\partial t} = 0$$

Leonhard Euler 1756

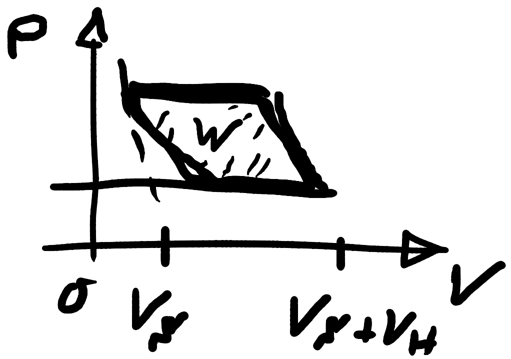
INVEST $\sim d^3$

Verdränger

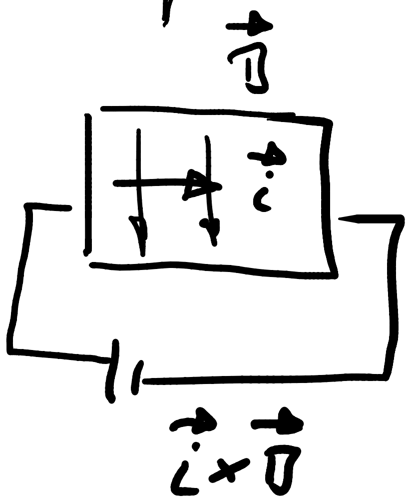
hydrostatische Maschine



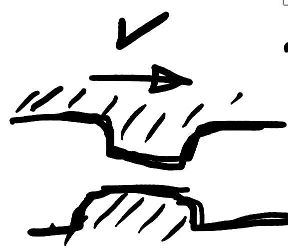
$$Q_{th} = z V_H n$$



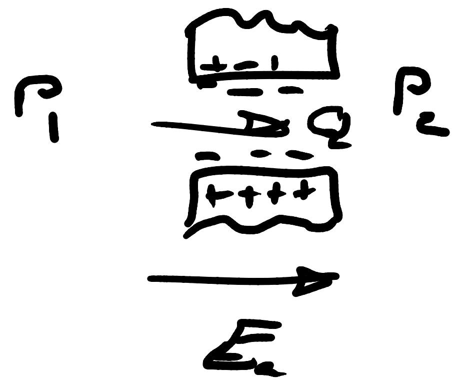
Elektrodynamische



Viskositätspumpe

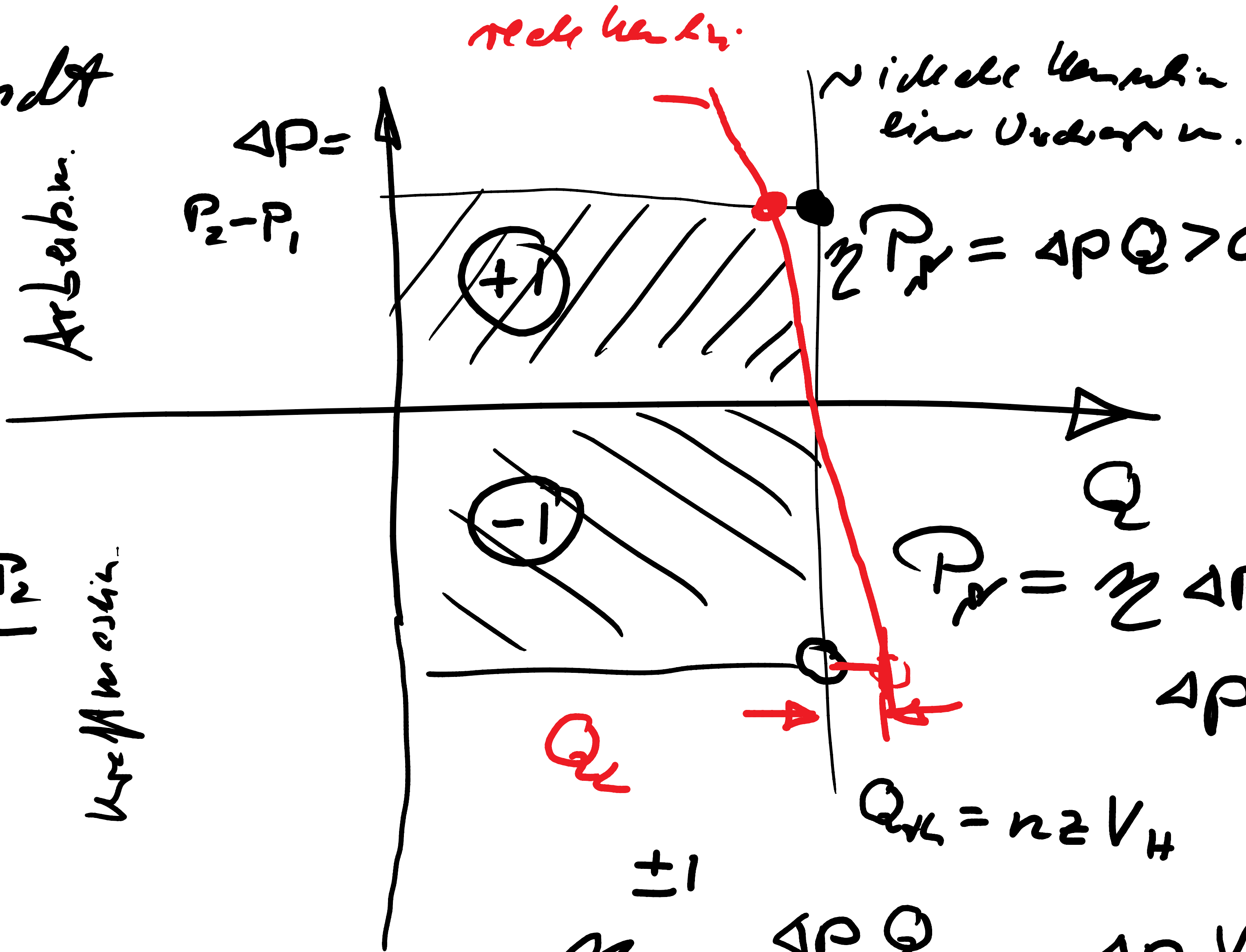


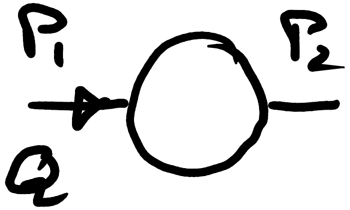
Elektrokinet.



$\rho_e \vec E$

Modellwelt





$$\eta P_M = \Delta P Q > 0$$

$$P_M = \eta \Delta P Q < 0$$

$$\Delta P = \rho g H_T$$

$$Q_{th} = n z V_H$$

$$\pm 1$$

$$\eta = \frac{\Delta P Q}{P_M} = \underbrace{\frac{\Delta P V_H z}{M_z 2\pi}}_{\eta_M} \cdot \underbrace{\frac{Q}{V_H z n}}_{\eta_{vol}}$$

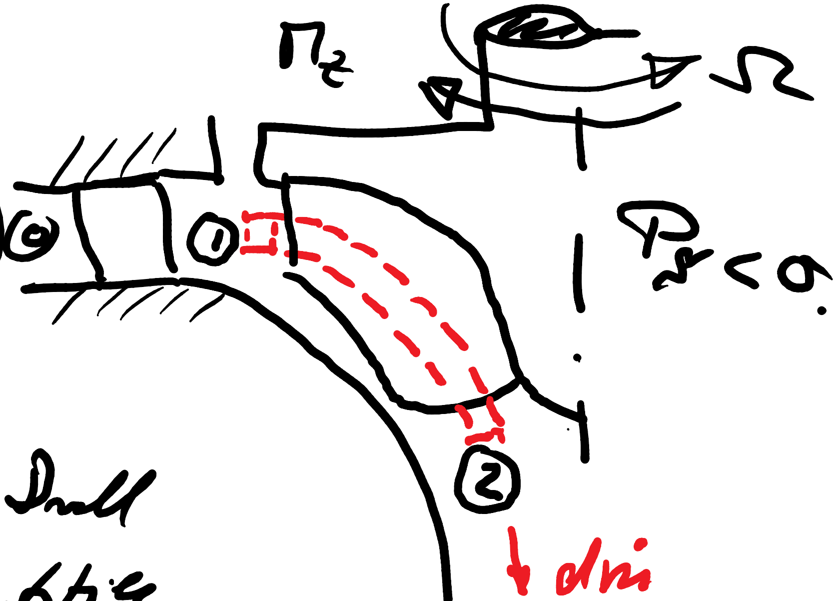
TECHNISCHE UNIVERSITÄT DARMSTADT
FLUID SYSTEM TECHNIK

Optimierung und Skalierung von Fluidsystemen

Turbomaschine (Turbine, sofern es eine Kraftmaschine ist)

Eulerscher Drallsatz in $\vec{e}_z$ Richtung

$$\Omega * \Big| \quad dM_z = d\dot{m}\left(r_2 c_{u2} - r_1 c_{u1}\right)$$



$$r c_u = (\vec{x} \times \vec{c}) \cdot \vec{e}_z$$

Massenspez. Drall eines Flüssigkeitsteilchens

$$\vec{x} = r\vec{e}_r + z\vec{e}_z$$

$$\vec{c} = c_r\vec{e}_r + c_u\vec{e}_\varphi + c_z\vec{e}_z$$

$$dP_{S'} = dQ\,(u_2 c_{u2} - u_1 c_{u1})\,\rho$$

< Eu [77]

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1. HS:

$$dP_{S'} + d\dot{Q} = d\dot{m}\,(h_{t2} - h_{t1}) \;; \qquad \rho = \rho_1 = \rho_2$$

$$d\dot{Q} \equiv 0.$$

$$\eta^{\pm 1}\, dP_{S'} = dQ\,(p_{t2} - p_{t1})$$

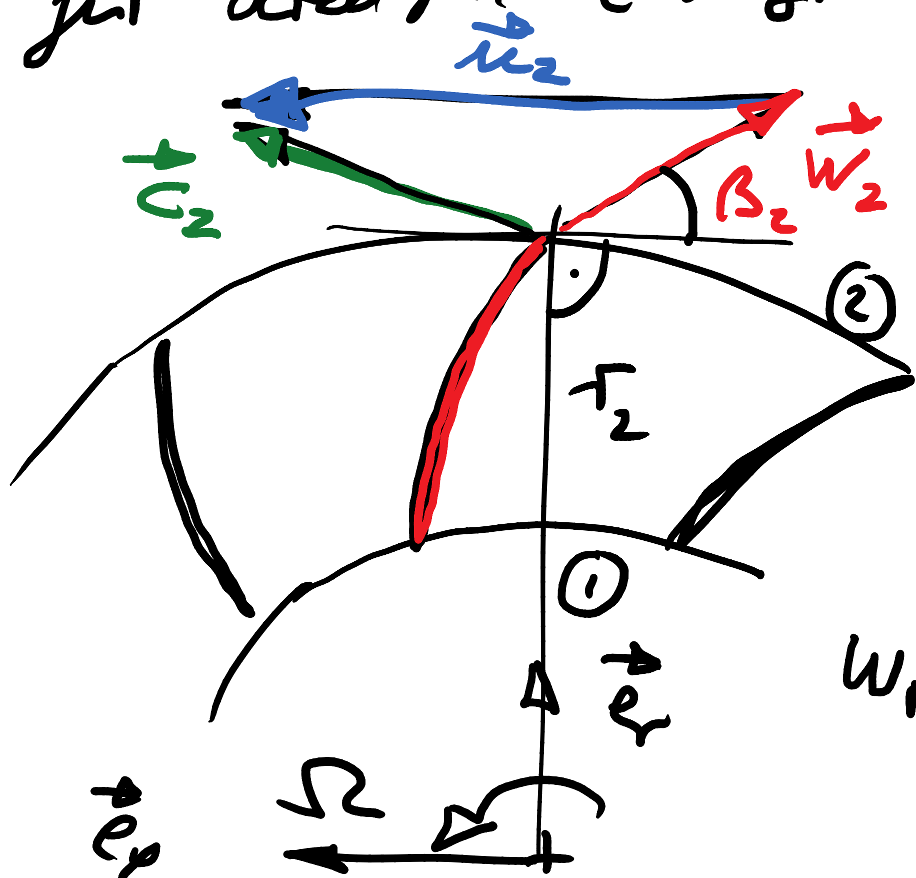
$$\parallel$$

$$\sim e_2 - e_1$$

$$\frac{p_{t2}-p_{t1}}{\rho} = \eta^{\pm}\left(u_2 \underset{?}{\underline{c_{u2}}} - \underbrace{u_1 c_{u1}}_{\equiv 0}\right)$$

$$c_{u2} = \vec{c}\cdot\vec{e}_\varphi = (\vec{u}+\vec{w})\cdot\vec{e}_\varphi$$

$c_{u1} \equiv 0$ für drallfreie Zuström. $= \Omega r_2 - w_{r2}\,\mathrm{ctg}\,\beta_2$



$$\vec{c} = \vec{u} + \vec{w} \; (+\,\vec{v})$$

Umfangsg. — Relativg. — Führungsg.

$$w_{r2} = \frac{Q}{2\pi r_2 b}$$

$$\frac{p_{t2}-p_{t1}}{\rho} = \eta^{\pm 1}\left((r_2\Omega)^2 - r_2\Omega \frac{Q}{2\pi r_2 b}\operatorname{ctg}\beta_2\right)$$

$$\frac{2}{(r_2\Omega)^2}$$

Annahme: Arbeitsmaschine, da

$c_{u1} = 0$

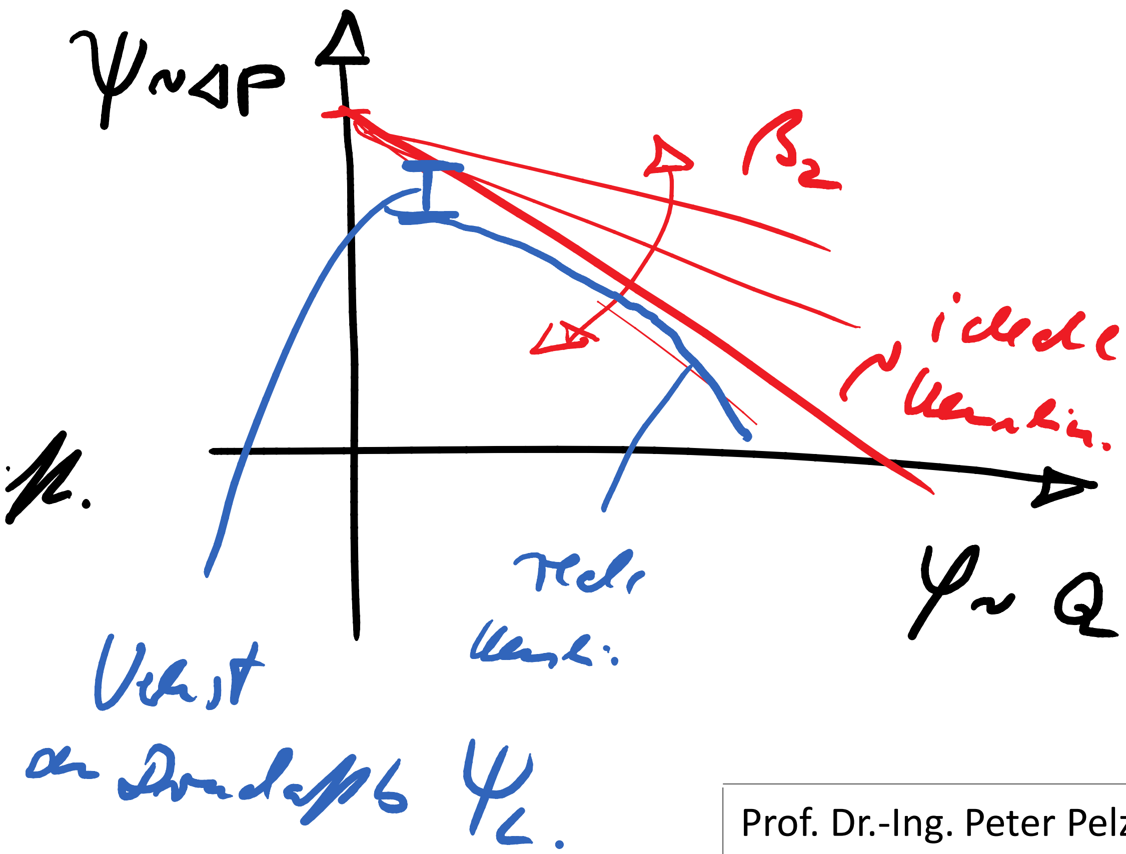
$$\frac{p_{t2}-p_{t1}}{\rho u_2^2 / 2} = \eta^{+1}\left(2 - 2\frac{Q}{2\pi r_2^2 b\,\Omega}\operatorname{ctg}\beta_2\right)$$

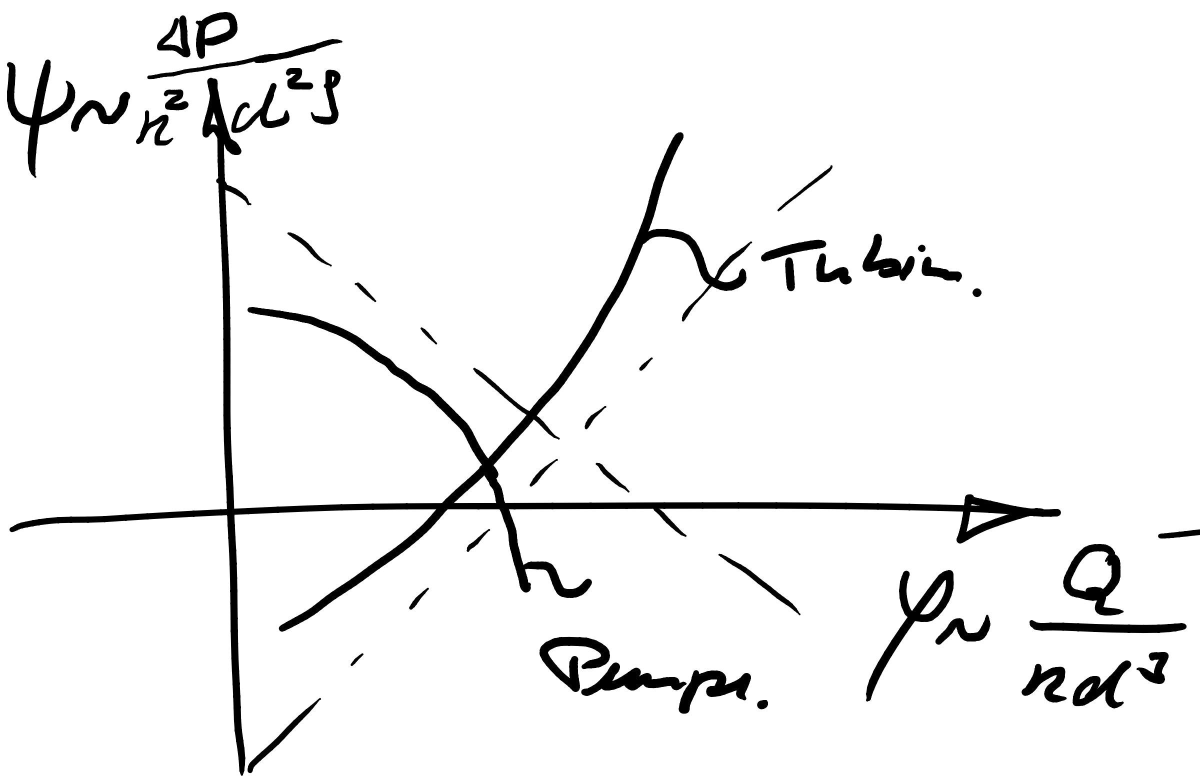
$= \psi$; $\frac{Q}{2\pi r_2^2 b\,\Omega} = \varphi$

$$\psi = 2\,\eta^{\pm 1}\left(1 - \cot\beta_2\,\varphi\right)$$

$$\psi = \frac{2\Delta p}{\rho u_2^2} \quad \text{Druckziffer.}$$

$$\varphi = \frac{Q}{2\pi r_2^2 b\,\Omega} \quad \text{Durchflussziffer.}$$





Turbomasch.:

$$\pm \frac{\psi}{\hat{\psi}} = \eta^{\pm 1}\left(1 - \frac{\varphi}{\hat{\varphi}}\right)$$

+1 Arbeitsm.
−1 Turbine

Hydrostatische Masch.:

$$\varphi = \eta^{\pm 1} \hat{\varphi}$$

$g H_T = g \frac{2}{5} H$ ✓

$x \in \sim d^3$ ✓

x klein, dito kann!

Drehzahl ~ Nettogefälle ✓

$(\psi, \varphi) \longrightarrow (\sigma, \delta)$

σ: Schnelllaufzahl

δ: Durchmesserzahl

$$\psi = 2\,\hat{\psi}\left(1-\frac{\varphi}{\hat{\varphi}}\right)$$

$$\psi = \frac{1}{\delta^2 \sigma^2} \qquad \varphi = \frac{1}{\delta^3 \sigma}$$

Schnellaufzahl

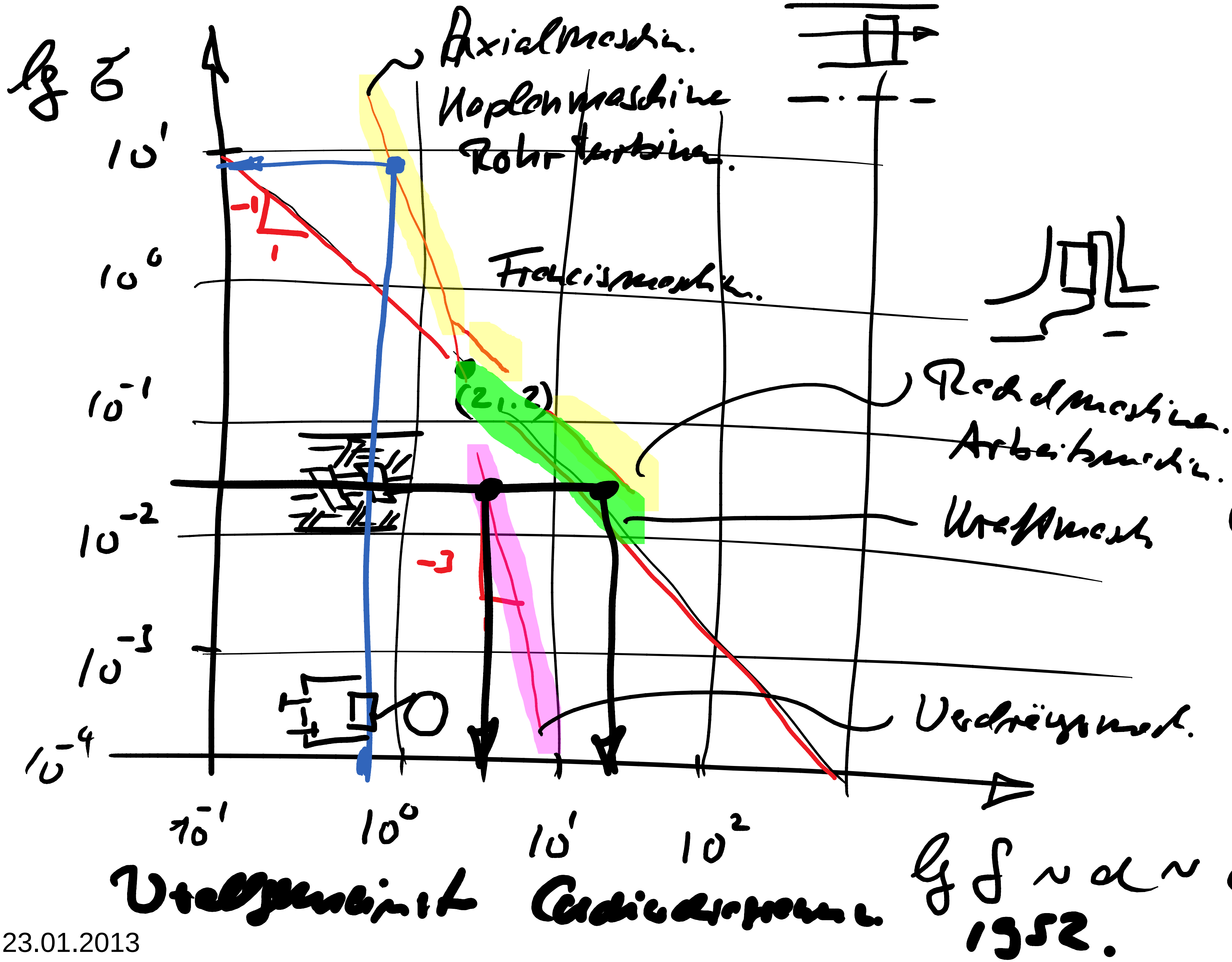
$$\sigma := 2\sqrt{\pi}\,(2gH_T)^{-\frac{3}{4}}\,Q^{1/2} \qquad n \neq fn(d)$$

Keller 1934: Diss. ETH Zürich.

Durchmesserzahl

$$\delta := \frac{\sqrt{\pi}}{2}\,(2gH_T)^{\frac{1}{4}}\,Q^{-\frac{1}{2}} \qquad d \neq fn(n)$$

✓ ✓ ✓ ✓



Otto Cordier

VDI 1952