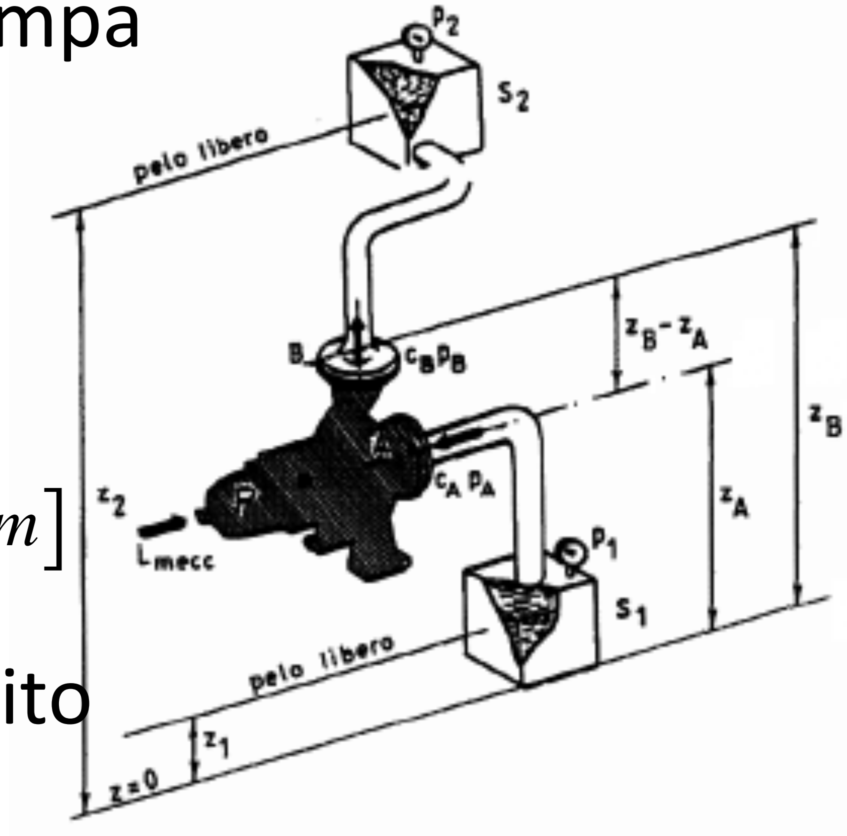
Pompe

Impianti idrici

- Prevalenza totale: $\mathrm{H_t} = (z_B - z_A) + \frac{c_B^2 - c_A^2}{2g} + \frac{p_B - p_A}{\rho g} \quad [m]$
- Lavoro per kg: $\mathrm{L}_{mecc} = (H_t + H_p) g \quad [J/kg]$
- H_p sono le perdite nella pompa
- Prevalenza manometrica:
  $\mathrm{H_m} = \frac{p_B - p_A}{\rho g} \quad [m]$
- Trai due serbatoi:

$$\mathrm{H_t} = (z_2 - z_1) + \frac{c_2^2 - c_1^2}{2g} + \frac{p_2 - p_1}{\rho g} + H_c \quad [m]$$

- H_c sono le perdite del circuito



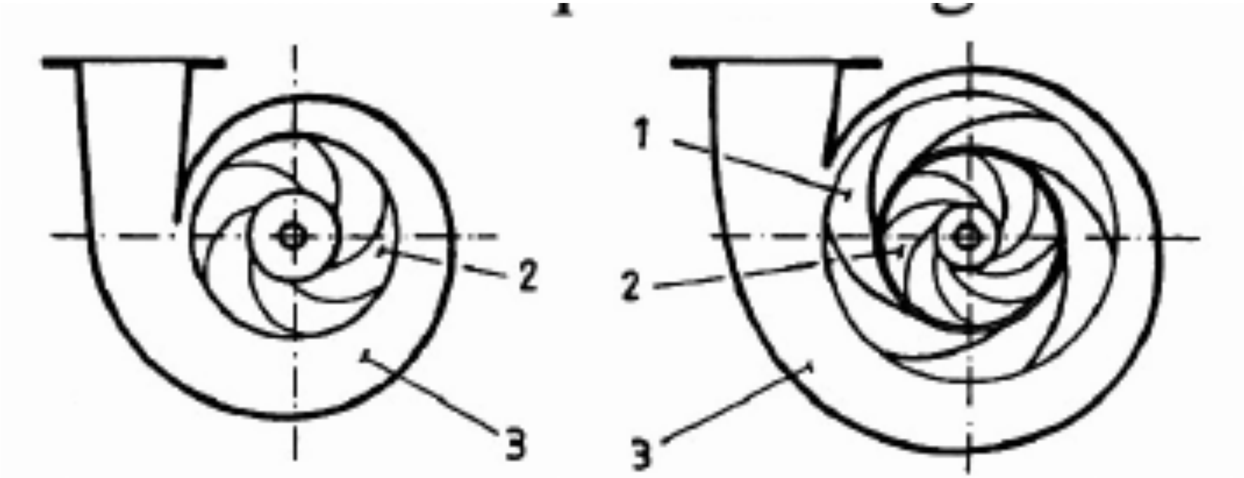
Potenza richiesta

- La potenza richiesta dalla pompa è data da:

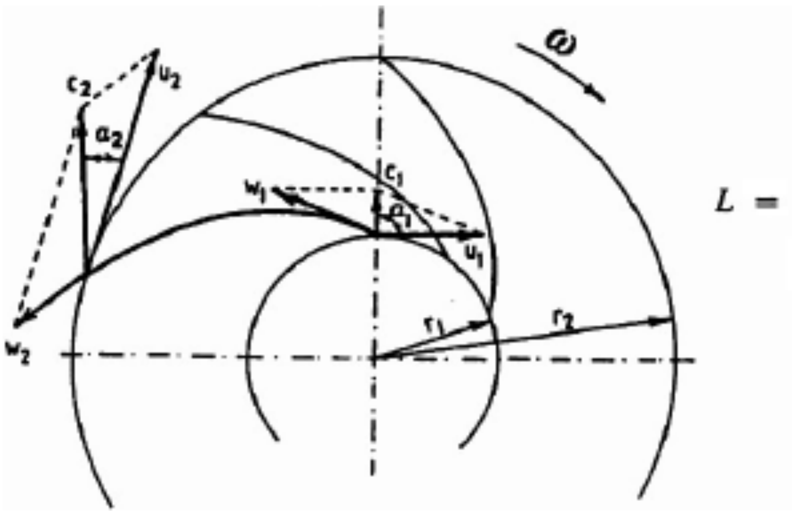
$$P = \frac{\rho Q g H_t}{1000 \eta_p} \quad \left[kW \right]$$

$$\eta_p = \frac{g H_t}{L_{mecc}}$$

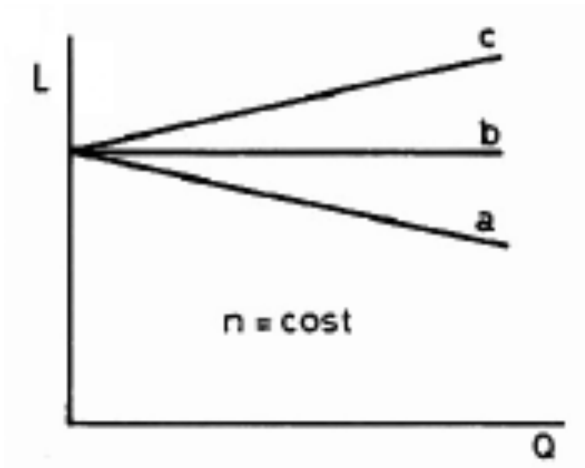
Pompe centrifughe



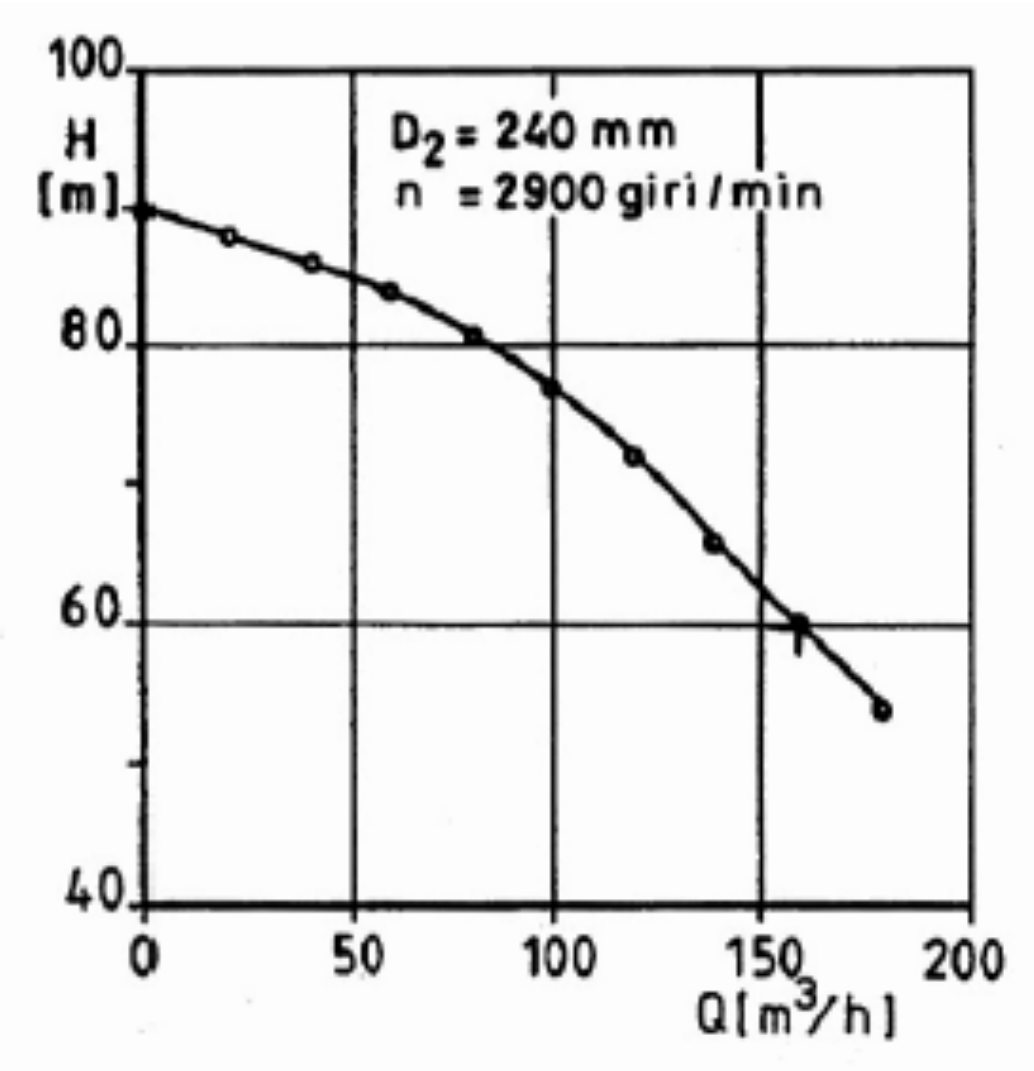
Adatte a fluidi
molto diversi
e fino anche a
p > 400 bar
Q > 150.000 m^3/h
P > 100 MW



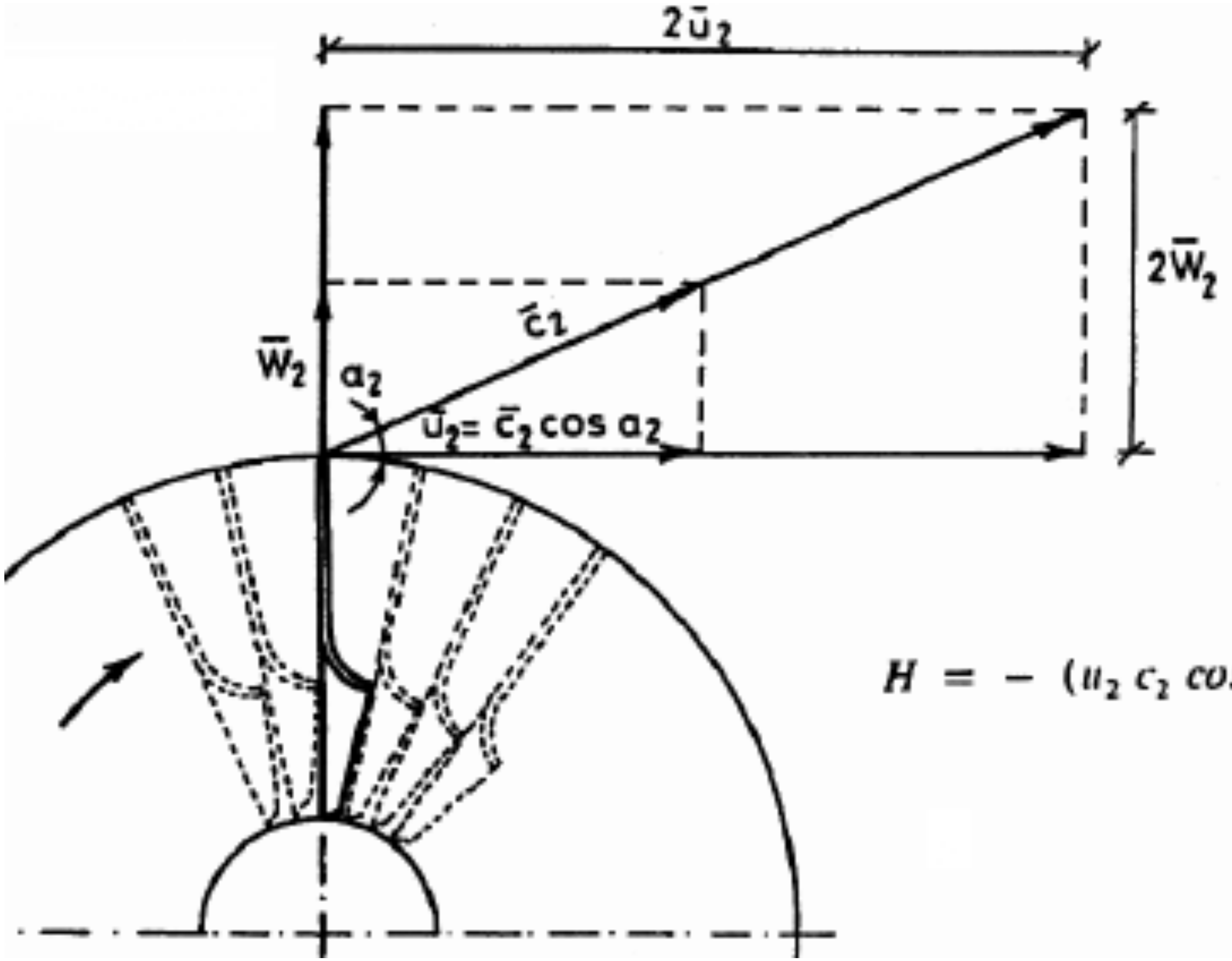
$$L = -\, u_2\, c_2 \cos \alpha_2 \left[\frac{J}{kg}\right]$$



Curva caratteristica



Similitudine



$$H = -(u_2 c_2 \cos \alpha_2)/g$$

Similitudine

- Due pompe con prevalenze e portate diverse hanno la potenza secondo questo rapporto:

$$\frac{P_1}{P_2} = \frac{Q_1 H_1}{Q_2 H_2}$$

- Se le macchine sono simili:

$$\left.\begin{aligned} \frac{Q_1}{Q_2} &= \frac{r_1^2 u_1}{r_2^2 u_2} = \frac{r_1^3 n_1}{r_2^3 n_2} \\ \frac{H_1}{H_2} &= \frac{u_1^2}{u_2^2} = \frac{r_1^2 n_1^2}{r_2^2 n_2^2} \end{aligned}\right\} \frac{P_1}{P_2} = \frac{r_1^5 n_1^3}{r_2^5 n_2^3}$$

Similitudine

- Possiamo scrivere il rapporto tra le dimensioni come:

$$\frac{H_1}{H_2} = \frac{u_1^2}{u_2^2} = \frac{r_1^2 n_1^2}{r_2^2 n_2^2} \Rightarrow \frac{r_1}{r_2} = \frac{\sqrt{H_1}}{\sqrt{H_2}} \frac{n_2}{n_1}$$

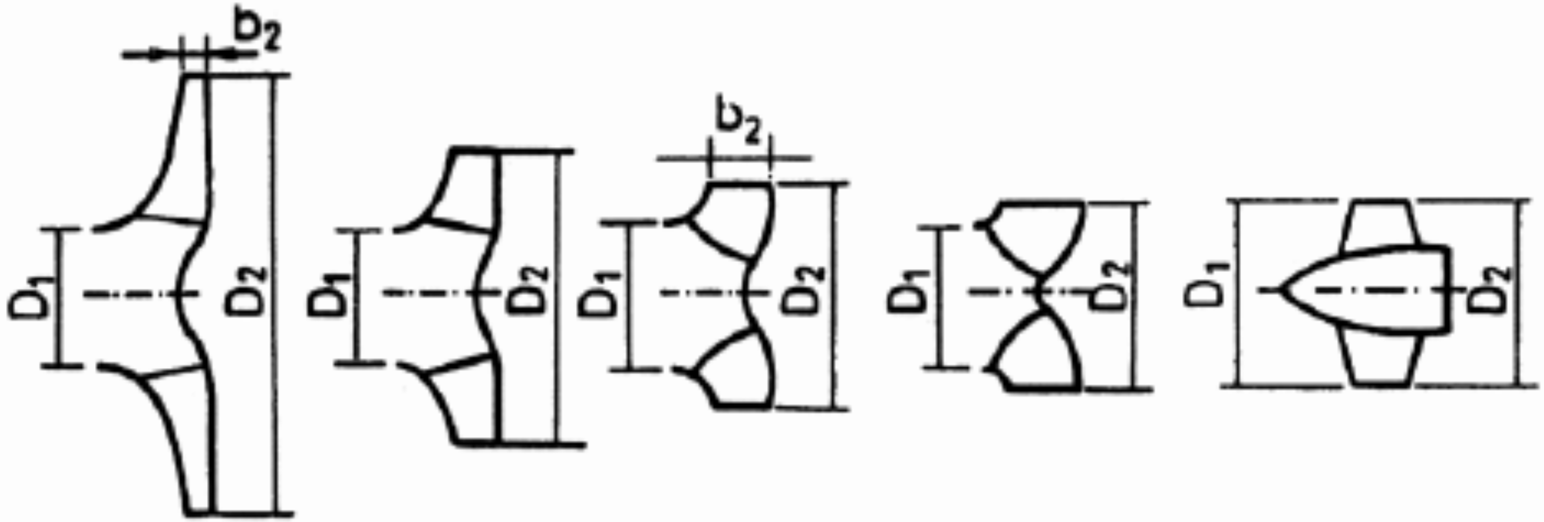
- Inserendolo nel rapporto delle potenze:

$$\frac{P_1}{P_2} = \frac{r_1^5 n_1^3}{r_2^5 n_2^3} = \frac{\sqrt{H_1^5} n_2^2}{\sqrt{H_2^5} n_1^2} \Rightarrow n_1 \frac{\sqrt{P_1}}{\sqrt[4]{H_1^5}} = n_2 \frac{\sqrt{P_2}}{\sqrt[4]{H_2^5}}$$

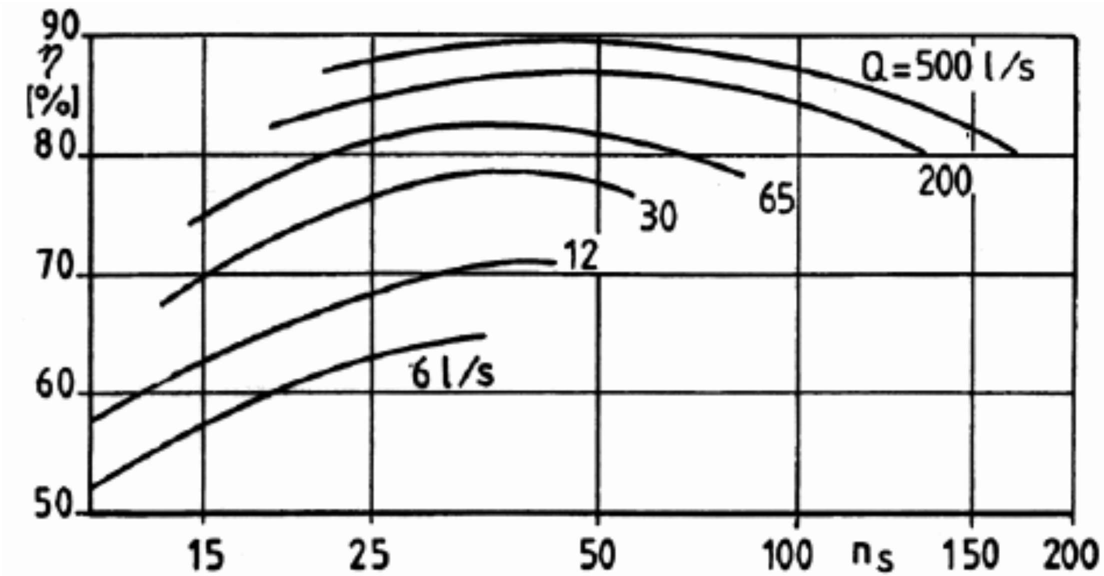
$$n_s = n \frac{\sqrt{P}}{\sqrt[4]{H^5}}$$

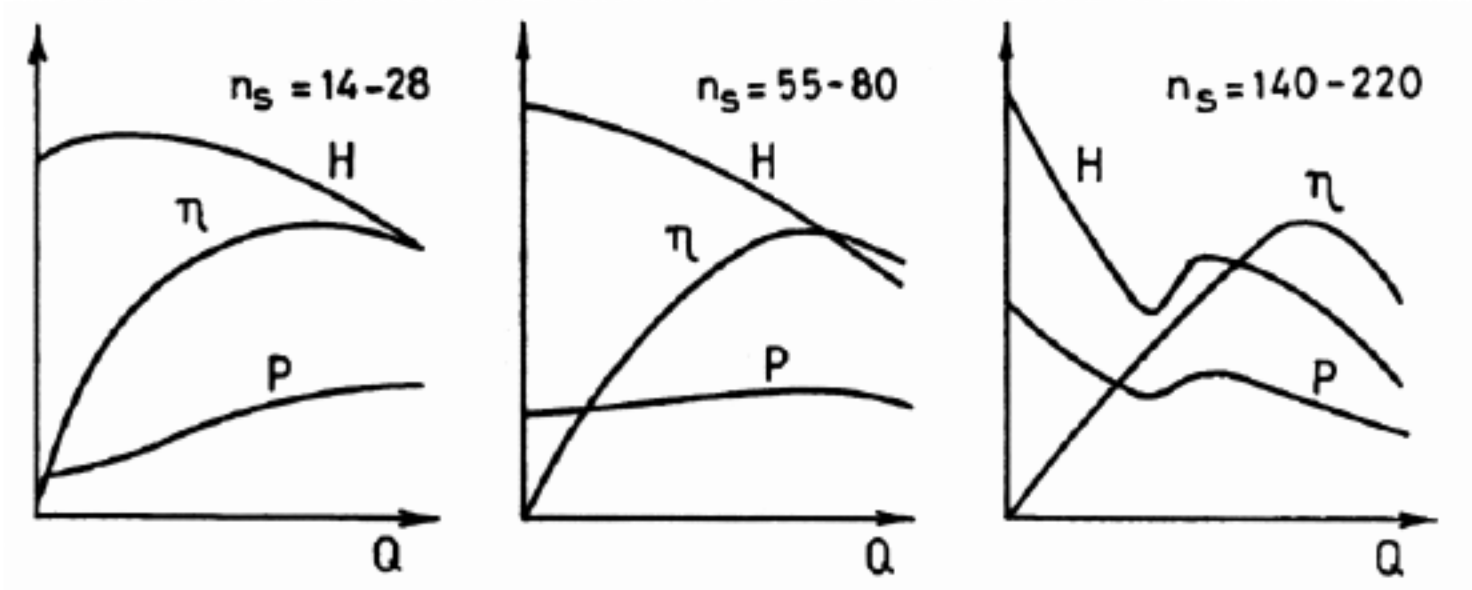
Geometria della pompa

n_s	16-22	22-32	32-64	64-96	110-220
D_2/D_1	3.0-2.4	2.4-1.8	1.8-1.3	1.3-1.1	1.0



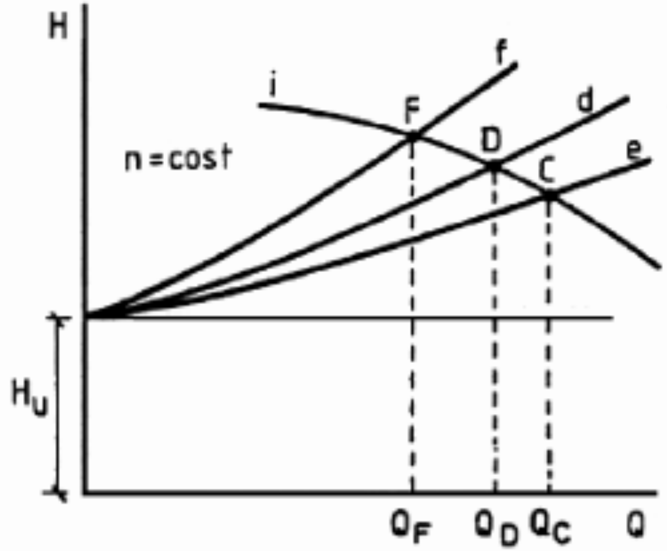
Influenza di n_s

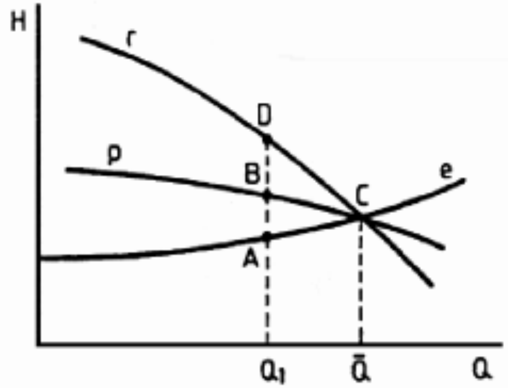




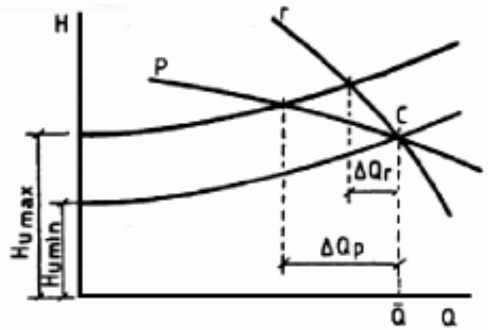
Regolazione per strozzamento

Regolazione per variazione della caratteristica esterna.



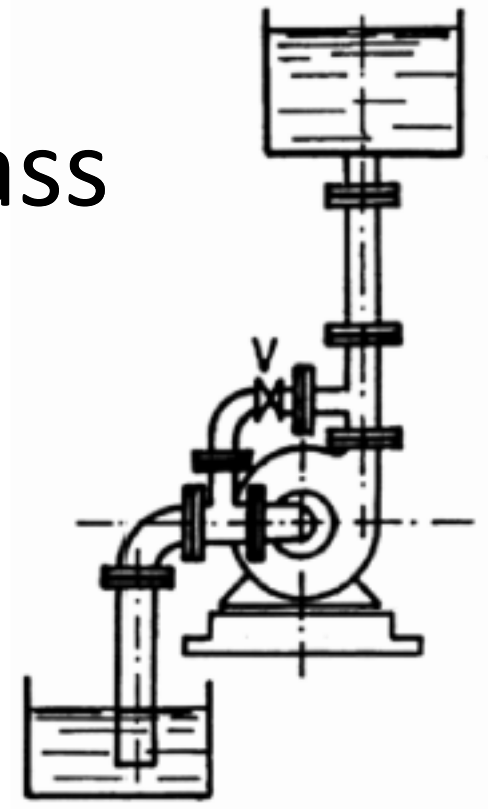


Influenza sulle perdite dell'andamento della caratteristica interna di una pompa quando si effettua la regolazione per strozzamento. Per regolare la portata per strozzamento: meglio caratteristica interna piatta.



Influenza sulla variazione della portata *Q* dell'andamento della caratteristica interna di una pompa al variare della prevalenza utile *Hu*. Per stabilità di portata: meglio caratteristica interna discendente.

Regolazione per by-pass



- Perdite di carico nel circuito iniziali: $H_{pA} = H_A - H_u$
- Perdite di carico a portata ridotta:

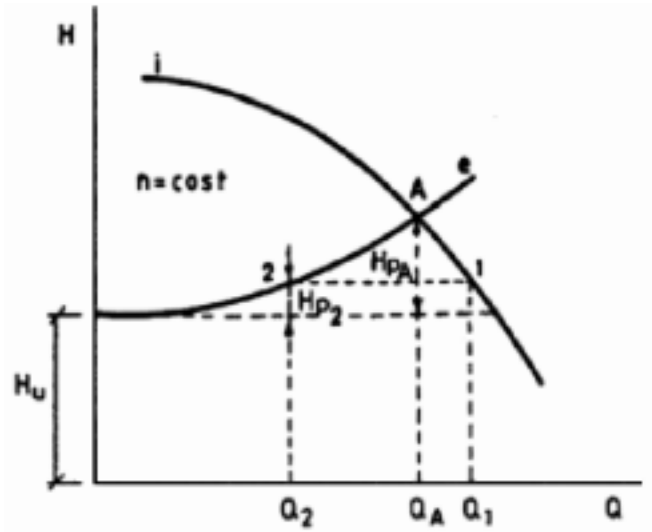
$$H_{p2} = H_2 - H_u$$

- Prevalenza richiesta alla pompa:

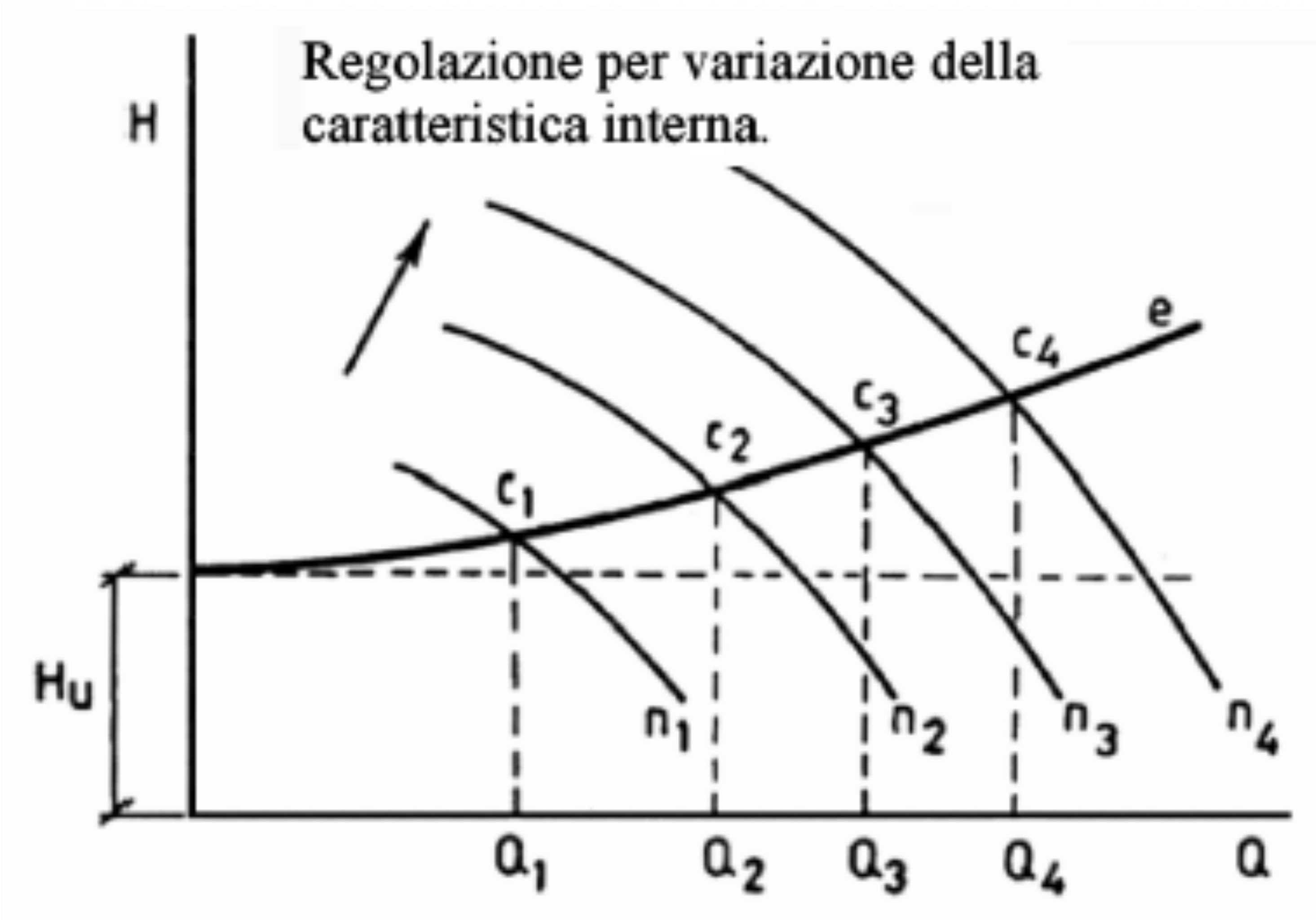
$$H_1 = H_2 = H_u + H_{p2}$$

- Portata bypassata:

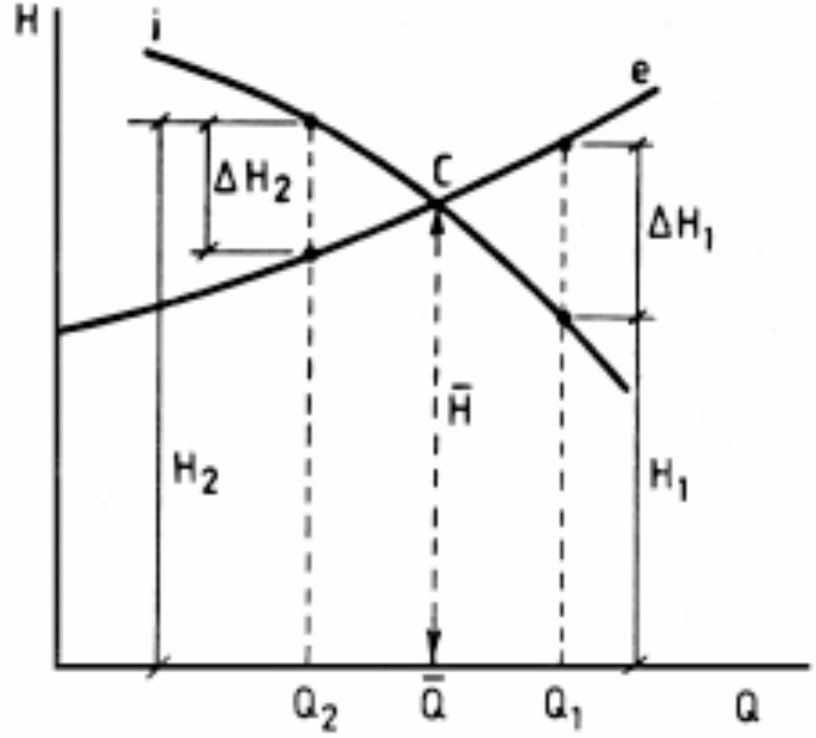
$$Q_3 = Q_1 - Q_2$$



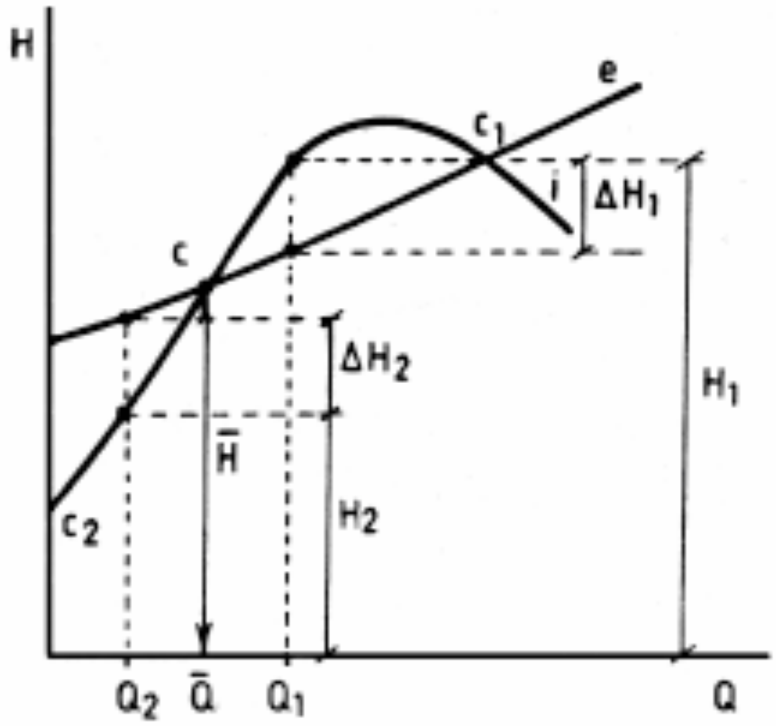
Regolazione per numero di giri



Pompaggio



Rappresentazione di condizioni di funzionamento *stabile*.

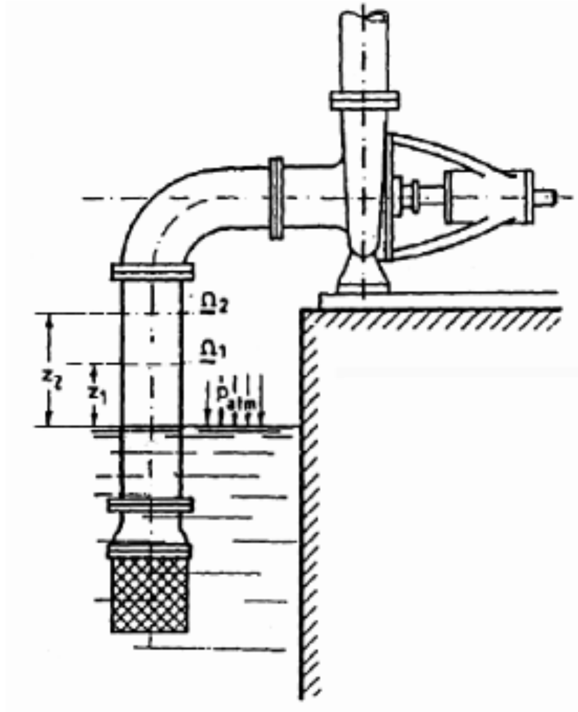


Rappresentazione di condizioni di funzionamento *instabile*.

Cavitazione

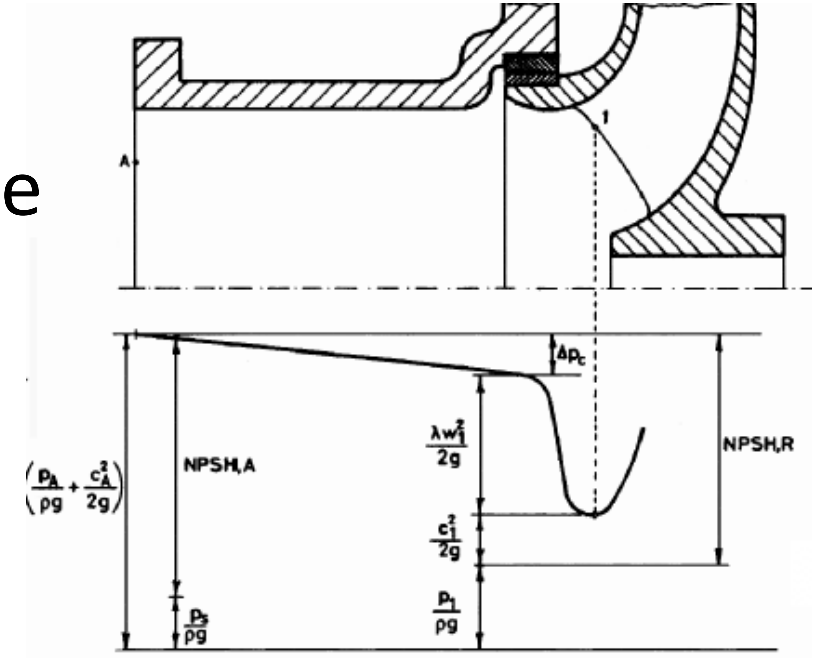
- In generale possiamo scrivere tra il pelo libero e la sezione di ingresso della pompa:

$$\frac{p_0 - p_A}{\rho g} = \left(z_A - z_0\right) + \frac{c_A^2 - c_0^2}{2g} + \mathrm{H_p}$$



- Tra la flangia di aspirazione e ingresso delle pale:

$$\frac{p_A}{\rho g} + \frac{c_A^2}{2g} = \frac{p_1}{\rho g} + \frac{c_1^2}{2g} + \mathrm{H_{pin}}$$



Cavitazione

- Possiamo scrivere le perdite dividendole in concentrate e distribuite:

$$\frac{p_A}{\rho g}+\frac{c_A^2}{2g}=\frac{p_1}{\rho g}+\frac{c_1^2}{2g}+\mathrm{H_{pd}}+\lambda\frac{w_1^2}{2g}\Rightarrow$$

$$\frac{p_1}{\rho g}=\left(\frac{p_A}{\rho g}+\frac{c_A^2}{2g}\right)-\left(\frac{c_1^2}{2g}+\mathrm{H_{pd}}+\lambda\frac{w_1^2}{2g}\right)>\frac{p_{sat}}{\rho g}\Rightarrow$$

$$\left(\frac{p_A}{\rho g}+\frac{c_A^2}{2g}\right)-\frac{p_{sat}}{\rho g}>\left(\frac{c_1^2}{2g}+\mathrm{H_{pd}}+\lambda\frac{w_1^2}{2g}\right)\Rightarrow$$

$$NPSH,A>NPSH,R$$

Massima altezza di aspirazione

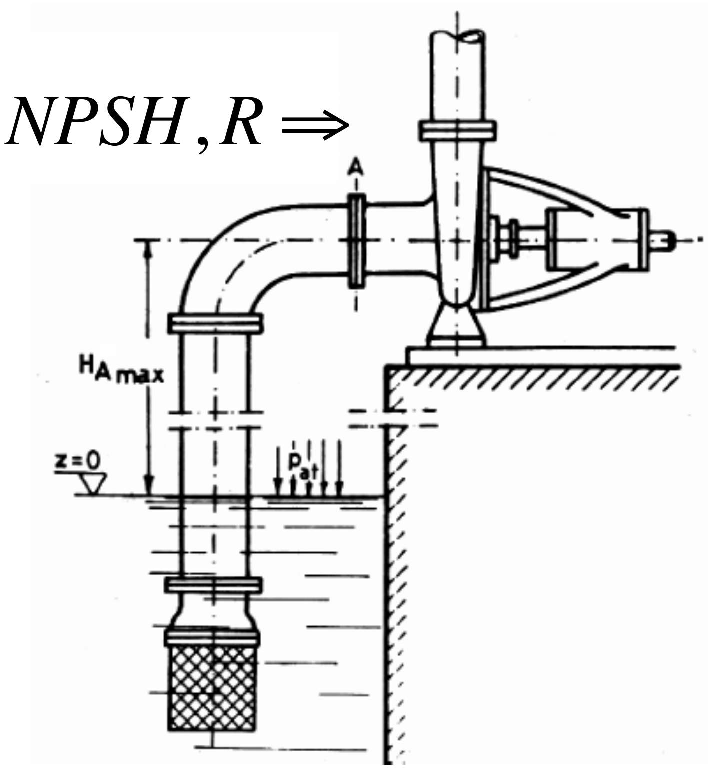
- Applicando Bernoulli:

$$\frac{p_{at}}{\rho g} = \frac{c_A^2}{2g} + \frac{p_A}{\rho g} + \mathrm{H_A} + \mathrm{H_p} \Rightarrow$$

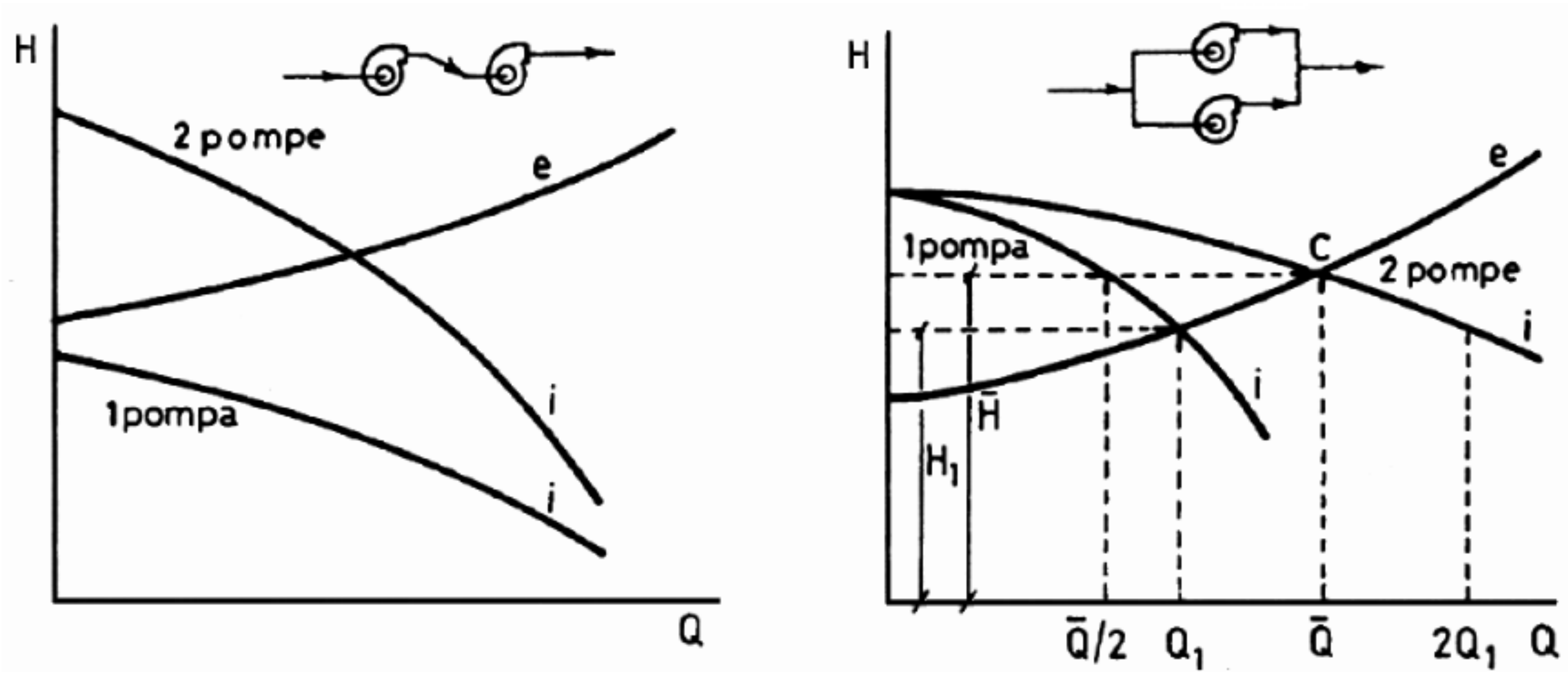
$$\left(\frac{p_A}{\rho g} + \frac{c_A^2}{2g}\right) - \frac{p_{sat}}{\rho g} = \frac{p_{at}}{\rho g} - \mathrm{H_A} - \mathrm{H_p} - \frac{p_{sat}}{\rho g} > NPSH, R \Rightarrow$$

$$\mathrm{H_A} < \frac{p_{at}}{\rho g} - \frac{p_{sat}}{\rho g} - \mathrm{H_p} - NPSH, R \Rightarrow$$

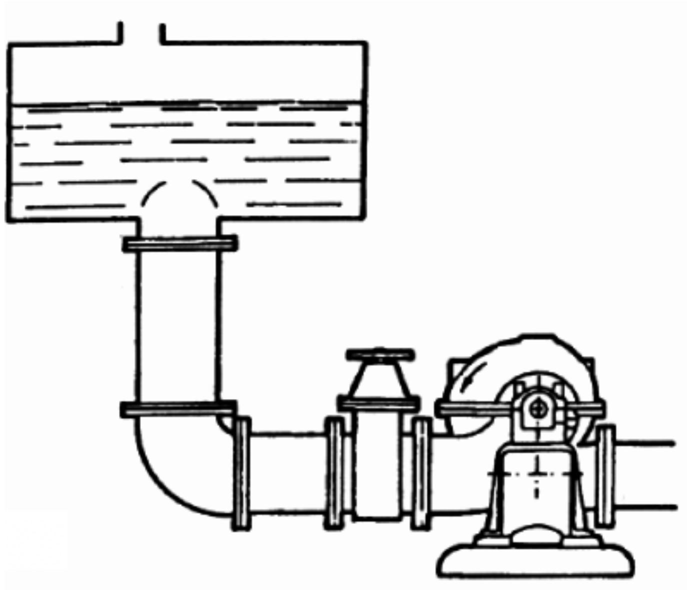
$$\mathrm{H_A} < 10{,}33 - \frac{p_{sat}}{\rho g} - \mathrm{H_p} - NPSH, R$$

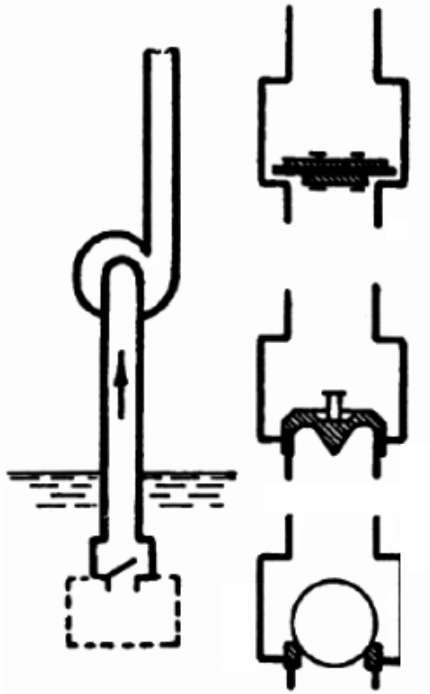


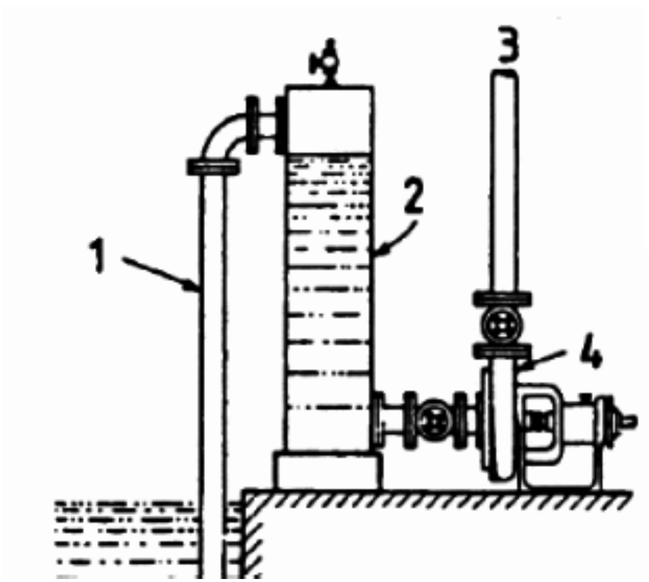
Pompe in serie e in parallelo

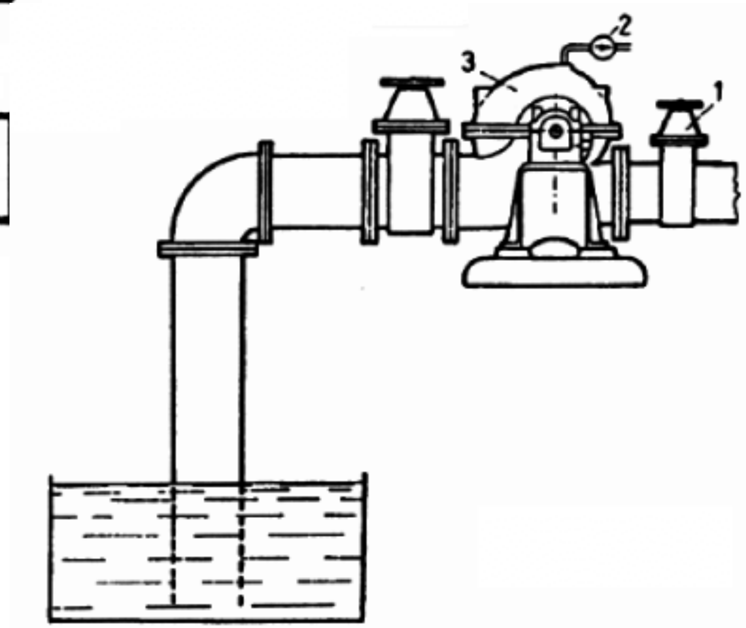


Innesco pompe centrifughe

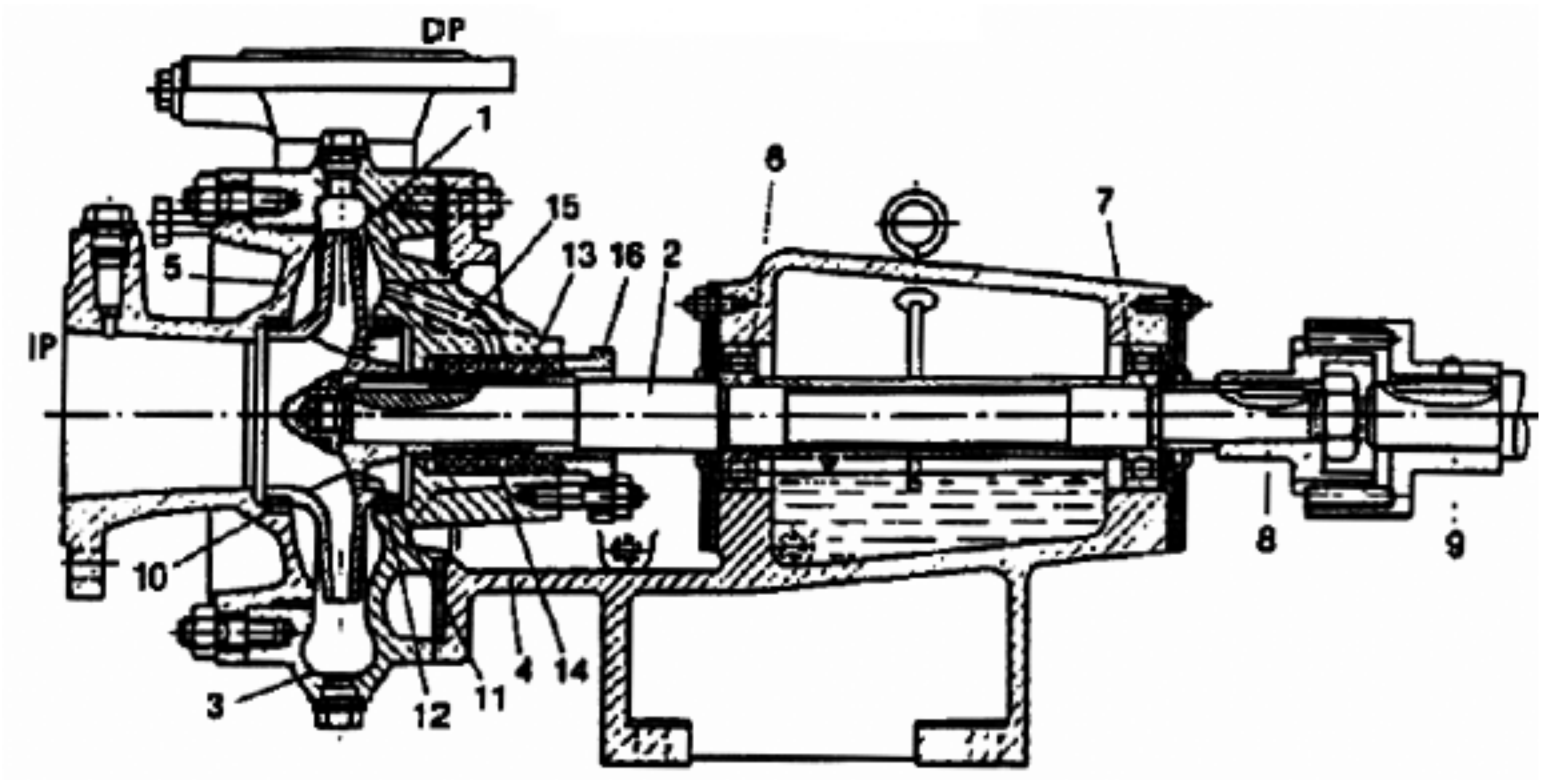




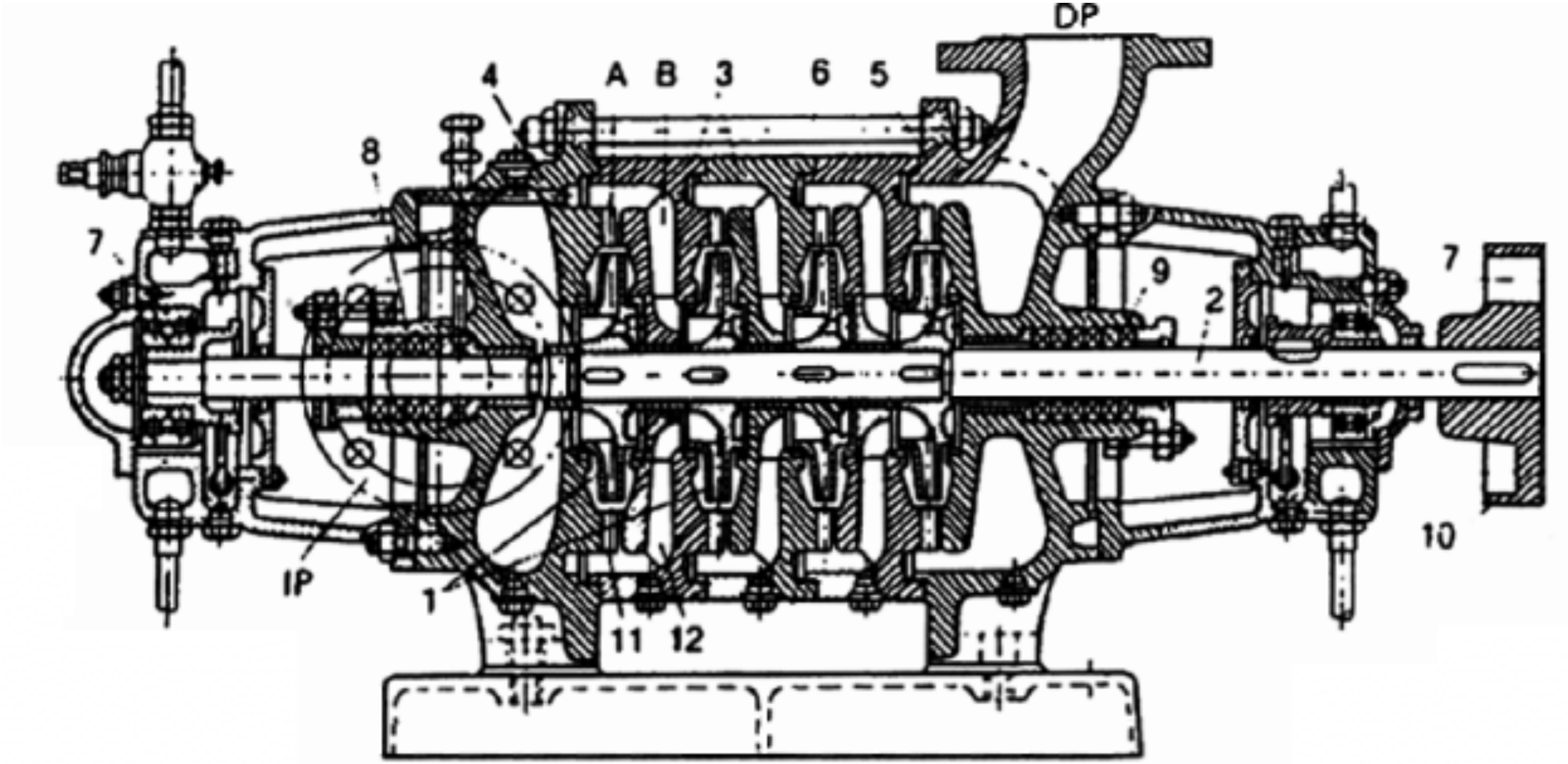




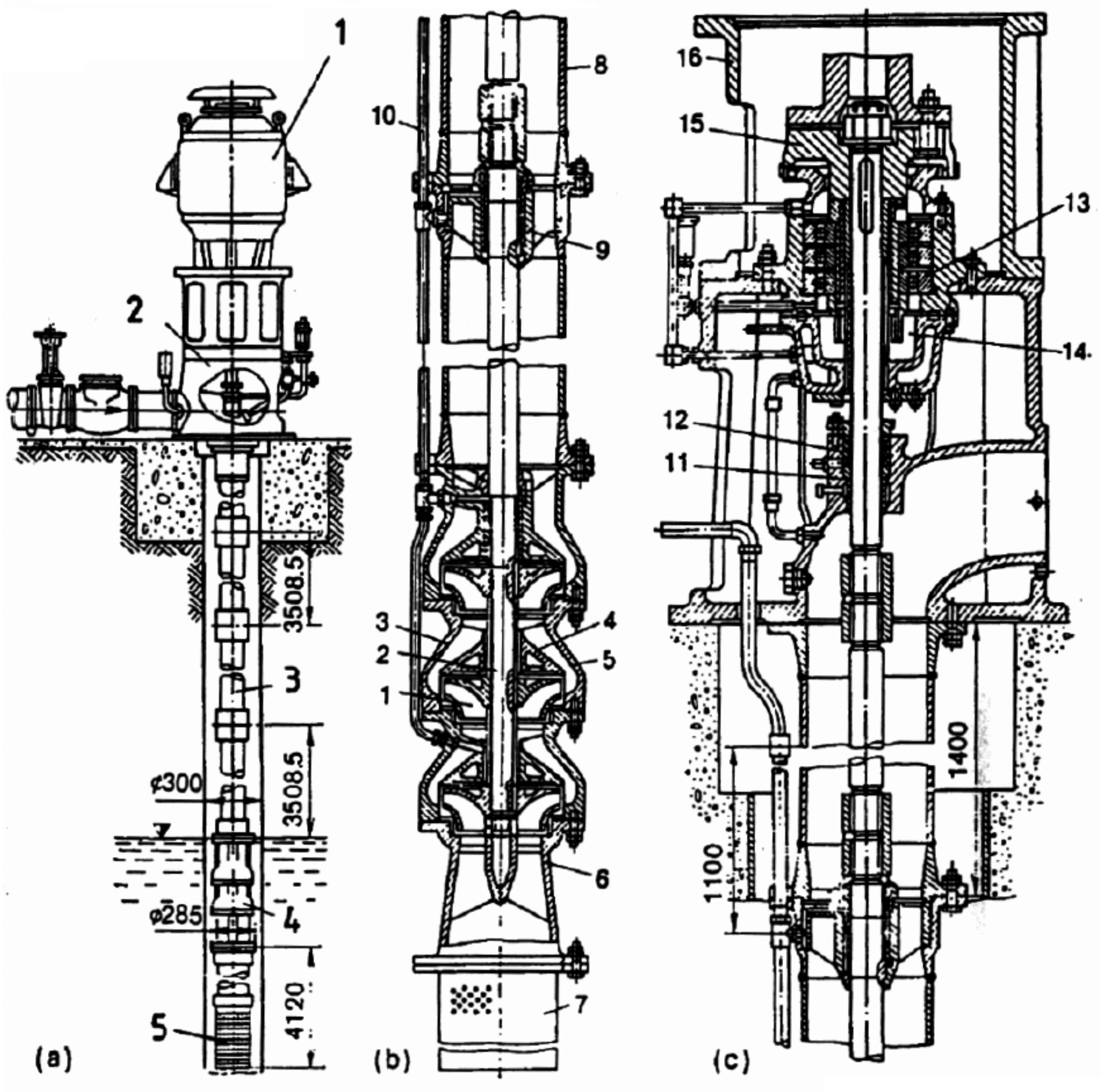
Pompe monostadio



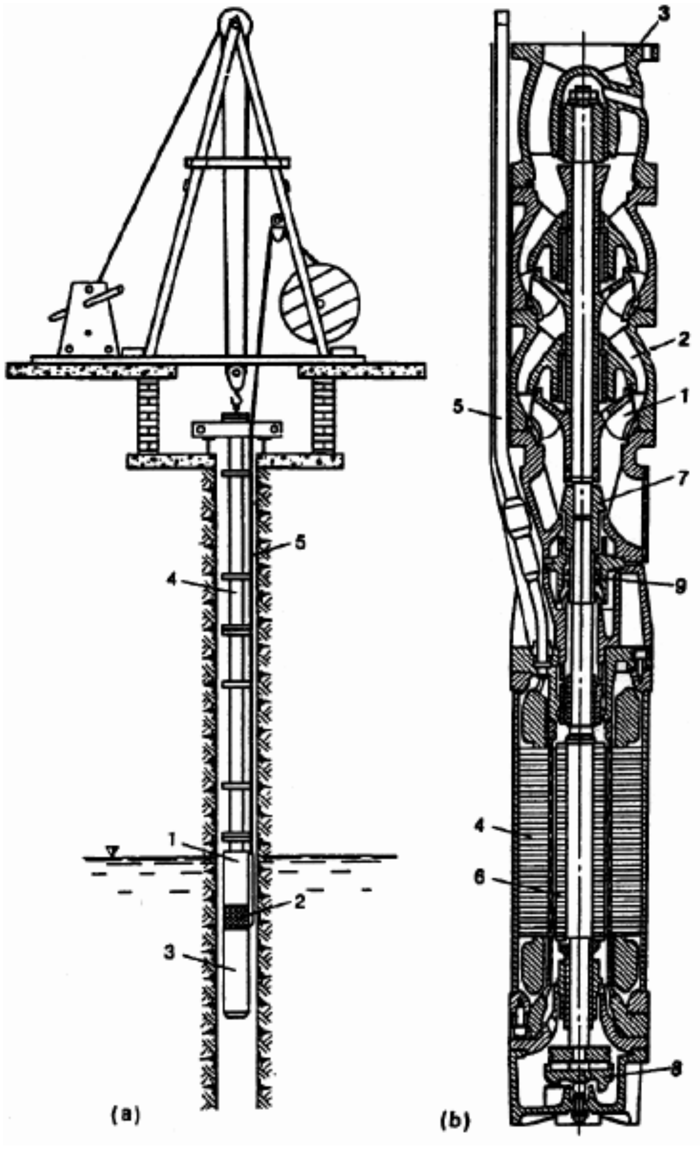
Pompe Multistadio



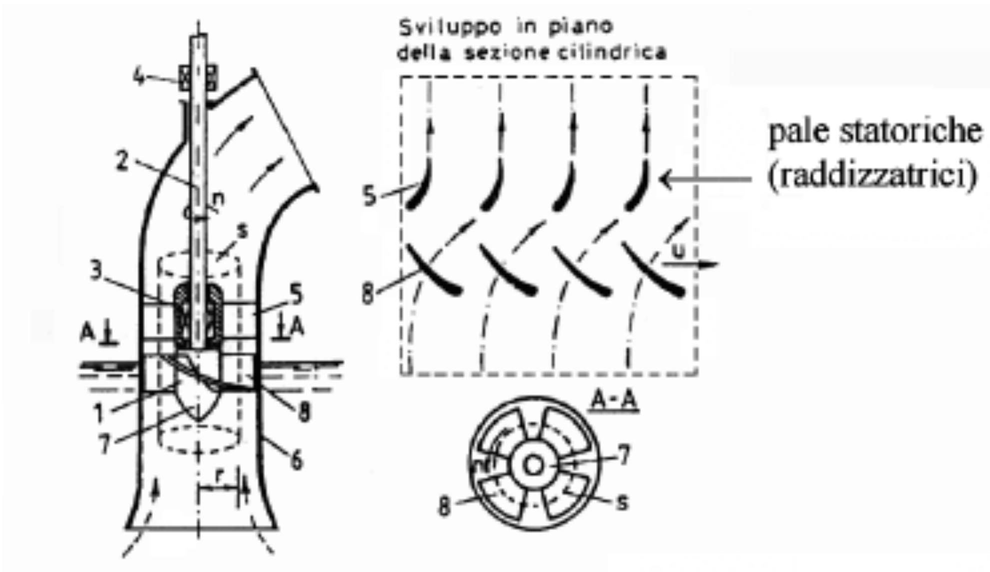
Pompe sommerse

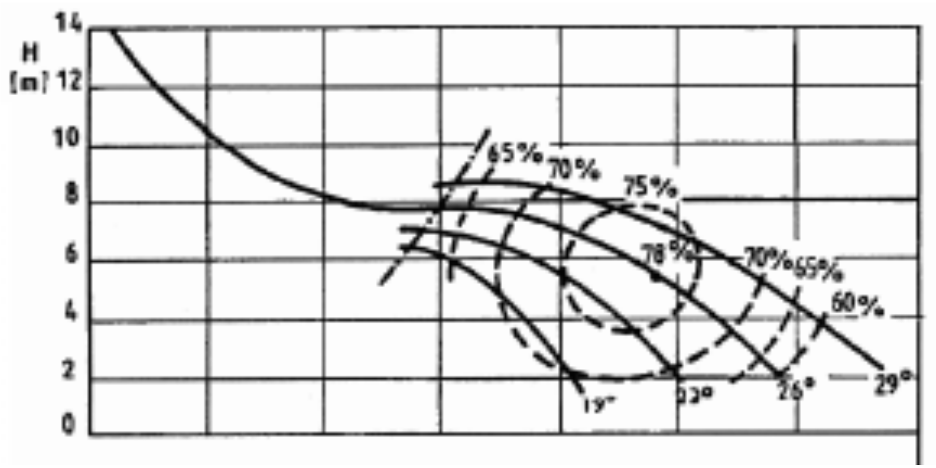


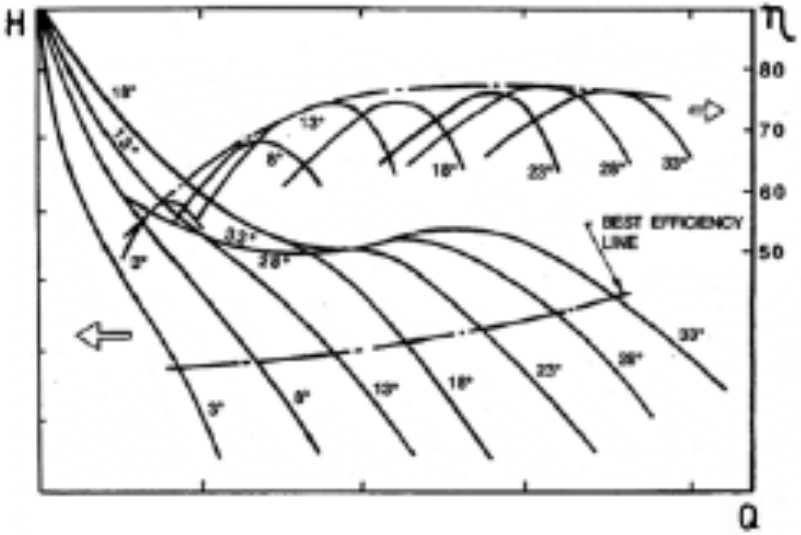
Pompe sommerse



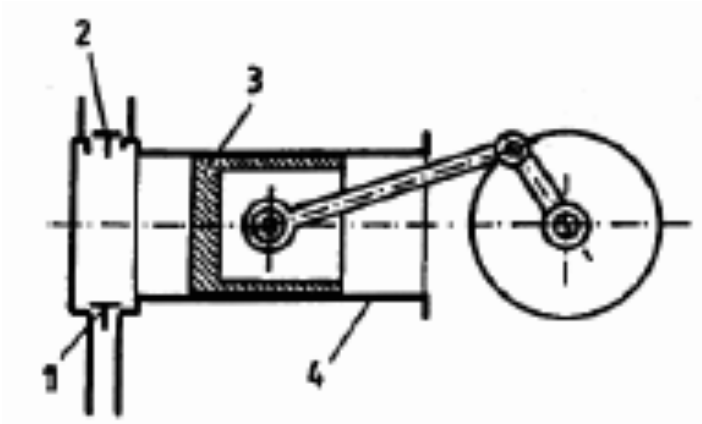
Pompe assiali o a elica

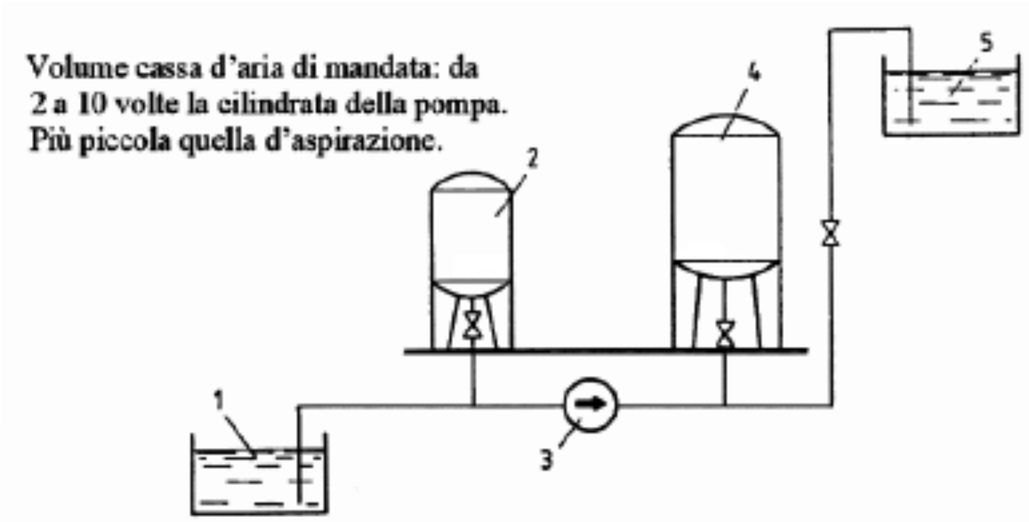


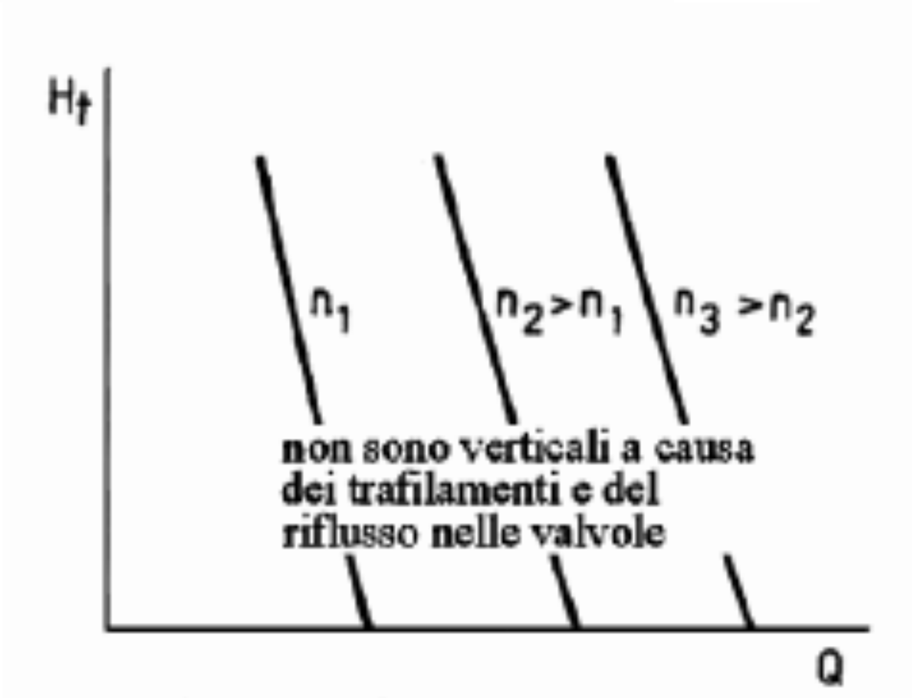




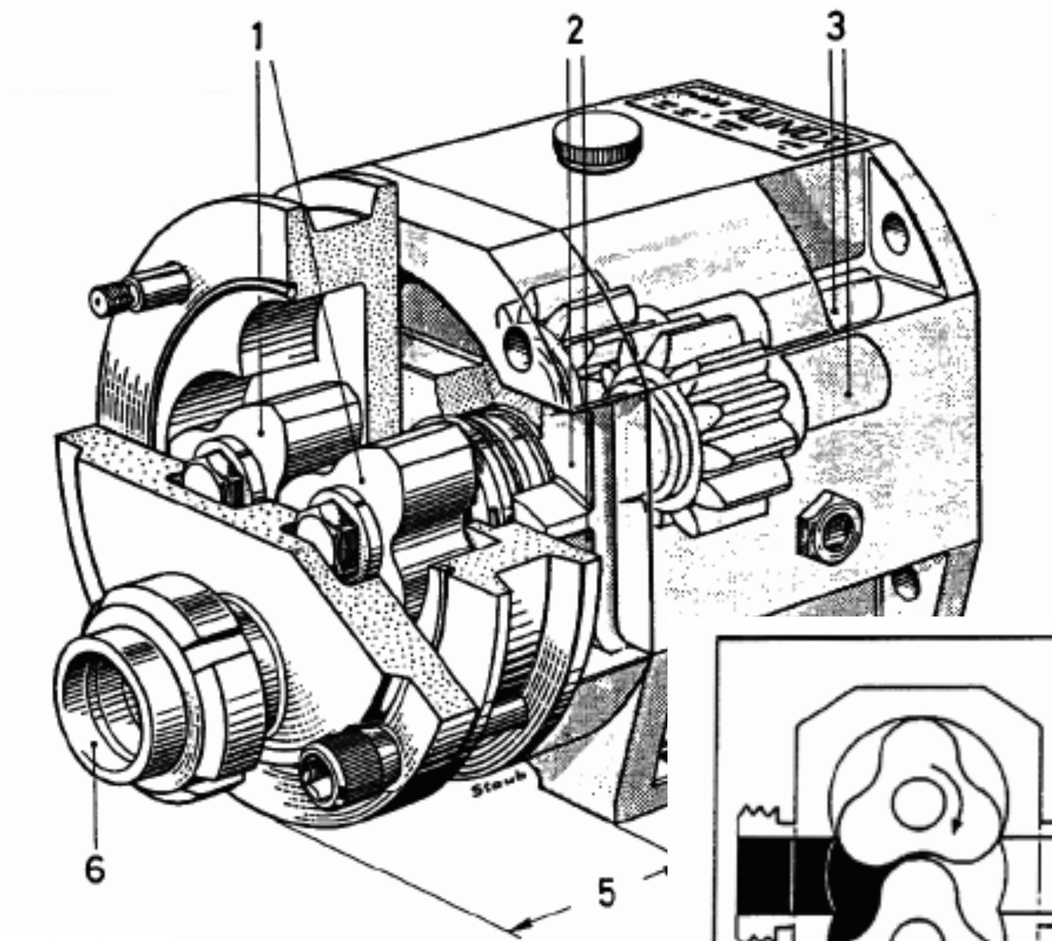
Pompe alternative

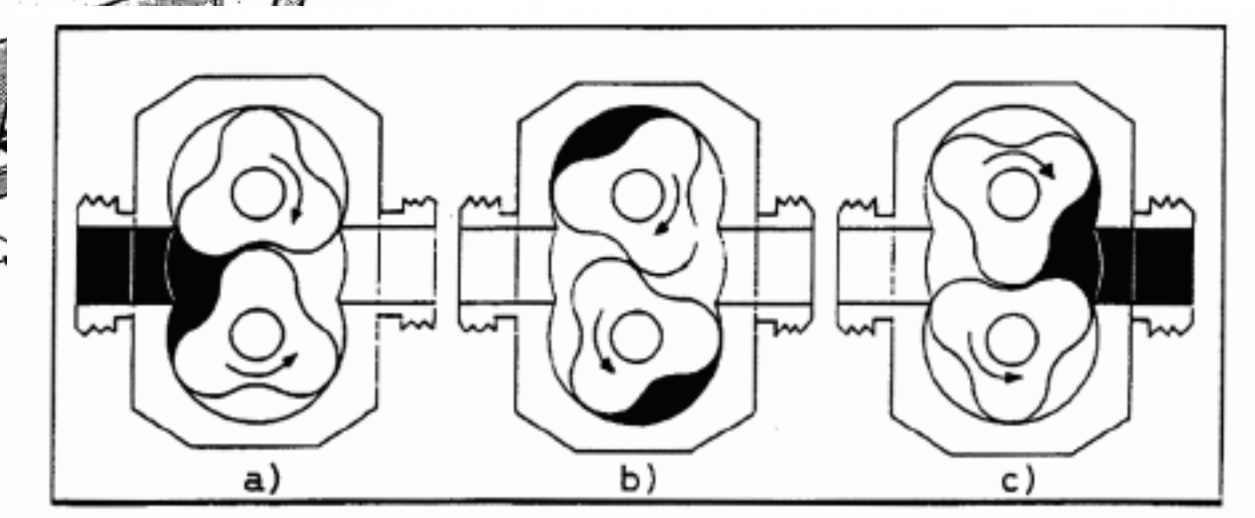




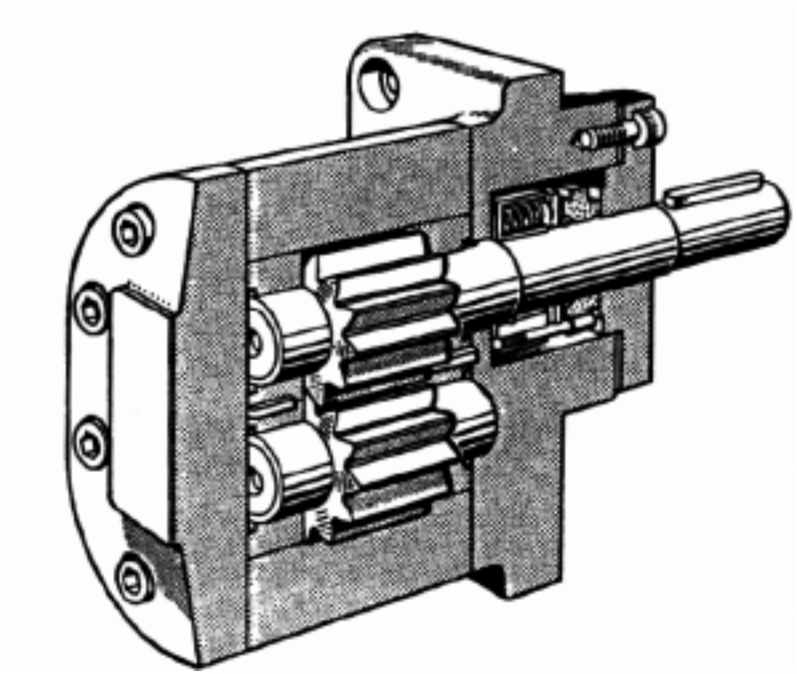


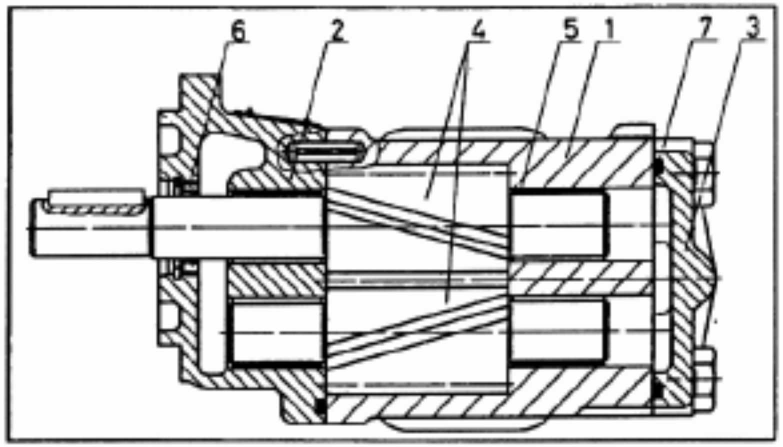
Pompe volumetriche a lobi

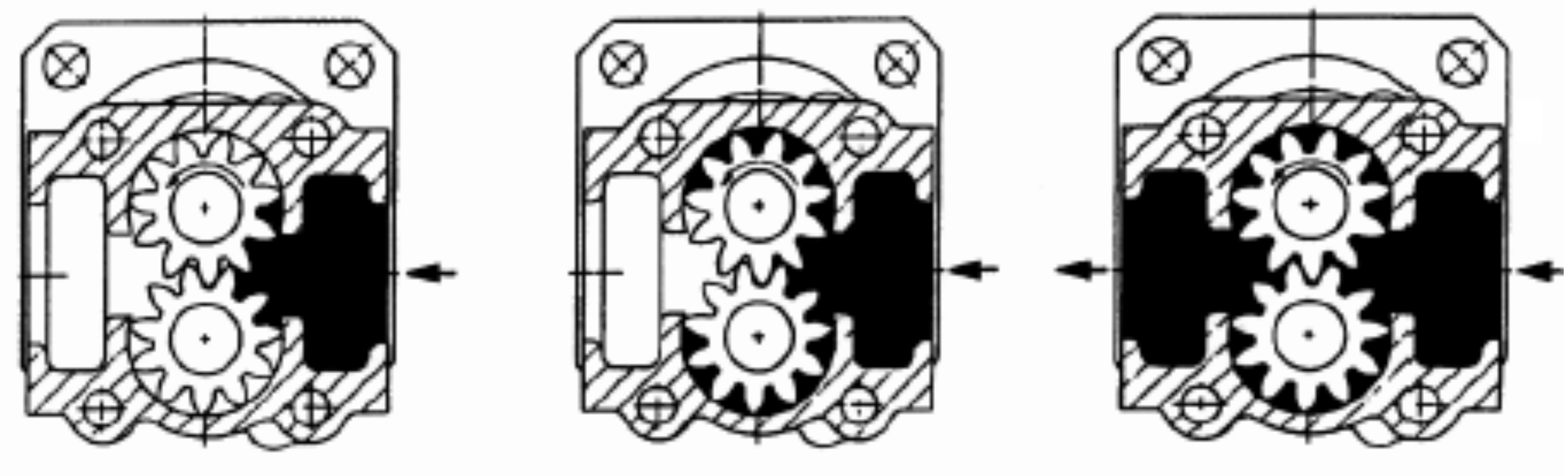




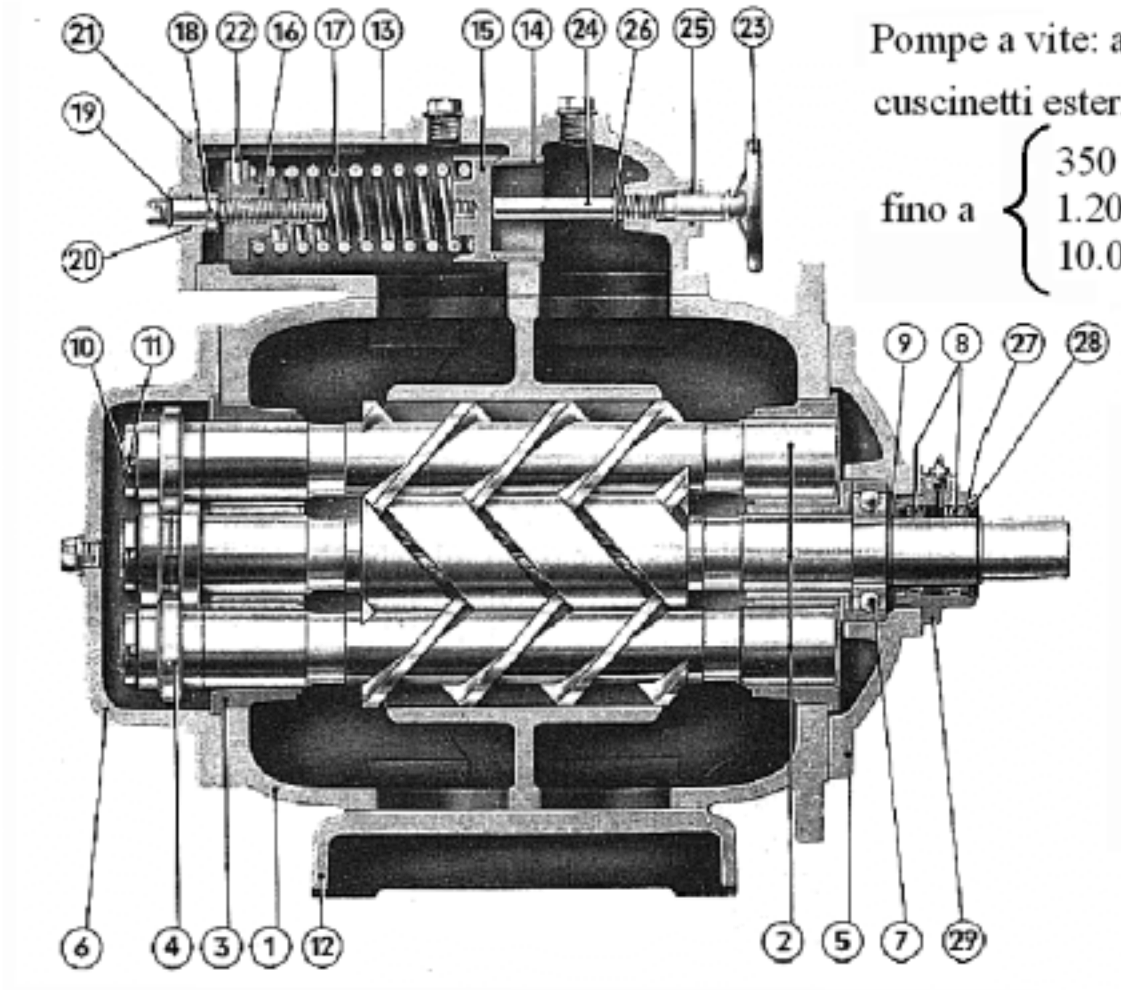
Pompe a ingranaggi







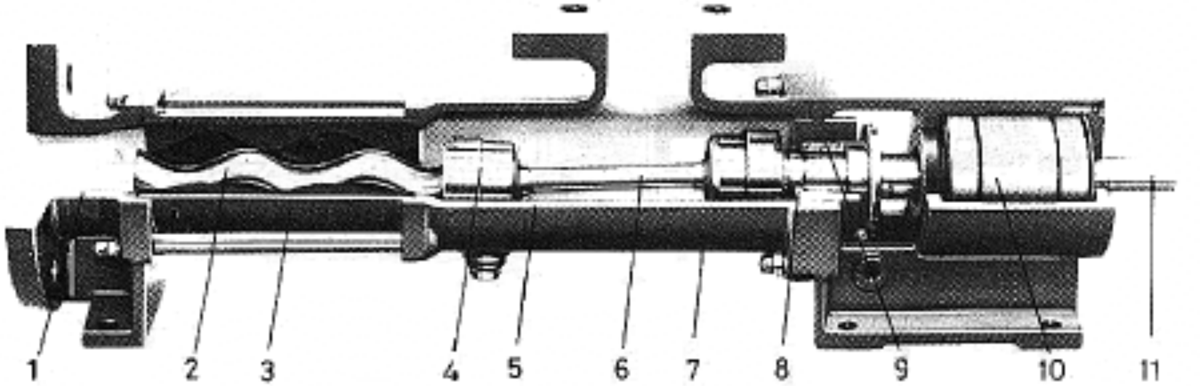
Pompe a vite

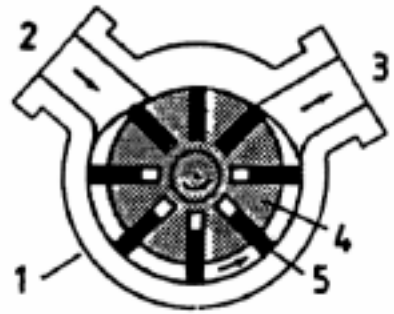


Pompe a vite: alto rendimento, cuscinetti esterni o interni

fino a
- 350 bar
- 1.200 m^3/h
- 10.000 giri/min

Altre pompe volumetriche





Spaccato di una pompa volumetrica rotativa *Mohno*.
Da pochi cm^3/min a 400 m^3/h e fino a 70 bar.
Rotore: vite arrotondata ad un principio a grande passo.
Statore: filettatura a due principi a passo doppio rispetto al rotore.
Adatte a liquidi viscosi e come pompe di sentina nelle navi.