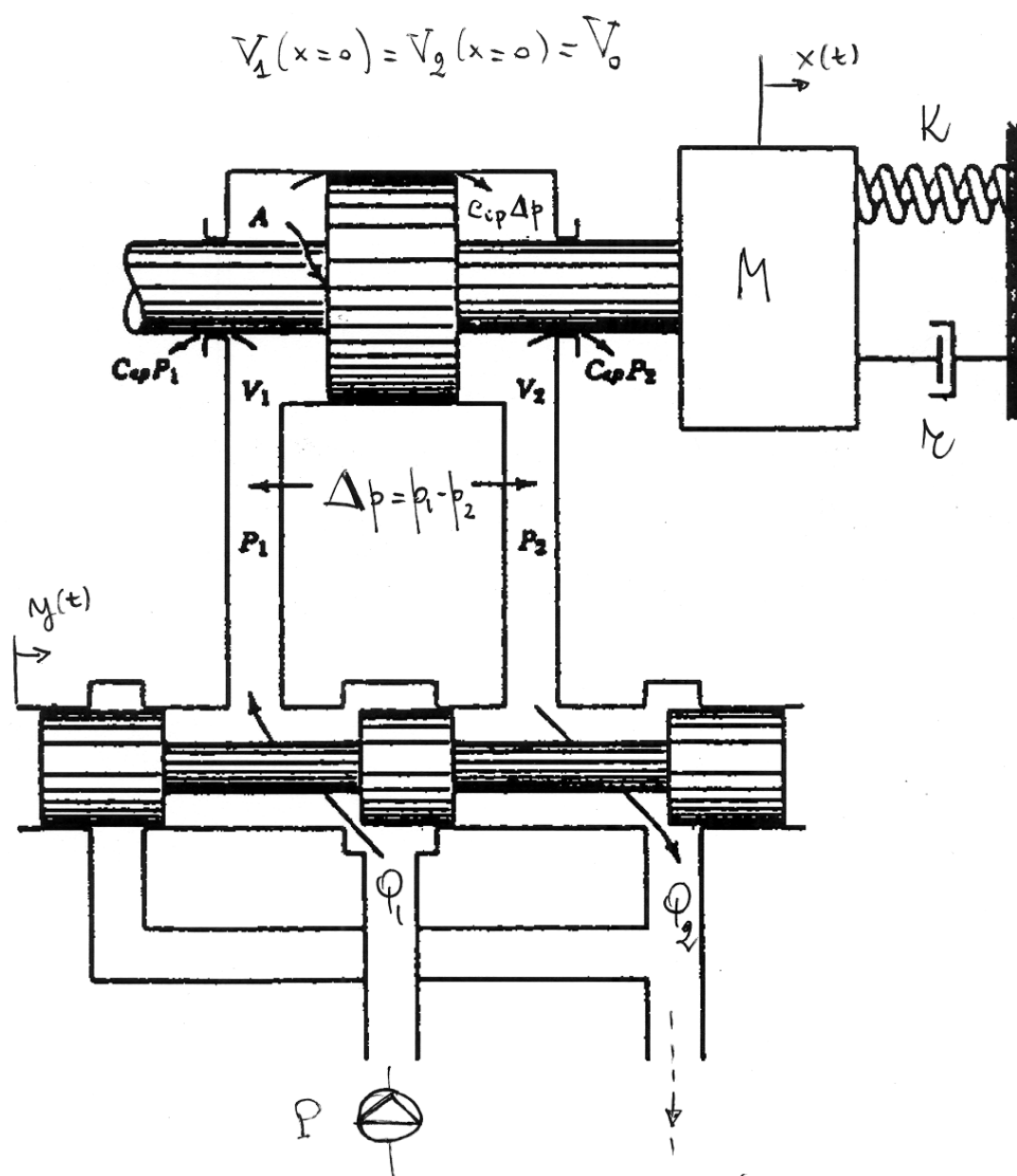


# Attuatore idraulico flusso incompressibile: sist II ordine



$$\sum \dot{m}_{in} - \sum \dot{m}_{out} = \frac{\partial}{\partial t} (\rho V)$$

for  $\rho = \text{const}$  (fluid incompressible)

$$\rho Q_{in} - \rho Q_{out} = \rho \frac{\partial V}{\partial t}$$

$$\text{CAMERA ①} \quad Q_1 - C_{ip} (p_1 - p_2) - C_{ep} p_1 = \frac{\partial V_1}{\partial t}$$

$$\text{CAMERA ②} \quad -Q_2 + C_{ip} (p_1 - p_2) - C_{ep} p_2 = \frac{\partial V_2}{\partial t}$$

$$\begin{cases} V_1 = V_0 + Ax \\ V_2 = V_0 - Ax \end{cases}$$

$$V_1 - V_2 = 2Ax$$

$$V_1 + V_2 = 2V_0 = \text{const}$$

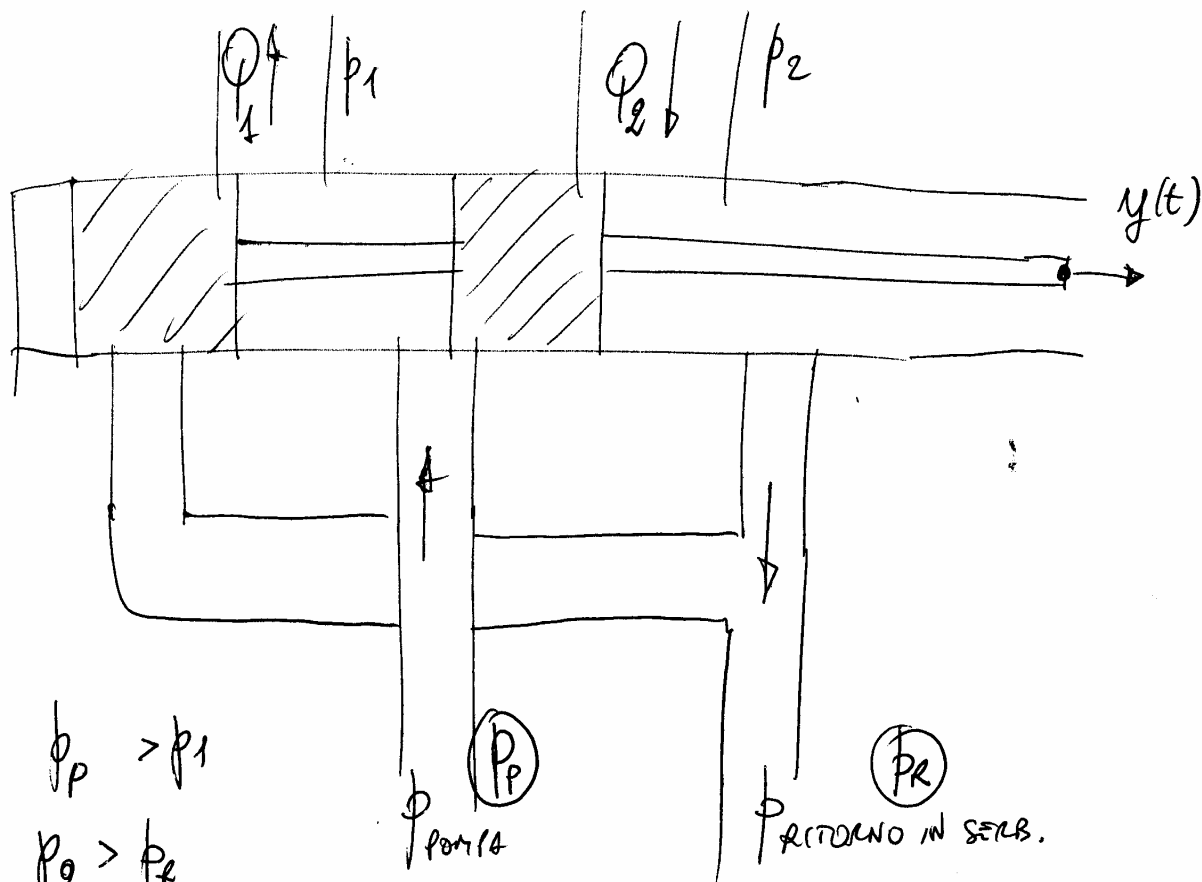
$$Q_1 + Q_2 - 2C_{ip} (p_1 - p_2) - C_{ep} (p_1 - p_2) = 2A \frac{dx}{dt}$$

$$\left( Q_L = \frac{Q_1 + Q_2}{2} \right) \quad (p_1 - p_2 = \Delta p)$$

$$Q_L = A \frac{dx}{dt} + C_{ip} \Delta p - \frac{C_{ep}}{2} \Delta p$$

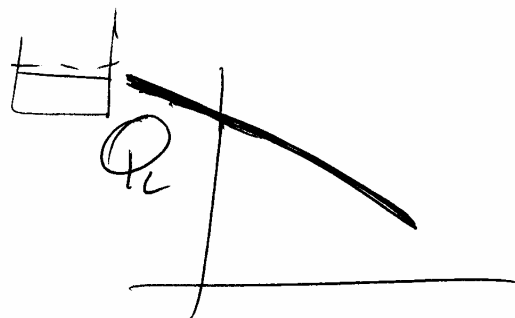
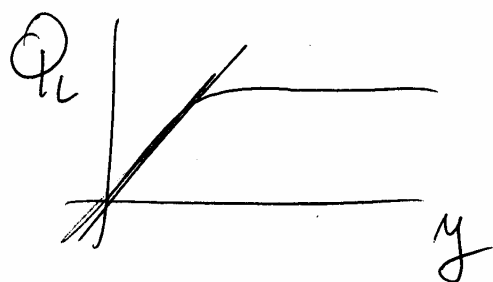
$$Q_L = Q_L(y, \Delta p)$$

servovalvole



$$p_P > p_1$$

$$p_2 > p_R$$



$$p_1 - p_2 = \Delta p$$

per  $\Delta p = 0$   
 sempre  $p_P > p_1$   
 $p_2 > p_R$

$$Q_L(y, \Delta p) \approx \underbrace{\frac{\partial Q_L}{\partial y} \bigg|_{y=0}}_{>0} y + \underbrace{\frac{\partial Q_L}{\partial (\Delta p)} \bigg|_{\Delta p=0}}_{<0} \Delta p =$$

$$= k_y y - k_p \Delta p \quad \text{con } k_p, k_y > 0$$

$$k_y y - k_p \Delta p = A \dot{x} + \left( C_{ip} + \frac{C_{ep}}{2} \right) \Delta p$$

$$\Delta \bar{p}(s) = \frac{k_y \bar{y}}{G} - \frac{A}{G} s \bar{x}(s)$$

$$\text{con } G = C_{ip} + \frac{C_{ep}}{2} + k_p$$

pistone  $M \ddot{x} + c \dot{x} + kx = A \Delta p$

$$(Ms^2 + cs + k) \bar{x}(s) = A \left( \frac{k_y}{G} \bar{y}(s) - \frac{As}{G} \bar{x}(s) \right)$$

$$G(s) = \frac{\bar{x}(s)}{\bar{y}(s)} = \frac{A \frac{k_y}{G}}{Ms^2 + \left( c + \frac{A^2}{G} \right) s + k}$$

DATI (TRASCURANDO  $C_{ip} \in C_{ep}$ ):  $M = 10^2 \text{ kg}$ ;  
 $k = 10^4 \text{ Nm}^{-1}$ ;  $c = 10\% \text{ } c_c$ ;  $A = \pi/4 d^2$ ;  $d = 10 \text{ cm}$ ;  
 $k_p = 5 \cdot 10^{-10} \frac{\text{m}^3/\text{s}}{\text{Pa}}$ ;  $k_y = 0.02 \frac{\text{m}^3/\text{s}}{\text{m}}$ ;

