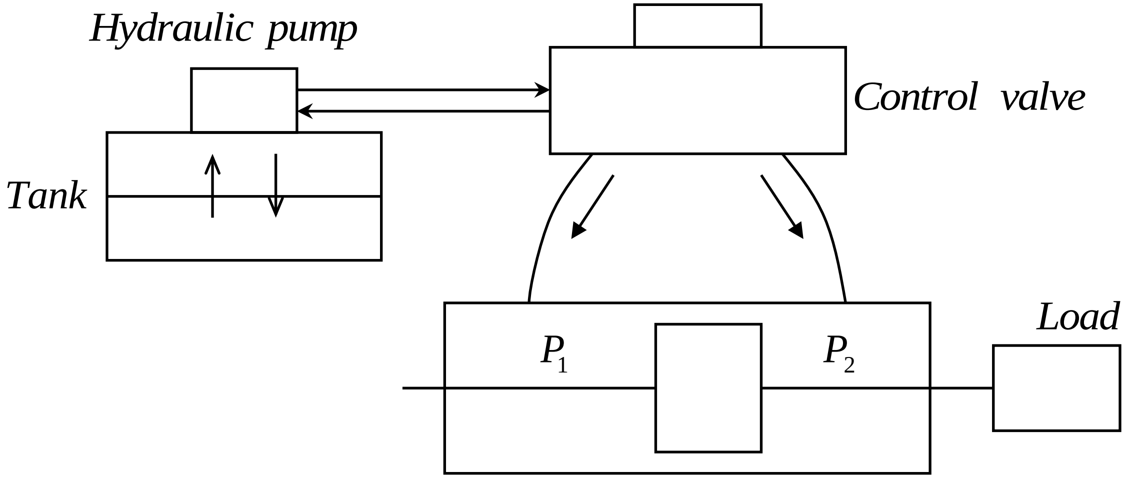
# Fluid Systems II

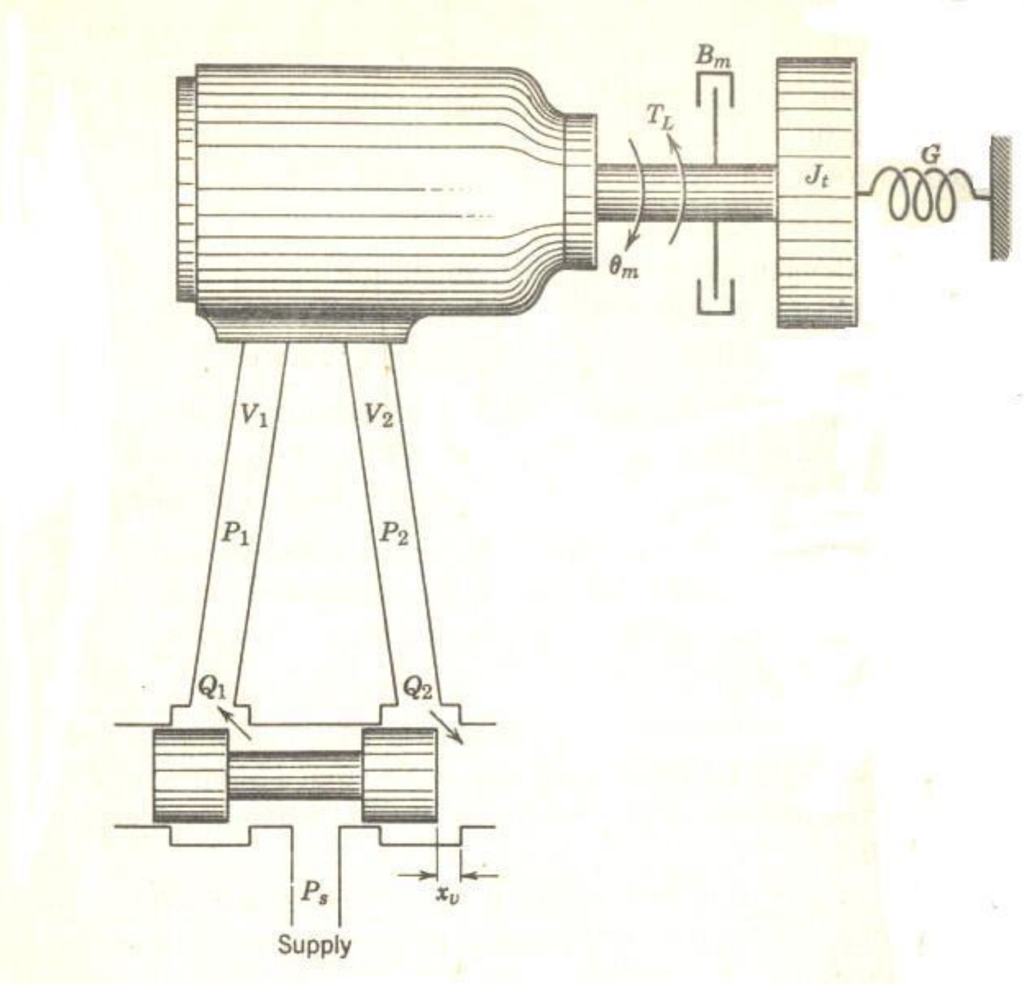
# Hydraulic Systems



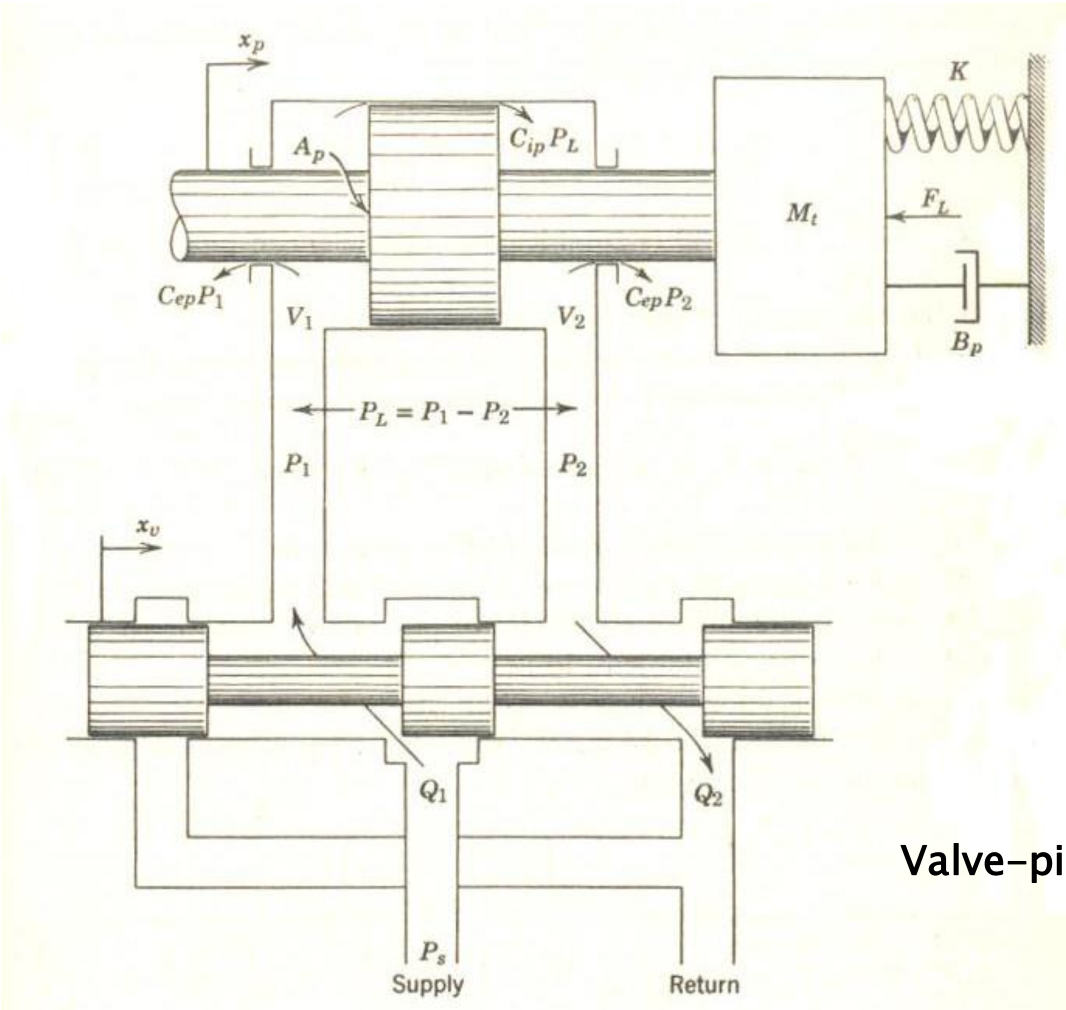

$$Hydraulic\ \ actuator\ \ (70 \sim 210bar)$$

$$F = A_P \cdot (P_1 - P_2)$$

# Hydraulic Systems : Valve-motor Combination

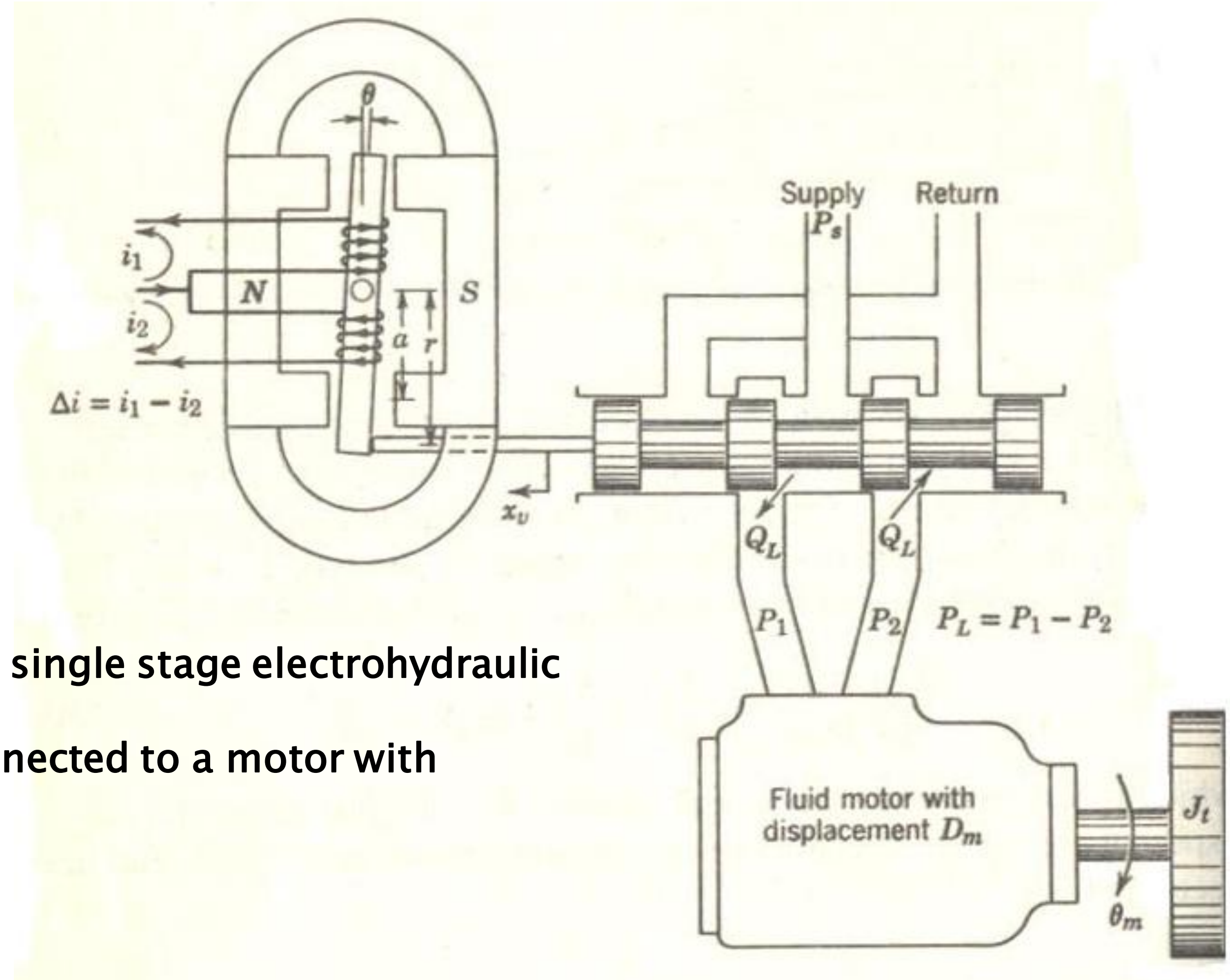


# Hydraulic Systems : Valve-piston Combination



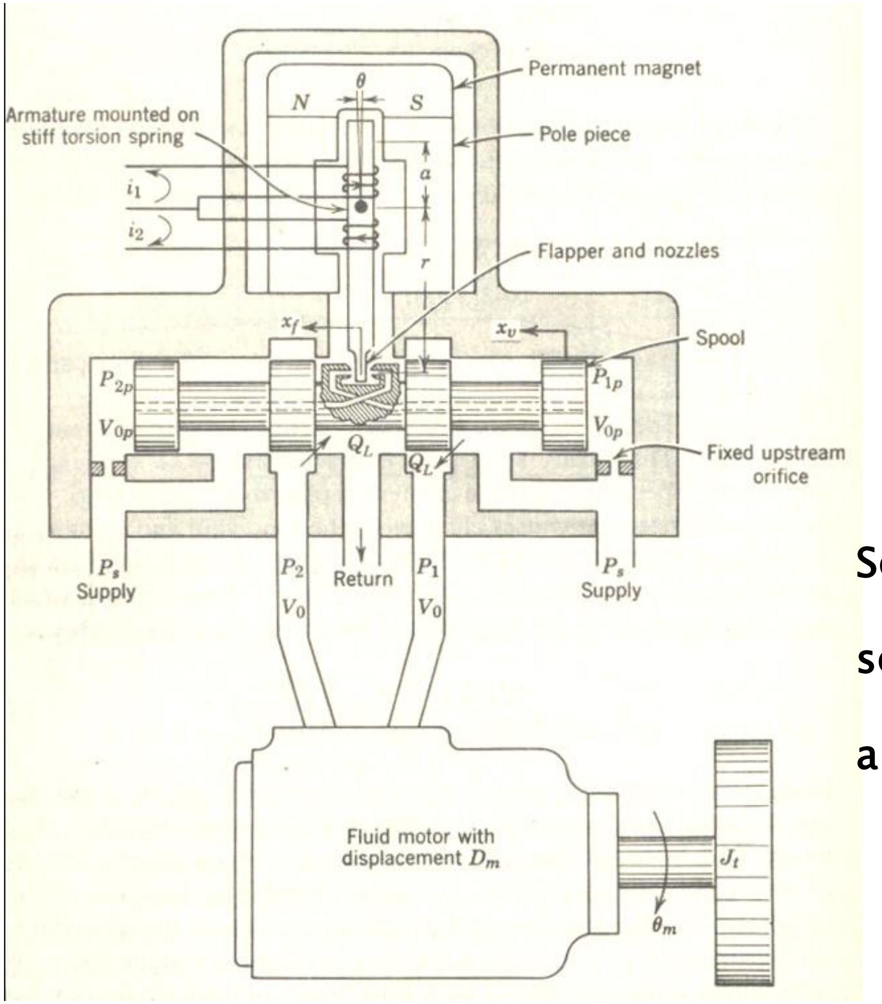

Valve-piston combination

# Hydraulic Systems : Single Stage Electrohydraulic Servovalve



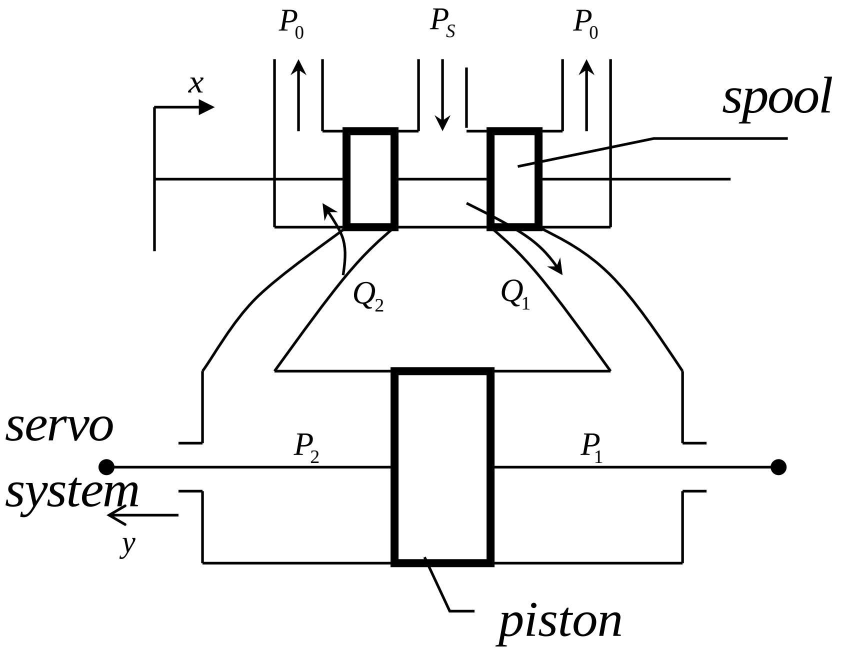

Schematic of a single stage electrohydraulic servovalve connected to a motor with inertia load

# Hydraulic Systems : Two-stage Electrohydraulic Servovalve




Schematic of a two-stage electrohydraulic servovalve with force feedback controlling a motor with inertia load

# Hydraulic Servo System




$P_S$ : *supply pressure*

$Q_1 =$ $\left[m^2/s\right]$

$a$ : *area gradient*, $x$ : *displacement*

$\rho$ : *density*, $C_d$ : *discharge coefficient*

$Q_2 =$

$$= C_d \cdot a \cdot x \sqrt{\frac{2}{\rho} P_2} \qquad (P_0 \approx 0)$$

# Hydraulic Servo System

no leakage, no compressibility

$$Q_1 = Q_2 \qquad = P_2 \quad \rightarrow \quad P_s = P_1 + P_2$$

$$P_L = \qquad \rightarrow \quad P_S + P_L = 2P_1, \quad P_S - P_L = 2P_2$$

$$\rightarrow \quad P_1 = \qquad P_2 =$$

$$Q = Q_1 = Q_2 = \qquad =$$

Q is proportional to →

$$Q =$$

$$\frac{dy}{dt} =$$

Nonlinear equation → linearize

# Hydraulic Servo System

$$\frac{d\bar{y}}{dt} = C \cdot \bar{x}\sqrt{P_S - \overline{P_L}}, \qquad y = \qquad\qquad x = \qquad\qquad P_L =$$

$$\frac{dy}{dt} = f(\bar{x}, \overline{P_L}) + \frac{\partial f}{\partial x}\Big|_{\bar{x}\ \overline{P_L}} \cdot (x - \bar{x}) + \frac{\partial f}{\partial P_L}\Big|_{\bar{x}\ \overline{P_L}} \cdot (P_L - \overline{P_L})$$

$$= \frac{d\bar{y}}{dt} + \qquad \cdot (x - \bar{x}) + \qquad (P_L - \overline{P_L})$$

$$if \quad \bar{x} = 0, \qquad \overline{P_L} = 0, \qquad \frac{d\bar{y}}{dt} = 0$$

$$\frac{dy}{dt} =$$

$$\therefore\ T.F = \frac{Y(s)}{X(s)} = \frac{K_1}{S}$$