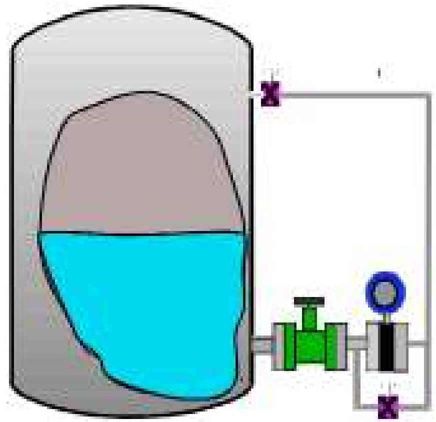
Process Control Equipments

Level sensors

- <u>Differential pressure:</u>

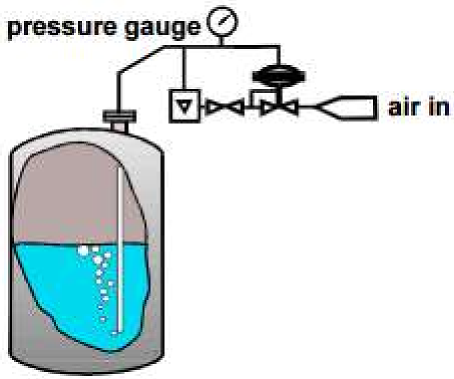
  This device does not really measure level. It measures the head pressure that the

  diaphragm senses due to the height of the material in the vessel multiplied by a second variable, the density of the product. This gives you the resultant force being exerted on the diaphragm, which is then translated into a measurement of level. The signal produced is pneumatic.



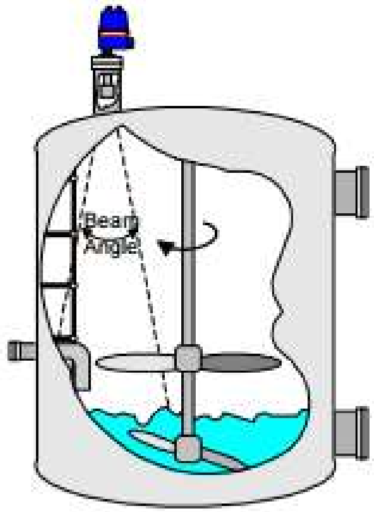
- <u>Bubblers</u>

  This simple level measurement has a dip tube installed with the open end close to the bottom of the process vessel. A flow of gas (usually air) passes through the tube and when air bubbles escape from the open end, the air pressure in the tube corresponds to the hydraulic head of the liquid in the vessel. The air pressure in the bubble pipe varies proportionally with the change in head pressure



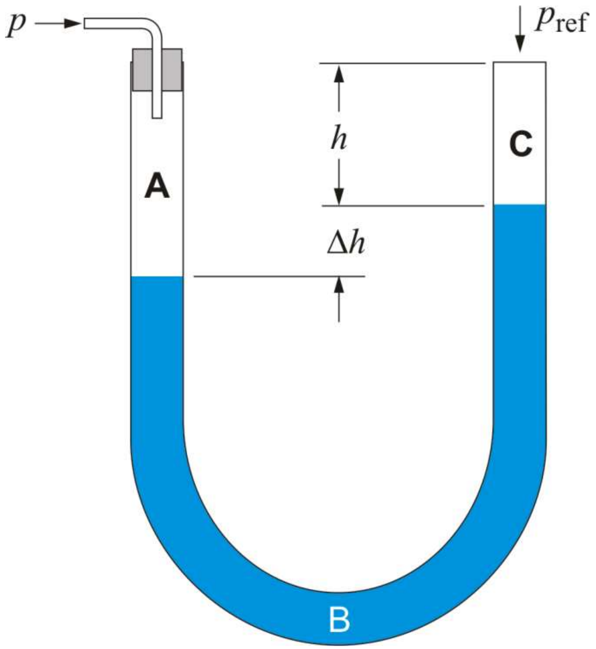
- <u>Ultrasonic</u>

Ultrasonic transmitters work on the principle of sending a sound wave from a peizo electric transducer to the contents of the vessel. The device measures the length of time it takes for the reflected sound wave to return to the transducer. A successful measurement depends on reflection from the process material in a straight line back to the transducer.

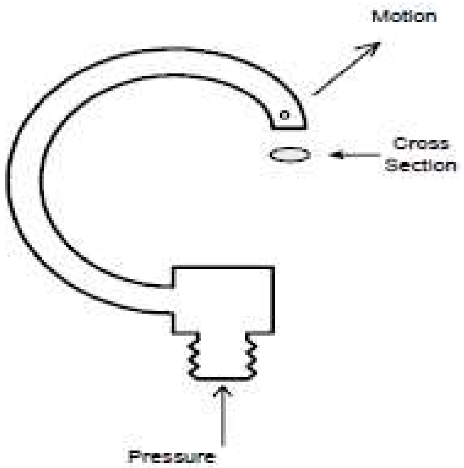


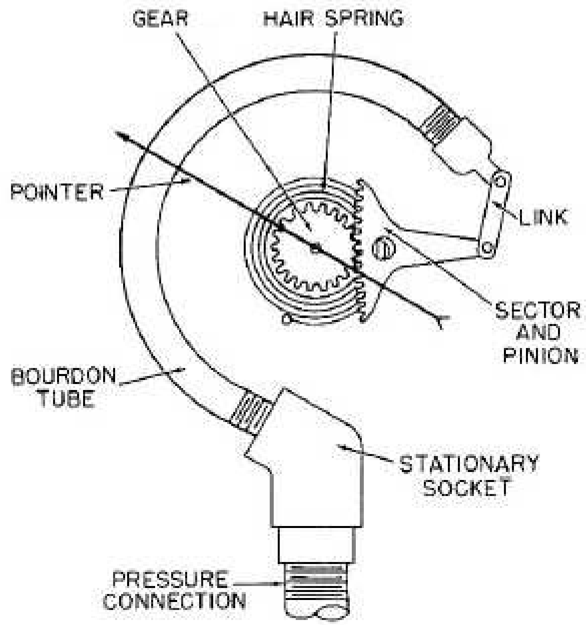
Pressure Measurement Devices

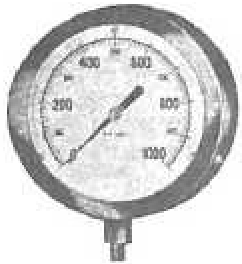
a) U Manometer



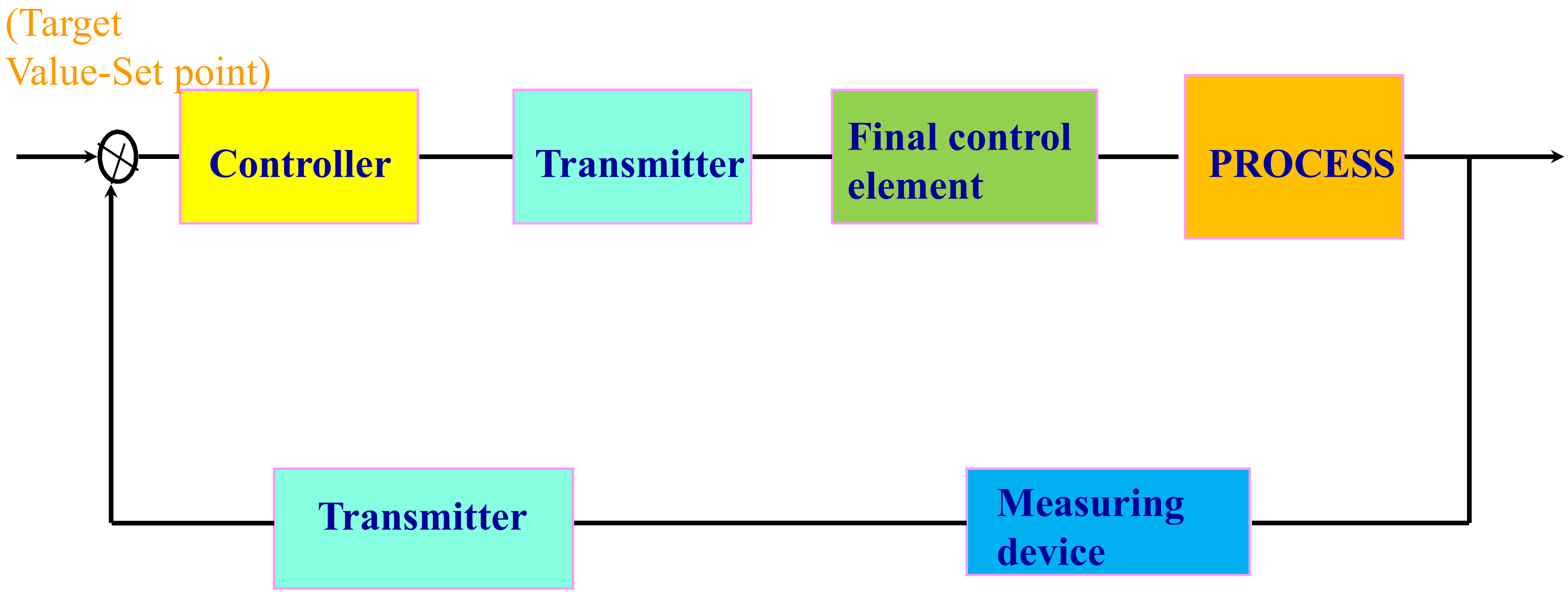
b) Bourdan-gage: A Bourdon pressure gauge works by measuring the amount of change in a coiled or semicircular metal tube by a pressurized fluid inside. This is due to the principle that a flattened tube tends to regain its circular form when pressurized.







Automatic control



The block diagram of closed loop feed back control system

Final Control Element

- It can be pump, valve, etc..
- It can work both with pneumatic or electrical signals
- The important point is that the controller and the final control element should talk the same language.

Final control element
(Control valve)

- Globe
- Butterfly
- Ball
- Disc

etc.

Final control element
(Control valve)

A-O : Air to open
A-C : Air to close

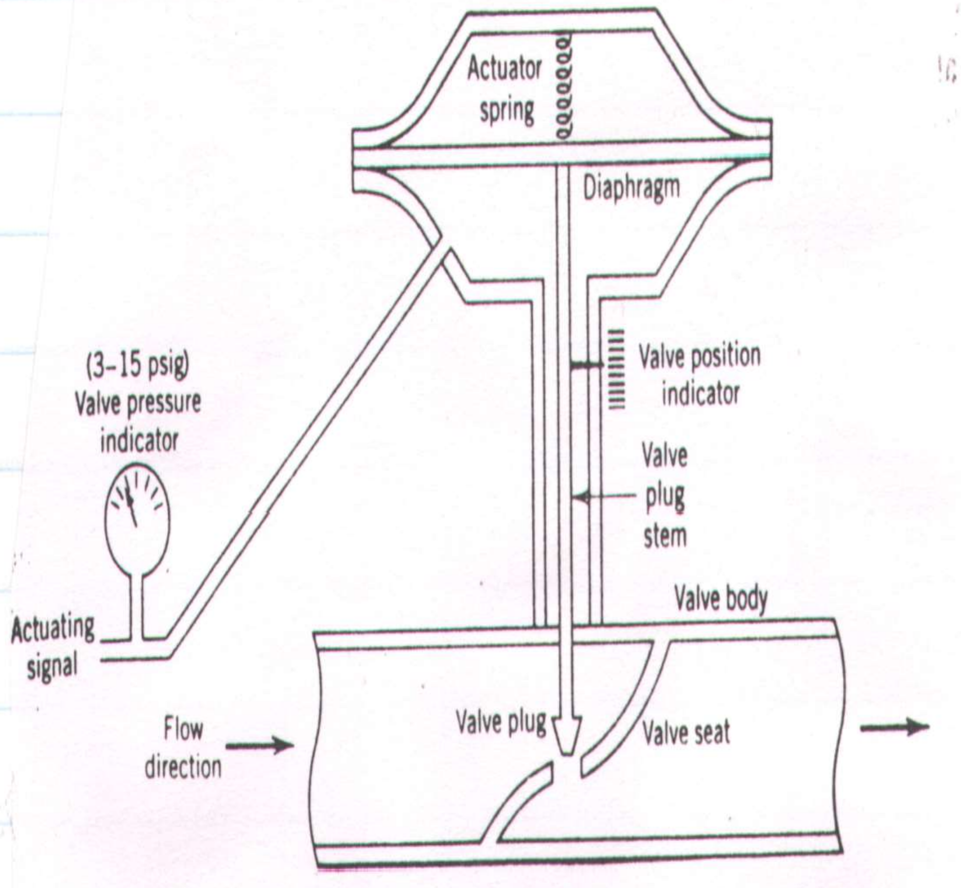


Figure 9.8. A pneumatic control valve.

Controllers

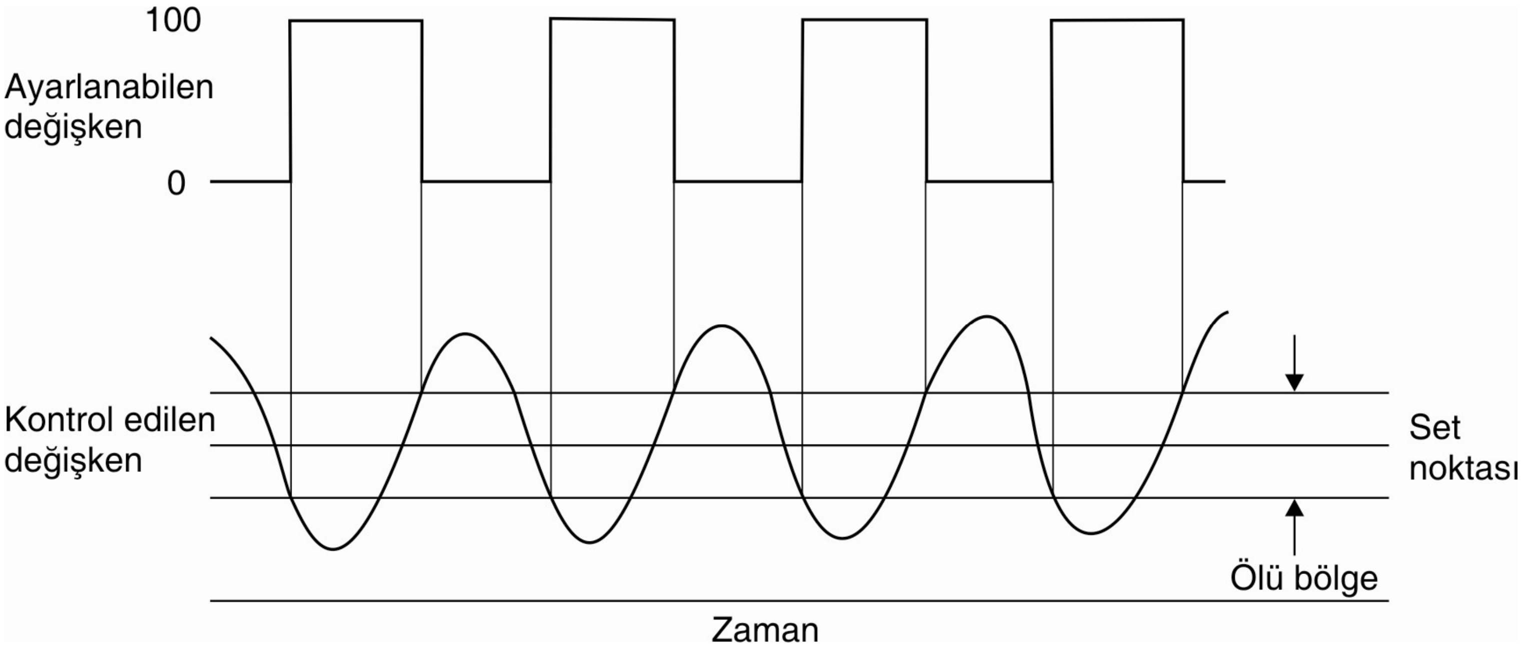
On/Off Control:

- These are the simplest controllers
- It finds application areas especially in house heating systems or uncritical industrial applications.
- It causes oscillation

<u>Controllers</u>

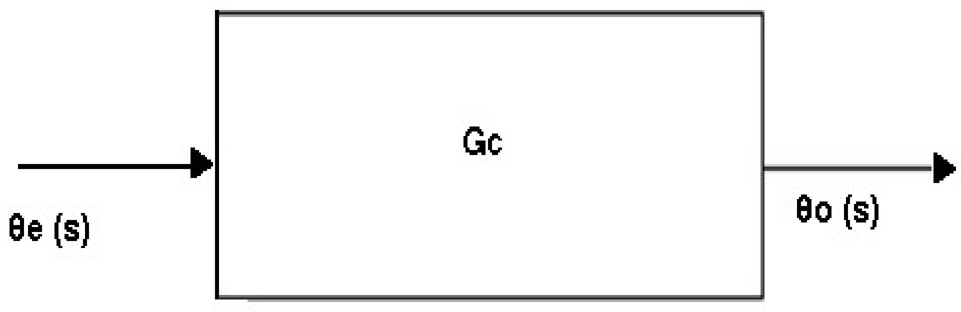
On/Off Control:

Example: house heating system



On/off control: causes oscillation (dalgalanmaya)

FEEDBACK CONTROL SYSTEMS



Block diagram representation of a controller

What is happening inside a controller?

$$\theta_o = k_1 \theta_e + k_2 \int_0^t \theta_e dt + k_3 \frac{d\theta_e}{dt}$$

Proportional control (P)

$$\theta_o = k_1 \theta_e$$

Integral control (I)

$$\theta_o = k_2 \int_0^t \theta_e dt$$

Derivative control (D)

$$\theta_o = k_3 \frac{d\theta_e}{dt}$$

- The output variable can be calculated by using the inlet error signal information in some mathematical equations.
- There can be three different terms in a controller and these terms can be combination of any; P, PI, PD, PID

- Lets find the transfer function of this system;

$$\theta_o = k_1\left[\theta_e + \frac{k_2}{k_1}\int_0^t \theta_e dt + \frac{k_3}{k_1}\frac{d\theta_e}{dt}\right]$$

$$\theta_o = k_1\left[\theta_e + \frac{1}{\tau_R}\int_0^t \theta_e dt + \tau_D\frac{d\theta_e}{dt}\right]$$

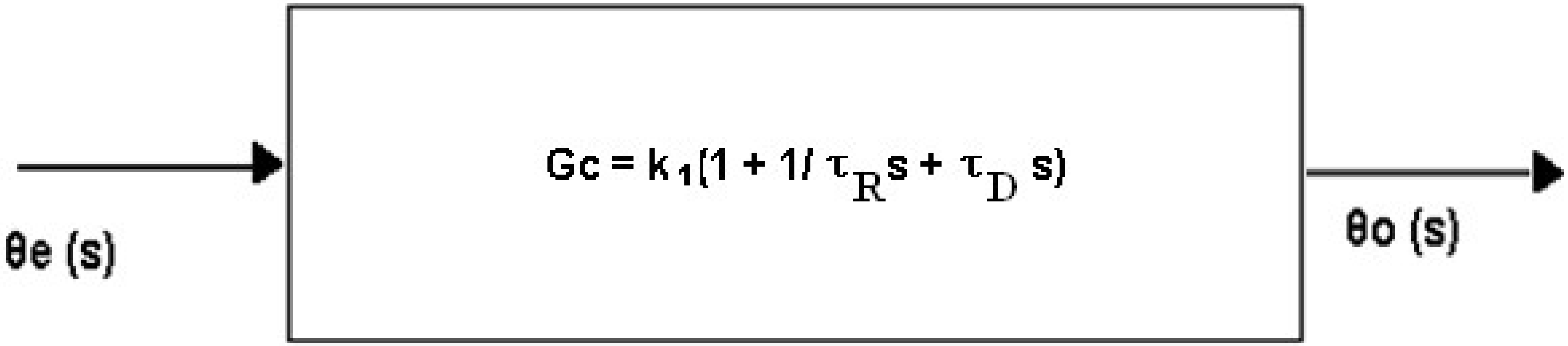
τ_R: integral time constant

τ_D: Derivative time constant

- **Taking laplace;**

$$\theta_0(s) = k_1\left(1 + \frac{1}{\tau_R s} + \tau_D s\right)\theta_e(s)$$

$$G_c = \frac{\theta_0(s)}{\theta_e(s)} \Rightarrow G_c = k_1\left(1 + \frac{1}{\tau_R s} + \tau_D s\right)$$



The block diagram representation of a control system with three terms