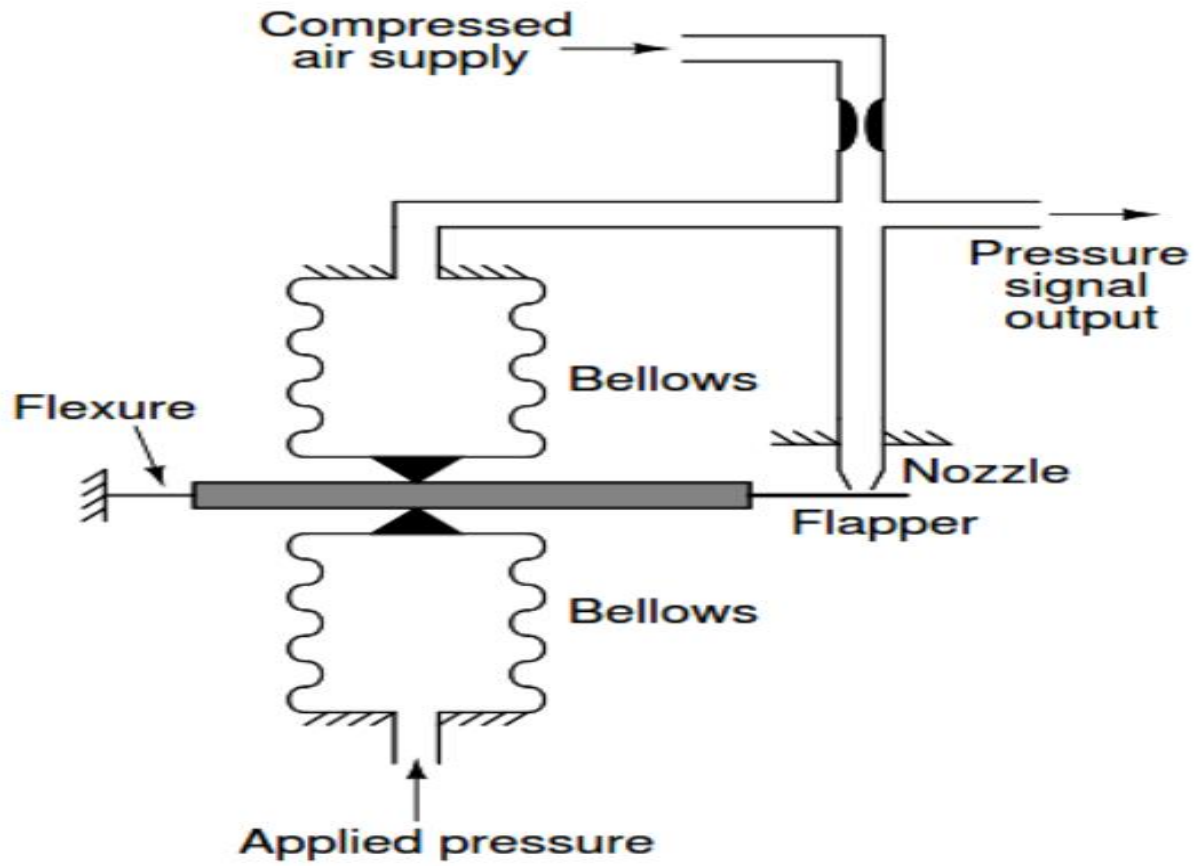
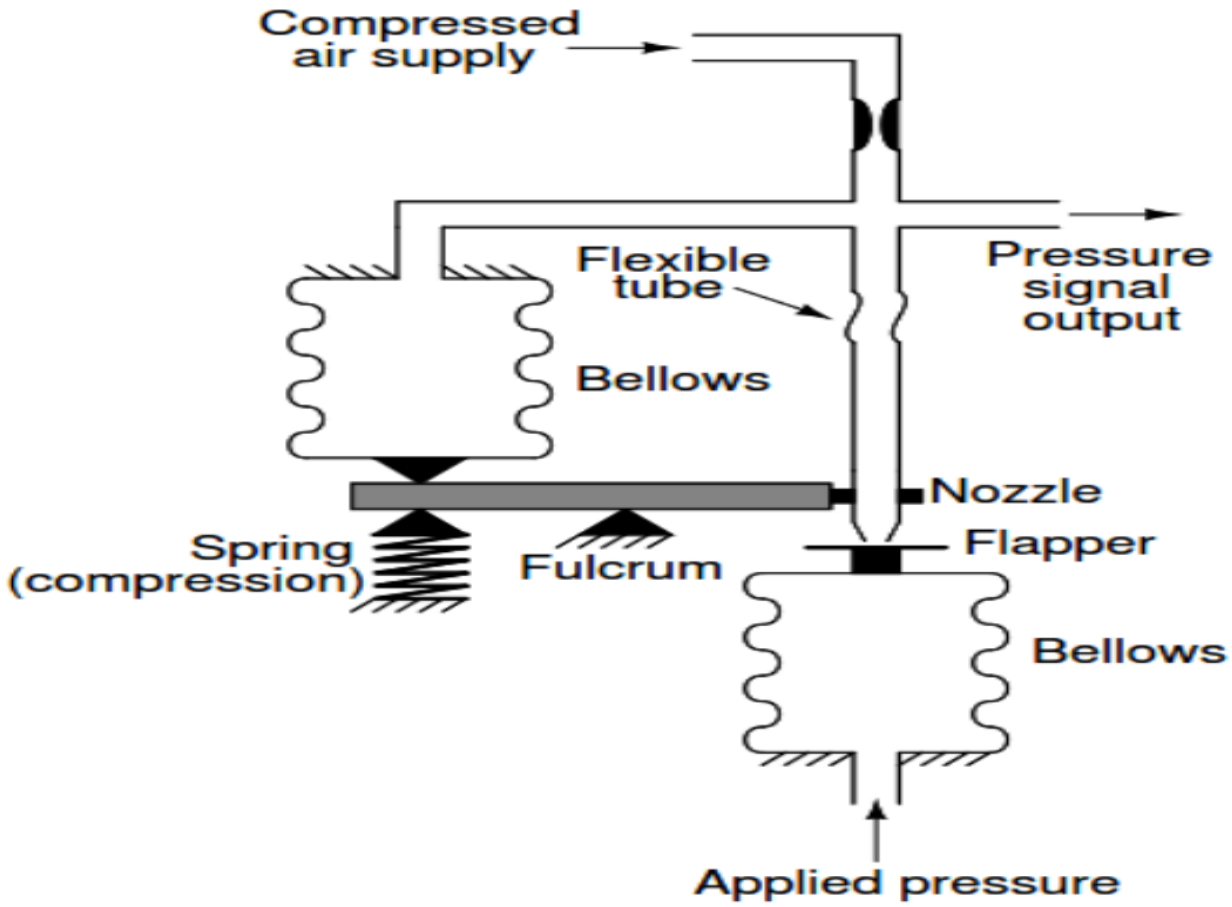
# Force and balance /Motion balance instruments

- The general principle to keep in mind here is that motion-balance instruments generate a motion to counteract an input motion in order to maintain a constant detector (flapper/nozzle) gap, while force-balance instruments generate a force to counteract an input force in order to maintain a constant detector (flapper/nozzle) gap.

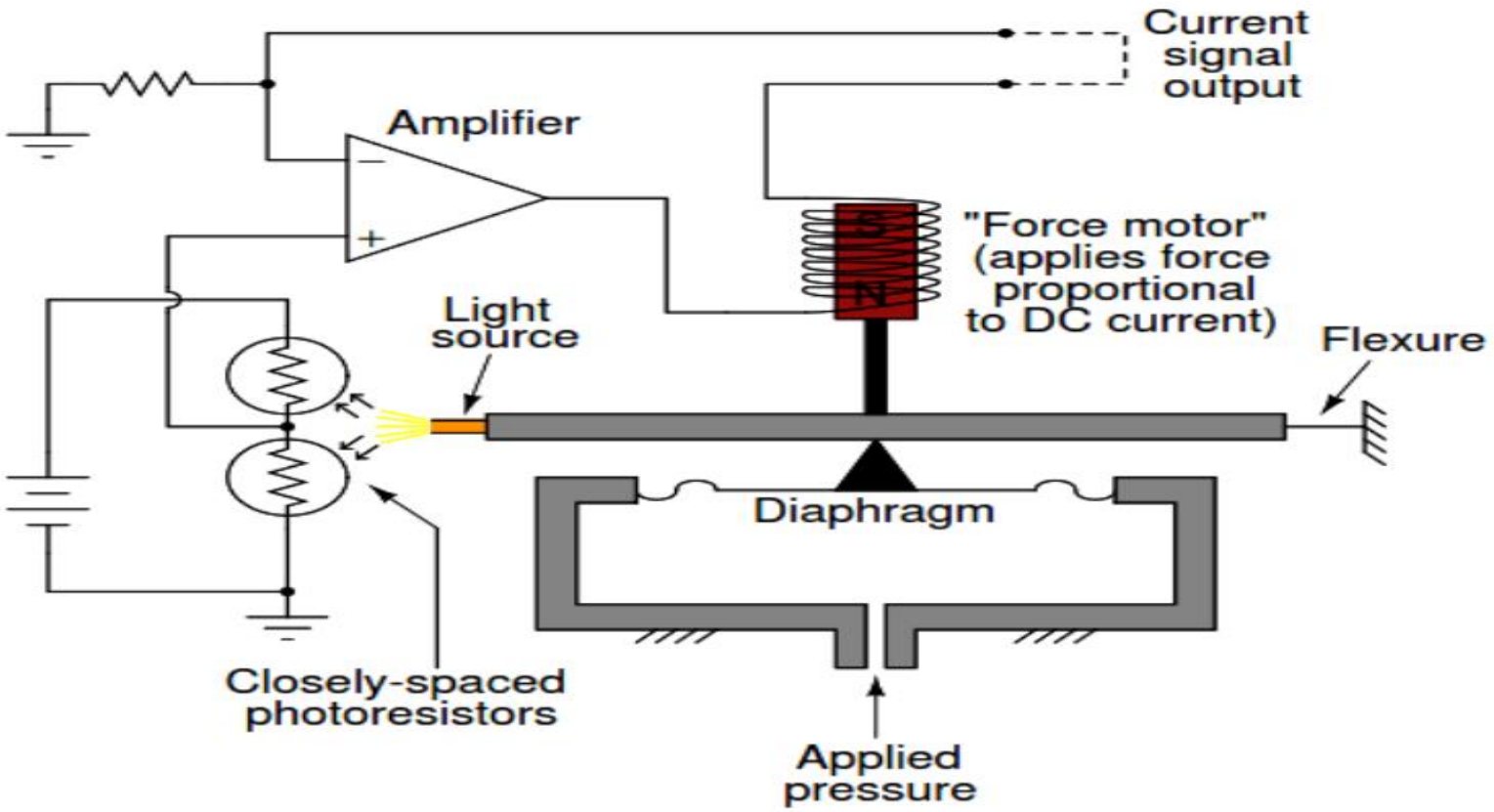
# Force – balance



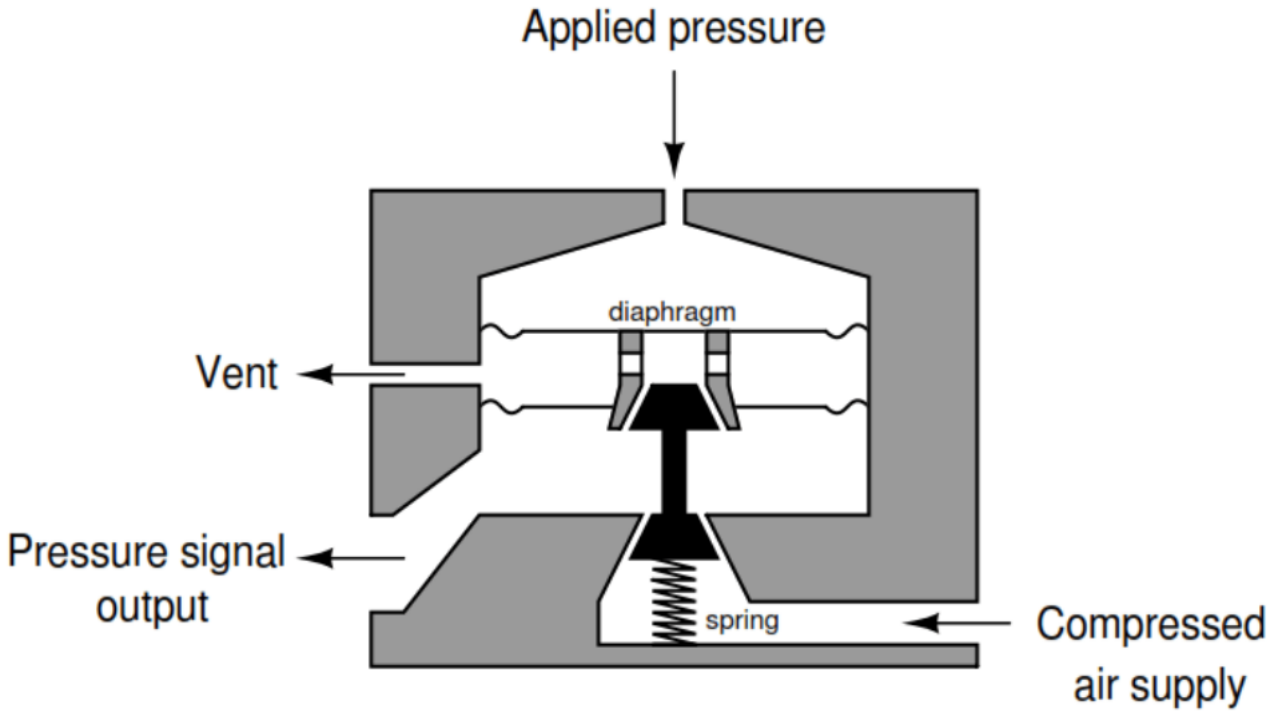
# Motion balance



# Force balance

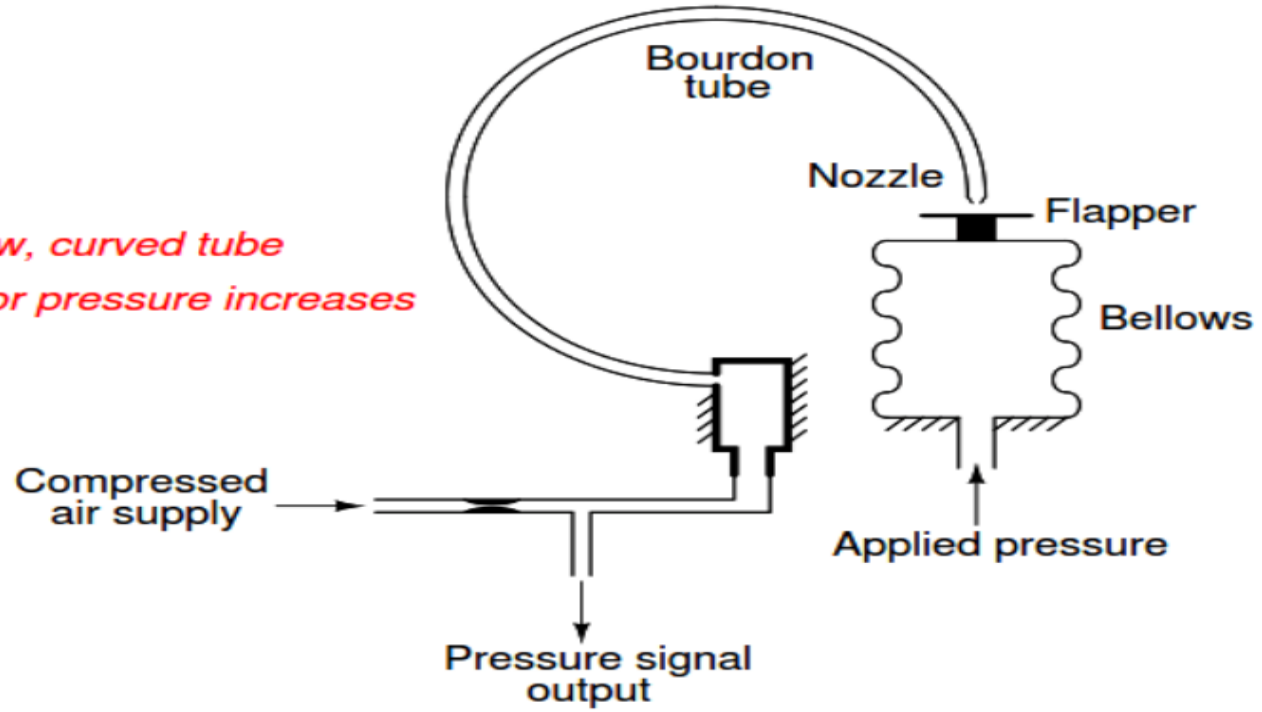


# Force balance

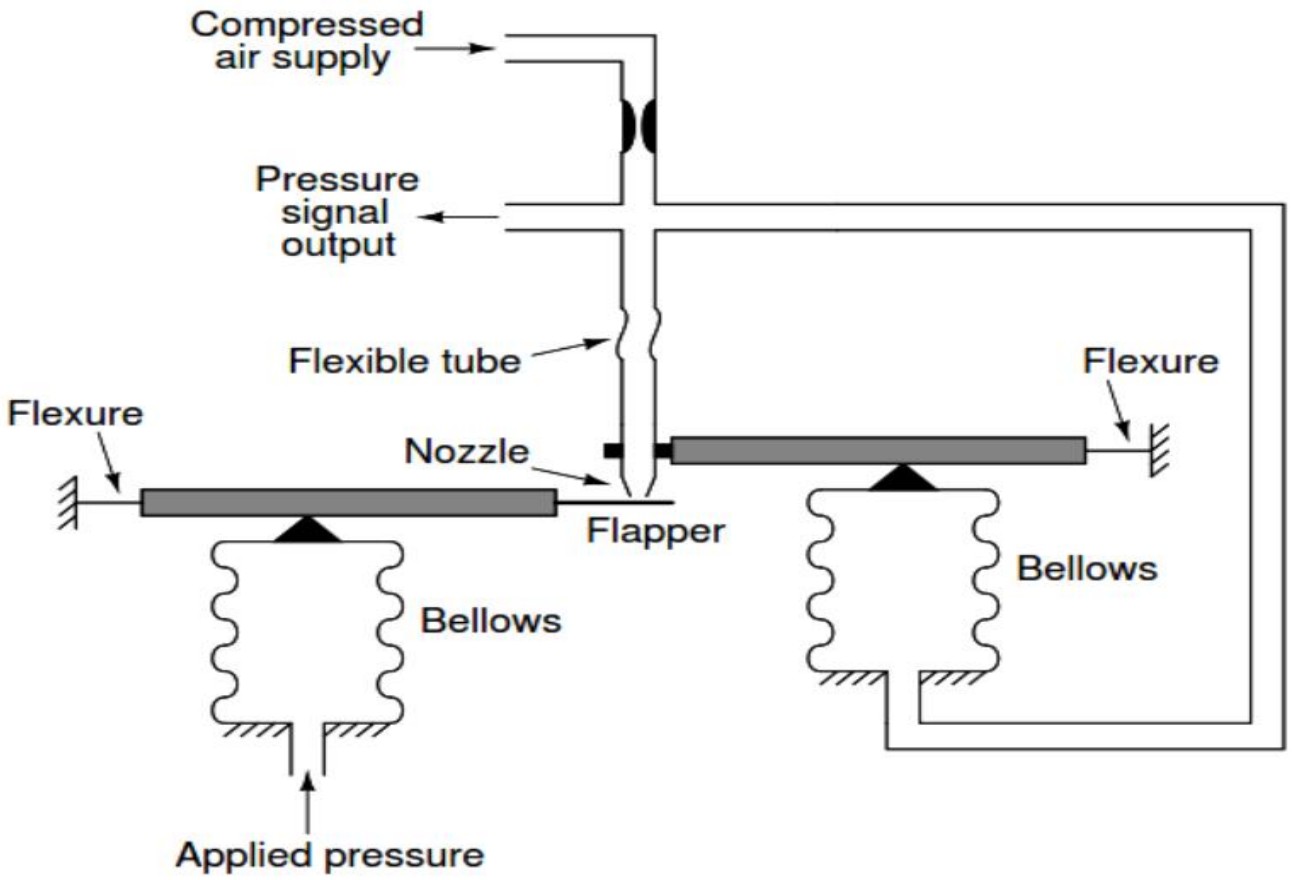


# Motion balance

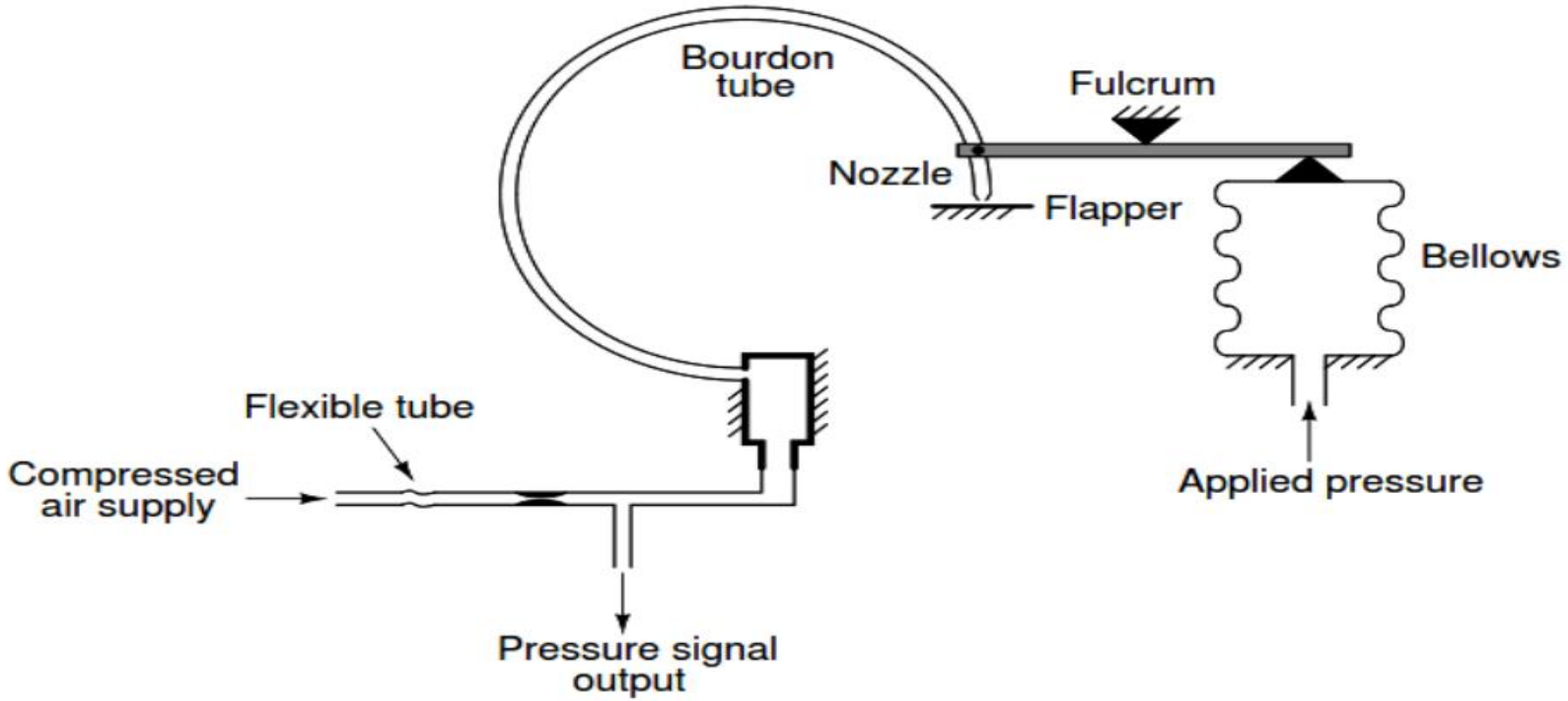
*Hint: a "Bourdon tube" is a hollow, curved tube that straightens out as the interior pressure increases*



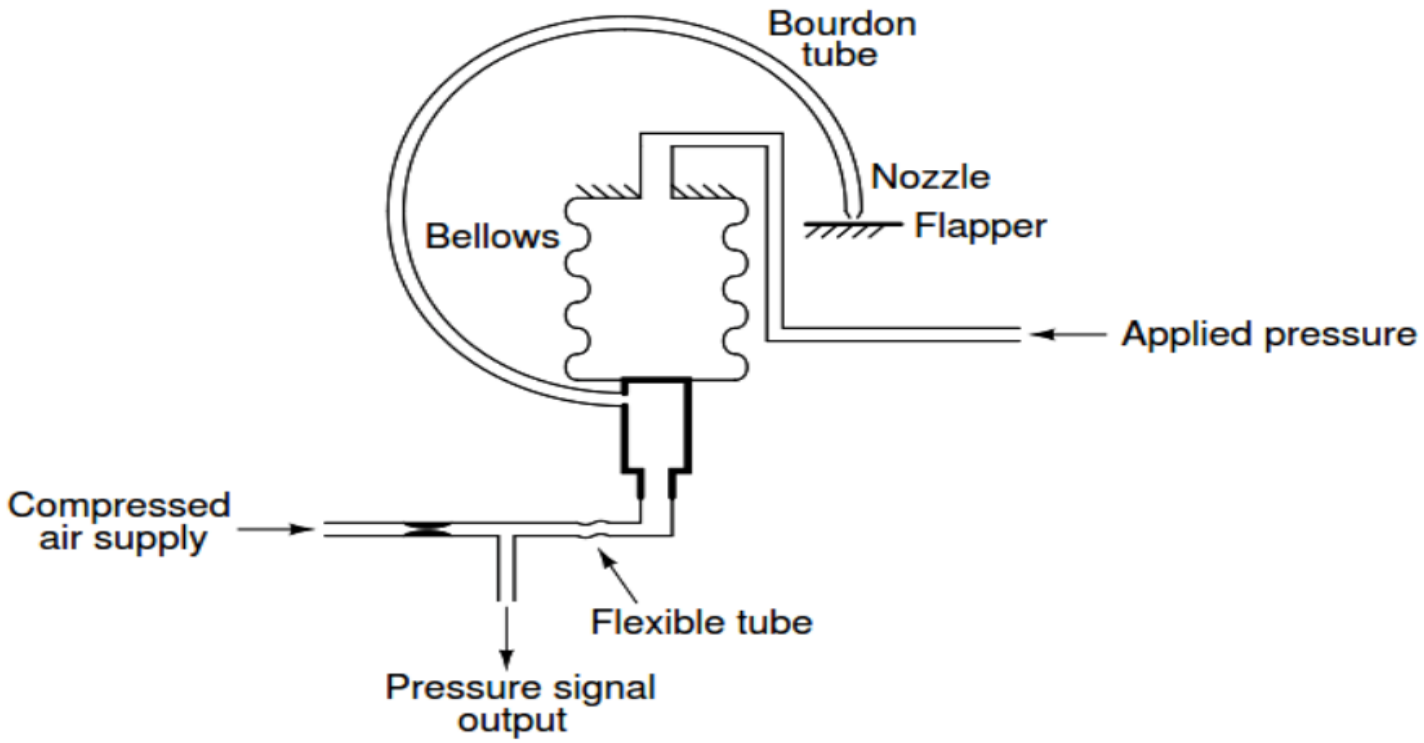
# Motion balance



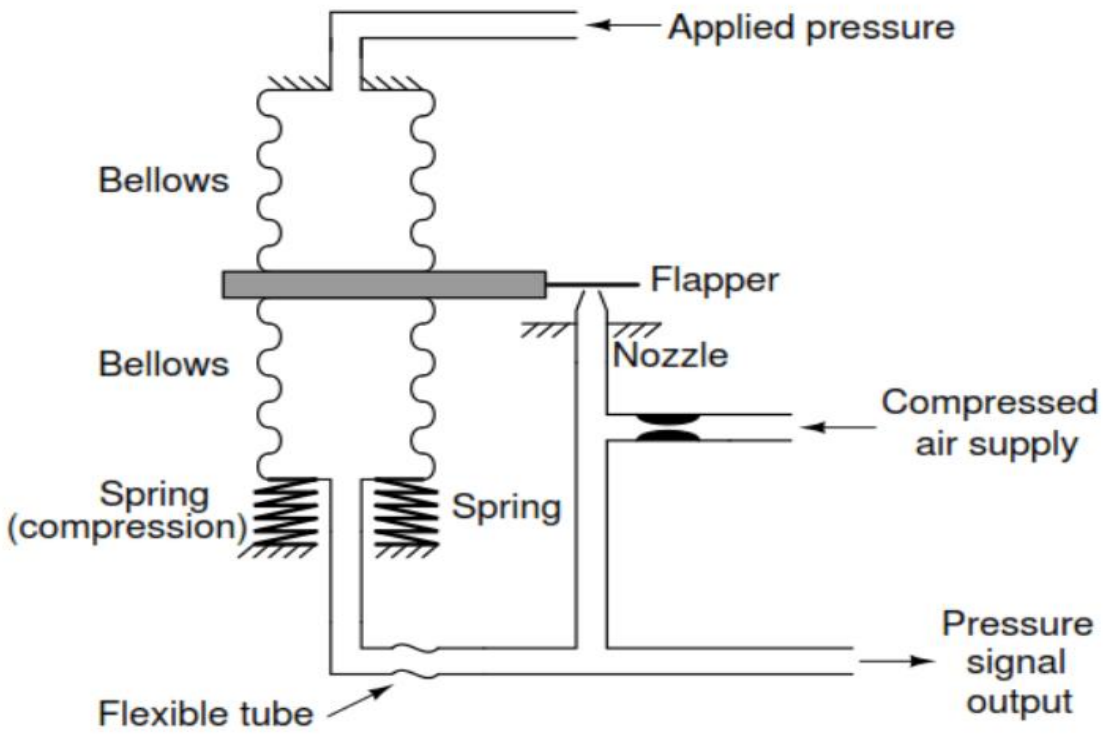
# Force balance



# Motion balance



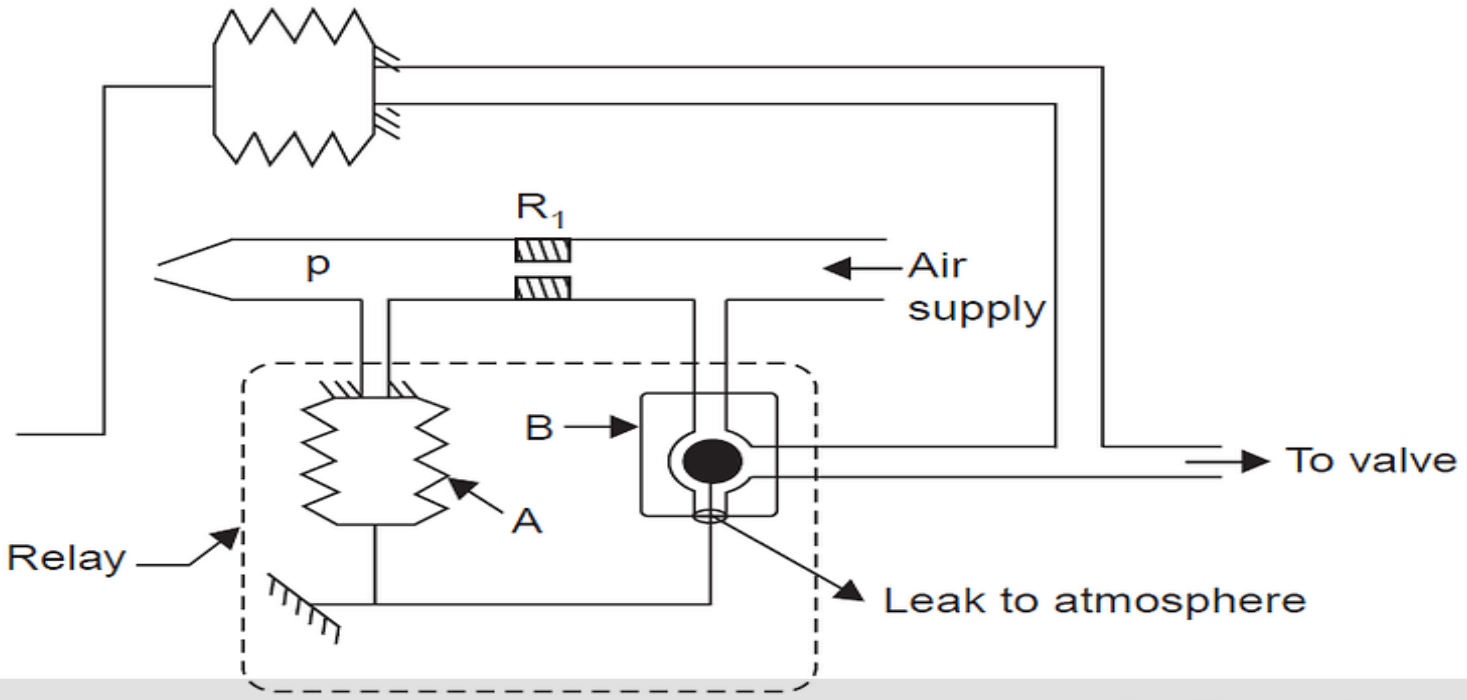
# Force balance



- Example number 9 is tricky because one might argue it is motion-balance by virtue of the lower bellows' stretching motion as output pressure increases.
- However, the fact that the two bellows' forces oppose each other to ensure the flapper remains stationary in order to hold a constant flapper/nozzle gap is a defining characteristic of any force-balance mechanism.
- Also, the degree of spring stiffness has no effect whatsoever on the gain of this mechanism, which it would if it were motion-balance (i.e. if the amount of motion generated per unit increase in output pressure were related at all to the amount of input pressure increase).
- The two bellows' forces will cancel each other to achieve equilibrium regardless of how much or how little the spring must compress in the process of achieving that balance. If this were a true motion-balance mechanism, weakening the spring (making it less stiff) would result in a decrease of output pressure because less pressure would be required to move as far as before.
- Here, a weakened spring would indeed result in the lower bellows expanding a greater distance than before to balance the same amount of input pressure, but this would actually be the same output pressure as before, meaning the change in required motion has no effect on the gain.

# Pneumatic relay

- Relay -
- is automatic switching device which can set ON/OFF large signal lines using comparatively small signals.
- Pneumatic relay -
- works in 3-15psi pneumatic signal which can control much higher signal that can control large devices large than 15 psi pressure.

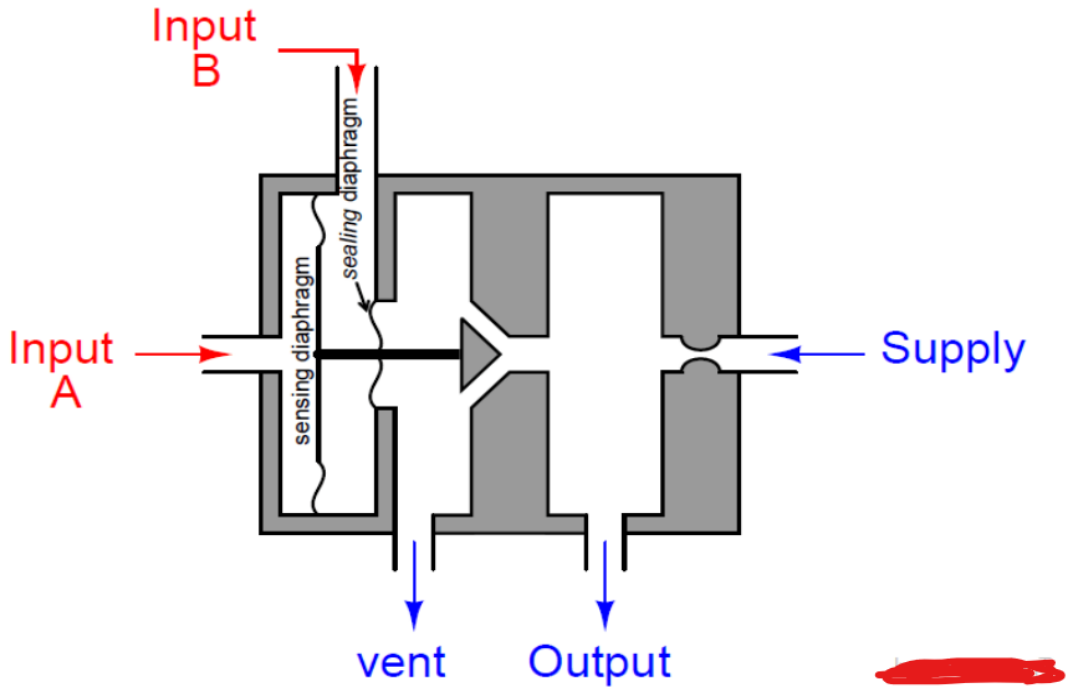

R1
p
Air
supply
B
To valve
A
Relay
Leak to atmosphere

- A power amplifier is needed to act on a large control valve. A pneumatic relay is a power amplifier. The relay is composed of small volume A bellows and a specially designed valve. In the nozzle pressure is transmitted to bellows A and, as the pressure increases, the bellows expand the ball down the valve B cavity, decreasing the leakage to the atmosphere and increasing the pressure Pv.

- The relay is made in such a way that the output pressure Pv is proportional to the signal pressure p. The airflow of the relay will be much greater than the flow rate through the nozzle, since the resistance to the air supply may be too small compared to the resistance Rr in the nozzle. A relay valve can be designed as direct acting, in which case the outlet pressure is directly proportional to the inlet pressure, or it can be reverse acting, in which case the outlet pressure is inversely proportional to the inlet pressure.

# Question 1

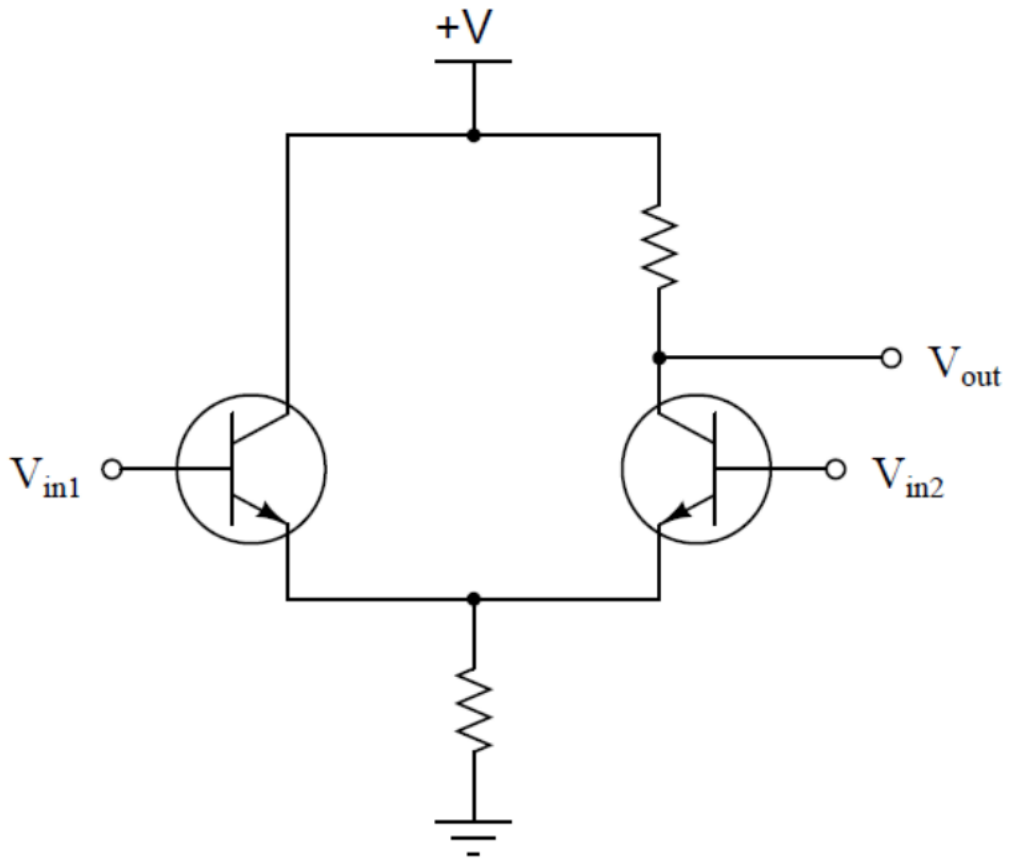
- What is the response of this pneumatic relay to increasing pressure on each of its inputs? Does the output pressure increase as input A's pressure increases? What happens when input B's pressure increases?



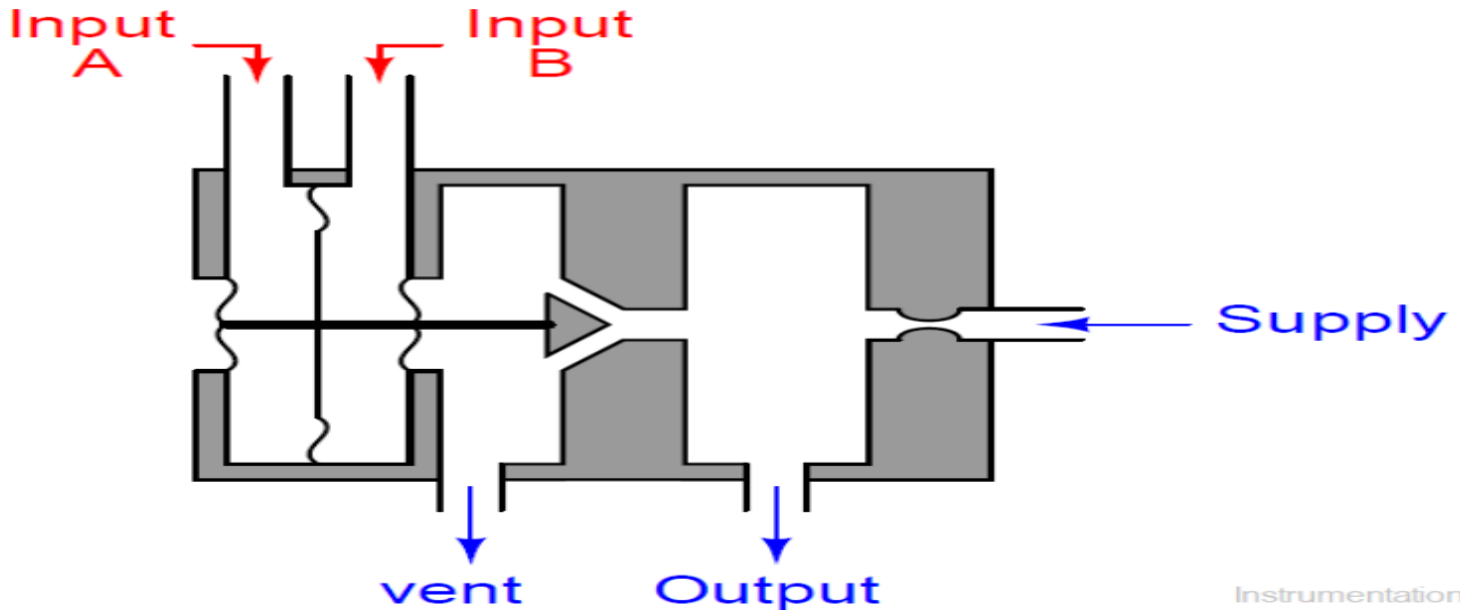
# Answer

- A bit of explanation might be in order for the two diaphragms. The larger diaphragm is called the sensing diaphragm, while the smaller diaphragm is called the sealing diaphragm.
- The purpose of the sealing diaphragm is to prevent air pressure at input B from leaking out into the vented chamber just to the left of the wedge-shaped pilot plug.

# Equivalent electronic diagram



why the following relay design is better, using two sealing diaphragms instead of just one. A hint is to consider the common-mode rejection capacity of each relay design.



- each of the metal diaphragms is welded to the rod to form leak-proof and frictionless seals

Does the output pressure of this relay increase with increasing input pressure, or decrease with increasing input pressure?