Generating Motion

- Moving a part adds no value (except in packaging)
- Moving a tool adds no value unless work is done on part.
- So, we want to avoid moving parts or tools any more than necessary
  - One metal machining batch factor: 95% of a parts time is spent moving or waiting, 5% of time is on tool, of which only 30% is spent cutting.

Linear Motion

- Linear translation is most common motion
- Linear movement can be caused by:
  - Pneumatic or hydraulic cylinders
  - Rotary motion converted to linear
  - Vibratory systems
  - Electric solenoids
  - Linear electric motors
  - Piezoelectric actuators

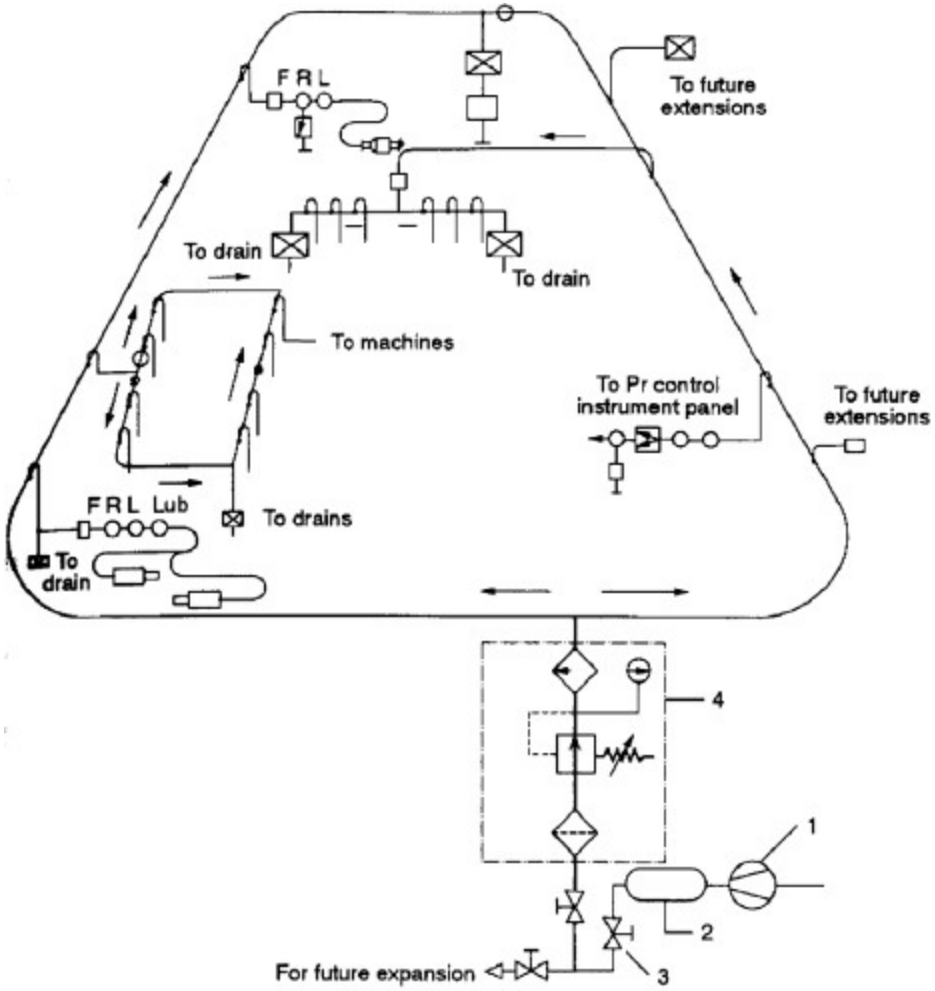
Pneumatic Systems

- Pneumatic power very popular in industry
  - High force, economical actuators
  - Force is independent of stroke
  - Non-flammable, compressible, storable medium
  - Compact, low heat production actuators
- Pneumatics best suited to discrete motion (not proportional)
- Energy costs of pneumatics are very high
  - ~$0.005 / cu.ft. / year
  - 1" cylinder with 6" stroke once/sec=>$392/year

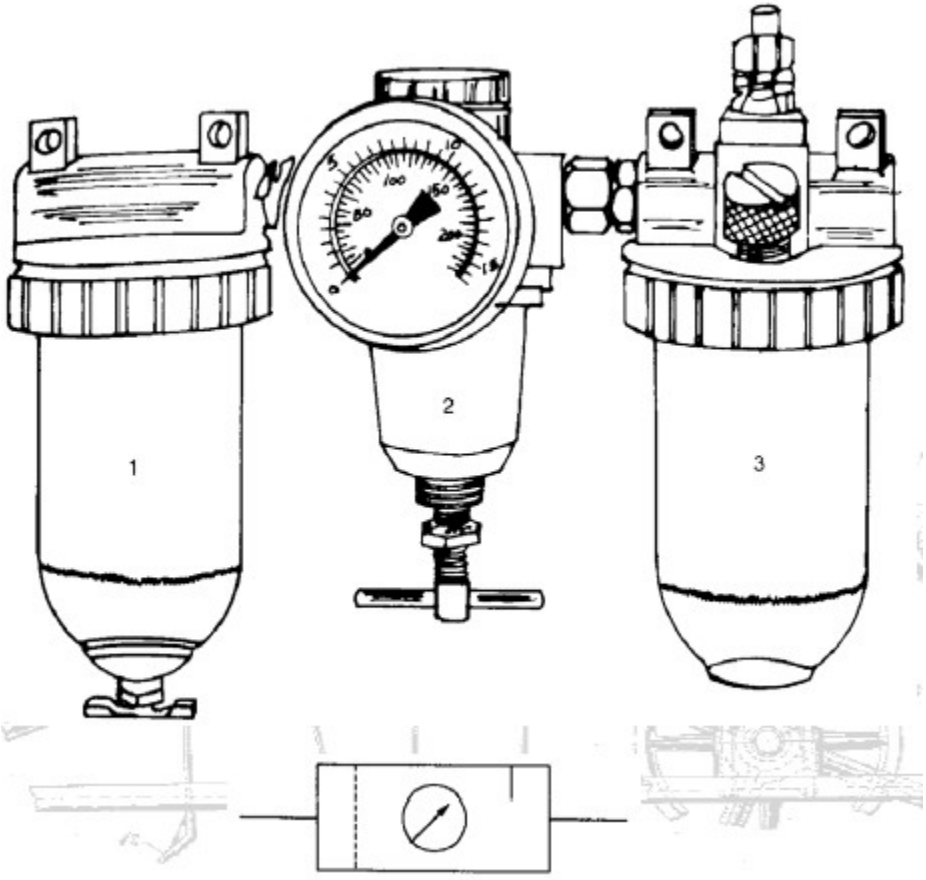
Pneumatic Systems

- Ideal Gas Law: $PV=mRT$
- Boyle's Law: $P_1V_1 = P_2V_2$

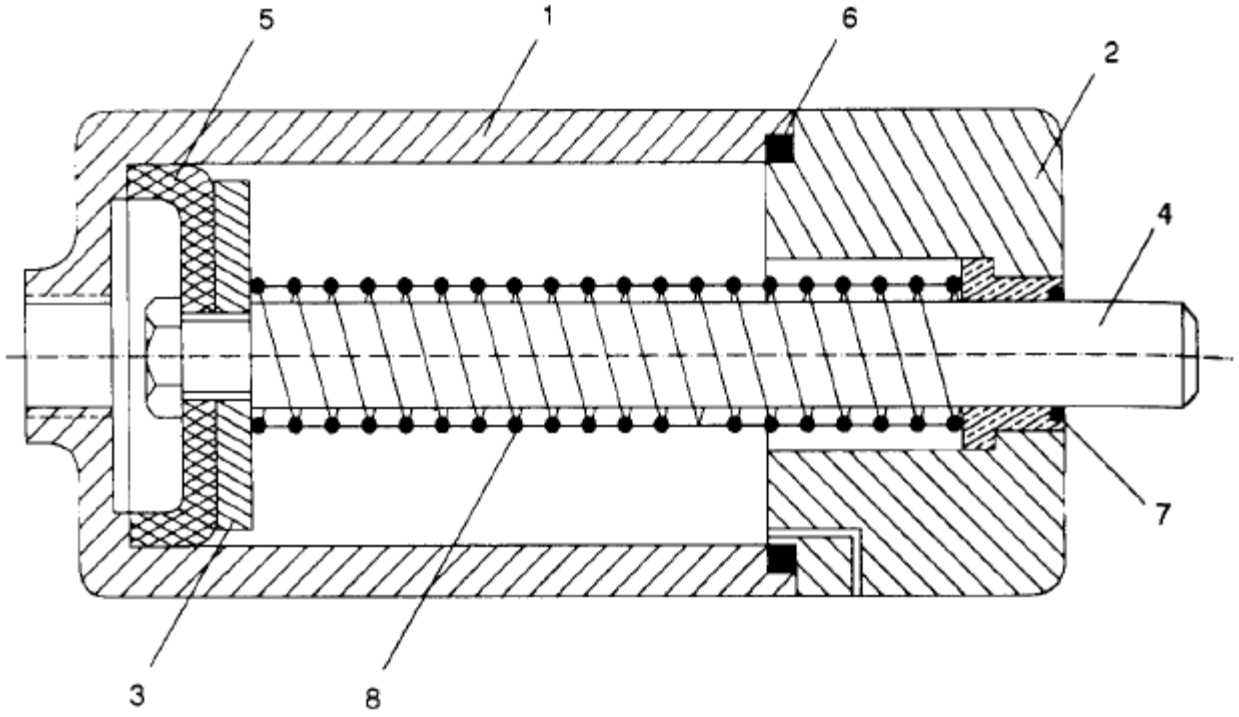
Pneumatic System Layout



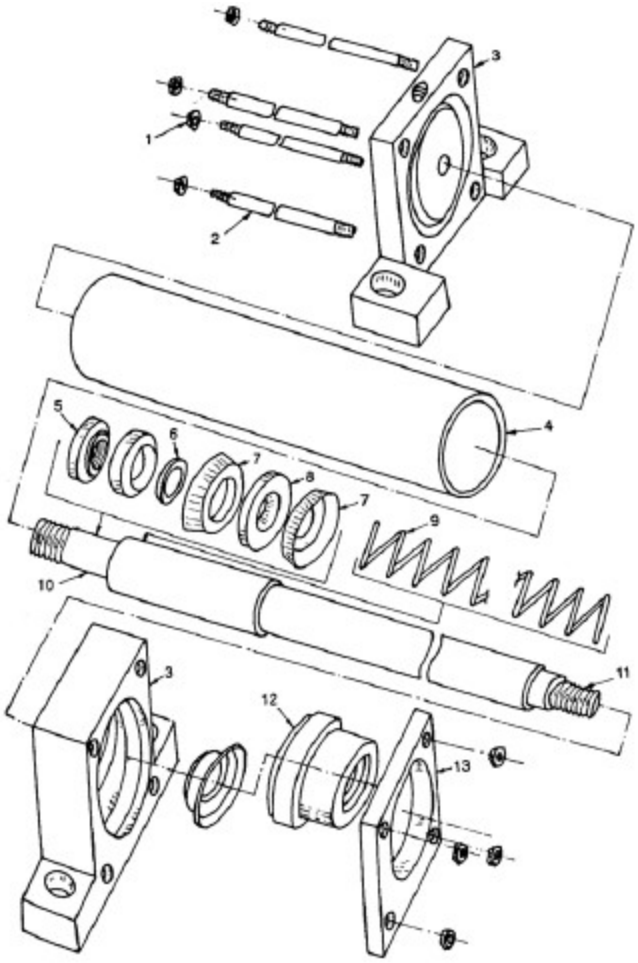
Air Preparation



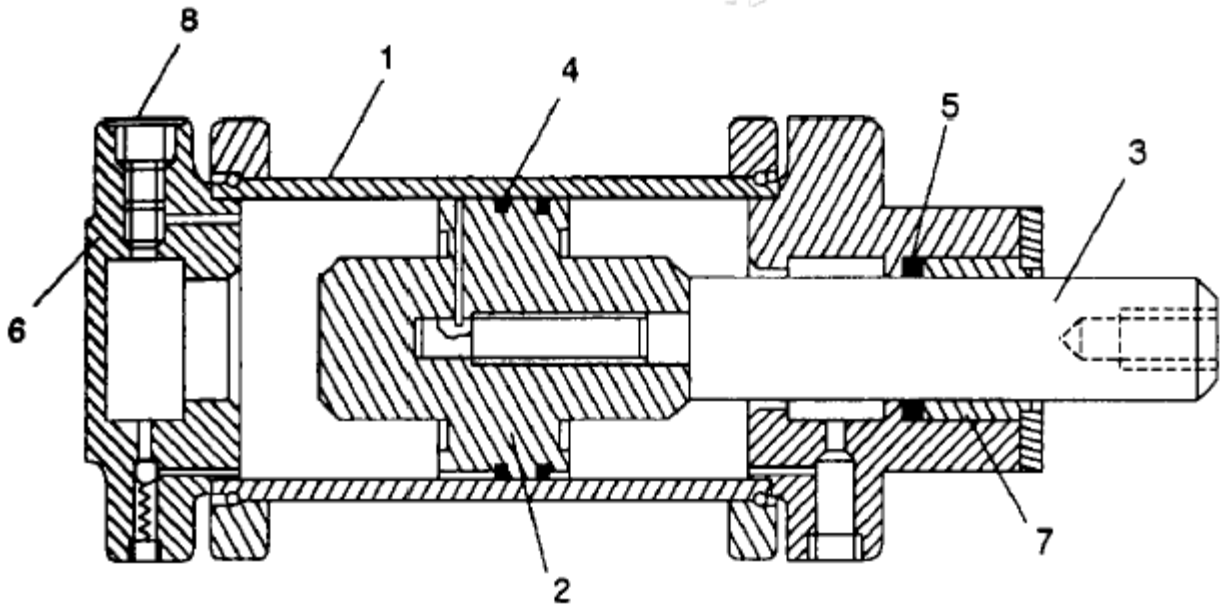
Single-Acting Cylinder



Single-Acting Cylinder



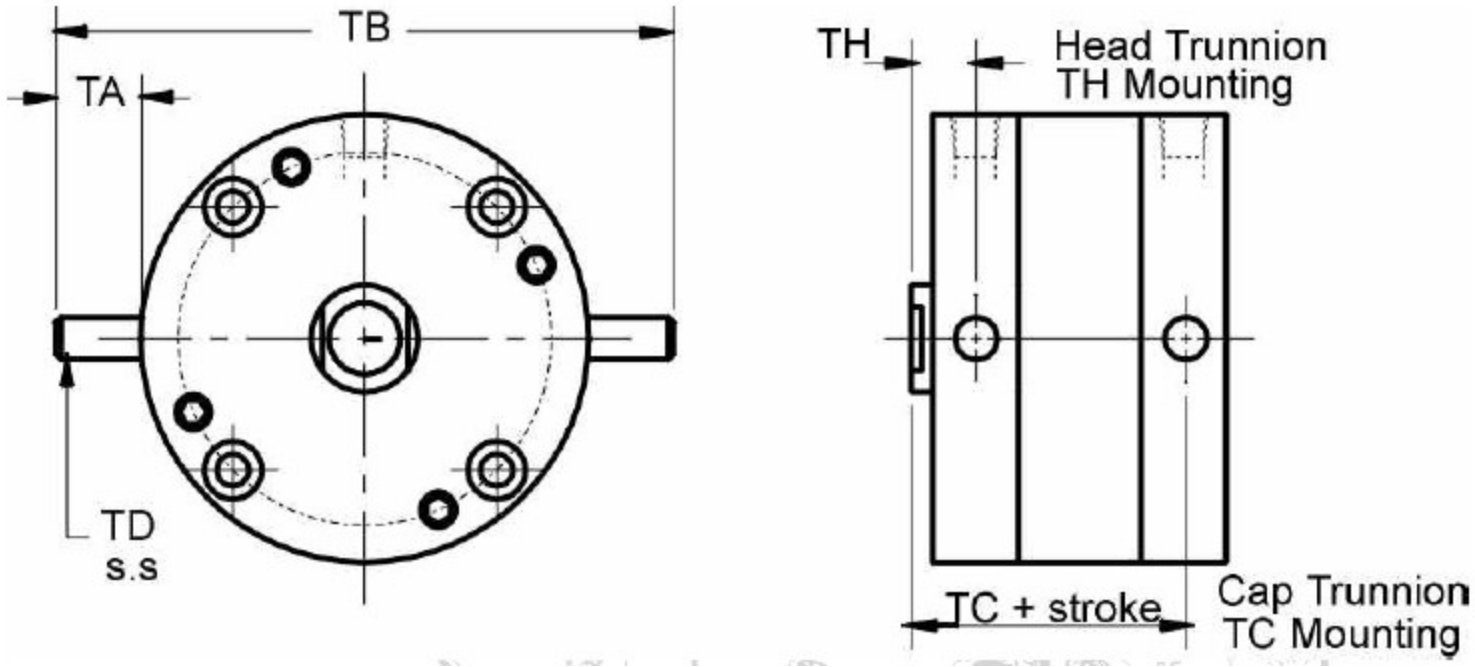
Double-Acting Cylinder



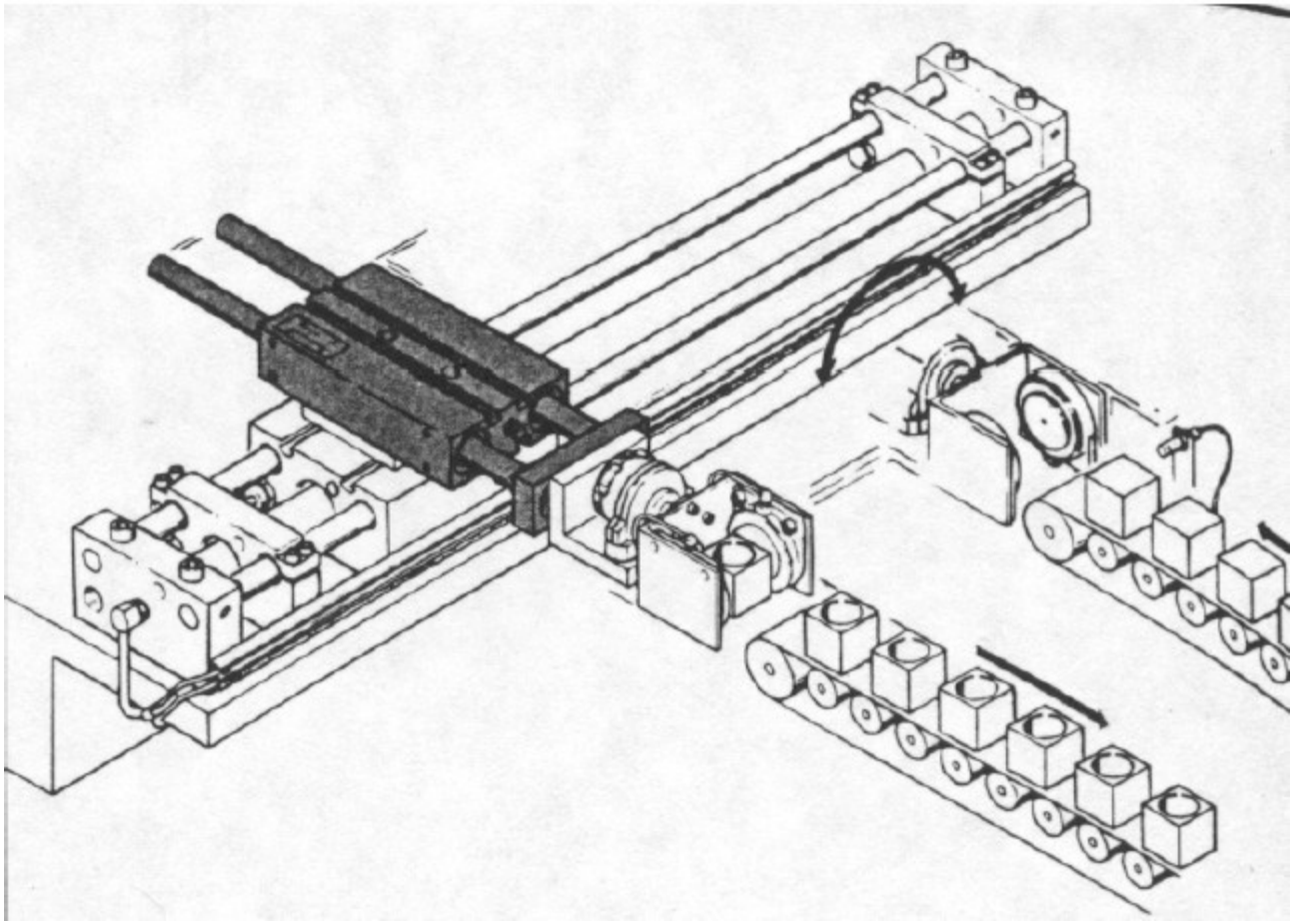
Pneumatic Cylinder Mounting

- Off-axis loading must be prevented!
- Pivoting mounts can eliminate axial loading:
  - Clevis mount
  - Trunnion mount
  - Universal joints
- Shaft may rotate unless antirotation model is used

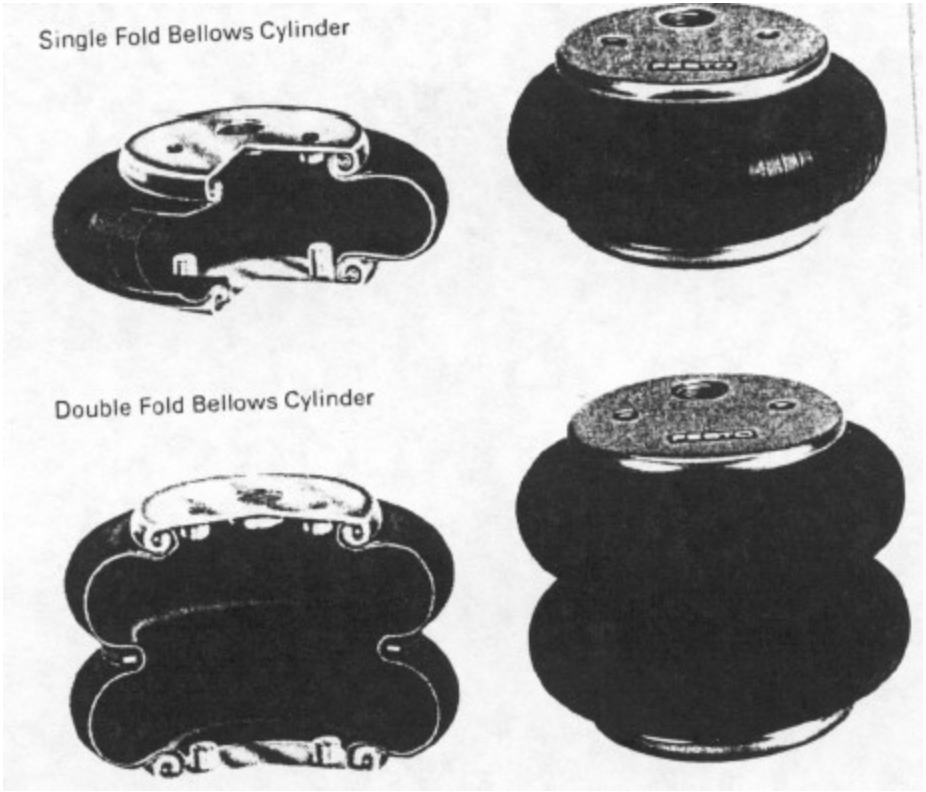
Trunnion Mount

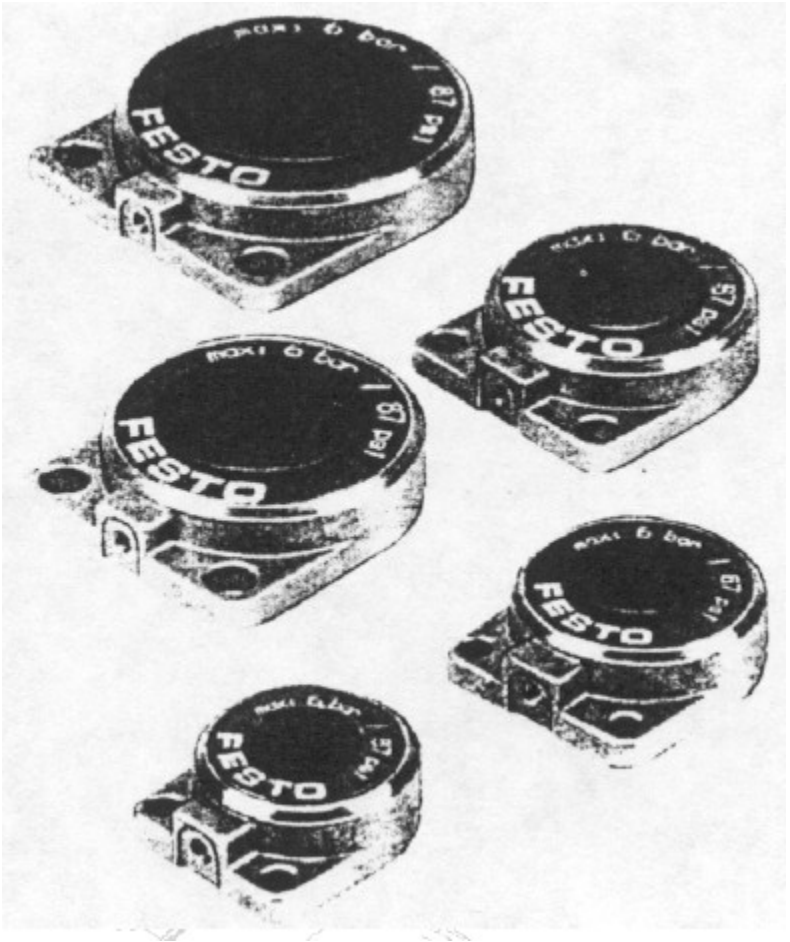


Pneumatic Twin Cylinder

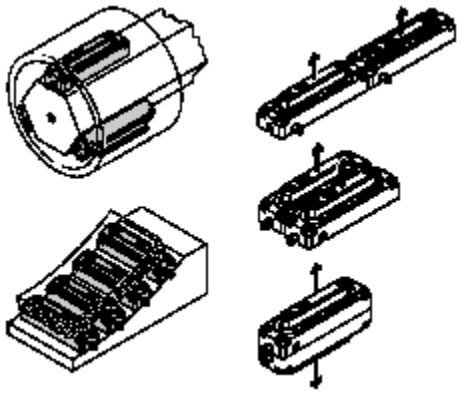


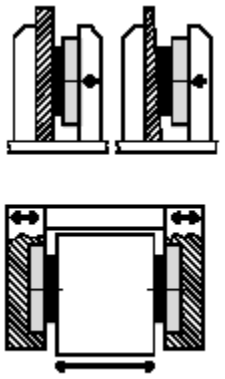
Pneumatic Bellows



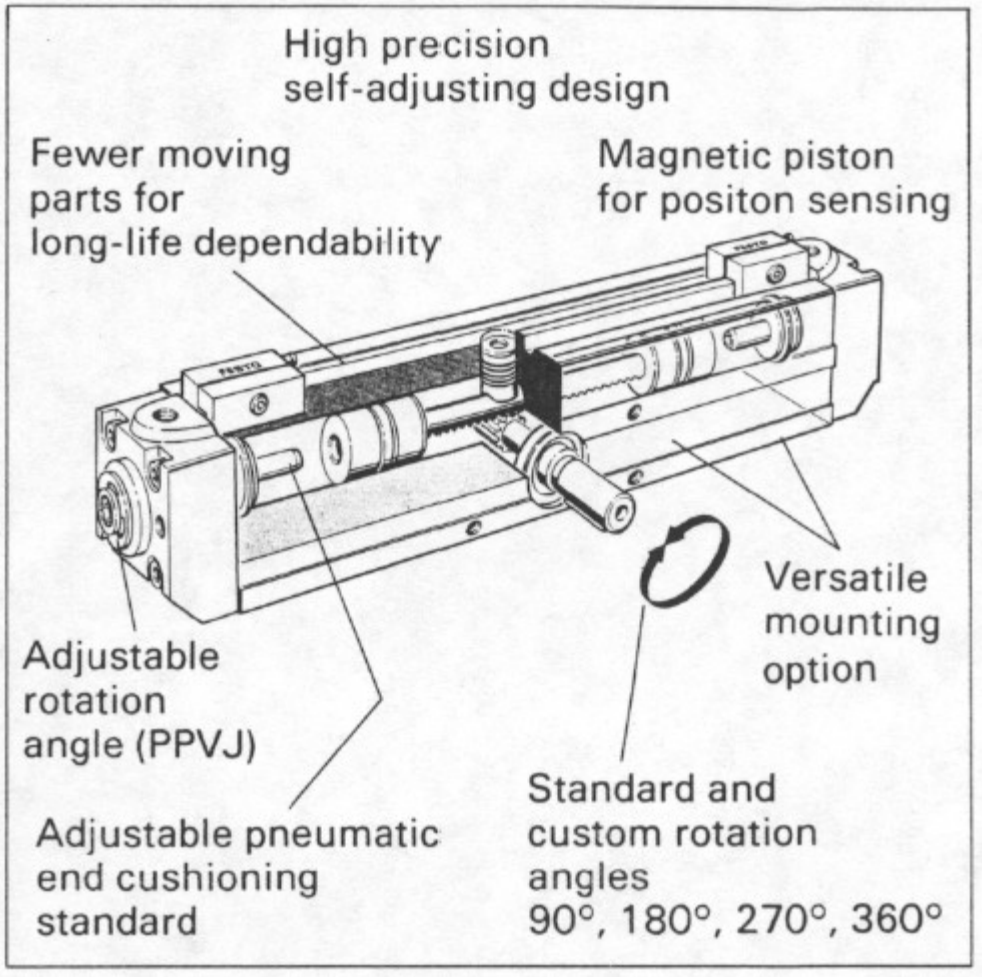


Pneumatic Bellows

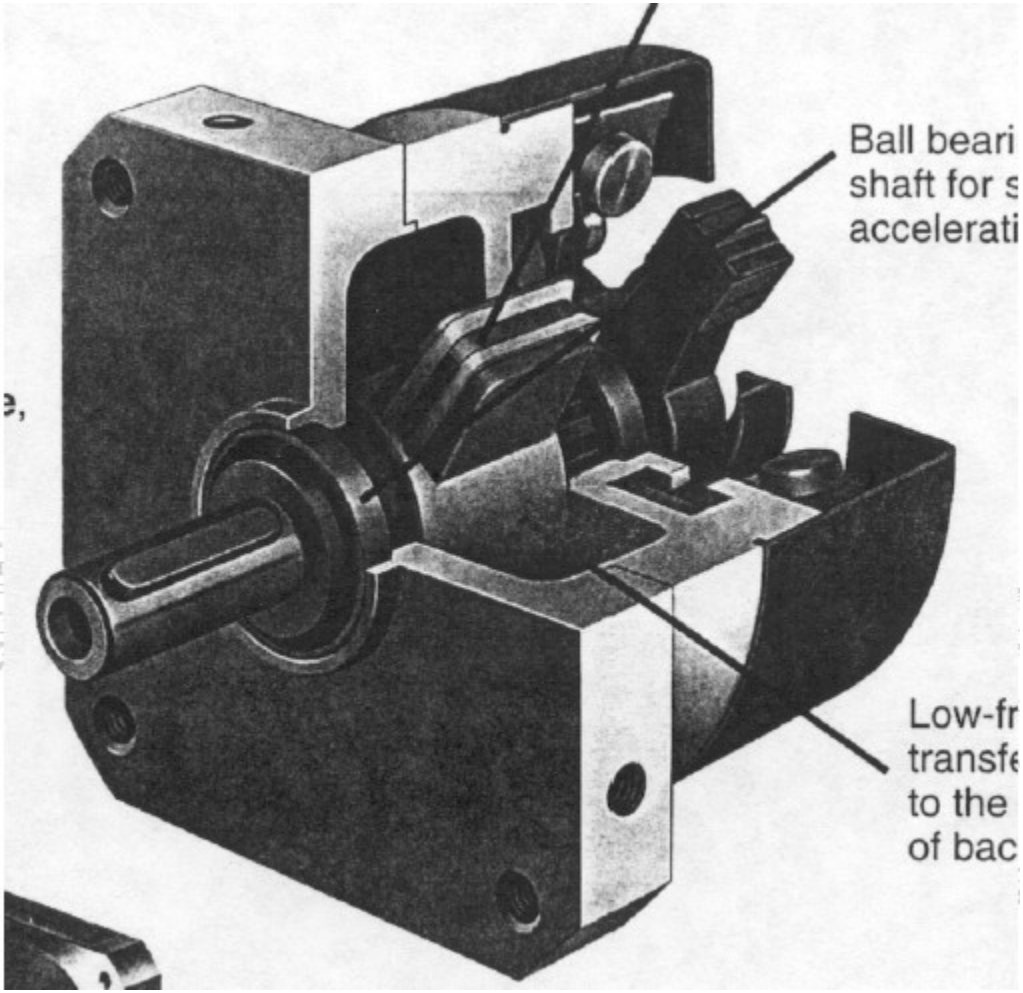




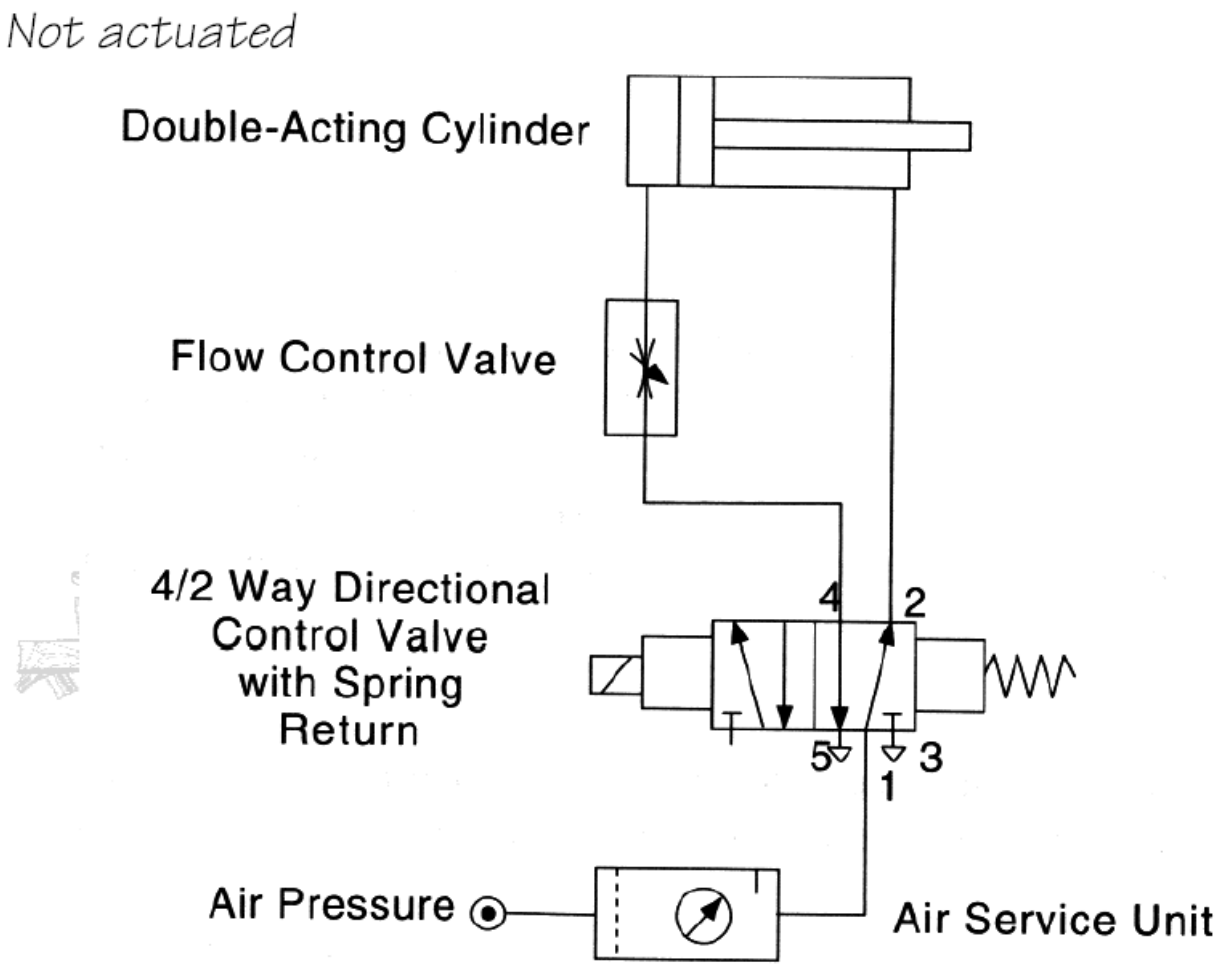
Pneumatic Rotary Actuators



Pneumatic Rotary Actuators



Pneumatic Schematics



Pneumatic Schematics

Actuated