

# GENERATING MOTION

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- 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

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- 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

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- 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

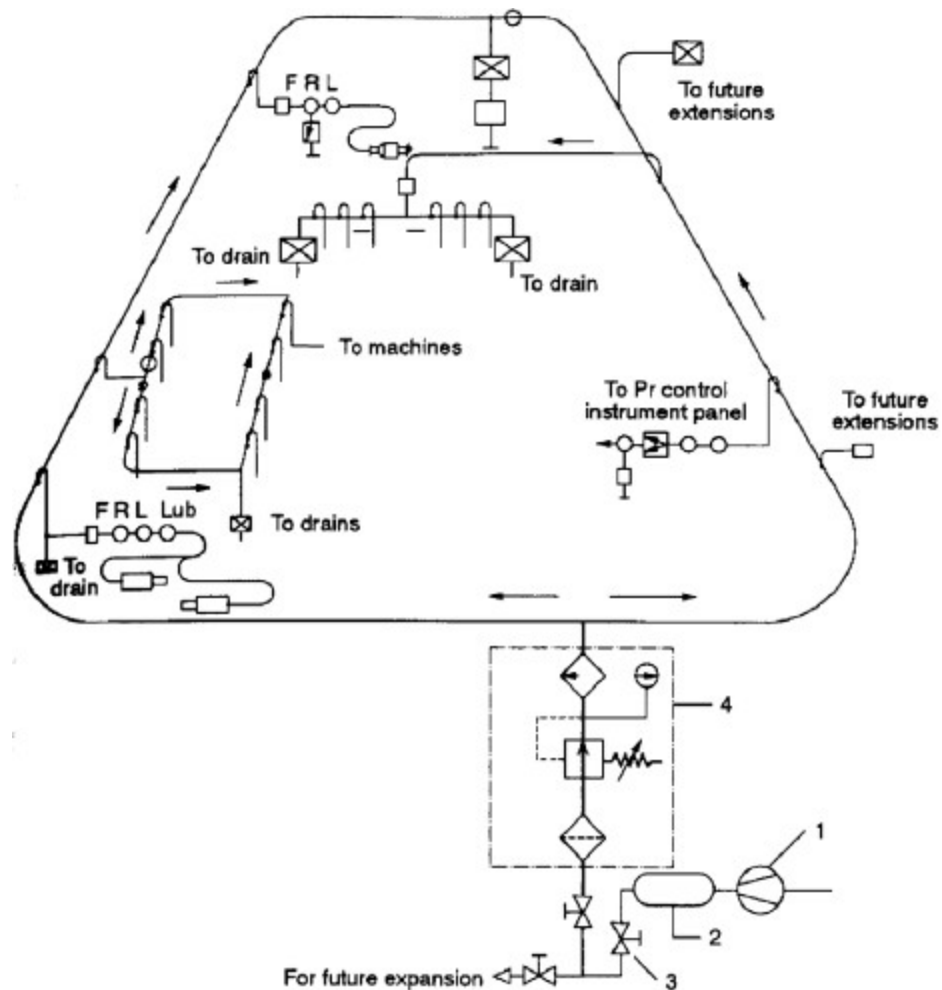
# PNEUMATIC SYSTEMS

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- Ideal Gas Law:  $PV = nRT$
- Boyle's Law:  $P_1 V_1 = P_2 V_2$

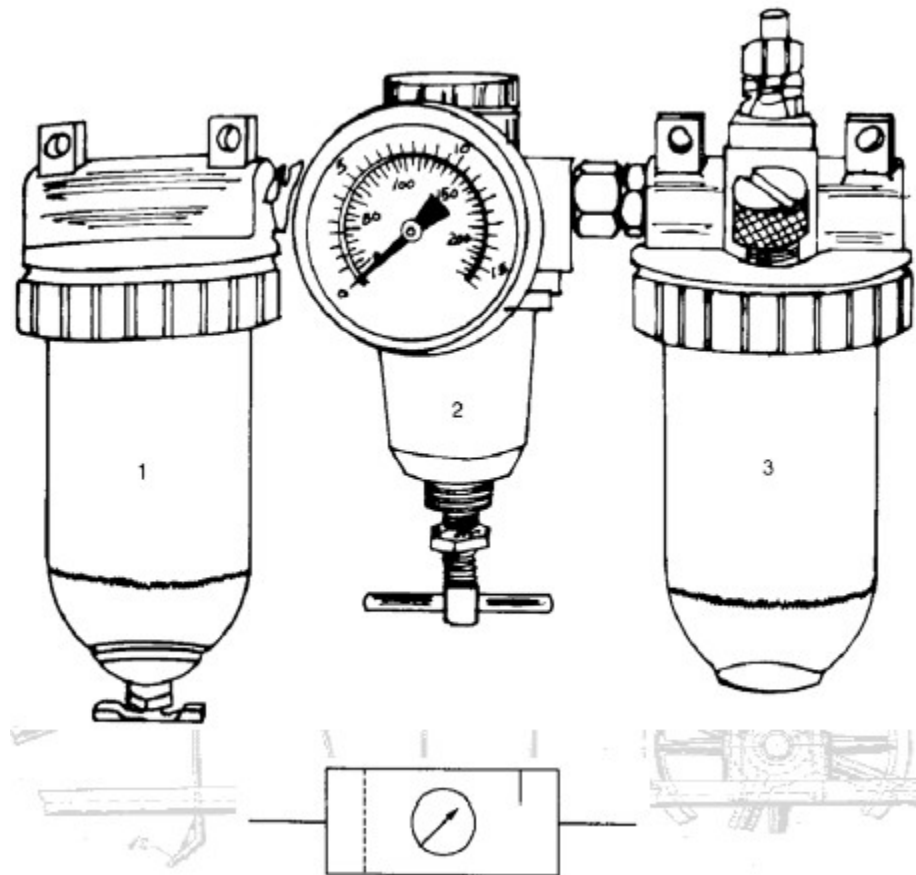
# PNEUMATIC SYSTEM LAYOUT

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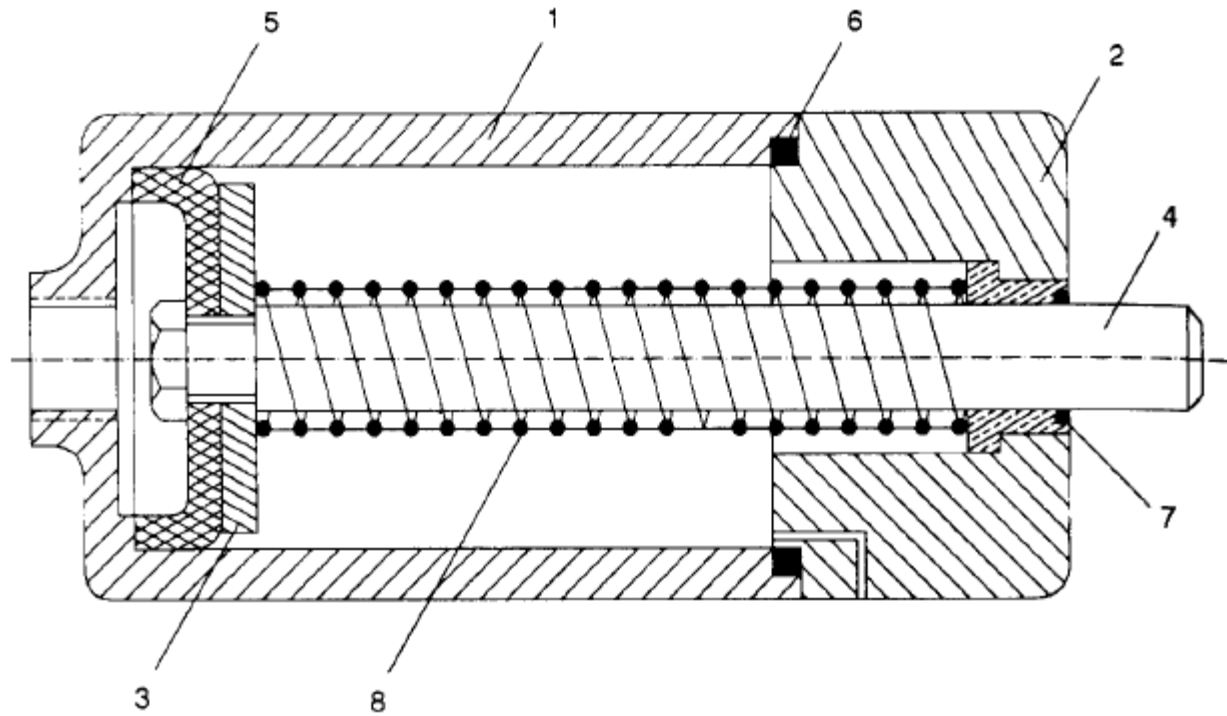
# AIR PREPARATION

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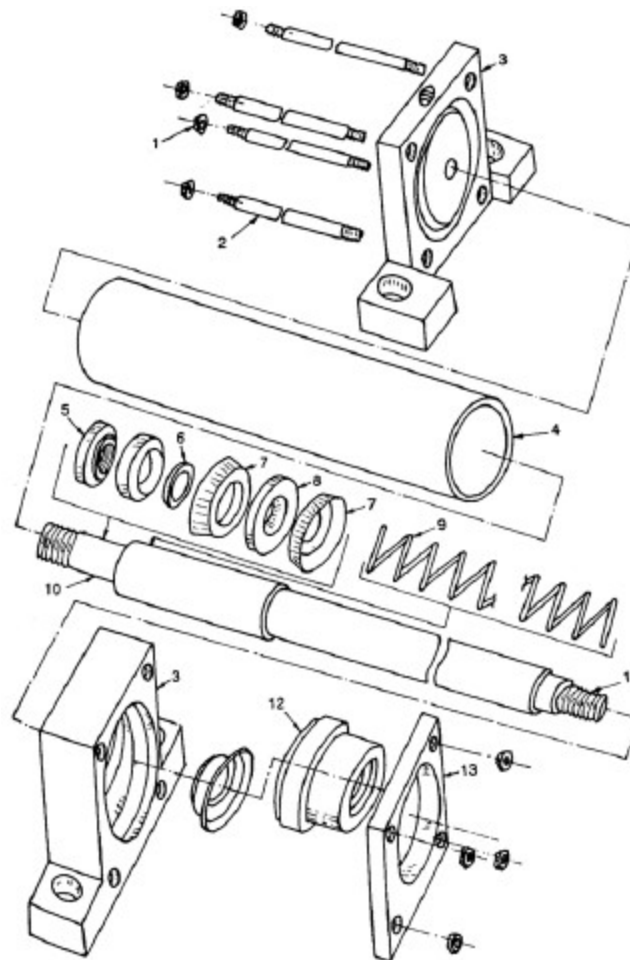
# SINGLE-ACTING CYLINDER

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# SINGLE-ACTING CYLINDER

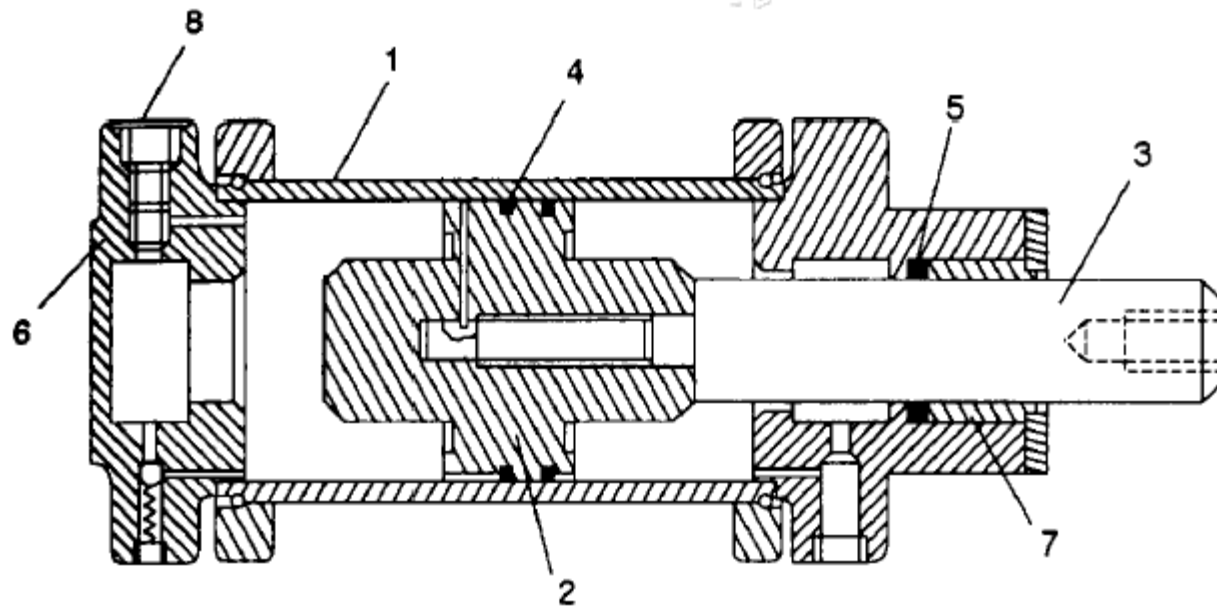
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# DOUBLE-ACTING CYLINDER

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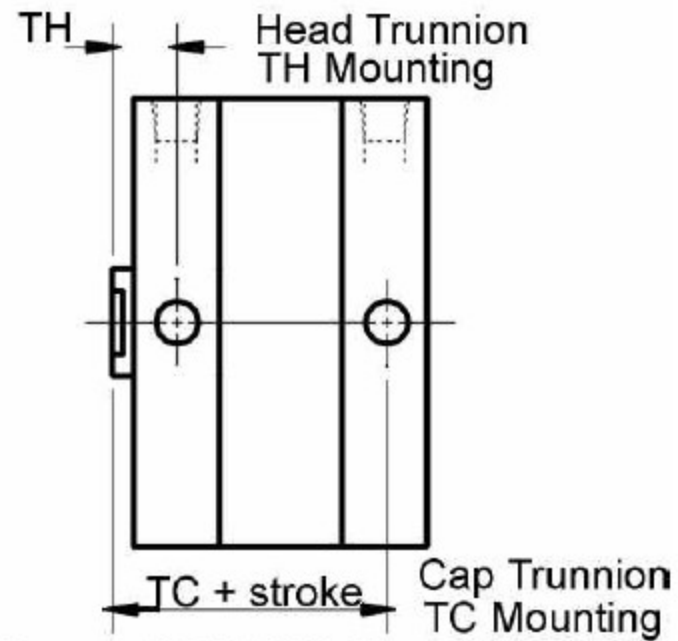
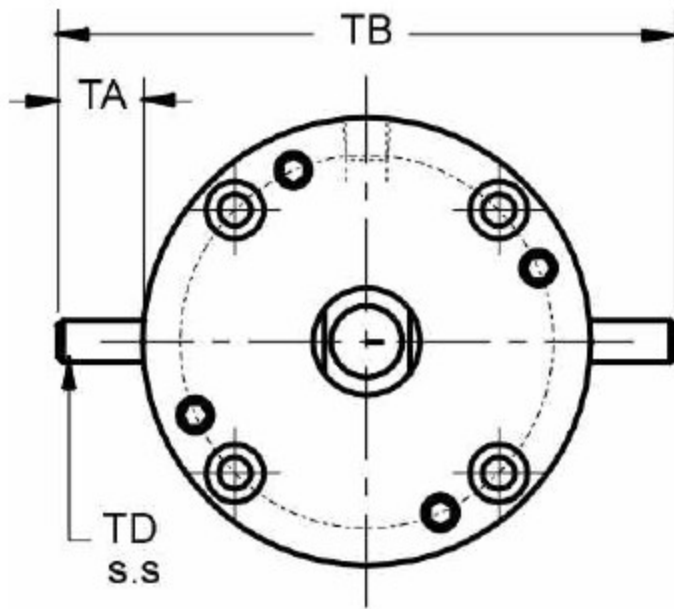
# PNEUMATIC CYLINDER MOUNTING

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- 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

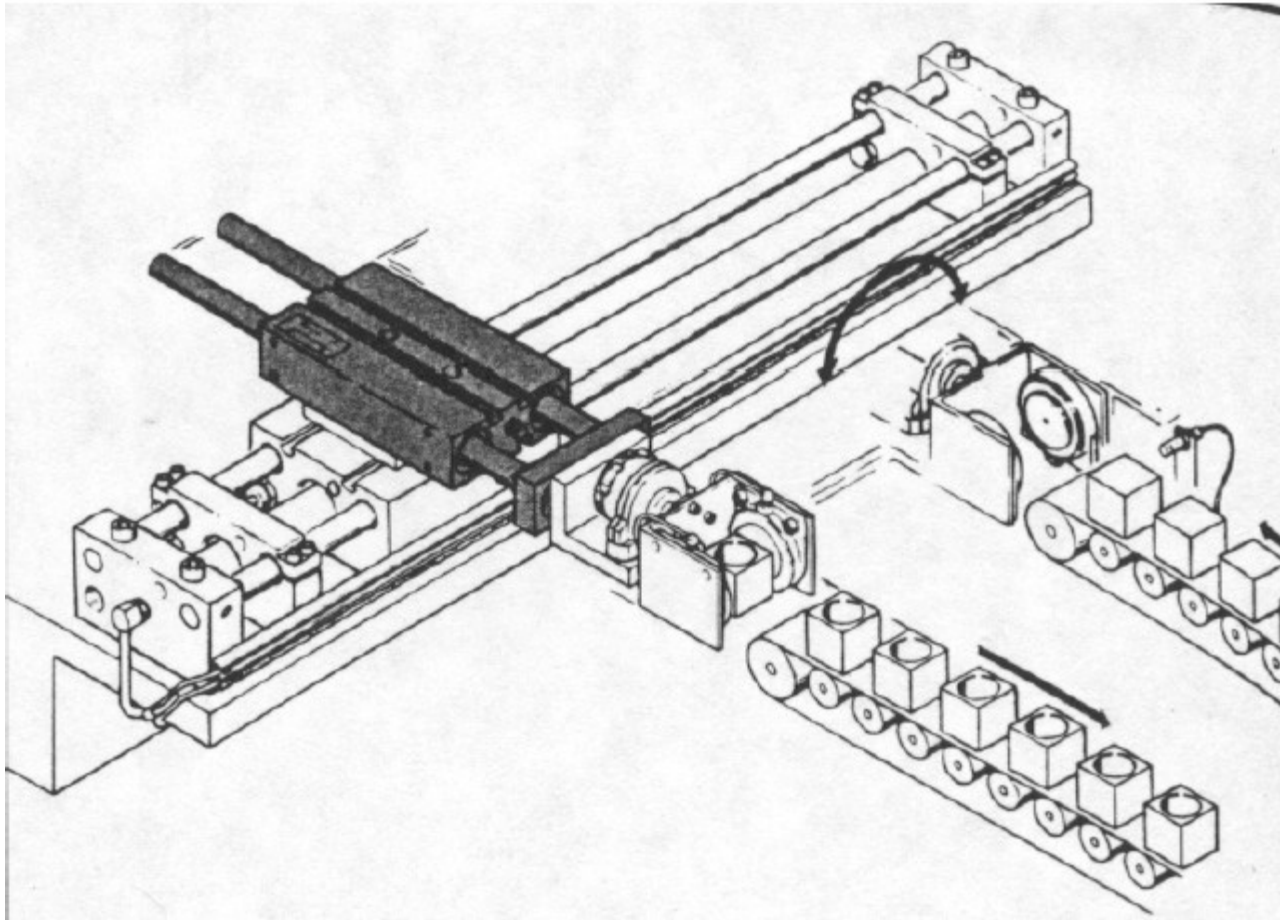
# TRUNNION MOUNT

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# PNEUMATIC TWIN CYLINDER

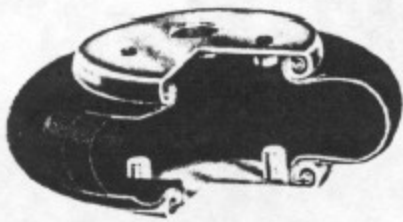
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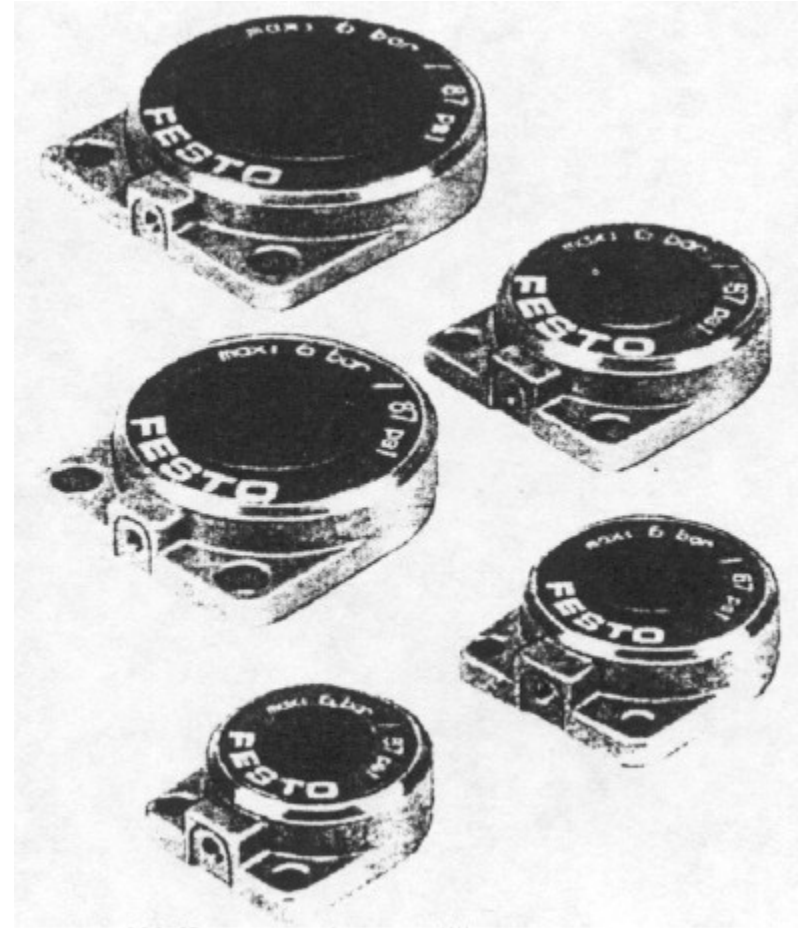
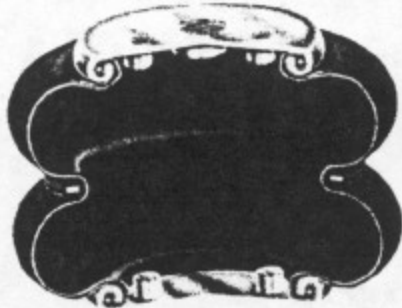
# PNEUMATIC BELLOWS

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Single Fold Bellows Cylinder

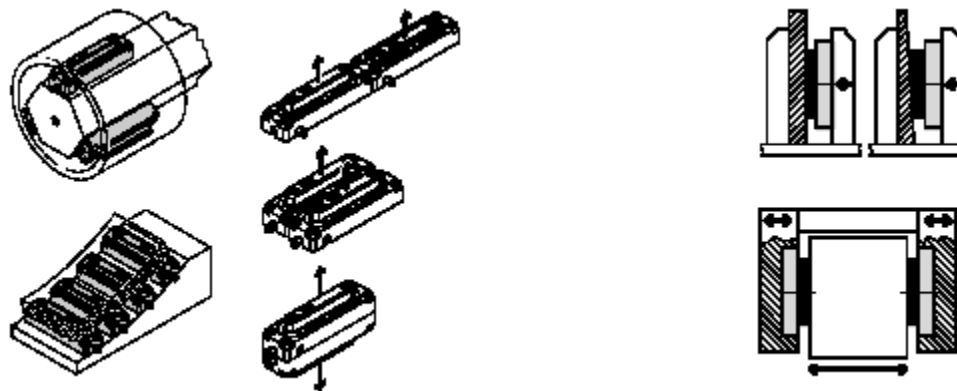


Double Fold Bellows Cylinder



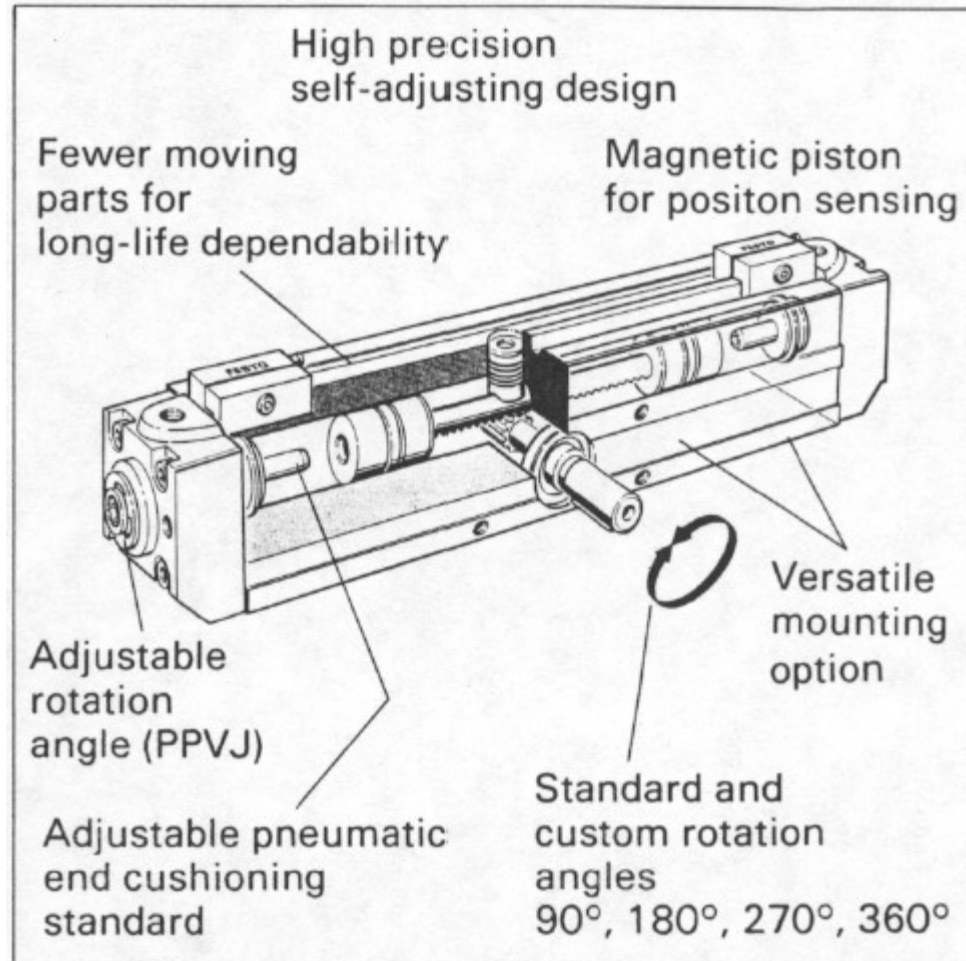
# PNEUMATIC BELLOWS

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# PNEUMATIC ROTARY ACTUATORS

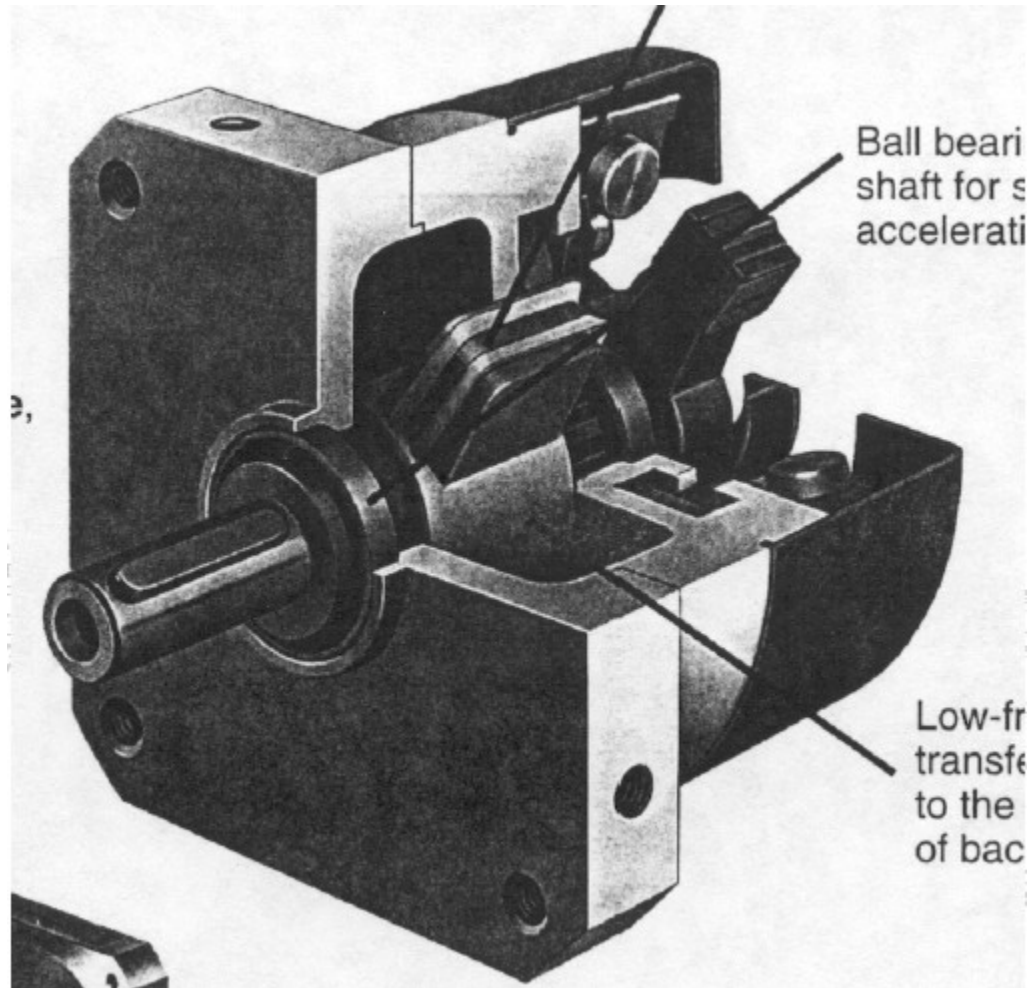
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# PNEUMATIC ROTARY ACTUATORS

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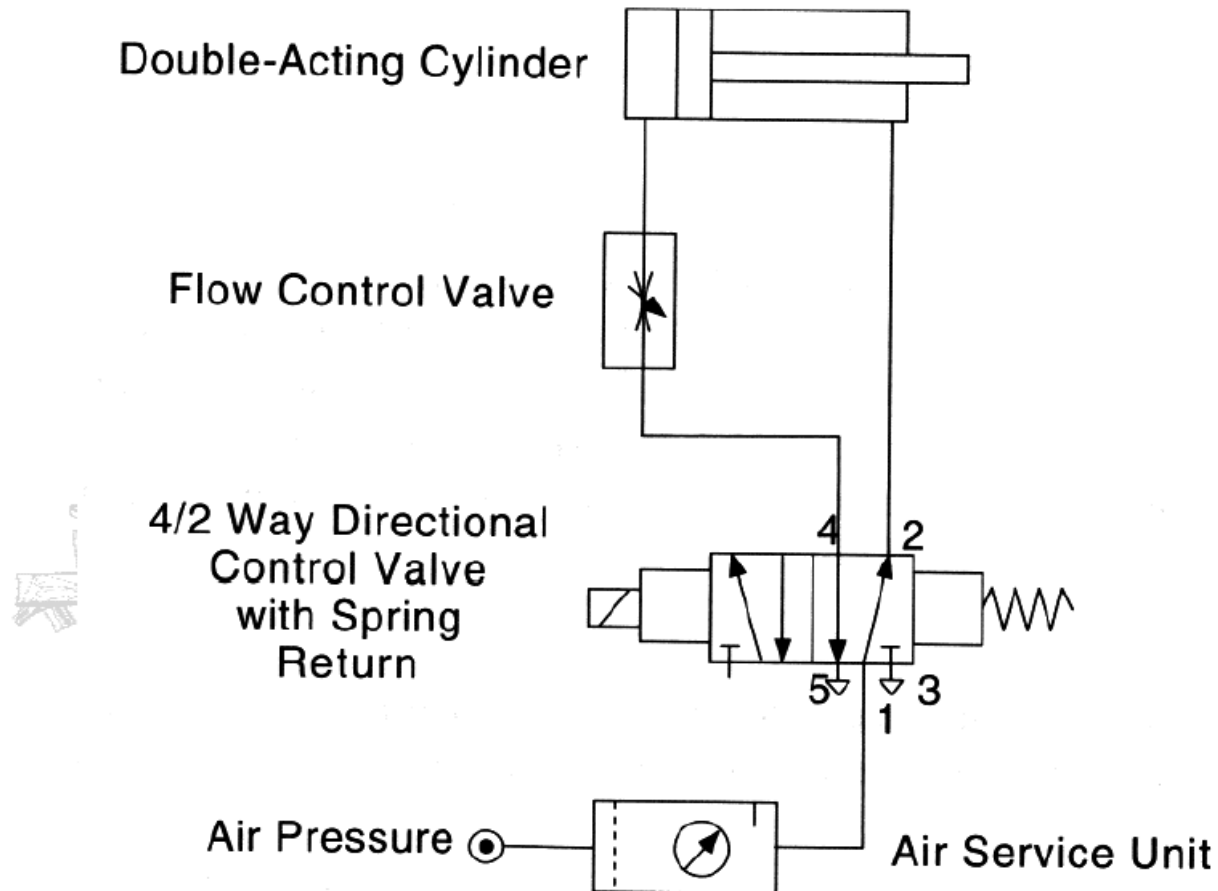




# PNEUMATIC SCHEMATICS

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*Not actuated*



# PNEUMATIC SCHEMATICS

*Actuated*

