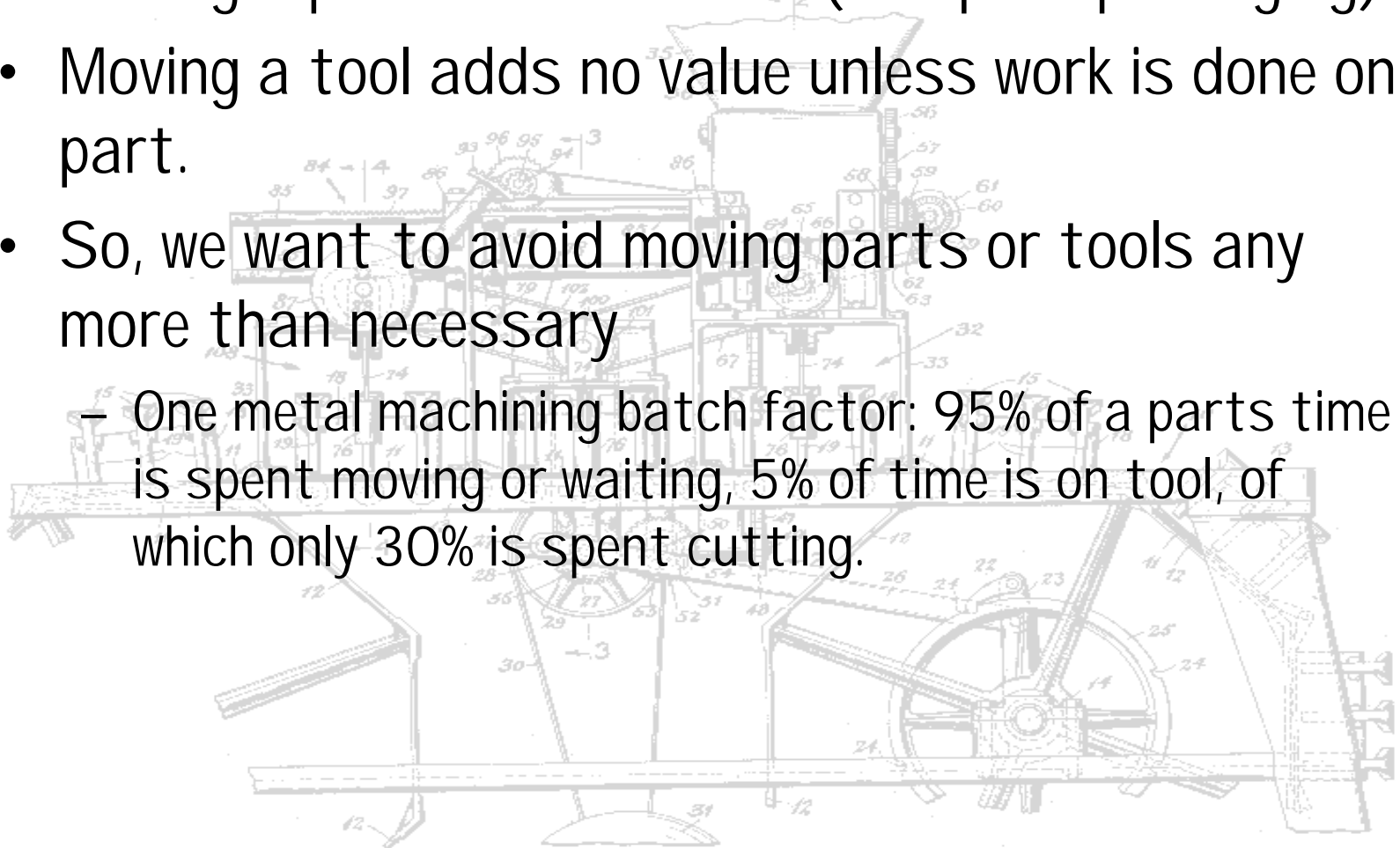


# Generating Motion

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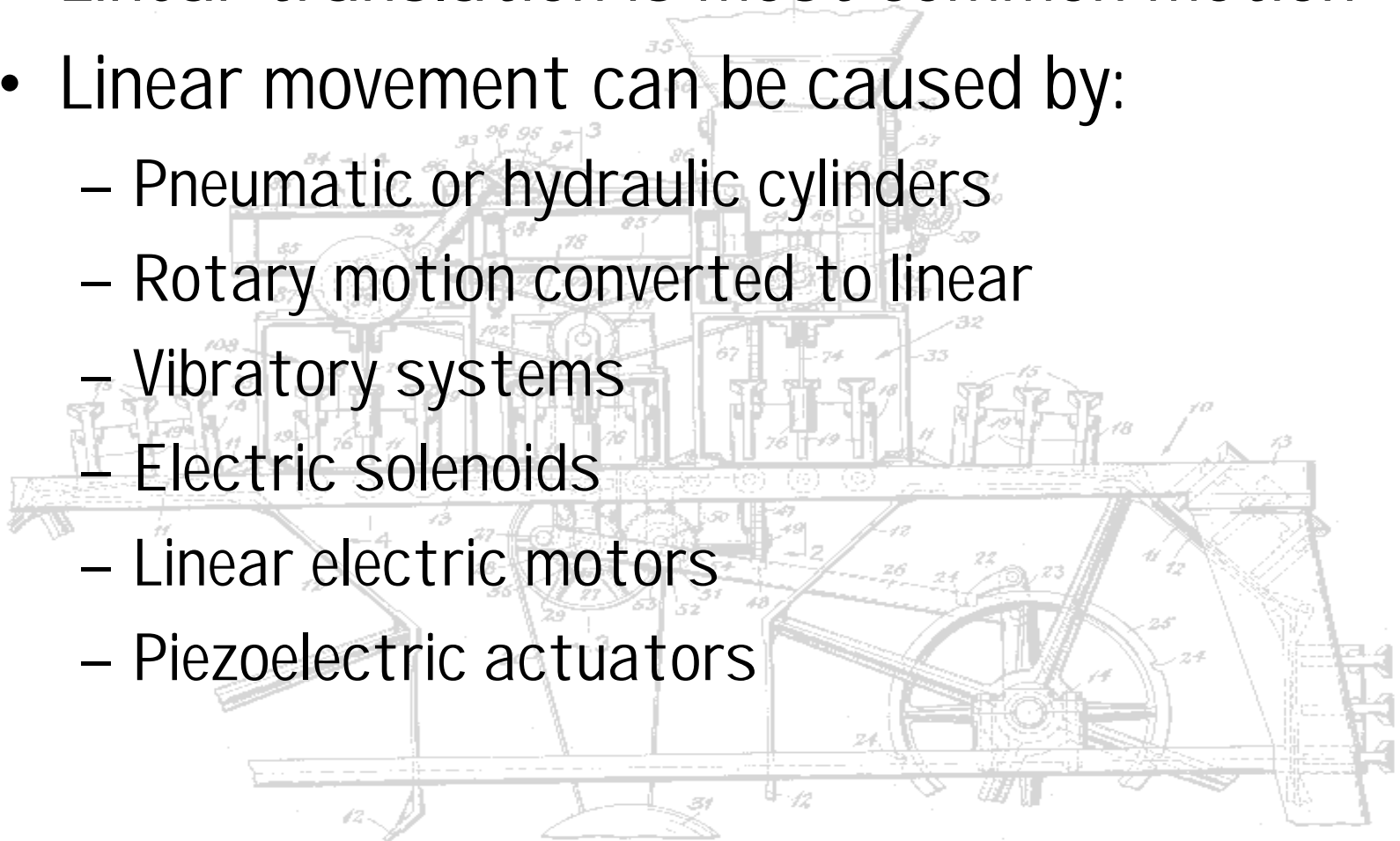
- Moving a part adds no value (except in packaging)
- Moving a tool adds no value unless work is done on part.
- So, we want to avoid moving parts or tools any more than necessary
  - One metal machining batch factor: 95% of a parts time is spent moving or waiting, 5% of time is on tool, of which only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



# Linear Motion

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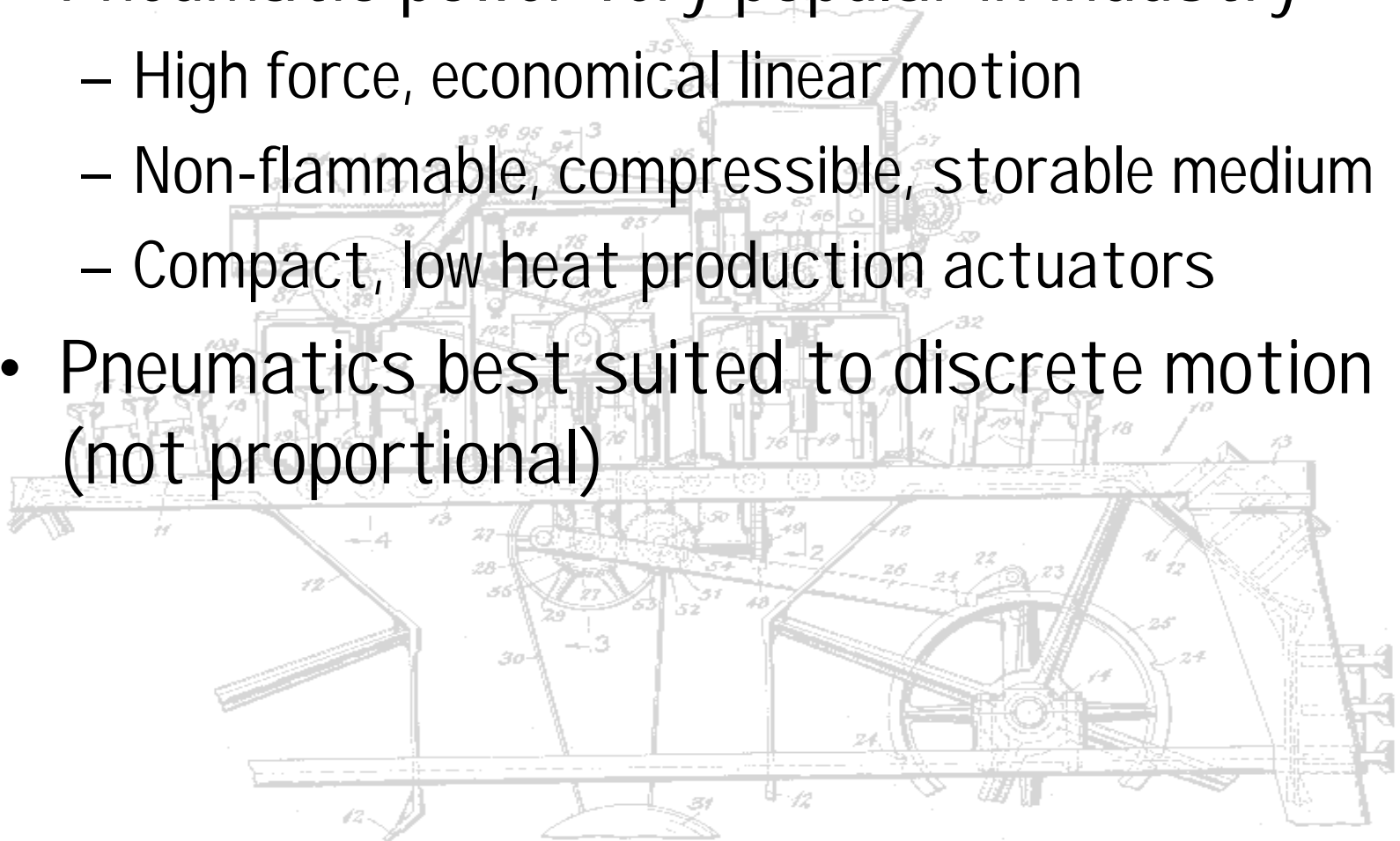
- Linear translation is most common motion
- Linear movement can be caused by:
  - Pneumatic or hydraulic cylinders
  - Rotary motion converted to linear
  - Vibratory systems
  - Electric solenoids
  - Linear electric motors
  - Piezoelectric actuators



# Pneumatic Systems

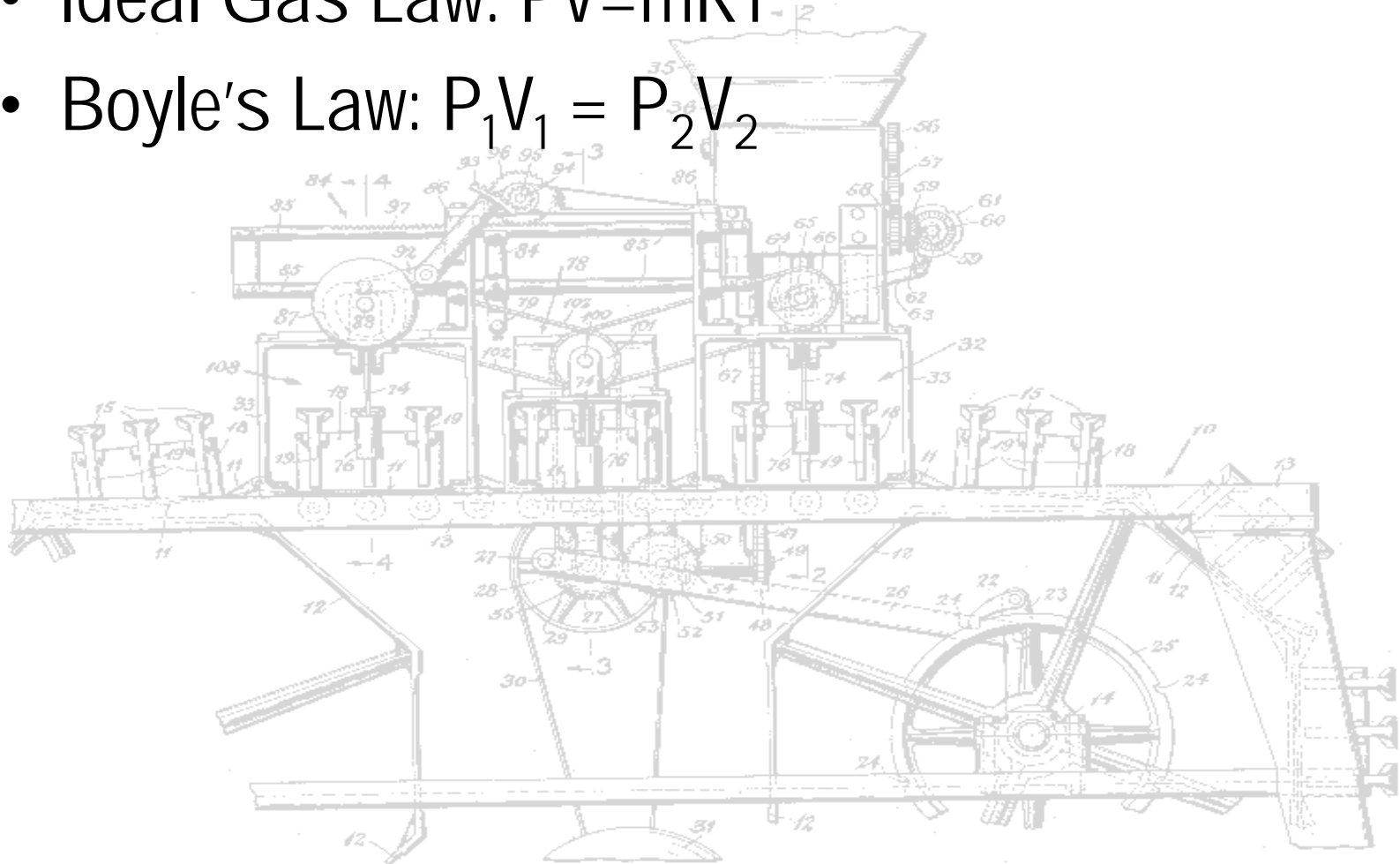
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- Pneumatic power very popular in industry
  - High force, economical linear motion
  - Non-flammable, compressible, storable medium
  - Compact, low heat production actuators
- Pneumatics best suited to discrete motion (not proportional)

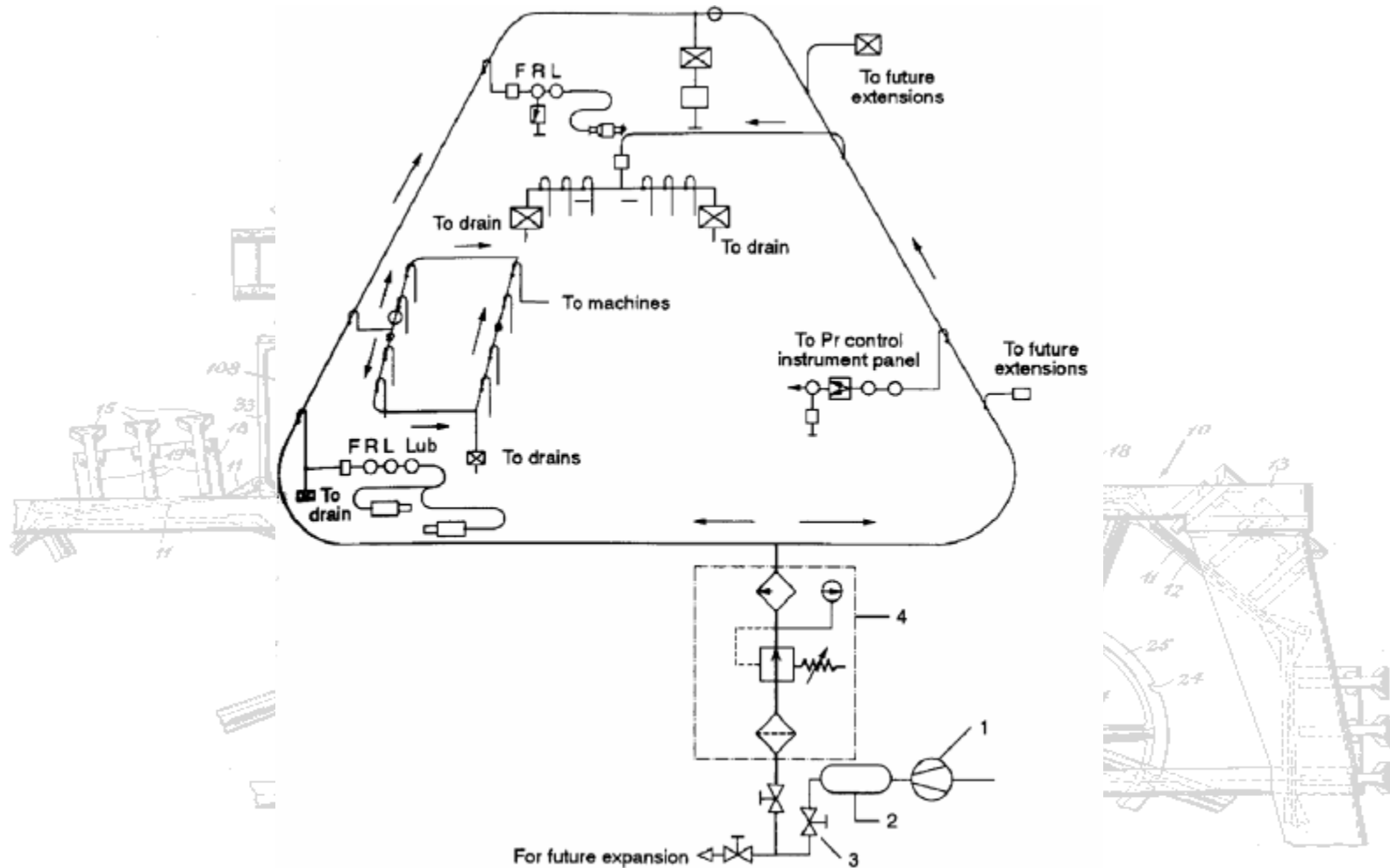


# Pneumatic Systems

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

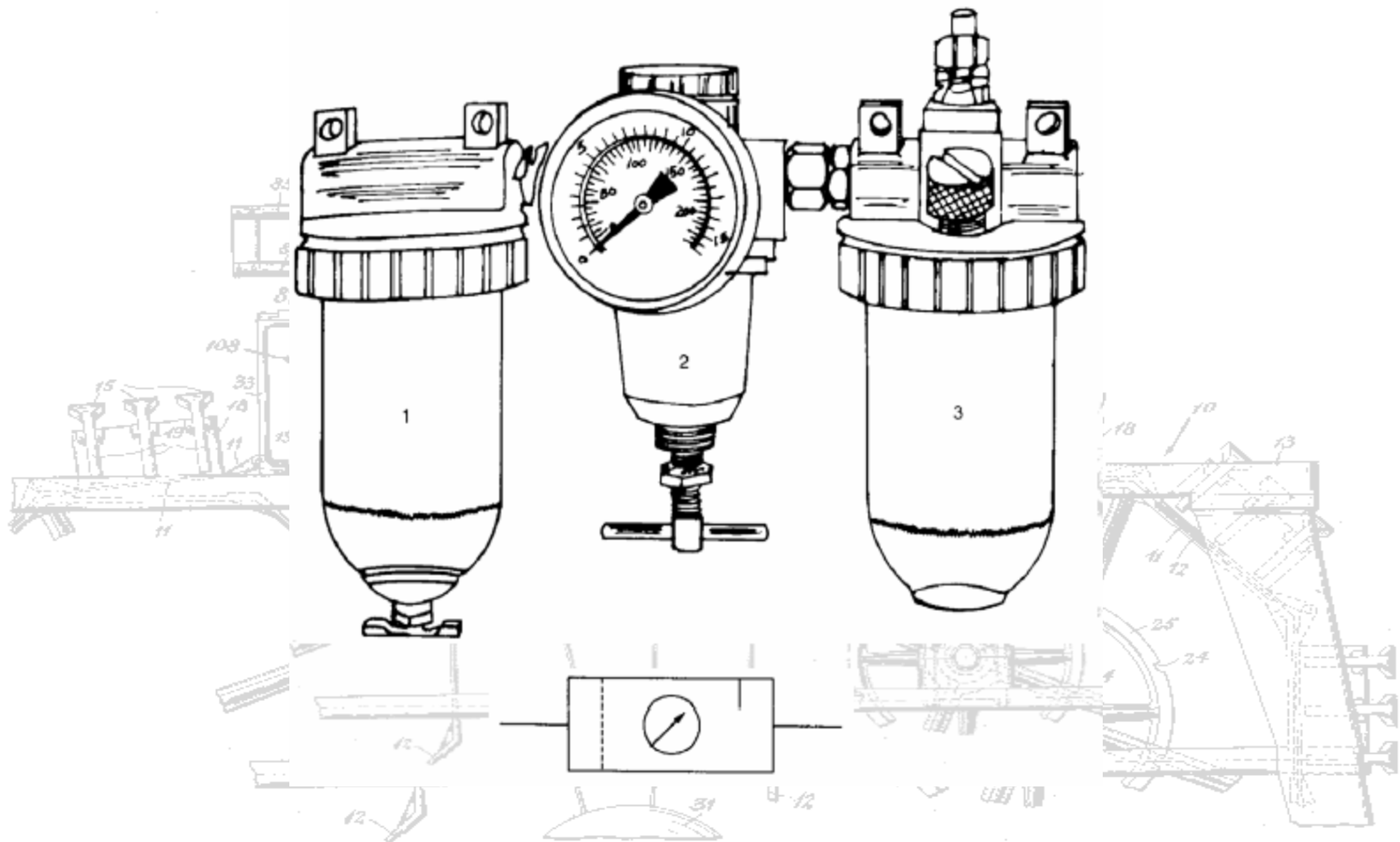


# Pneumatic System Layout



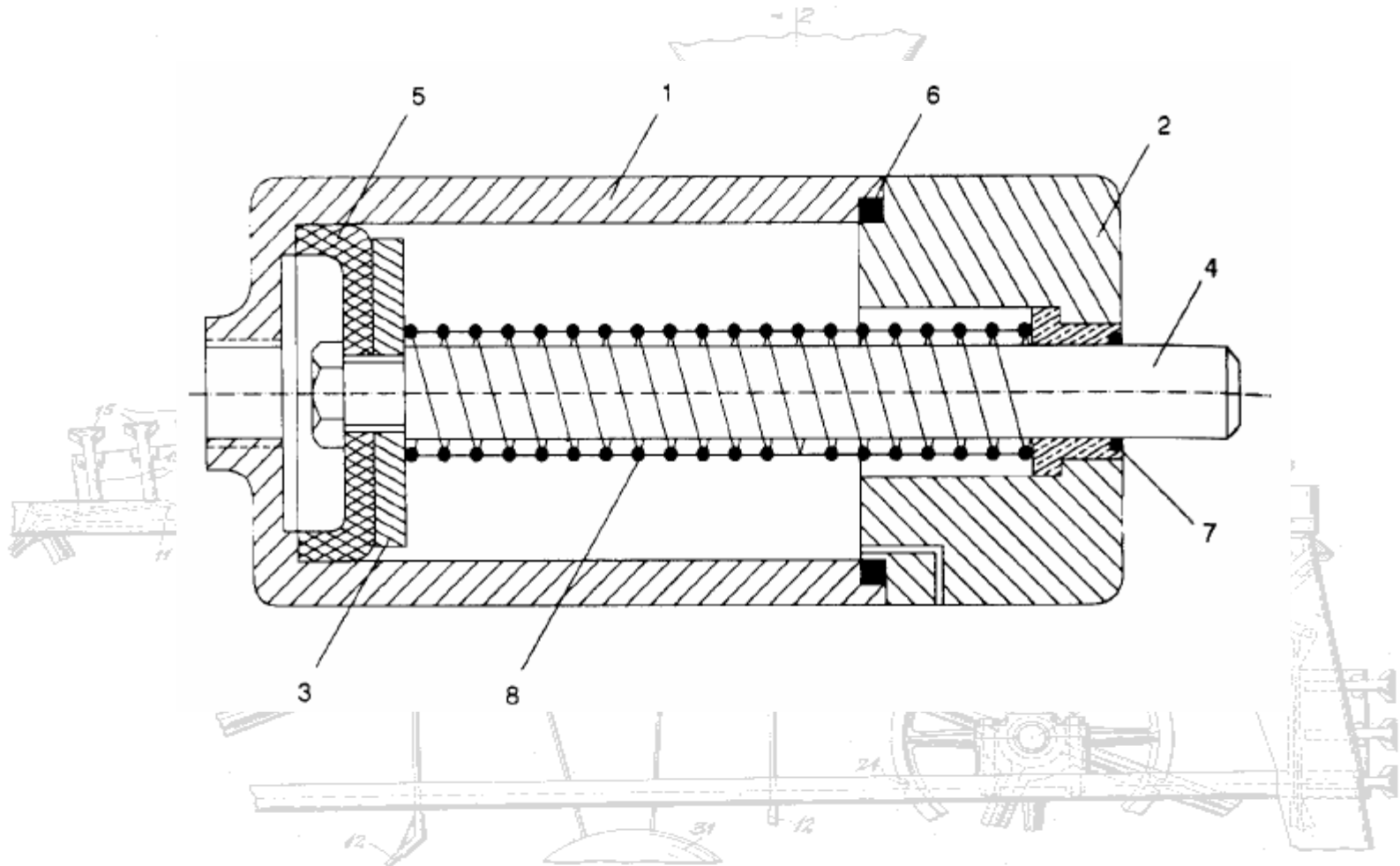
# Air Preparation

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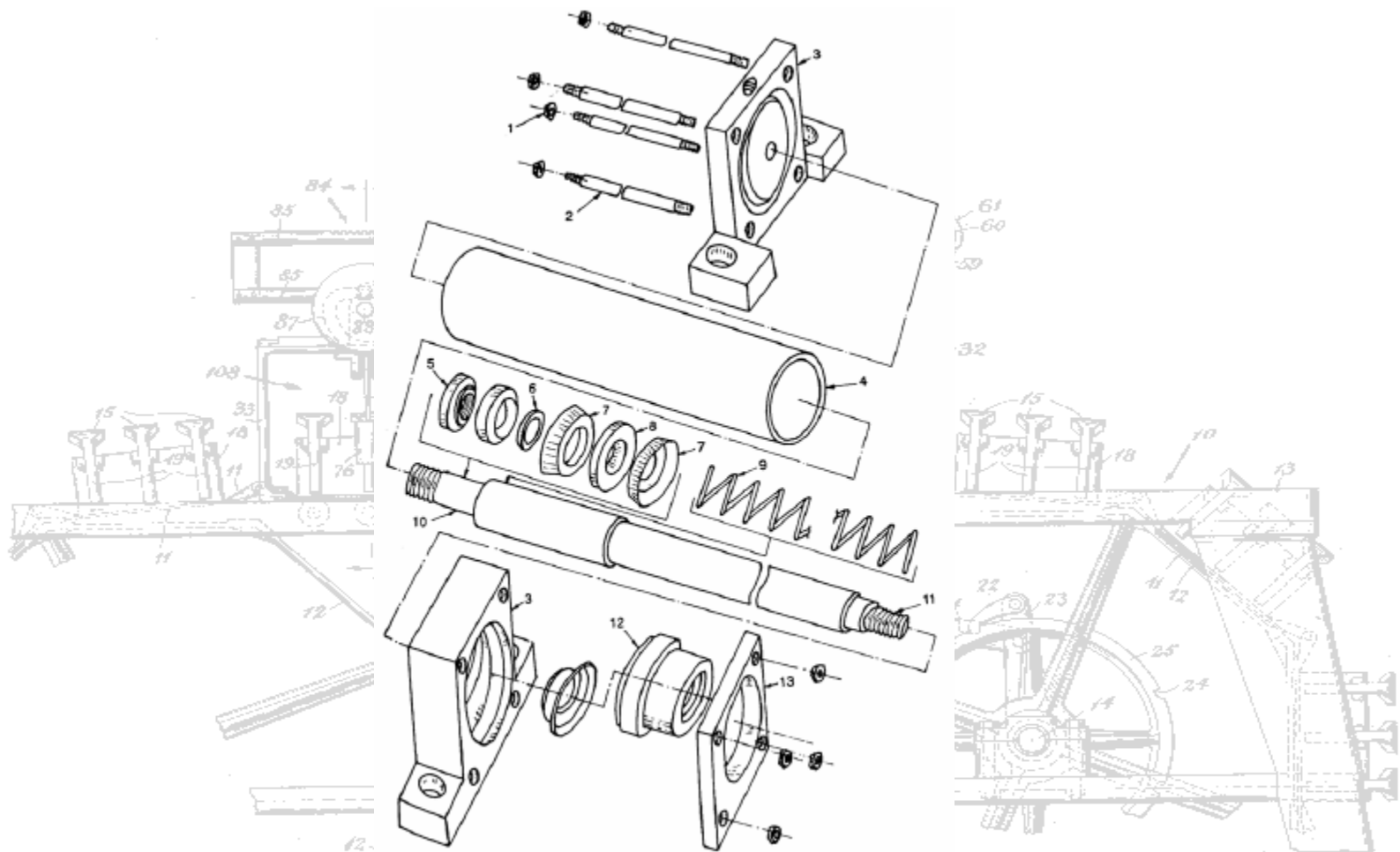
# Single-Acting Cylinder

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# Single-Acting Cylinder

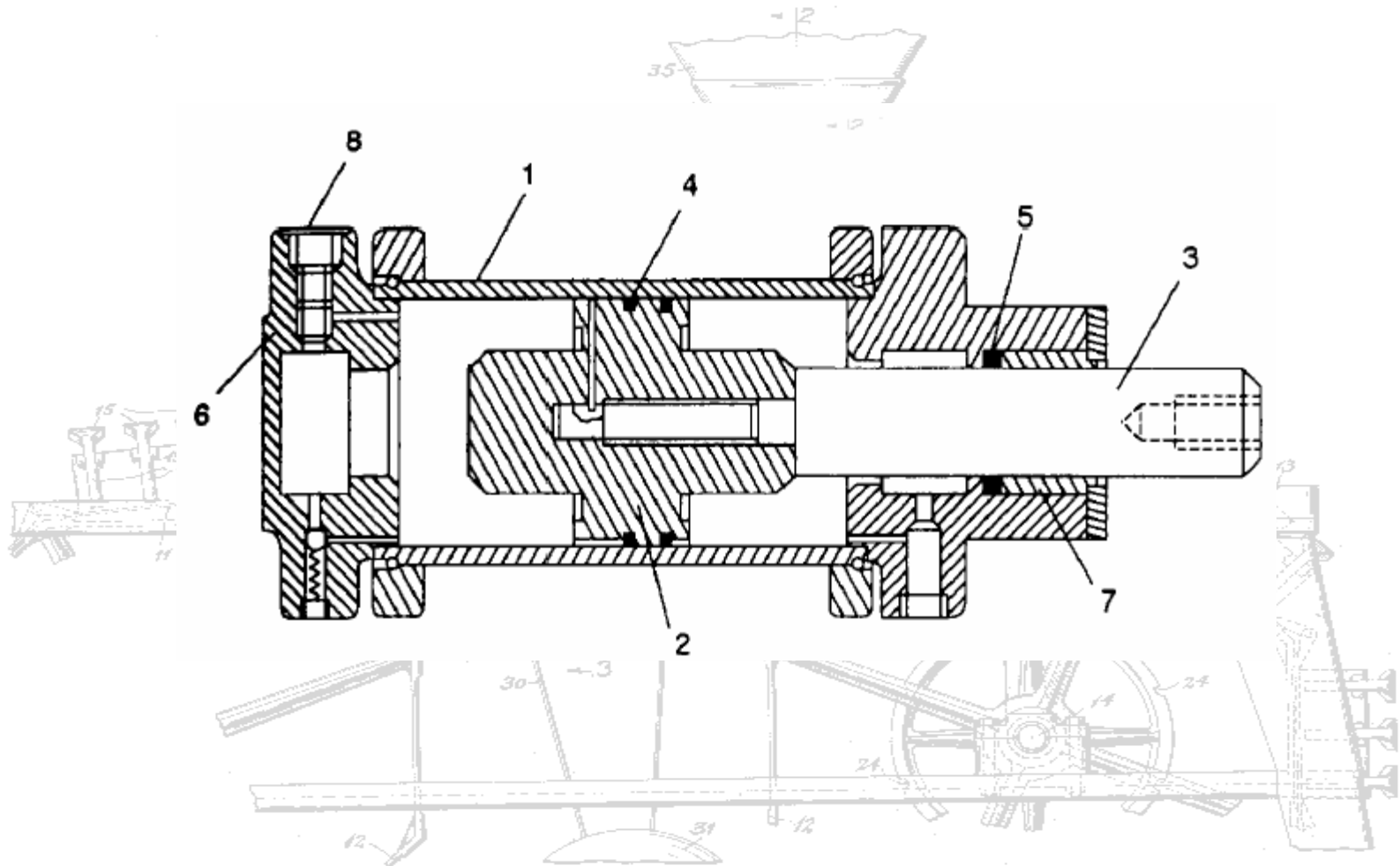
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# Double-Acting Cylinder

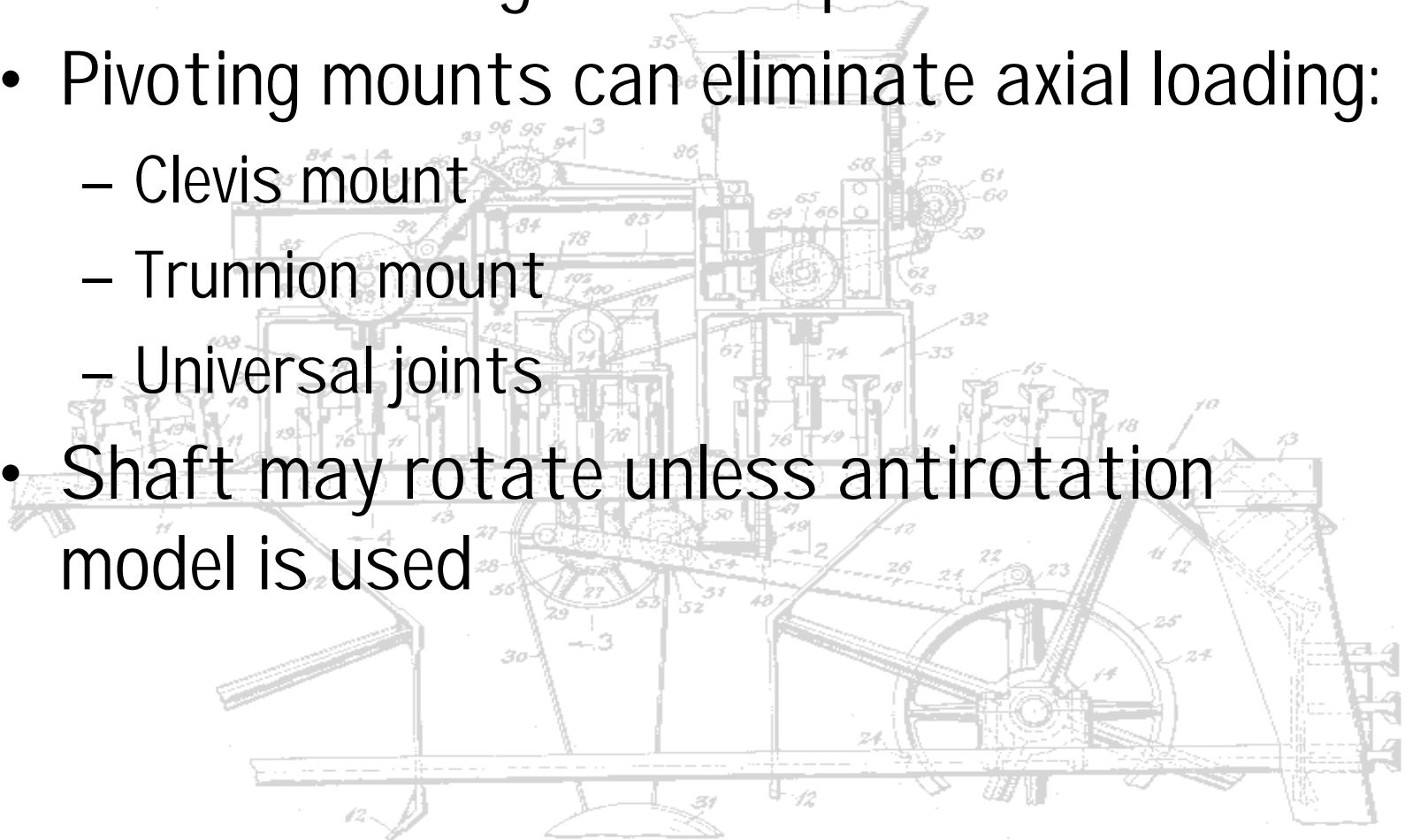
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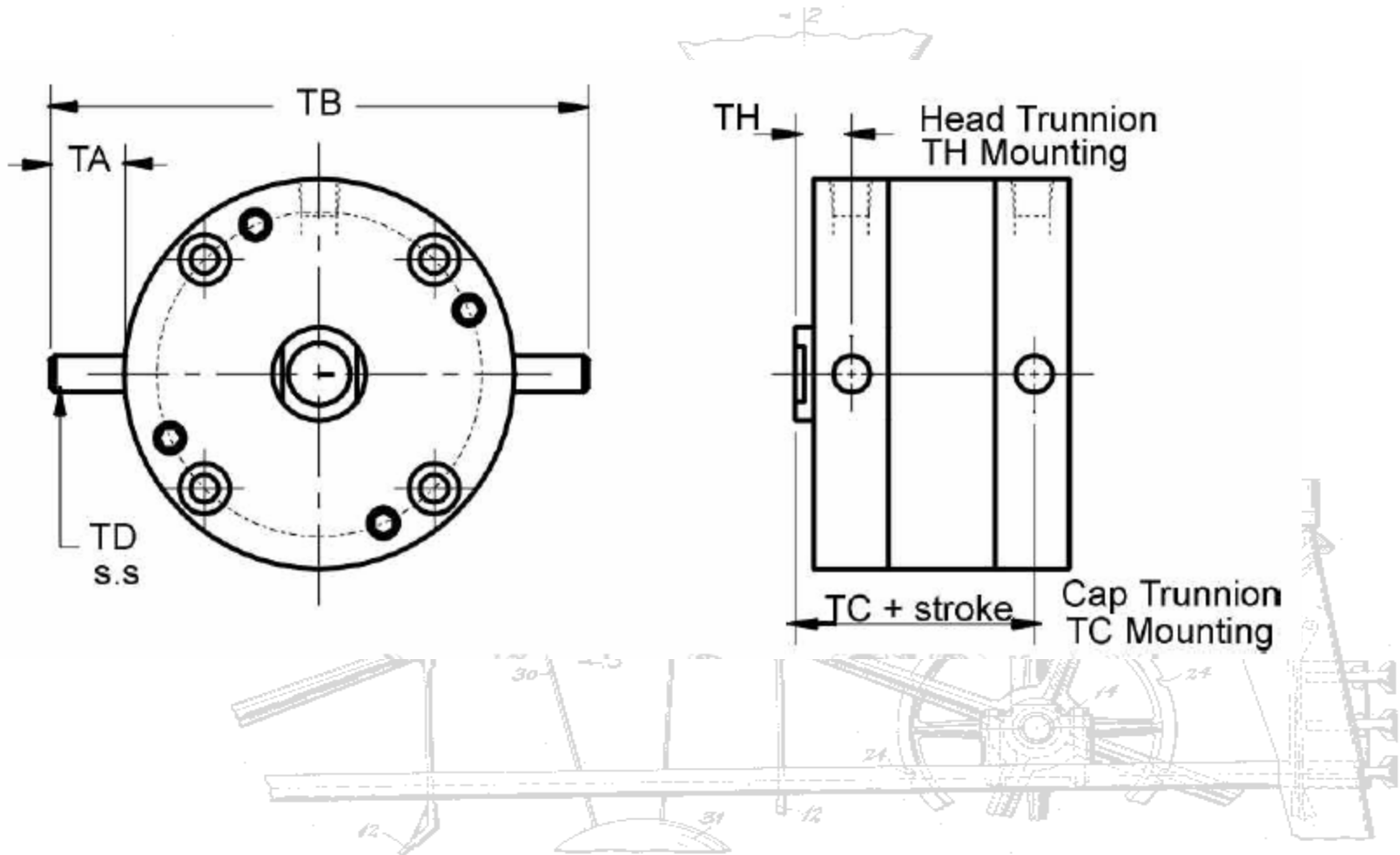
# Pneumatic Cylinder Mounting

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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

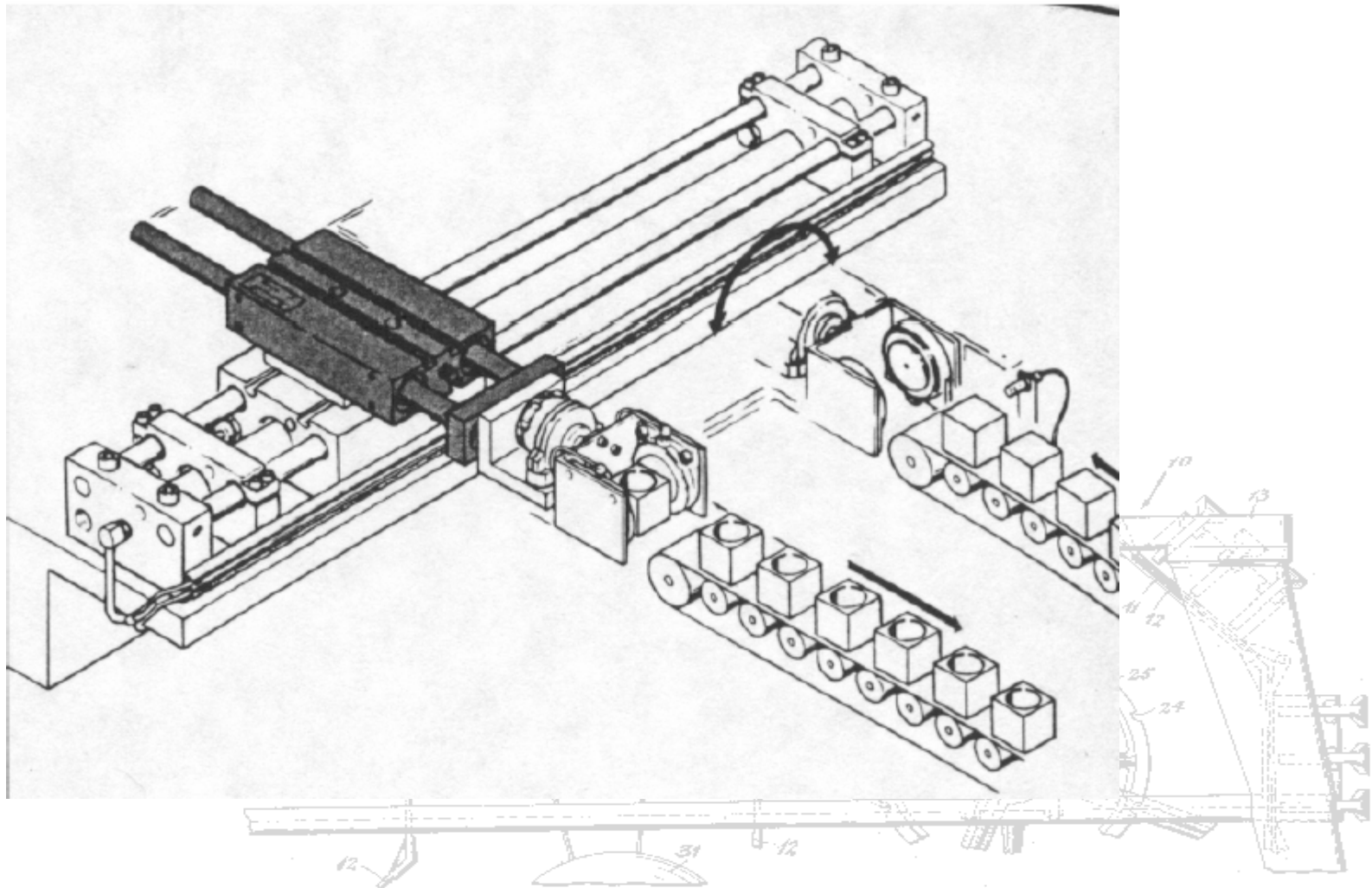


# Trunnion Mount



# Pneumatic Twin Cylinder

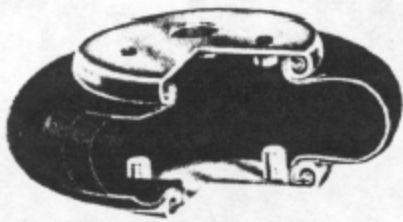
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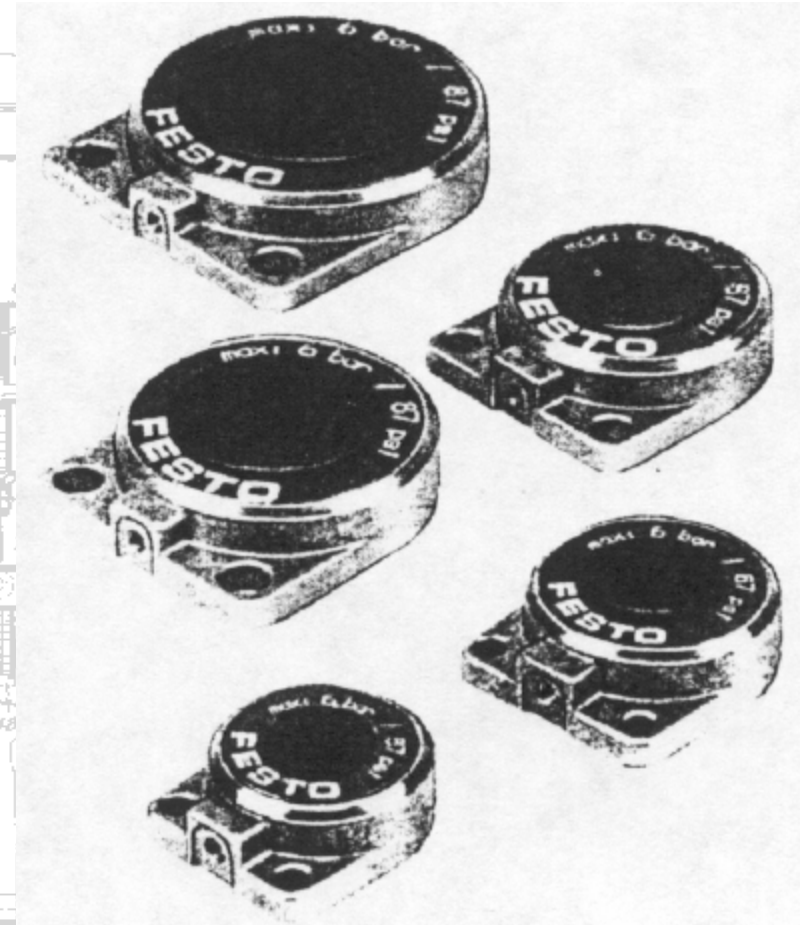
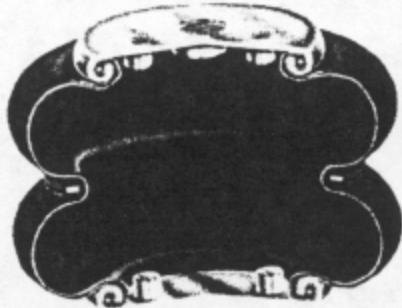
# Pneumatic Bellows

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Single Fold Bellows Cylinder

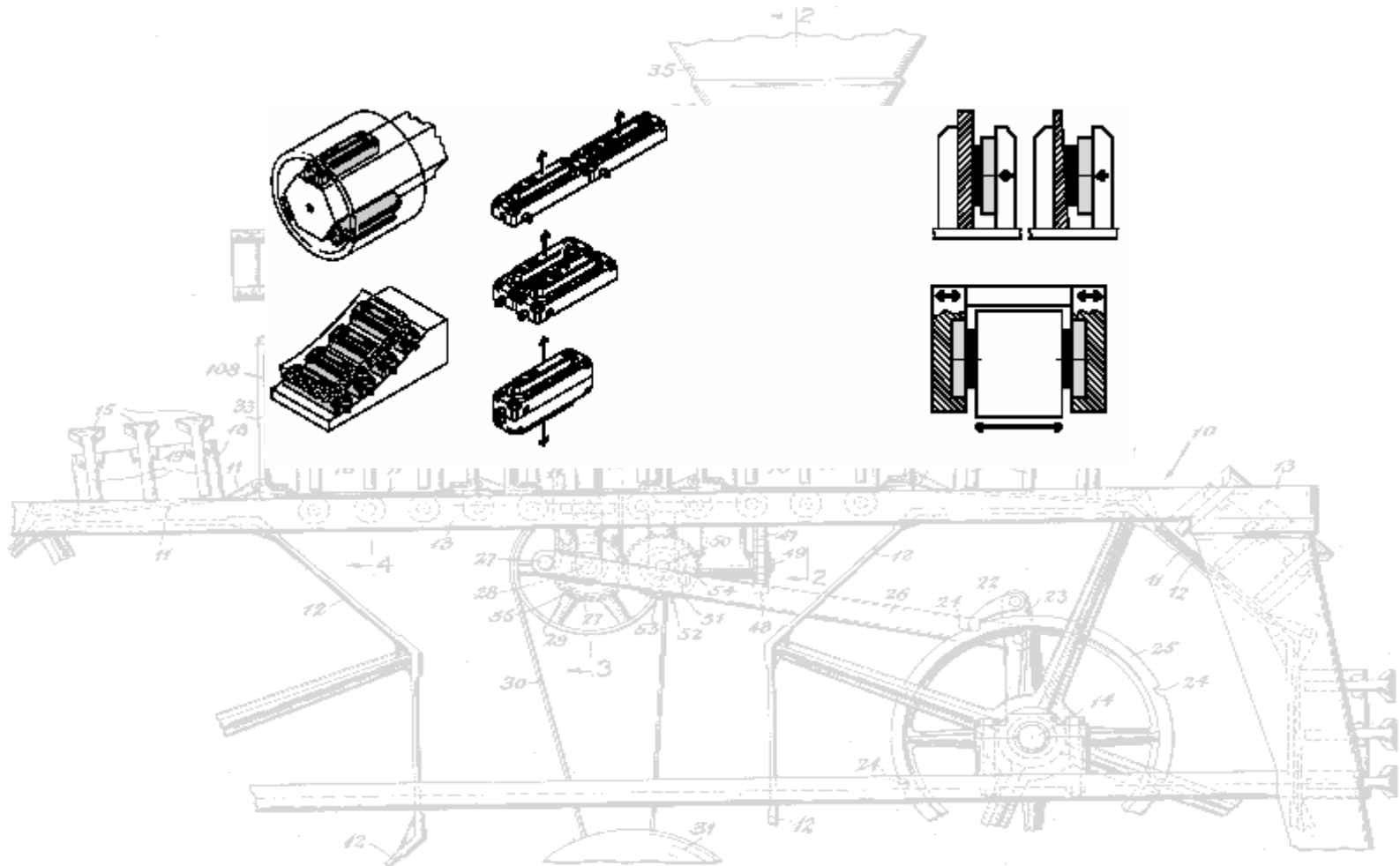


Double Fold Bellows Cylinder



# Pneumatic Bel lows

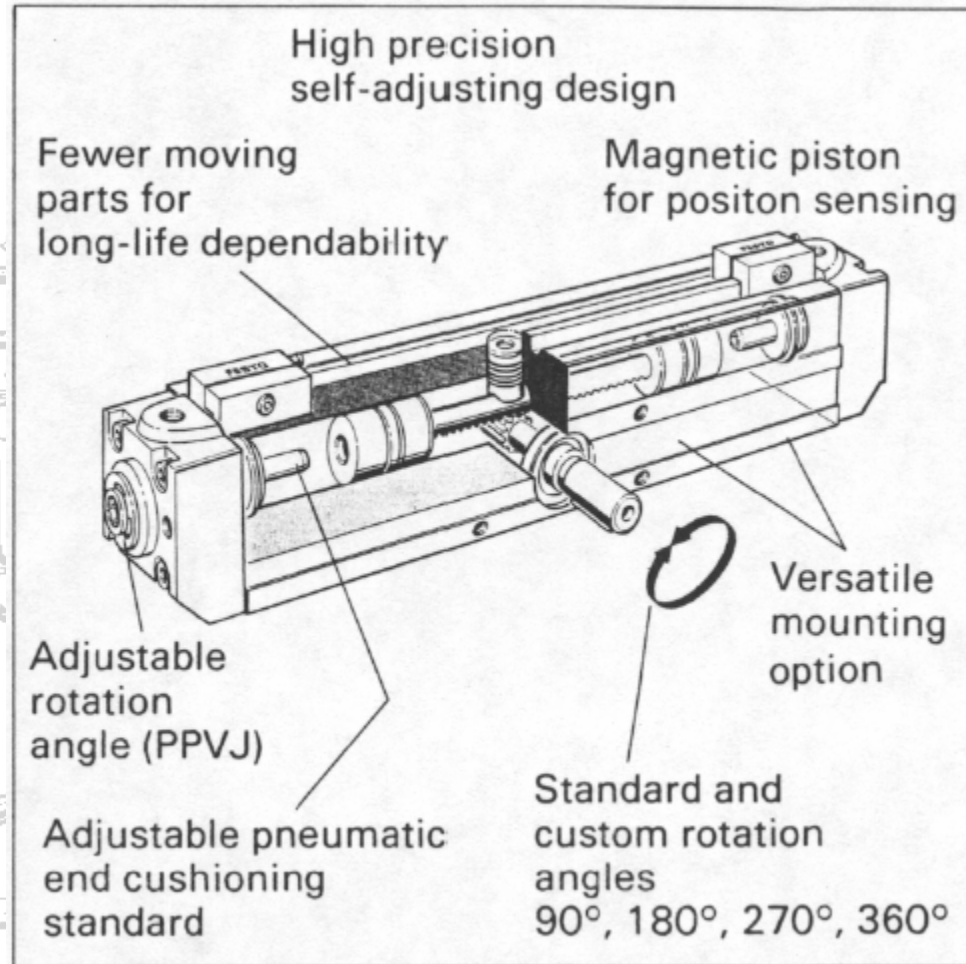
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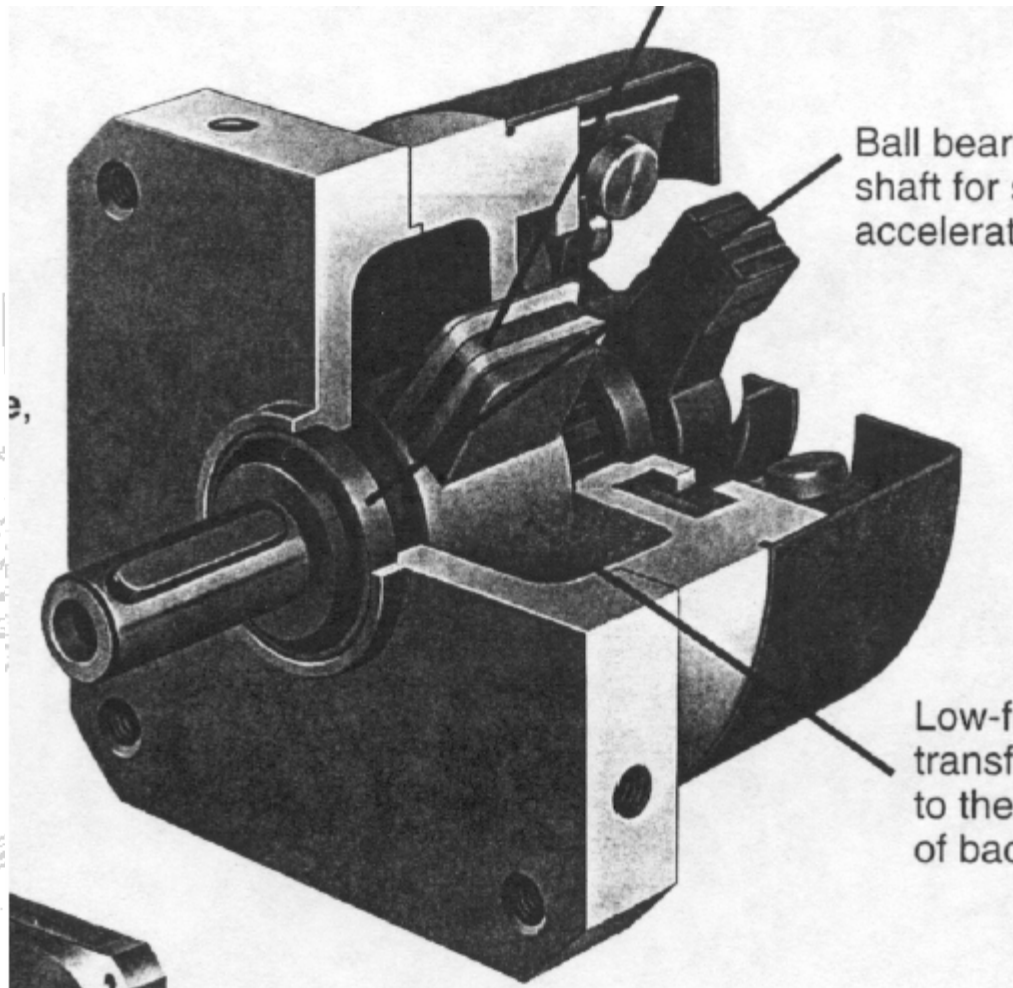
# Pneumatic Rotary Actuators

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# Pneumatic Rotary Actuators

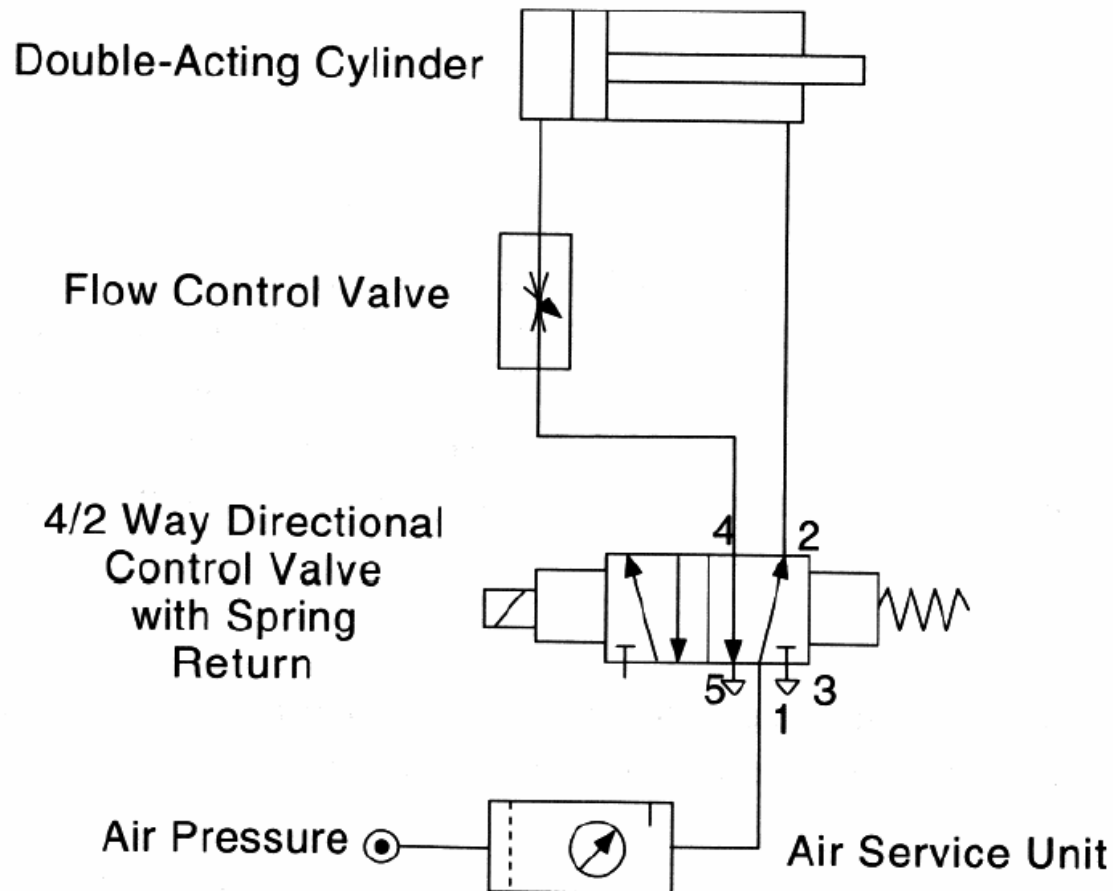
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# Pneumatic Schematics

*Not actuated*



# Pneumatic Schematics

*Actuated*

