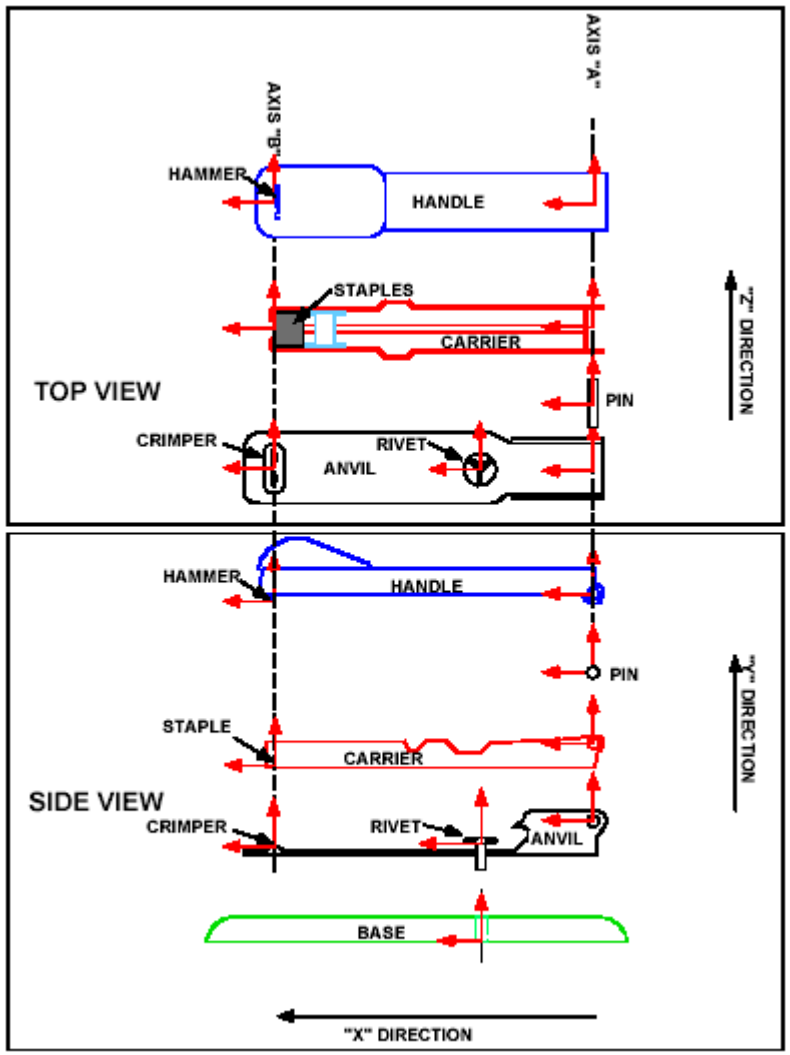
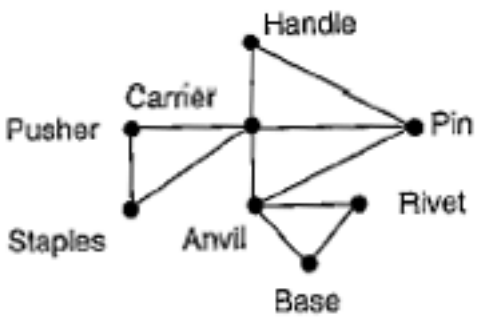
Analyzing the Product

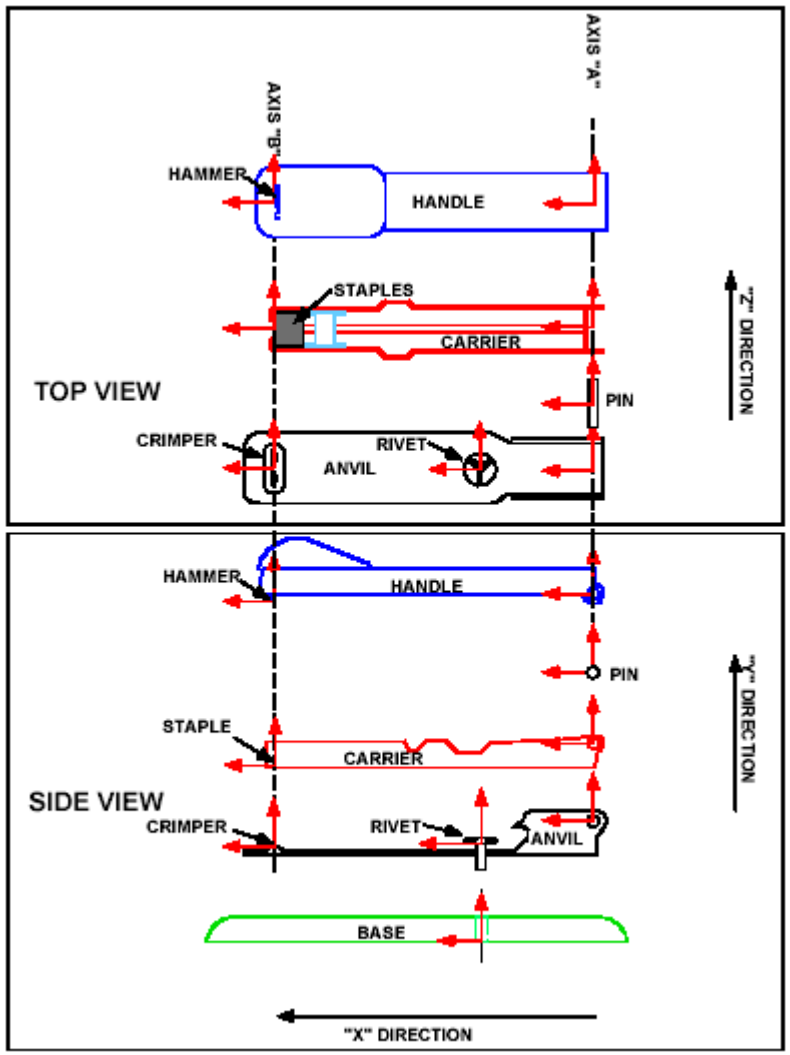
- Stapler example:



Analyzing the Stapler

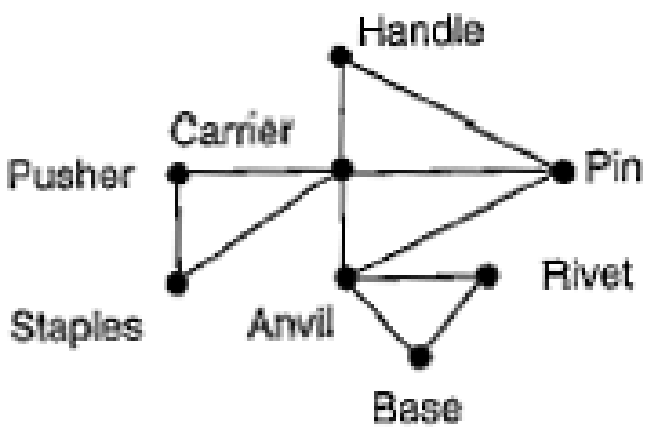
- What would cause the stapler not to work?
- What is the "architecture" of the stapler? (how parts are laid out, functions, arrangement in space)
- Liaison Diagram (p.4)

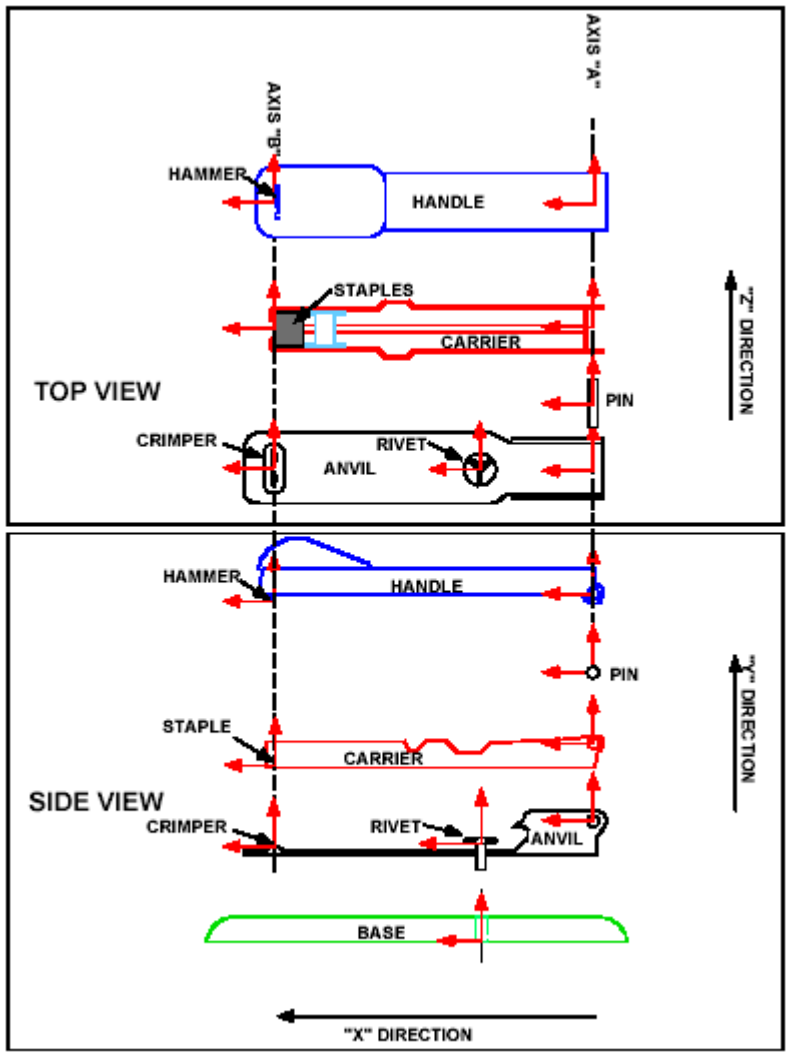




Liaison Diagram

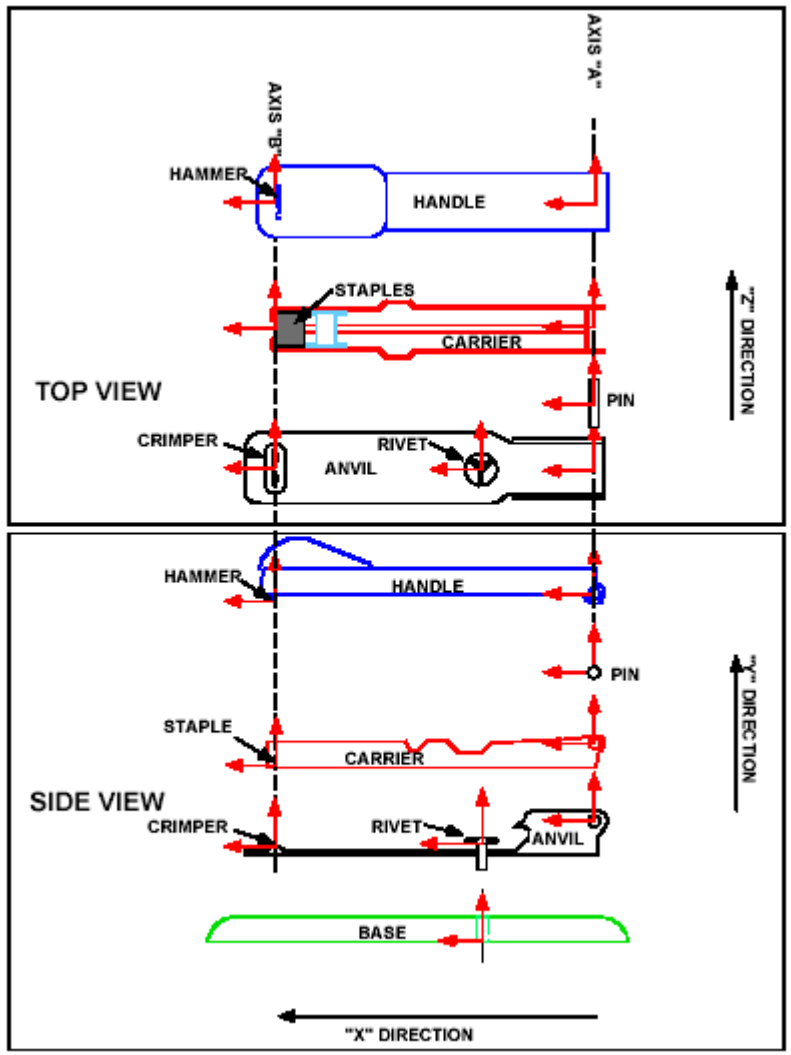
- rivet connects anvil to base
- pin connects anvil, carrier, and handle
- carrier connects pusher and staples





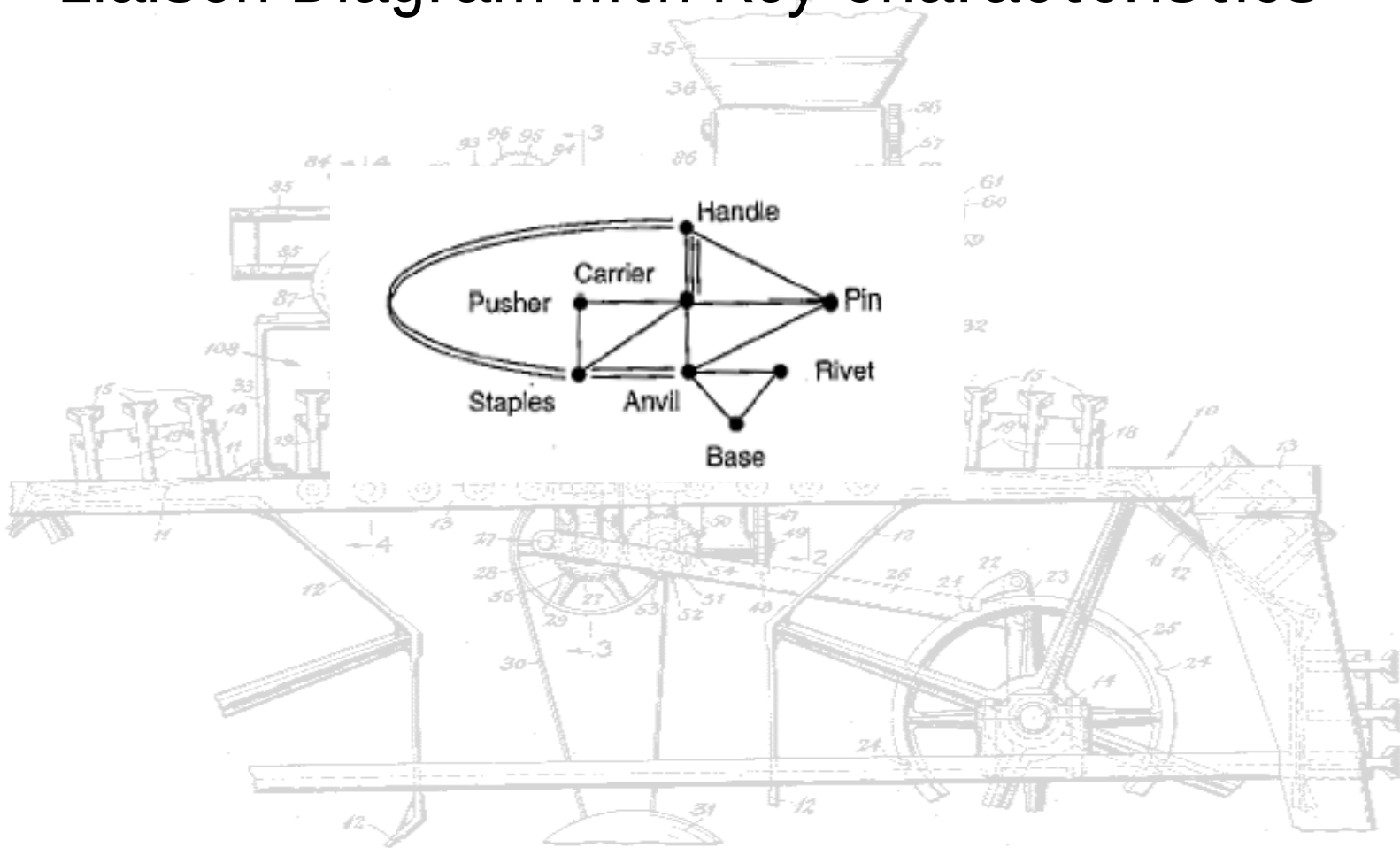
Stapler Example

- What are some "Key Characteristics" that could affect function?
  - *–In X direction:*
    - *•position of hammer*
    - *•thickness of hammer*
    - *•anvil length*
    - *•position of pin & holes*



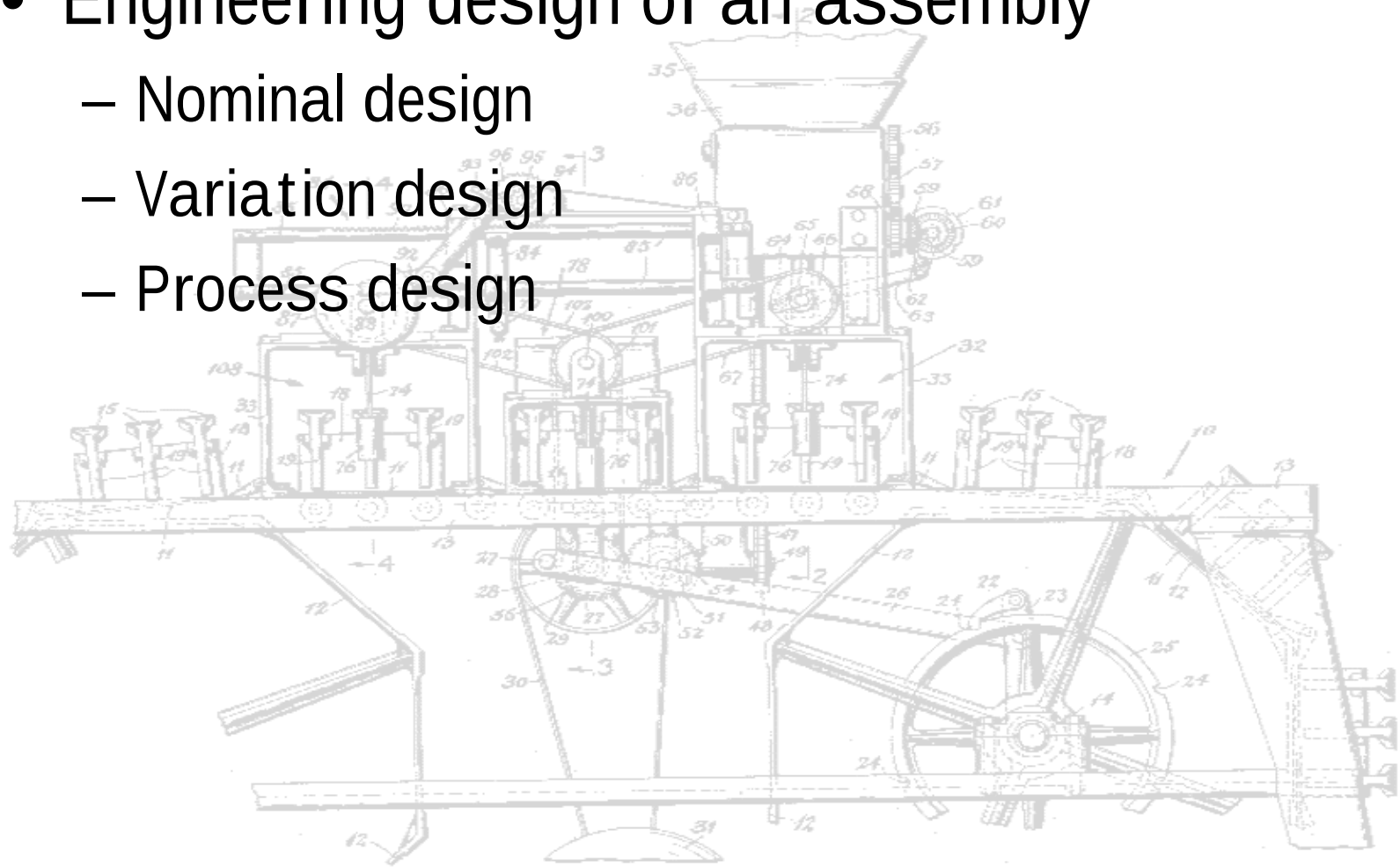
Stapler Example

- Liaison Diagram with Key Characteristics



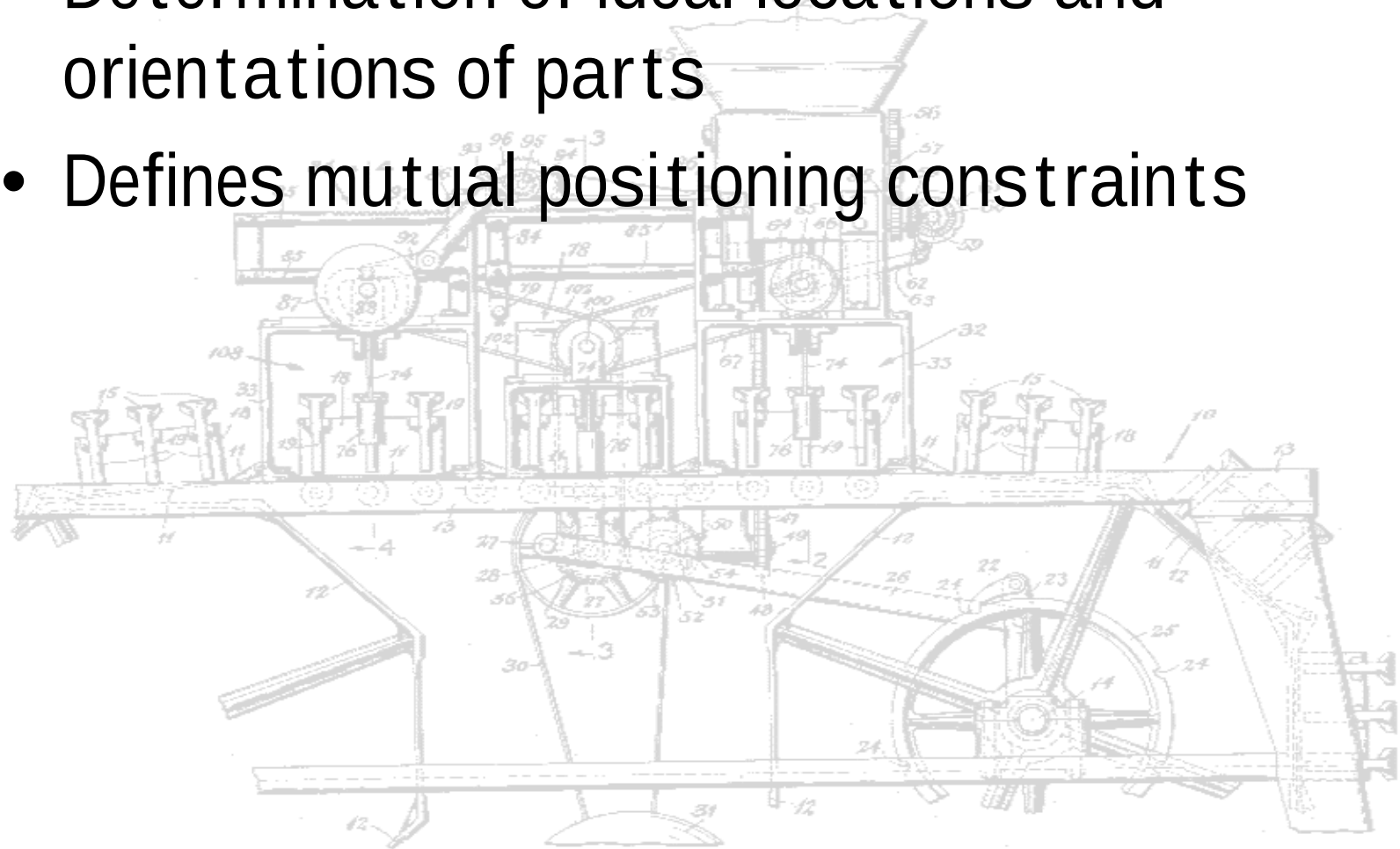
Manufacturing and Assembly Variation

- Engineering design of an assembly
  - Nominal design
  - Variation design
  - Process design



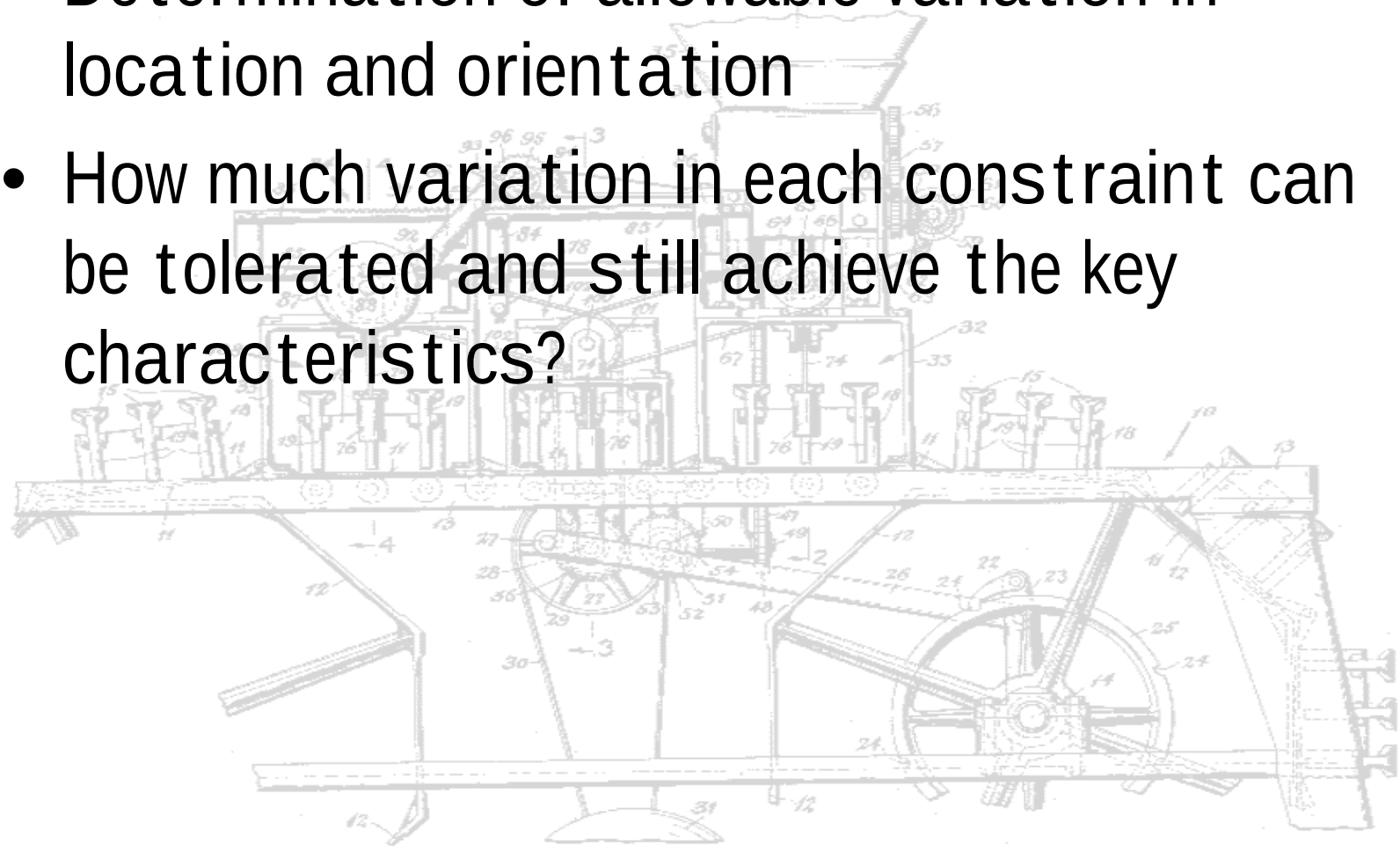
Nominal Design

- Determination of ideal locations and orientations of parts
- Defines mutual positioning constraints



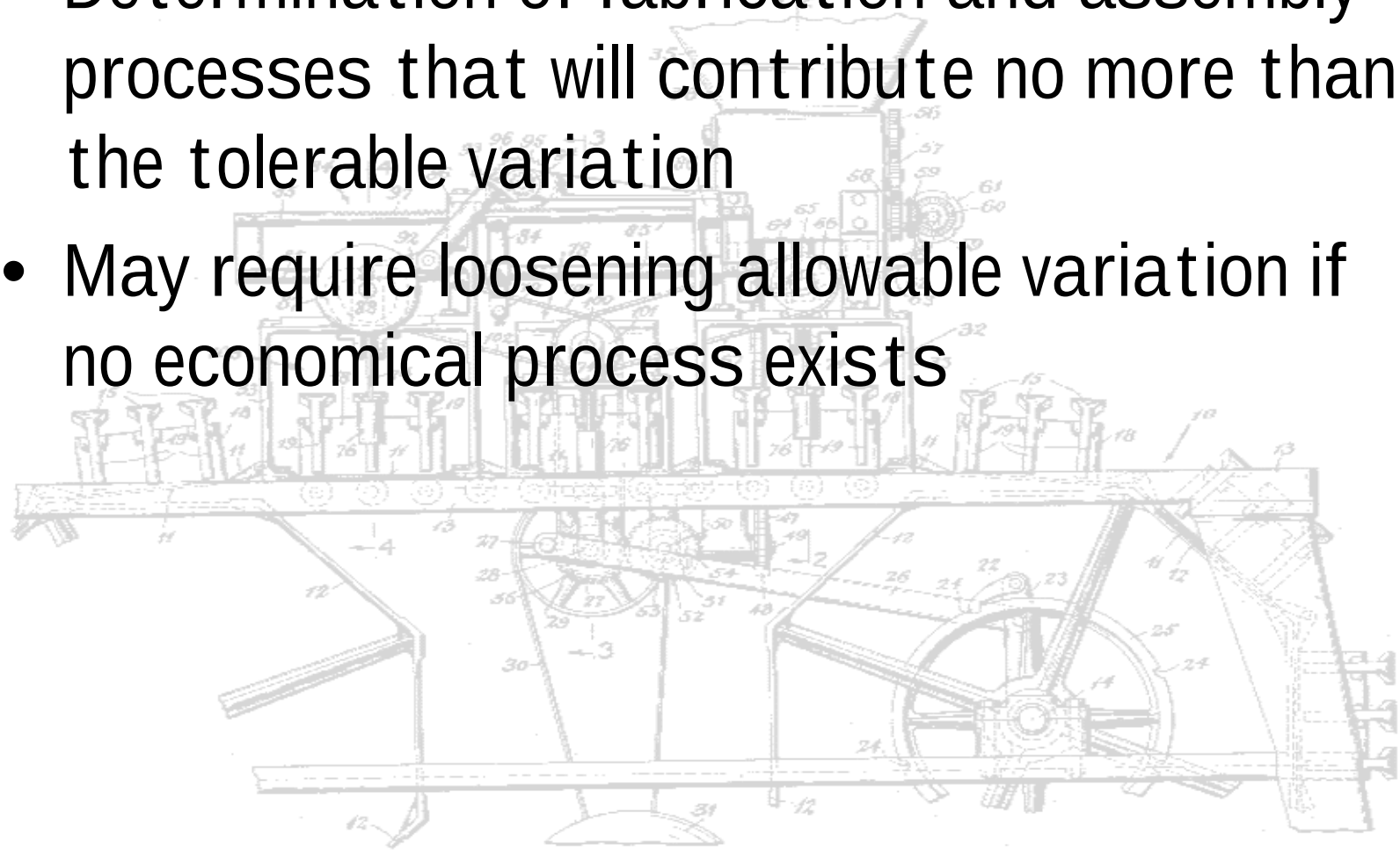
Variation Design

- Determination of allowable variation in location and orientation
- How much variation in each constraint can be tolerated and still achieve the key characteristics?



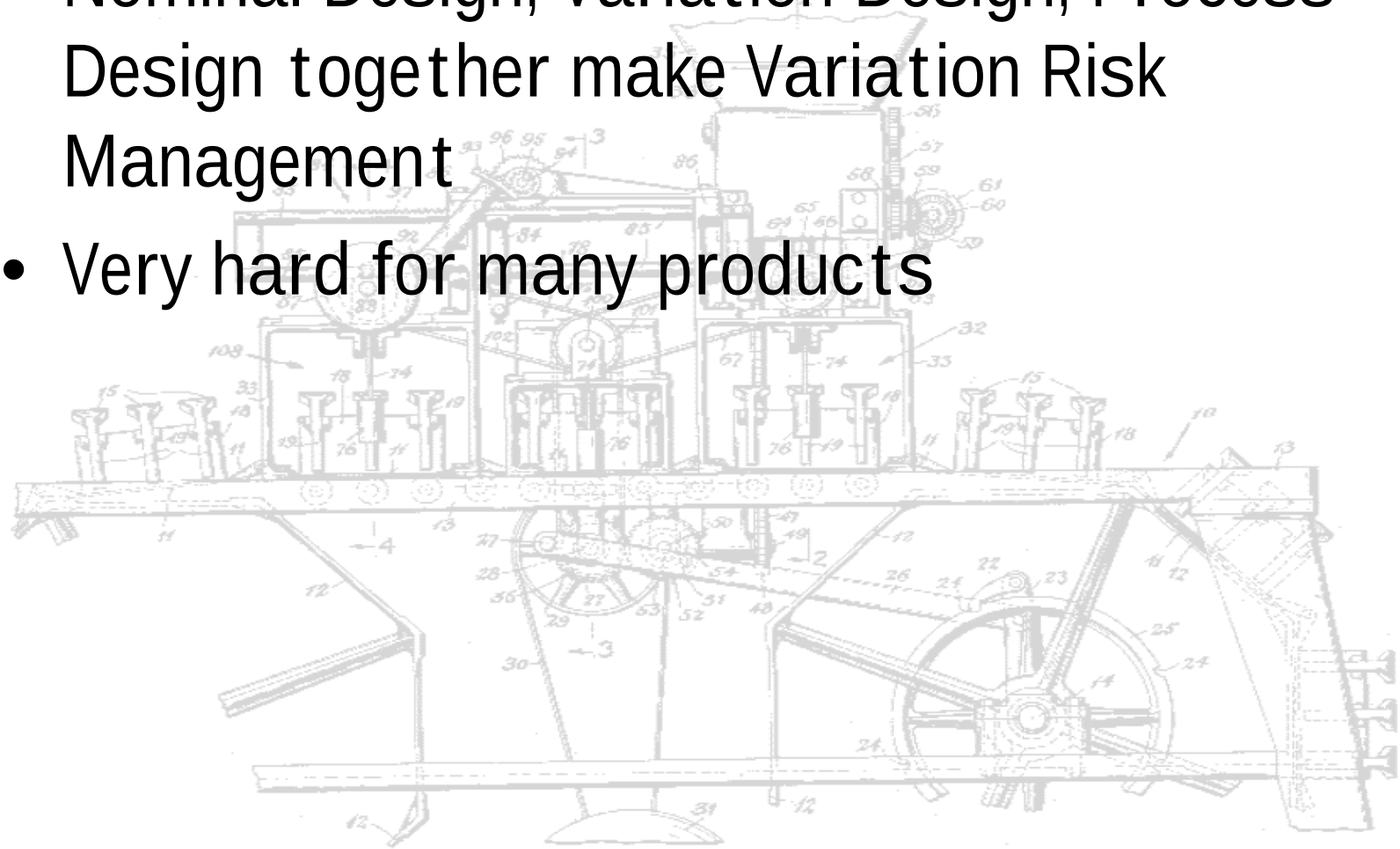
Process Design

- Determination of fabrication and assembly processes that will contribute no more than the tolerable variation
- May require loosening allowable variation if no economical process exists



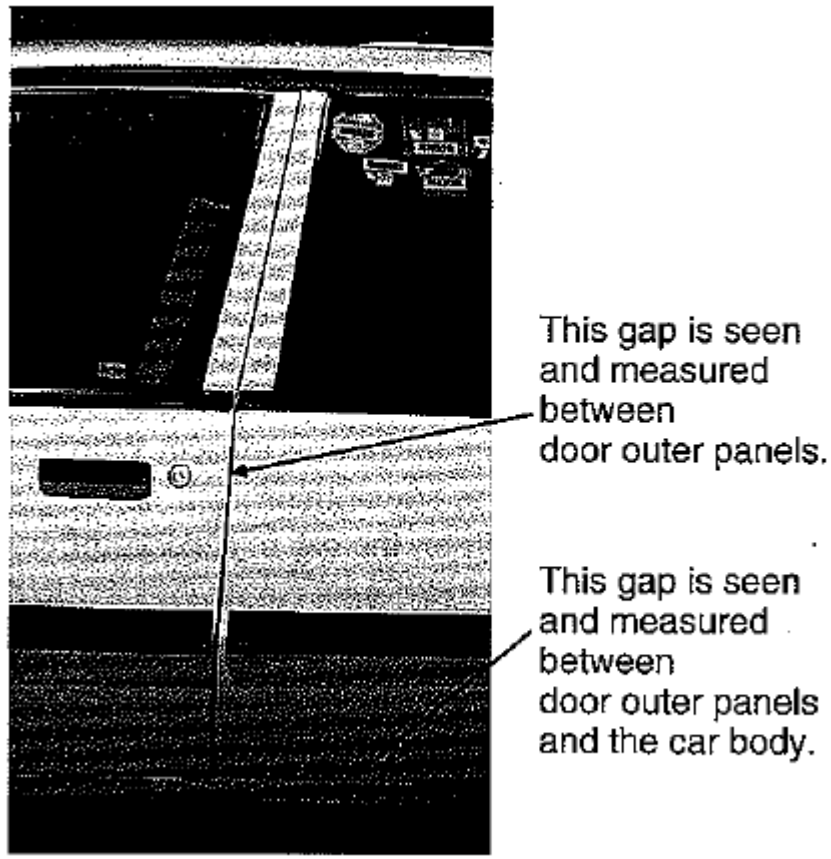
Variation Risk Management (VRM)

- Nominal Design, Variation Design, Process Design together make Variation Risk Management
- Very hard for many products

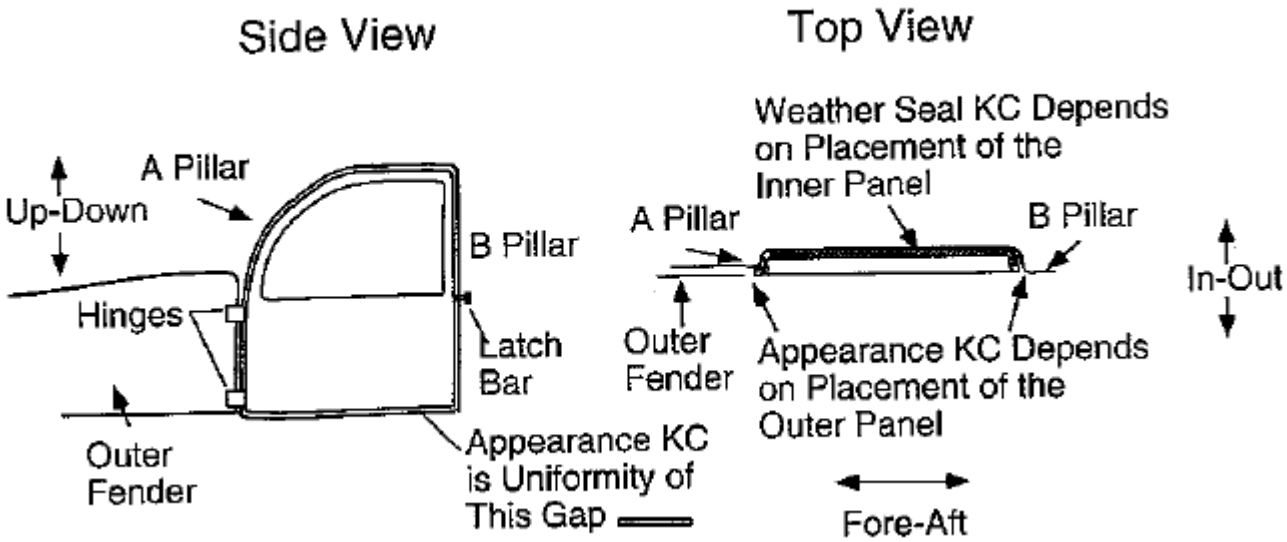


Example - Car Doors

- Door gap KC
- Weatherstripping KC

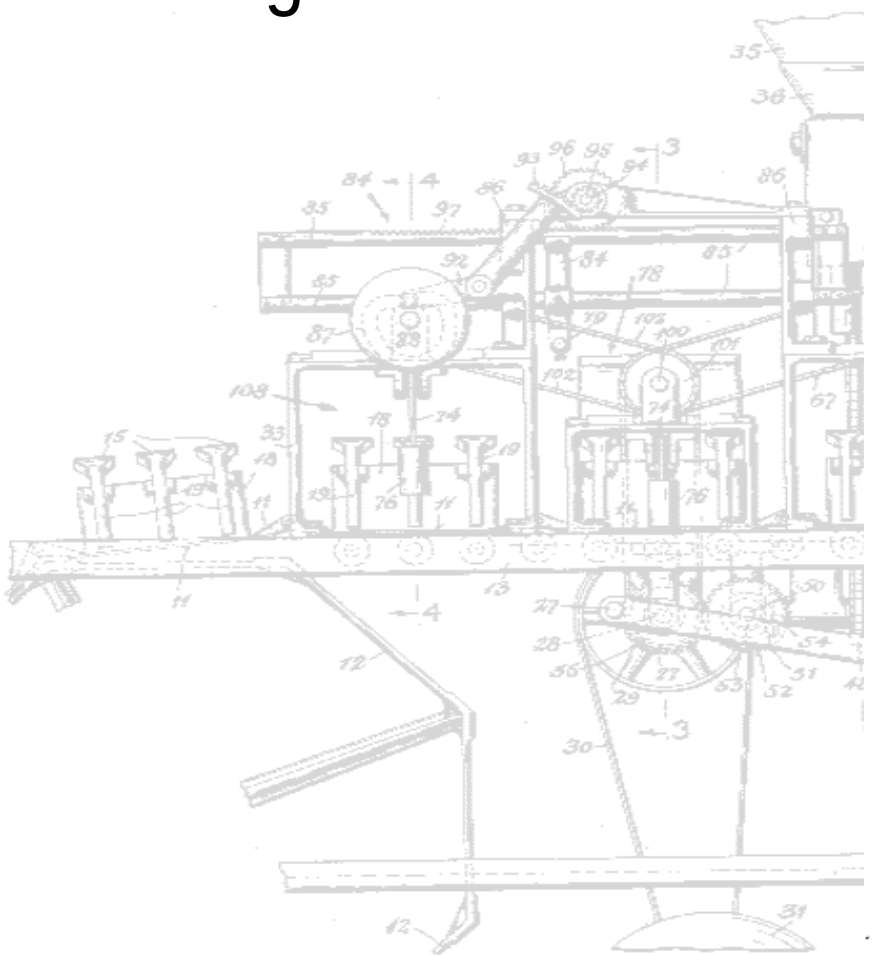


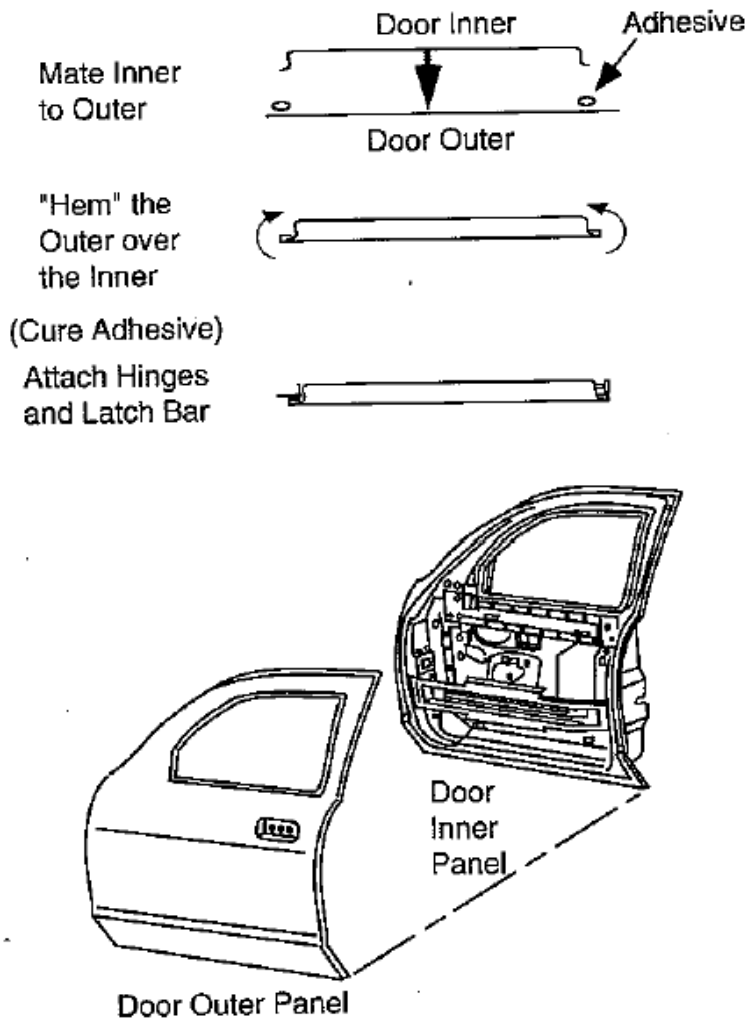
Car Door Example



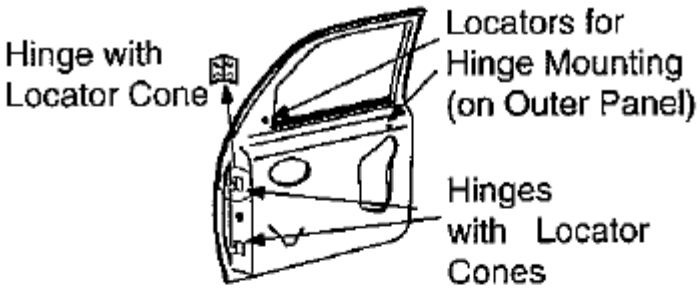
Car Door Example

- Making a door

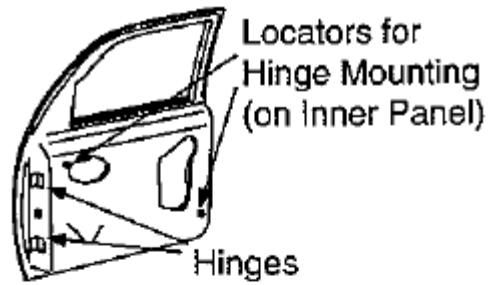




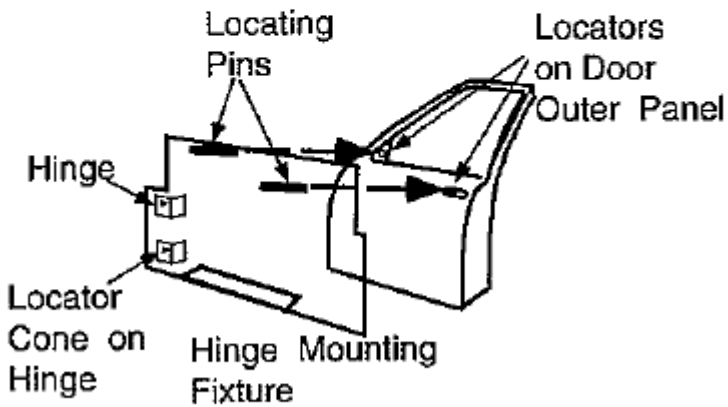
Car Doors - Mounting



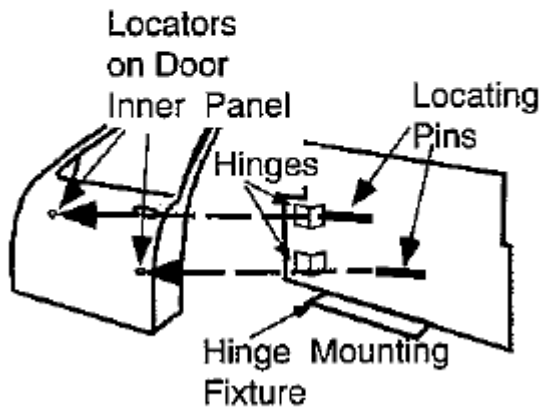
GM Door and Hinges



Ford Door and Hinges

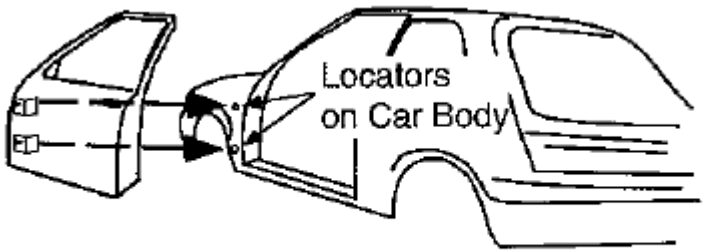


GM Method of Mounting
Hinges on Doors

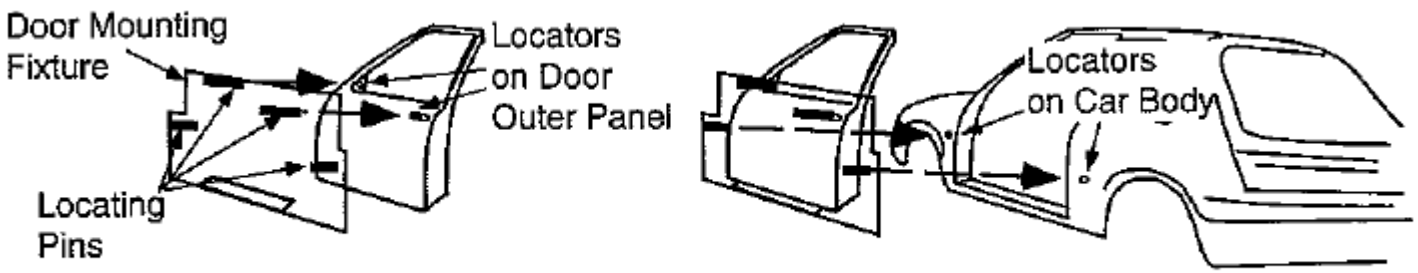


Ford Method of Mounting
Hinges on Doors

Car Doors - Mounting



GM Method of Mounting Doors to Car Bodies



Ford Method of Mounting Doors to Car Bodies

Mathematical Modeling of Assembly

- Coordinate frames
  - each part has a base coordinate frame
- Relationships between parts are expressed as 4x4 matrix transforms