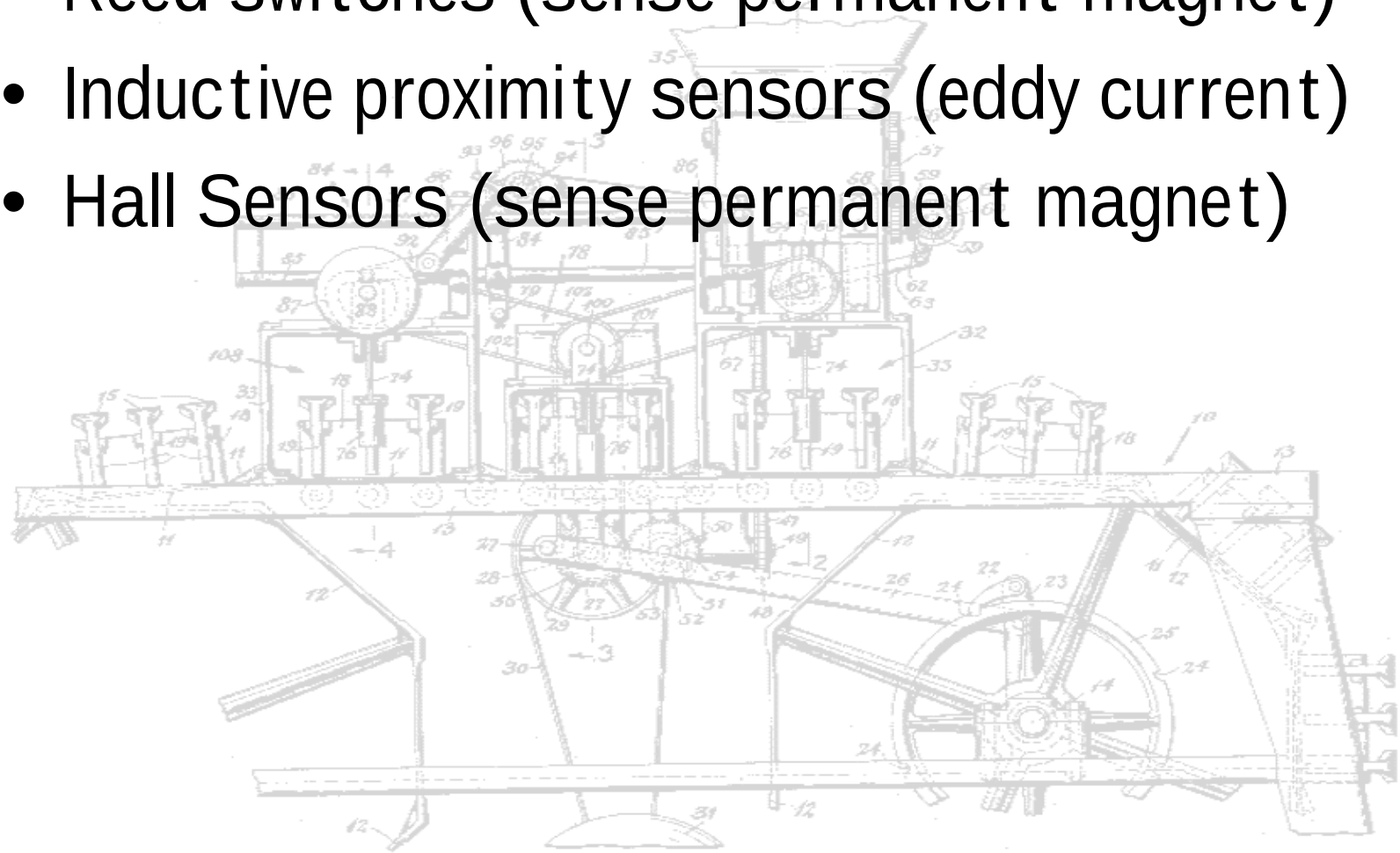
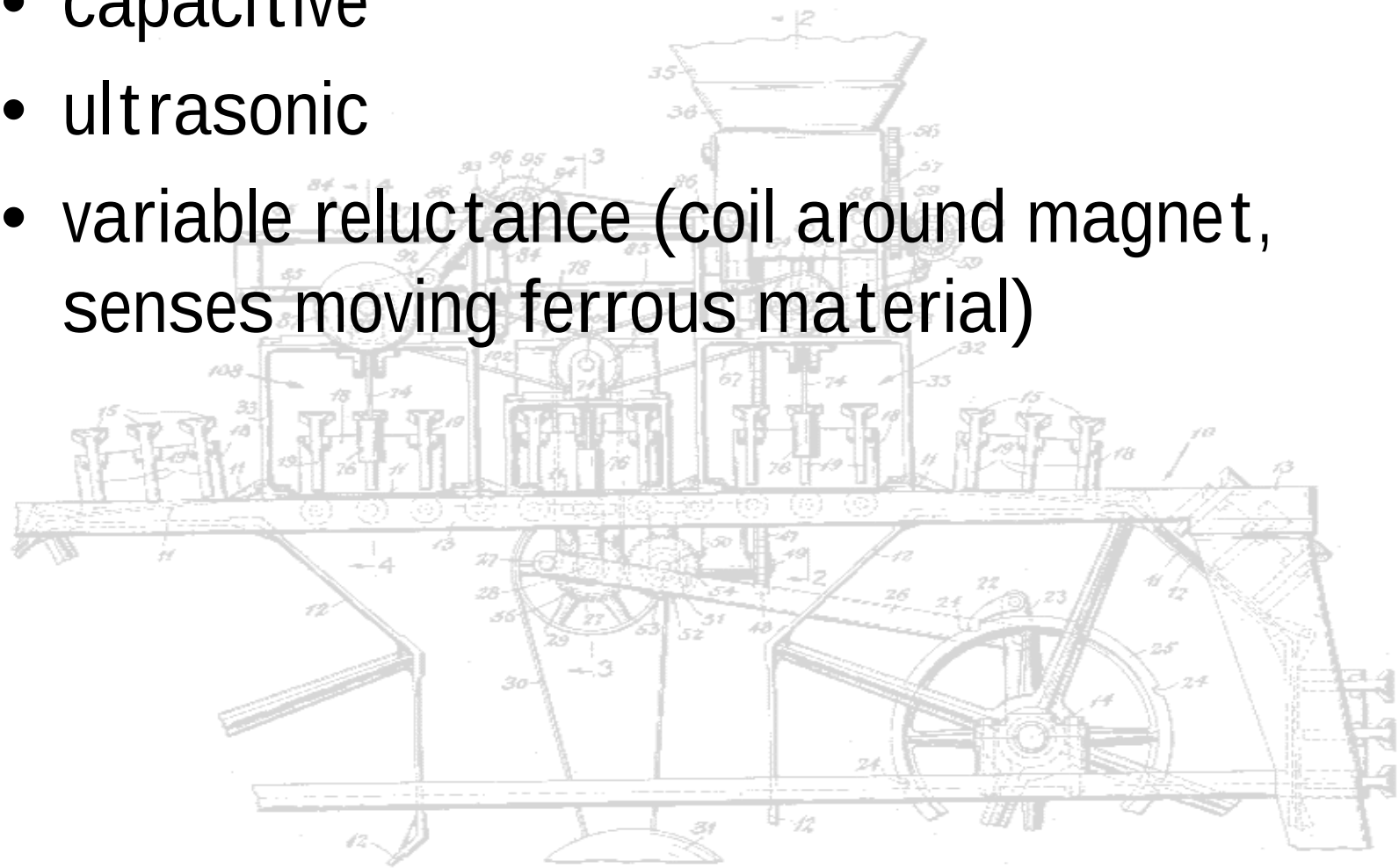
Magnetic Position Sensors

- Reed switches (sense permanent magnet)
- Inductive proximity sensors (eddy current)
- Hall Sensors (sense permanent magnet)

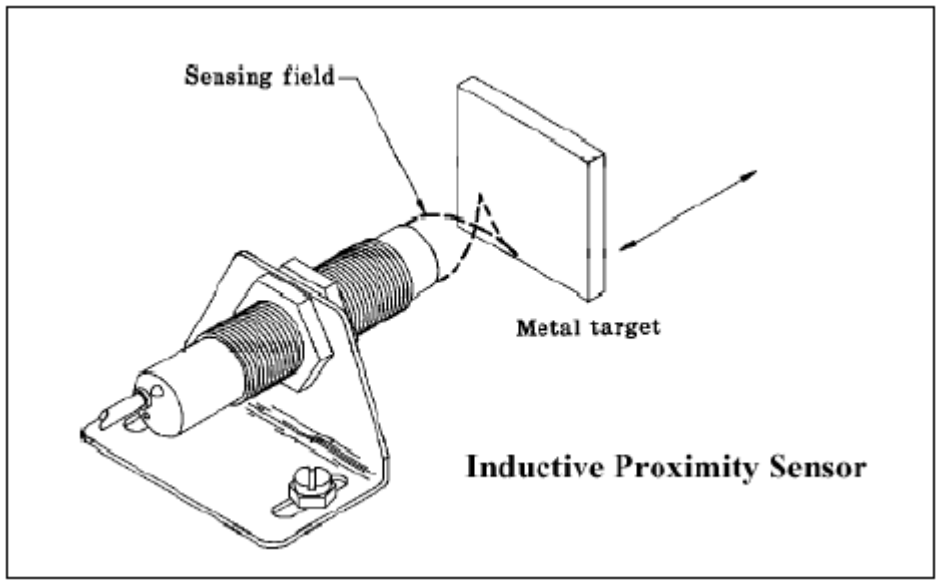


Other Discrete Position Sensors

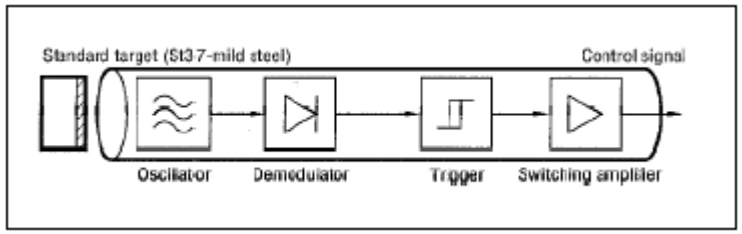
- capacitive
- ultrasonic
- variable reluctance (coil around magnet, senses moving ferrous material)

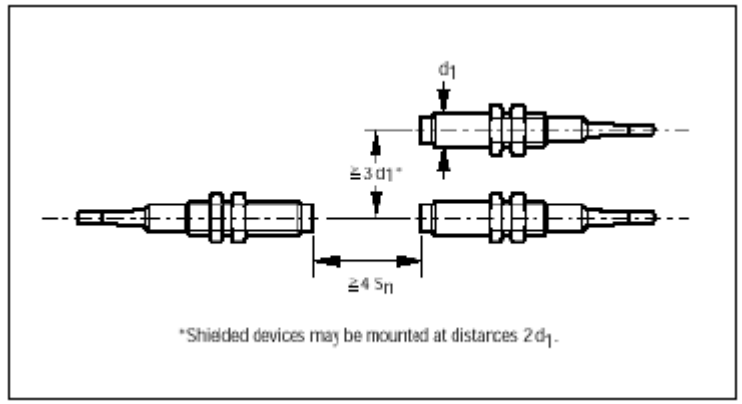


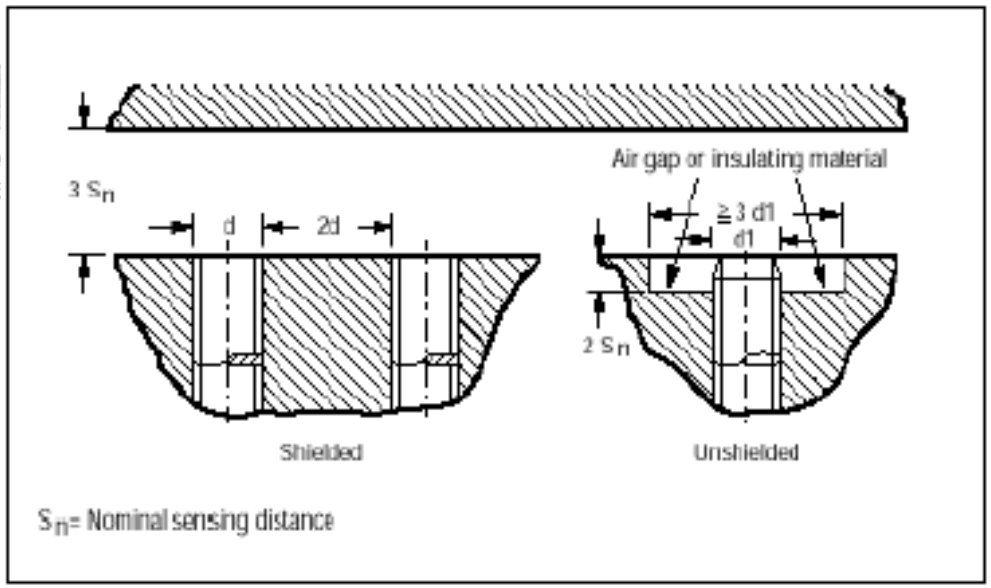
Inductive Proximity Sensor



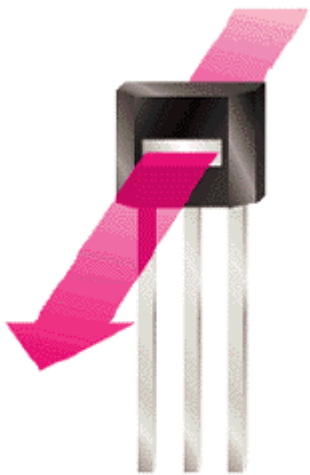
Inductive Proximity Sensors





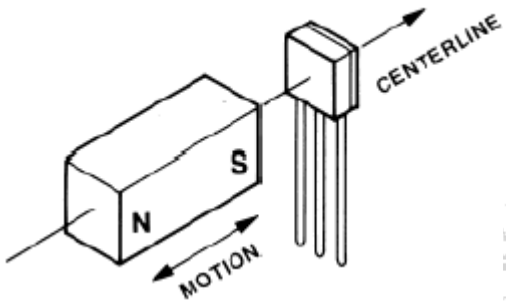


Hall Sensors

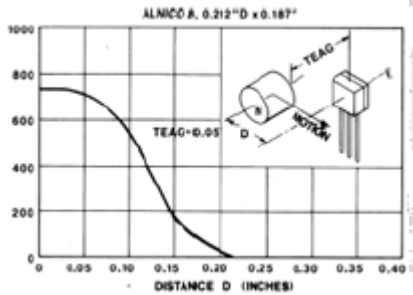


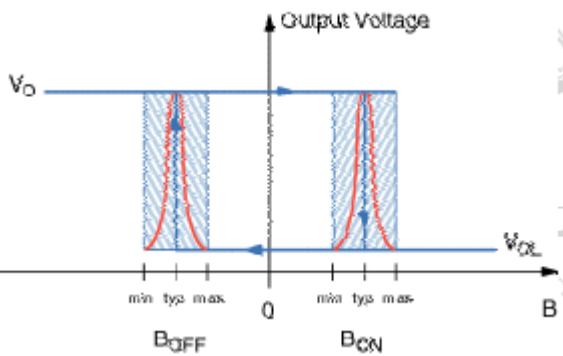
- Hall effect:
  - constant voltage forces a constant current in semiconductor sheet
  - magnetic field flux lines perpendicular to current cause proportional voltage across sheet.
  - discovered by E.F.Hall in 1879
- Linear sensor needs voltage regulator and amplifier
- Switch also needs threshold circuit, with hysteresis

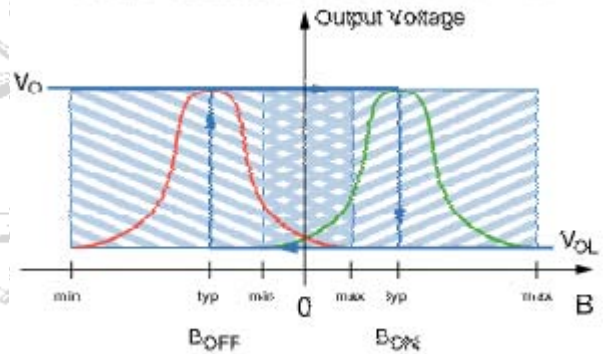
Hall Switch

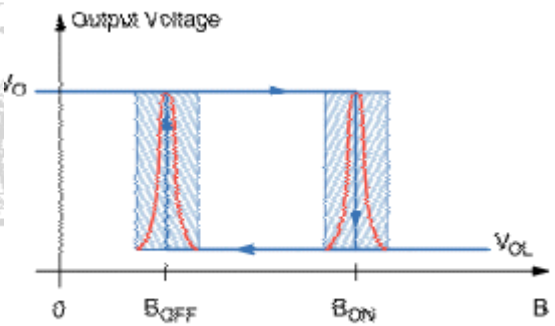


- Magnet motion
  - head-on
  - bypass or slide-by
- Total effective air gap (TEAG)
- Sensitivity, Hysteresis, & Temperature



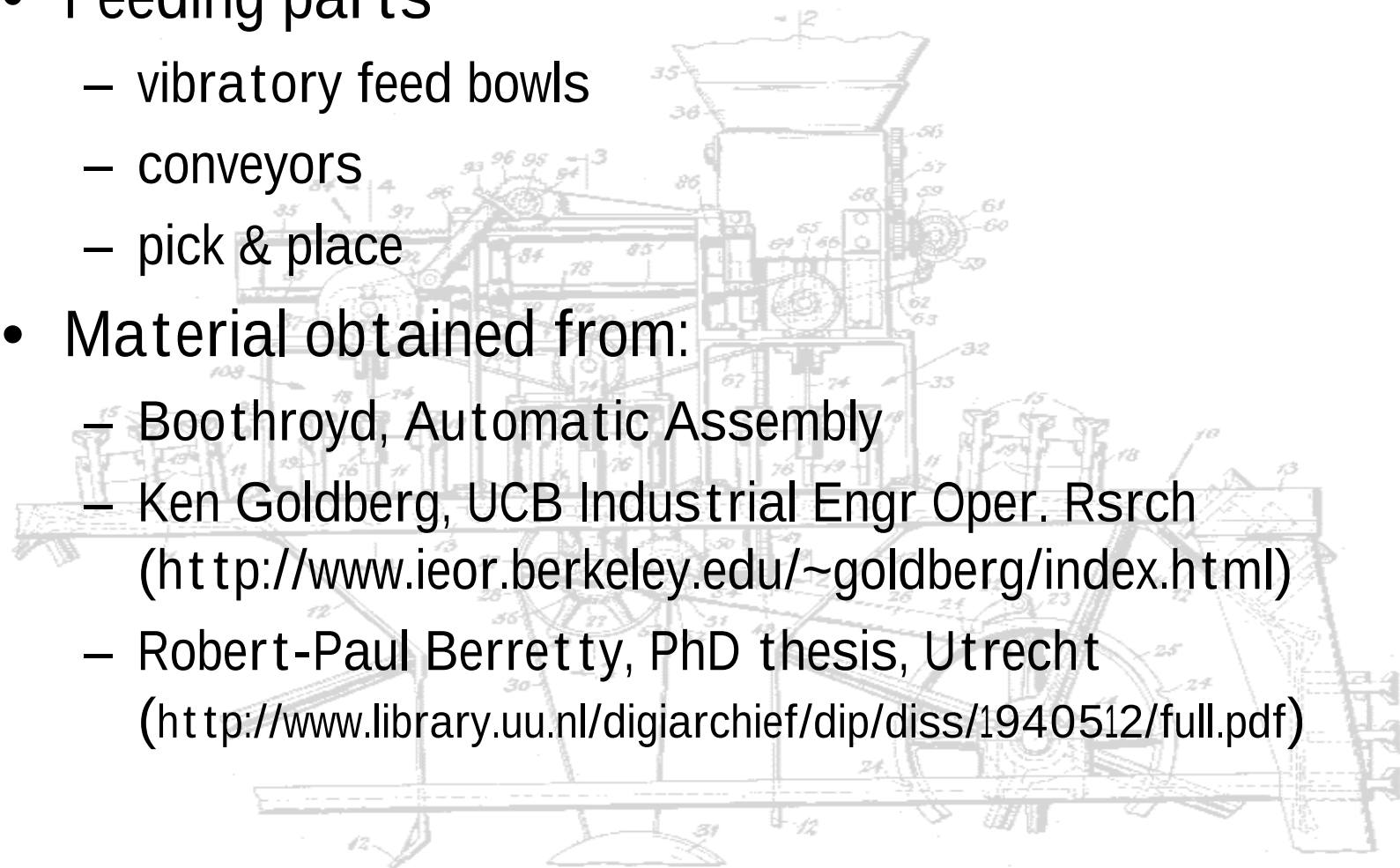






Care & Feeding of Machines

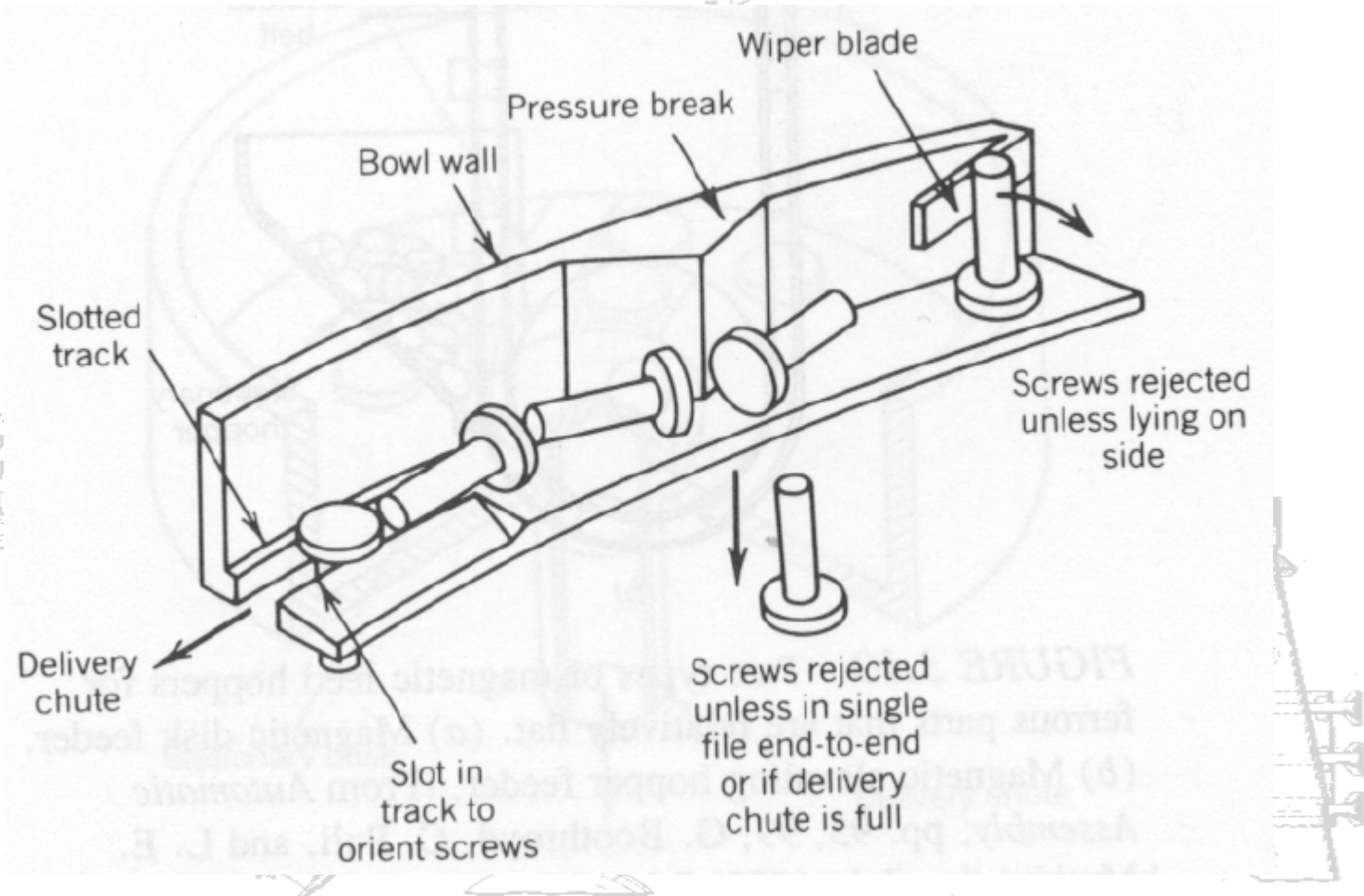
- Feeding parts
  - vibratory feed bowls
  - conveyors
  - pick & place
- Material obtained from:
  - Boothroyd, Automatic Assembly
  - Ken Goldberg, UCB Industrial Engr Oper. Rsrch (http://www.ieor.berkeley.edu/~goldberg/index.html)
  - Robert-Paul Berretty, PhD thesis, Utrecht (http://www.library.uu.nl/digiarchief/dip/diss/1940512/full.pdf)



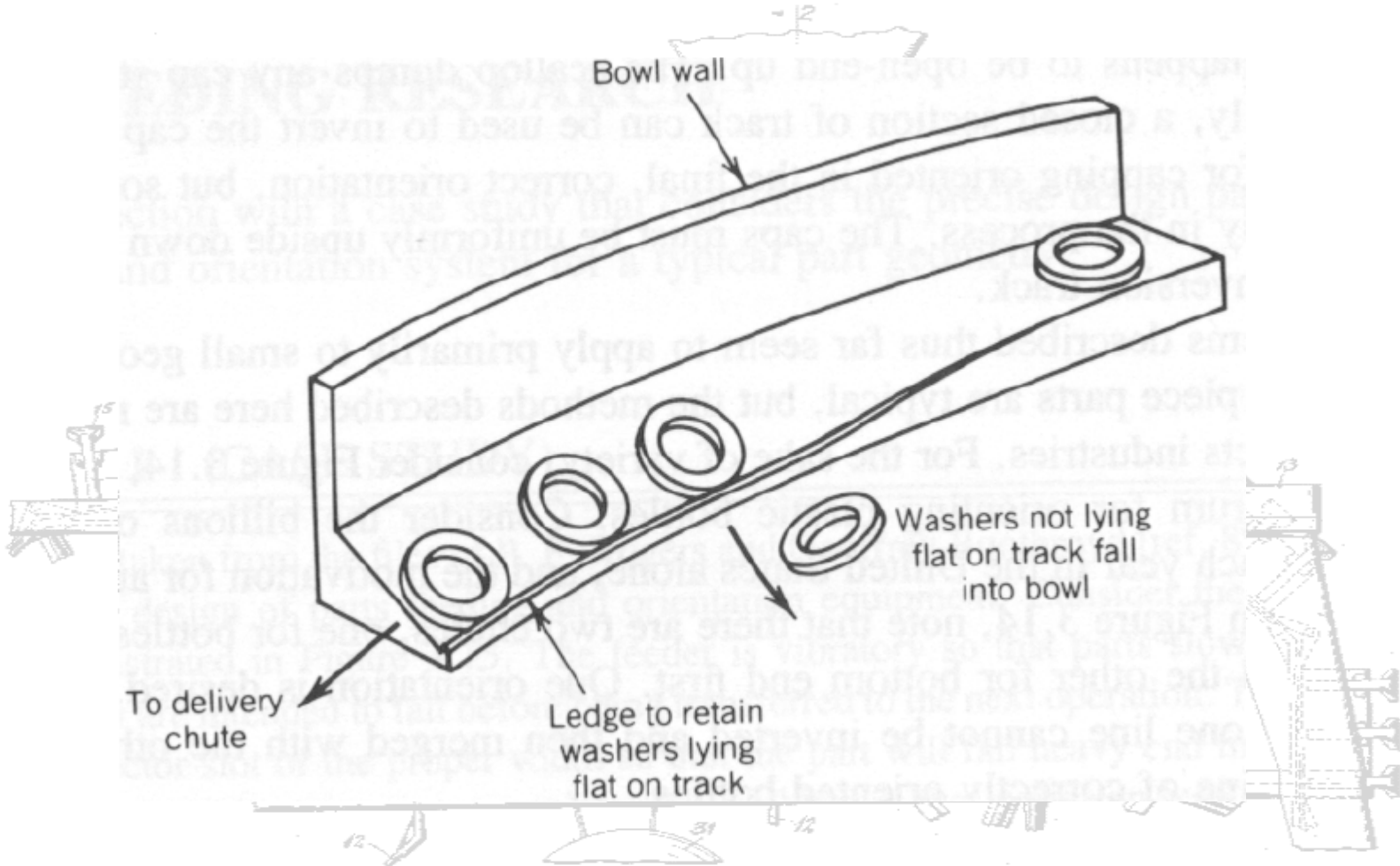
Bowl Feeders

Bowl Feeders

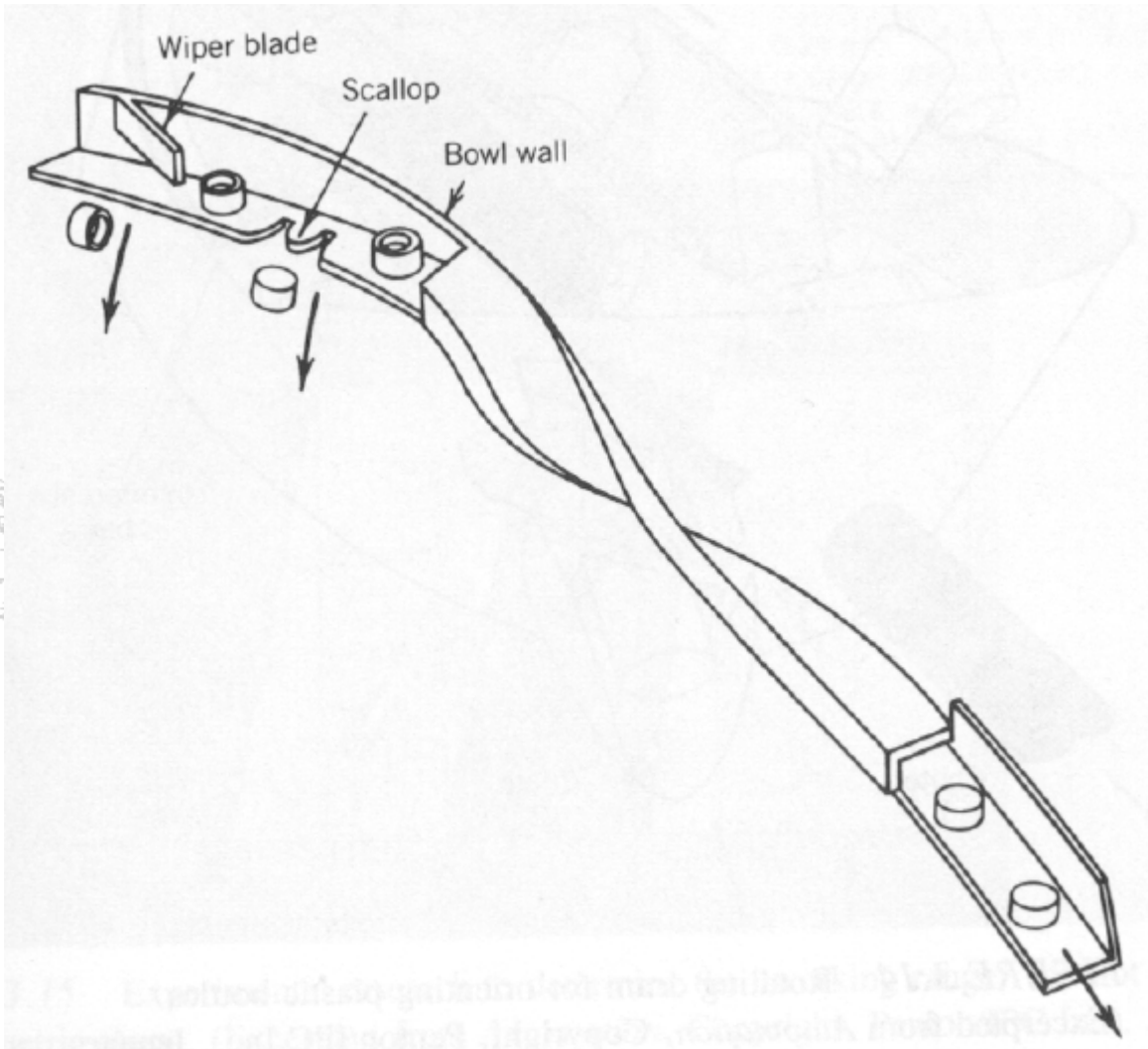
Bowl Feeders



Bowl Feeders



Bowl Feeders

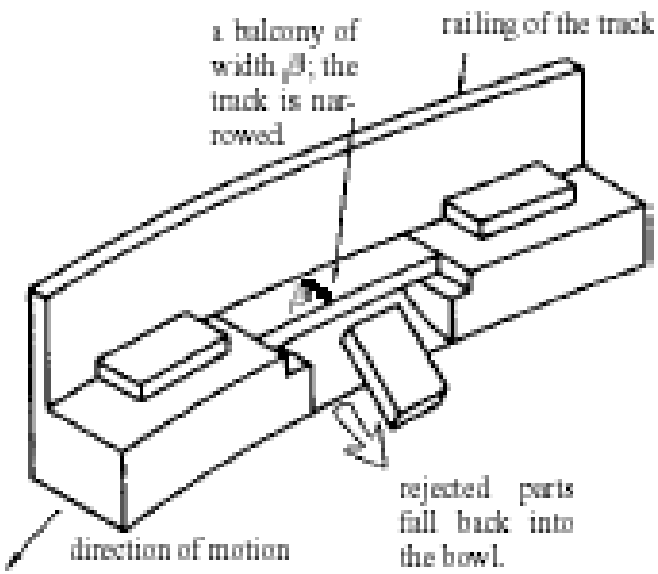


Bowl Feeders

- Design Factors
  - Part symmetry
  - Selector efficiency $E=F_o/F_i$
  - Recirculation effects

$$p_k = \left[\frac{E}{100}\right]\left[1-\frac{E}{100}\right]^k$$

Bowl Feeders - Trap Design



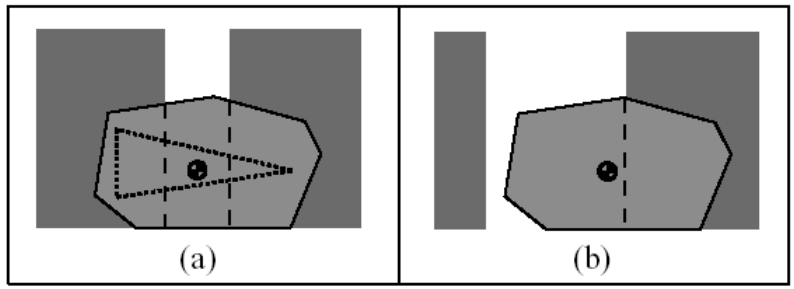


Figure 2: (a) A safe pose. The triangle is evidence of safeness. (b) An unsafe pose of the same part above a different trap.

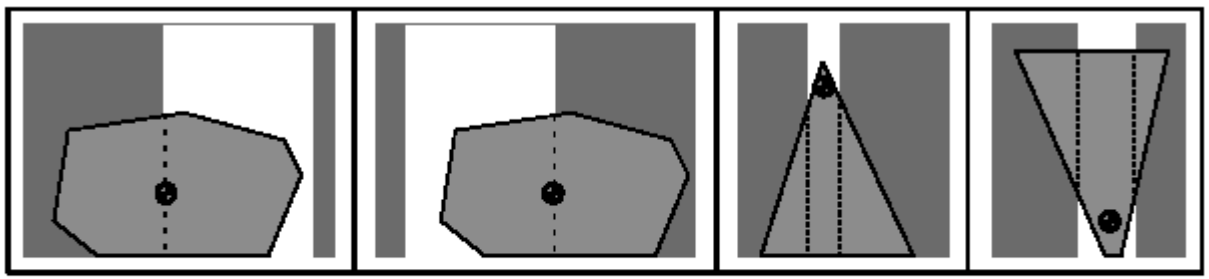


Figure 4: The types of rejected poses.

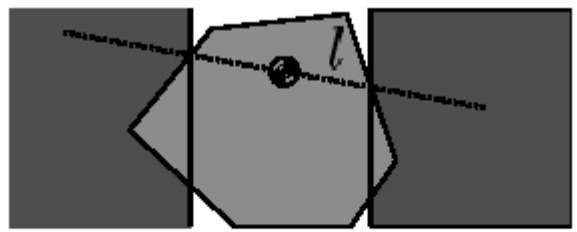
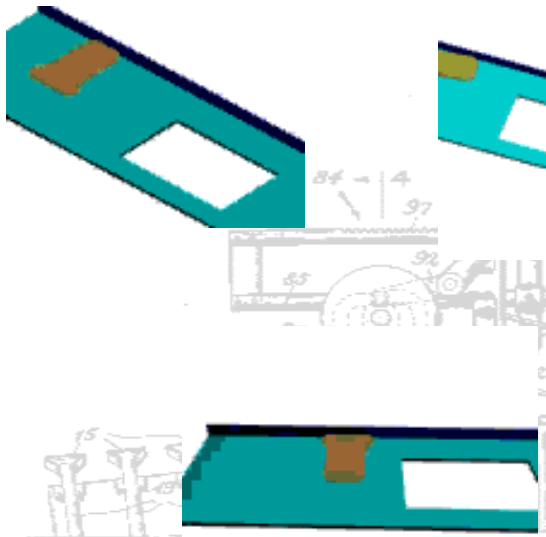
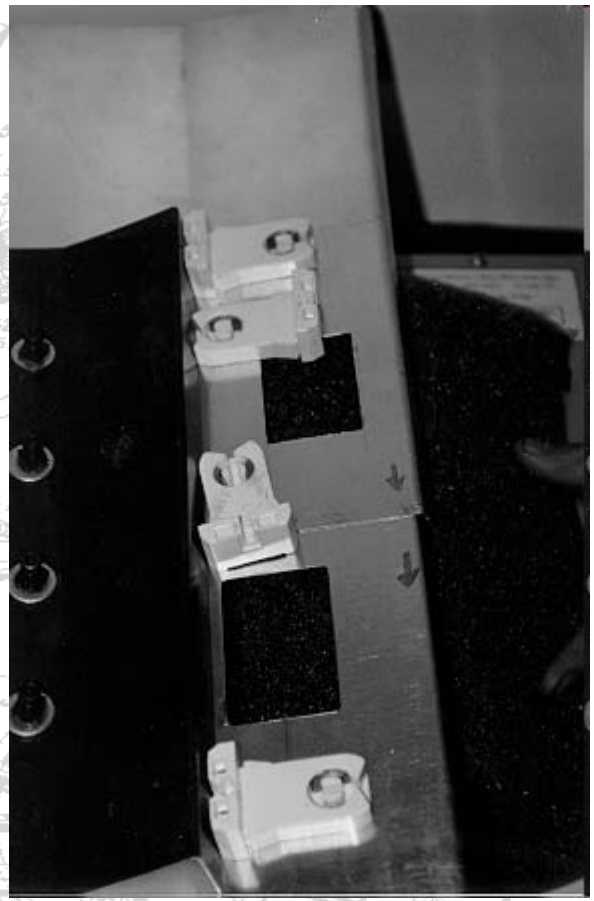


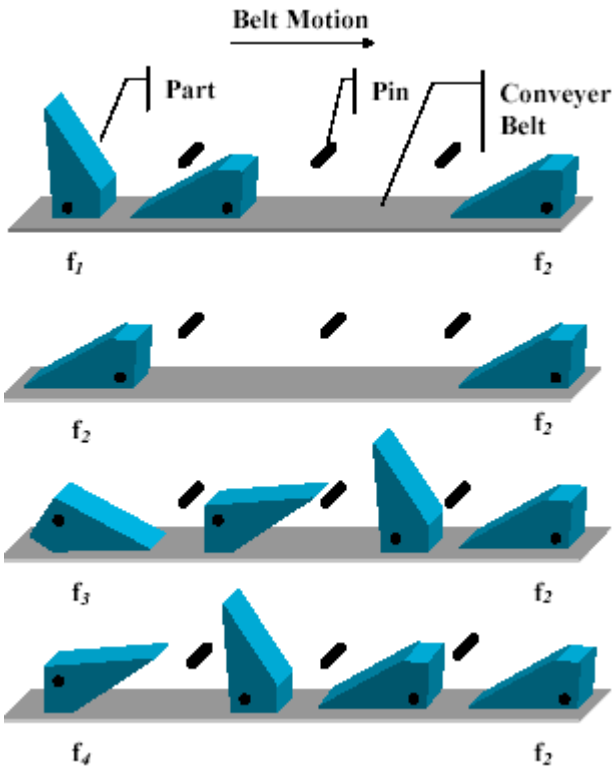
Figure 5: A critical pose.

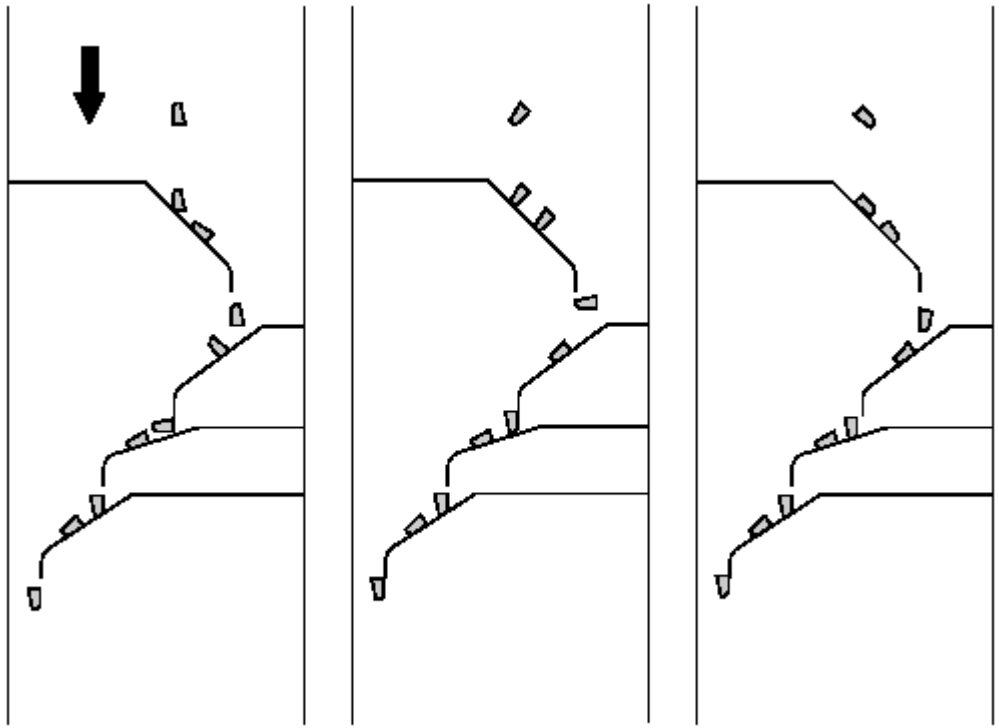
Bowl Feeders - Trap Design





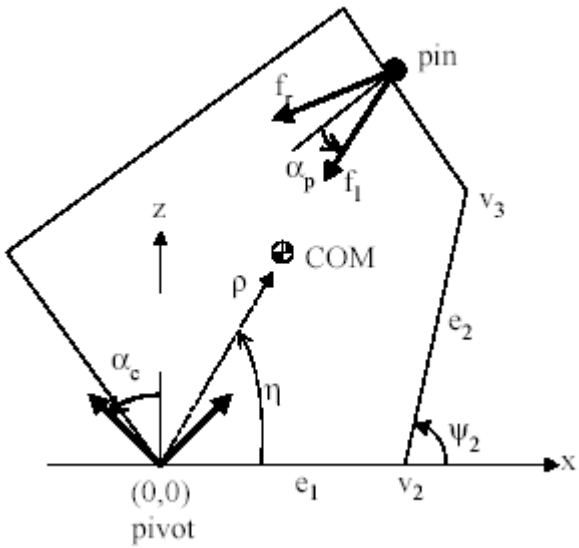
Conveyors





- Orienting with pins or fences

Conveyor part orientation - pins



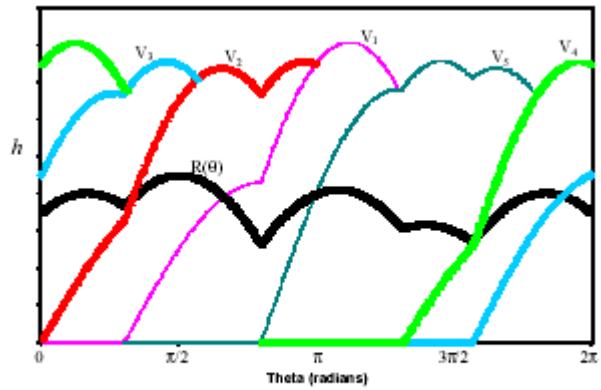


Figure 4. Radius function, $R(\theta)$, and vertex functions, $V_i(\theta)$.

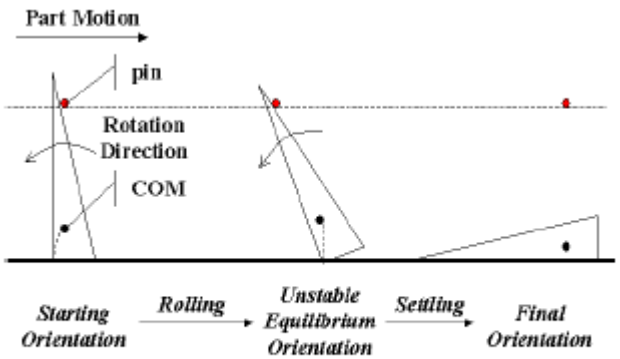


Figure 3. Two phases of toppling: *rolling and settling*.

Conveyor part orientation - pins

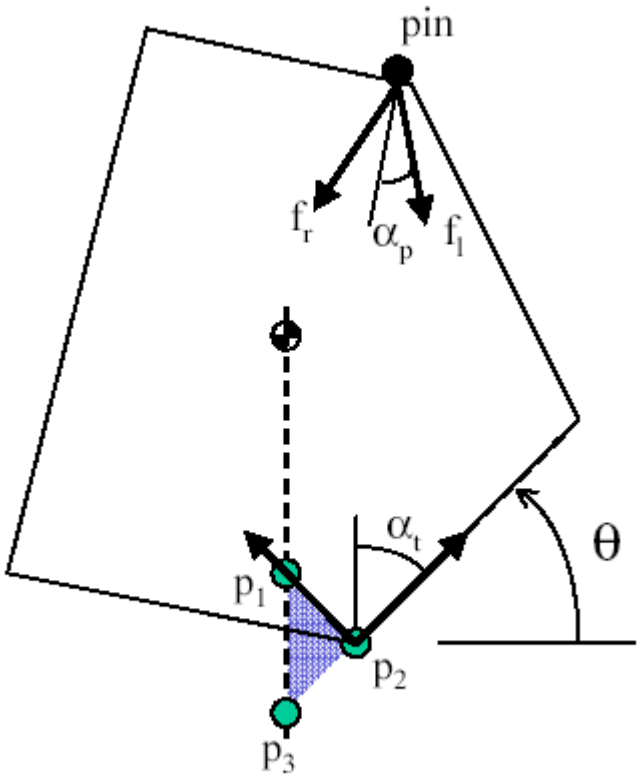


Figure 7. Jamming conditions.

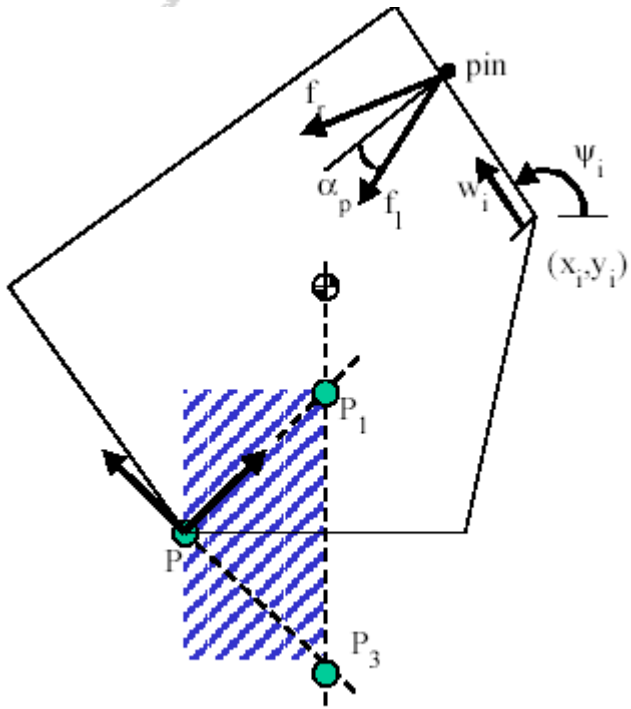
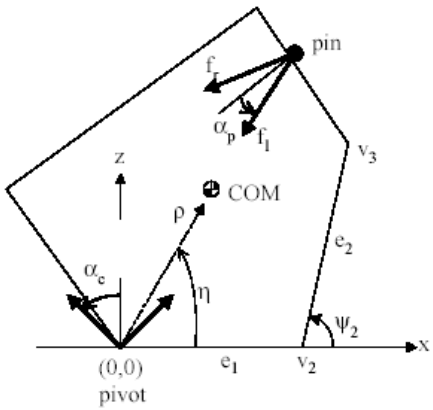
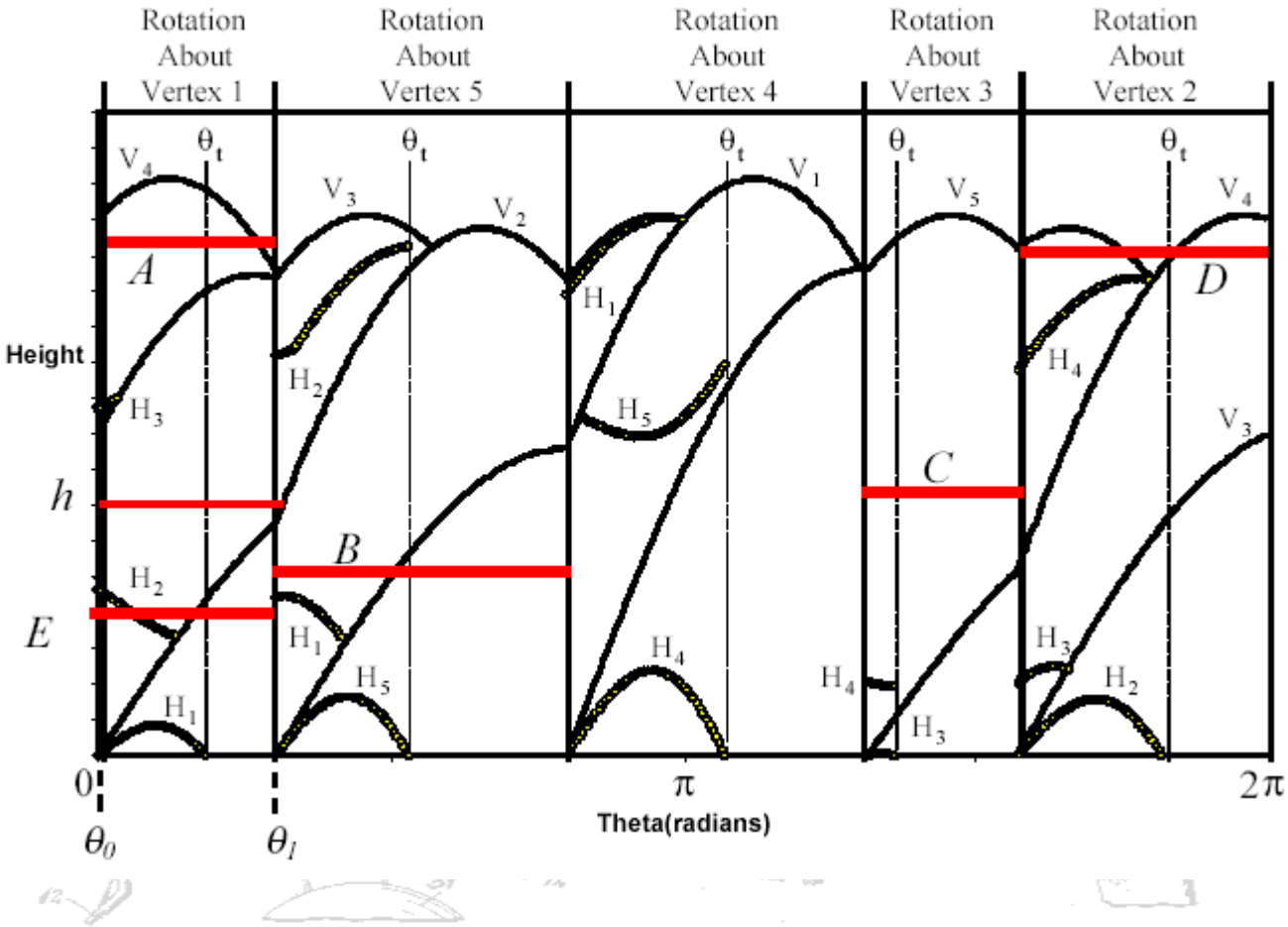


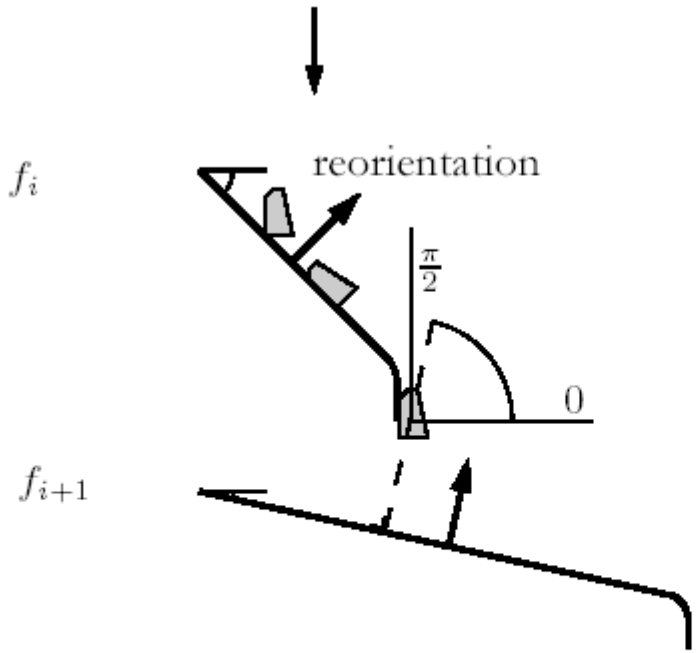
Figure 5. Conditions for the rolling phase.

Conveyor part orientation - pins





Conveyor part orientation - fences



(a)

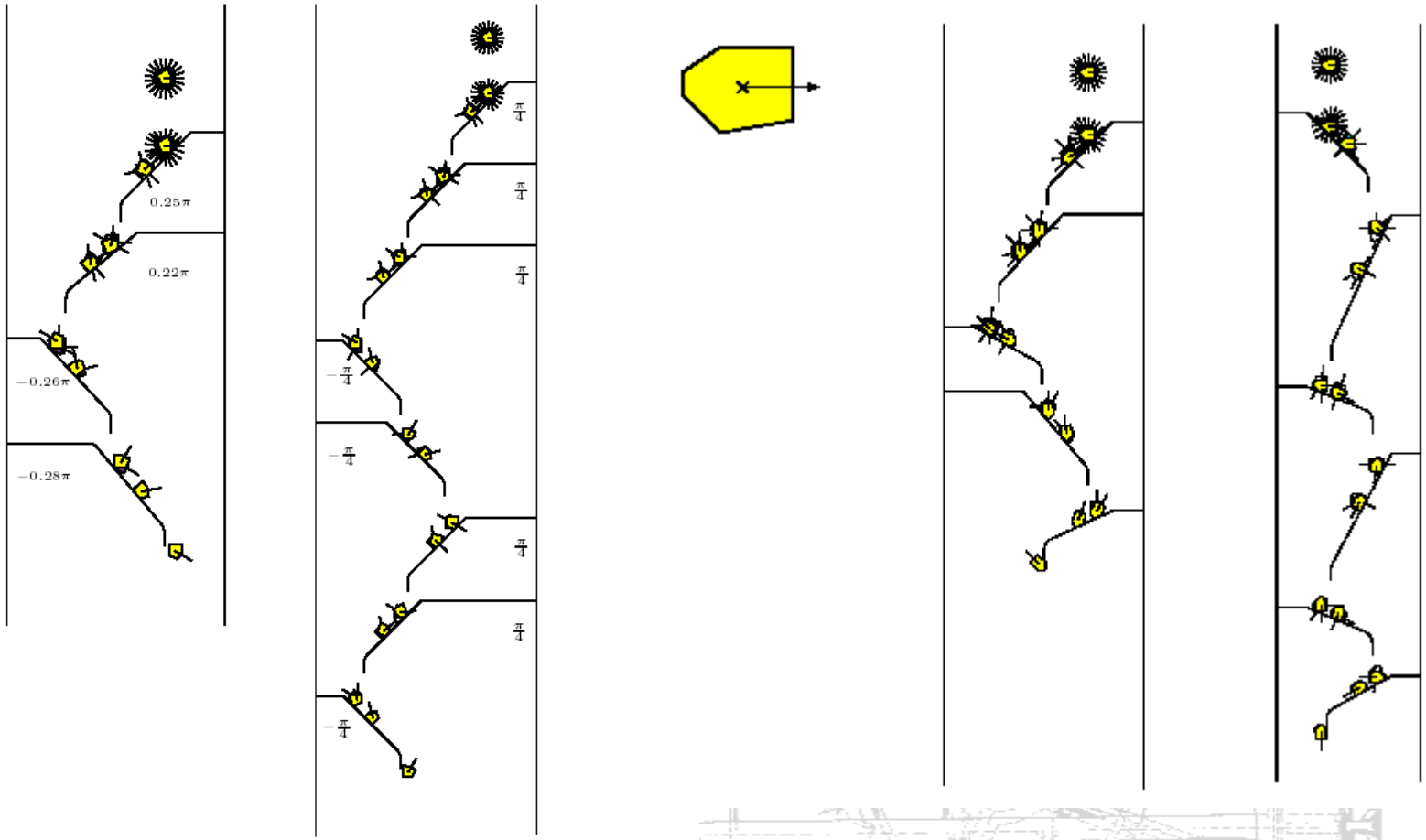
t_i	α_{i+1}	t_{i+1}
left	$(0, \pi/2)$	left
left	$(\pi/2, \pi)$	right
right	$(-\pi, -\pi/2)$	left
right	$(-\pi/2, 0)$	right

(b)

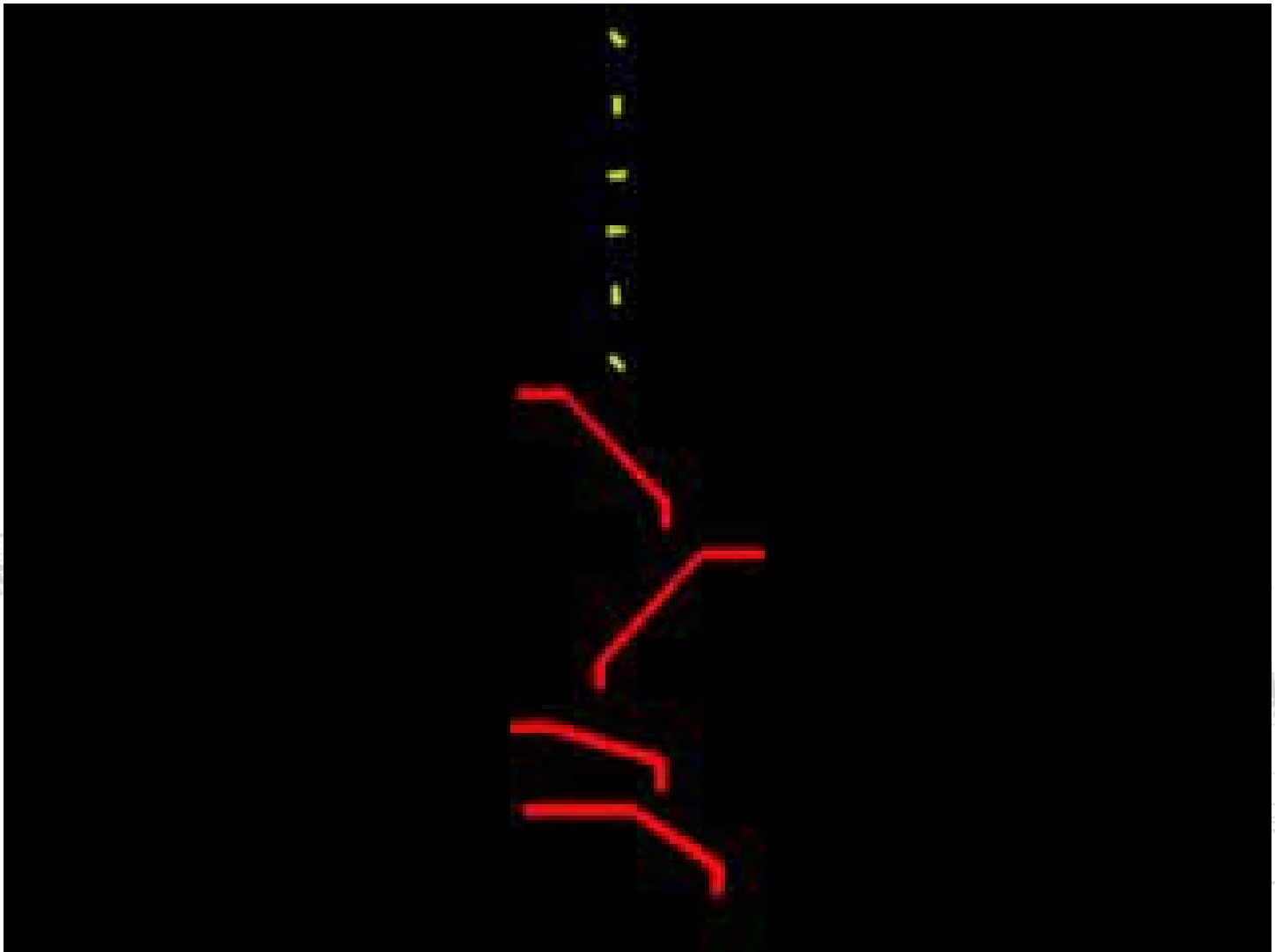
Figure 3.2 (a) For two successive left fences, the reorientation of the push direction lies in the range $(0, \pi/2)$. (b) The ranges op possible reorientations of the push direction for all pairs of fence types.

- Any polygonal part can be oriented up to symmetry by a fence design

Conveyor part orientation - fences



Conveyor part orientation - fences



Conveyor part orienting - 3D parts

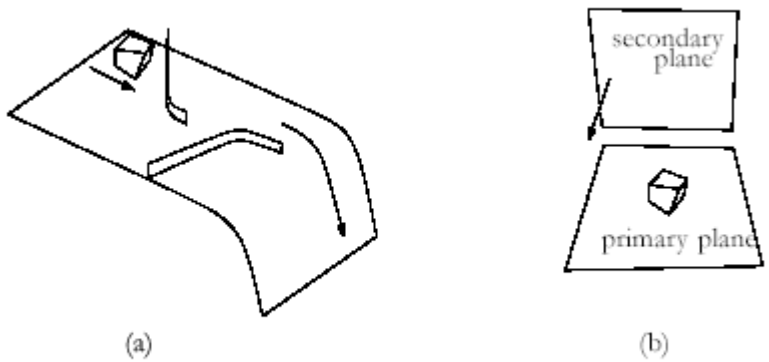
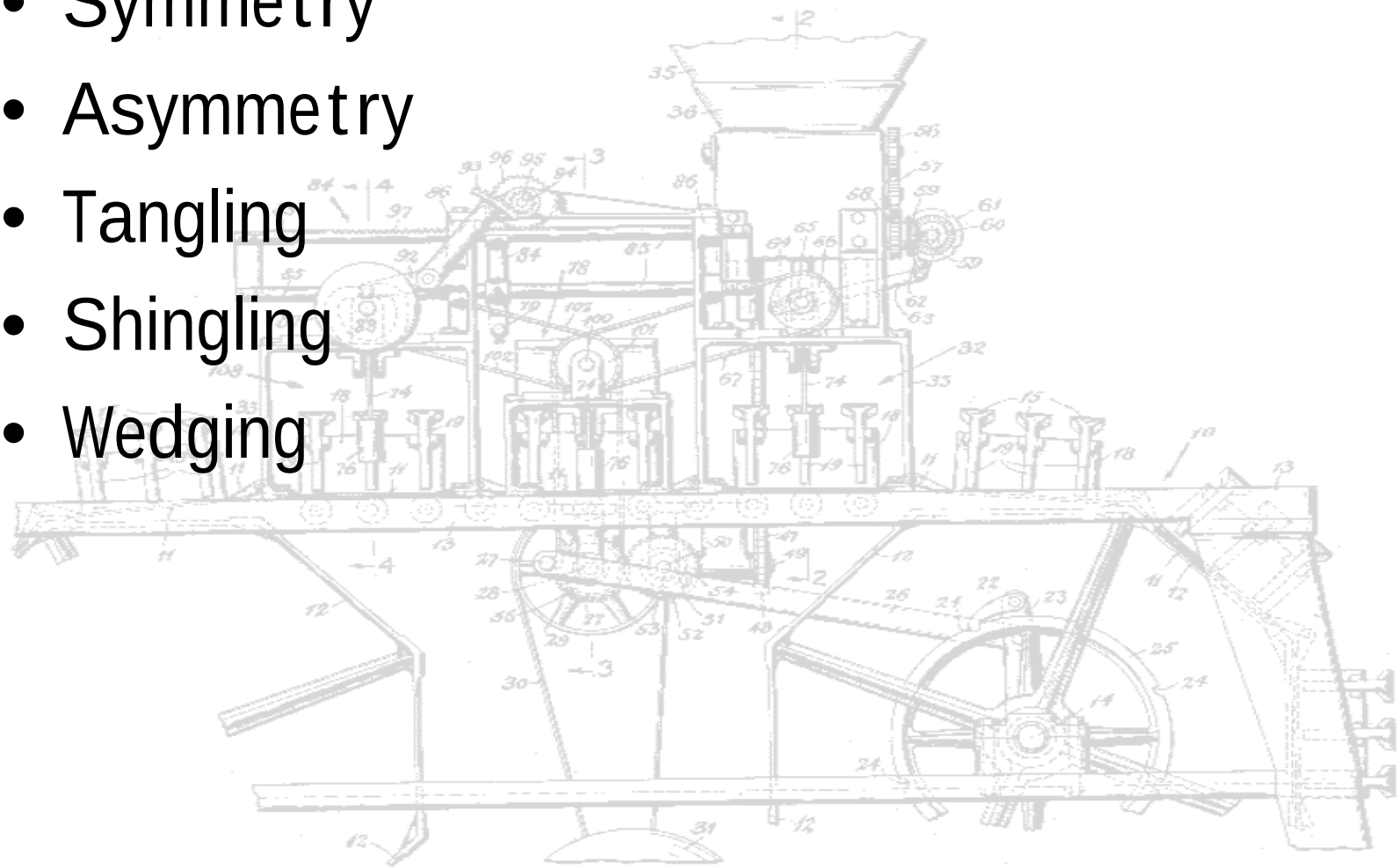


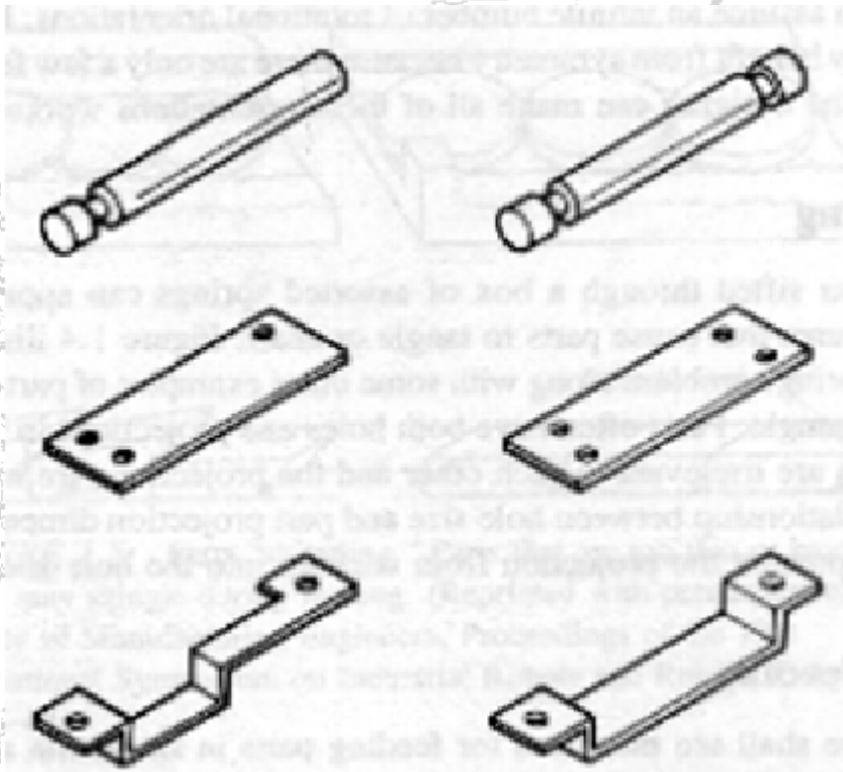
Figure 5.3 (a) A part sliding down a plate with fences. (b) The same part on the jaw.

Designing Parts for Feeding

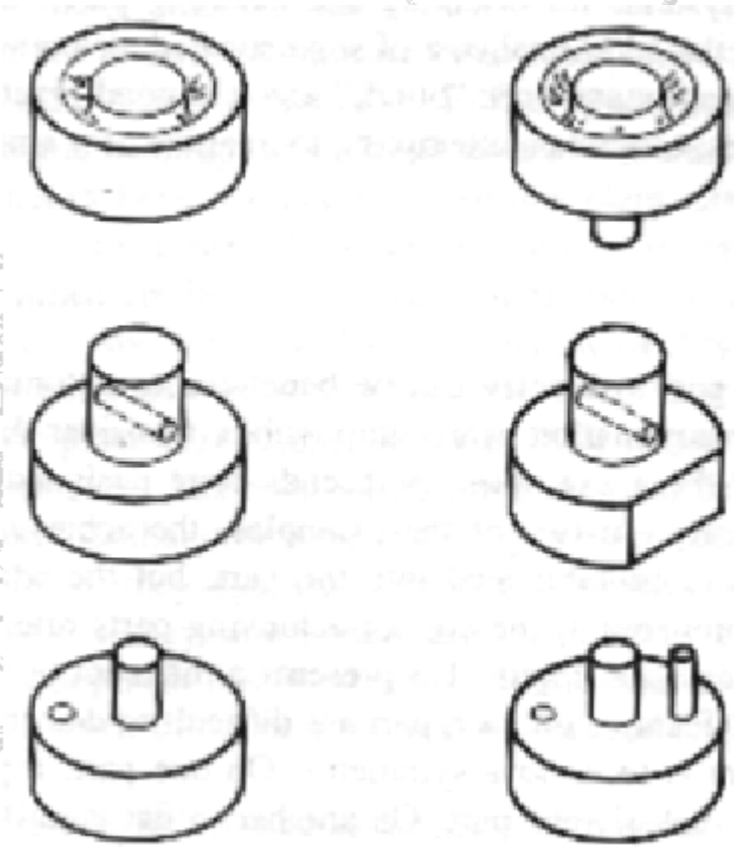
- Symmetry
- Asymmetry
- Tangling
- Shingling
- Wedging



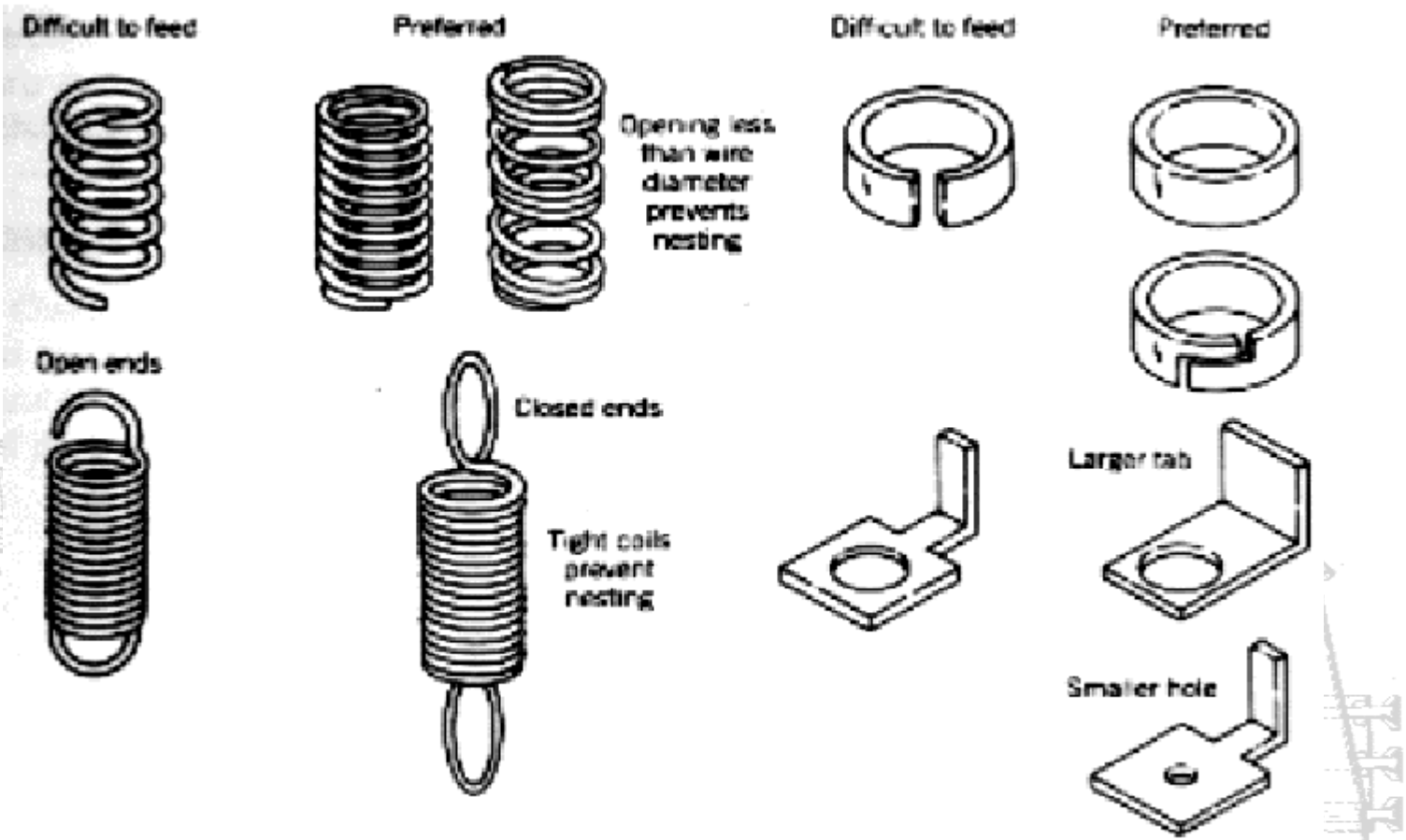
Symmetry



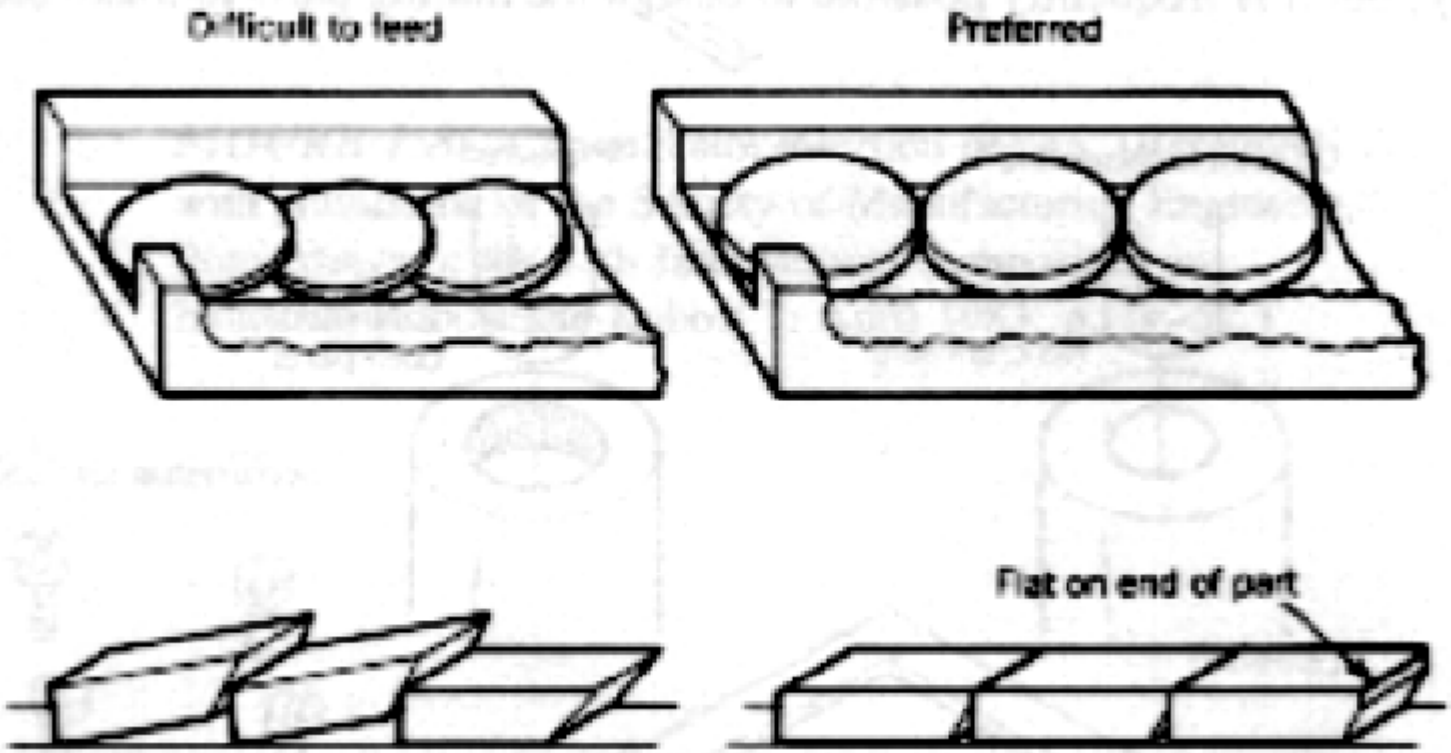
Asymmetry



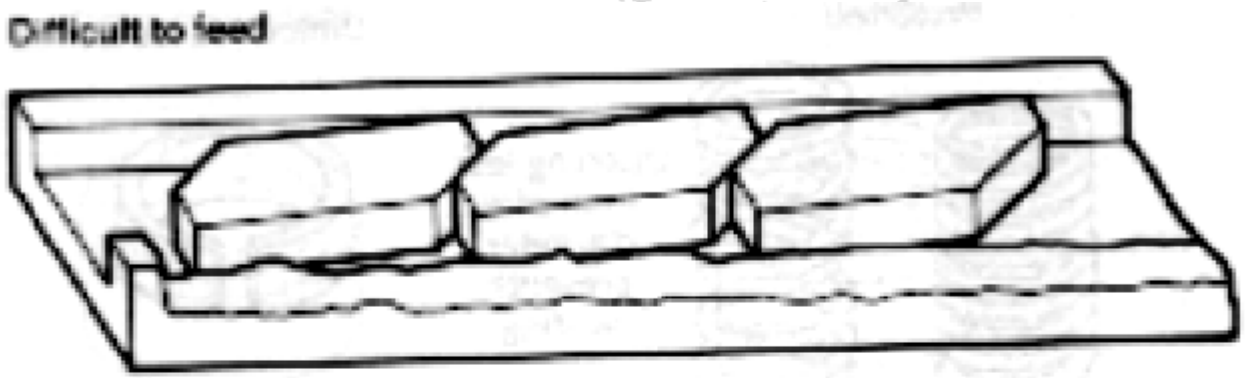
Tangling

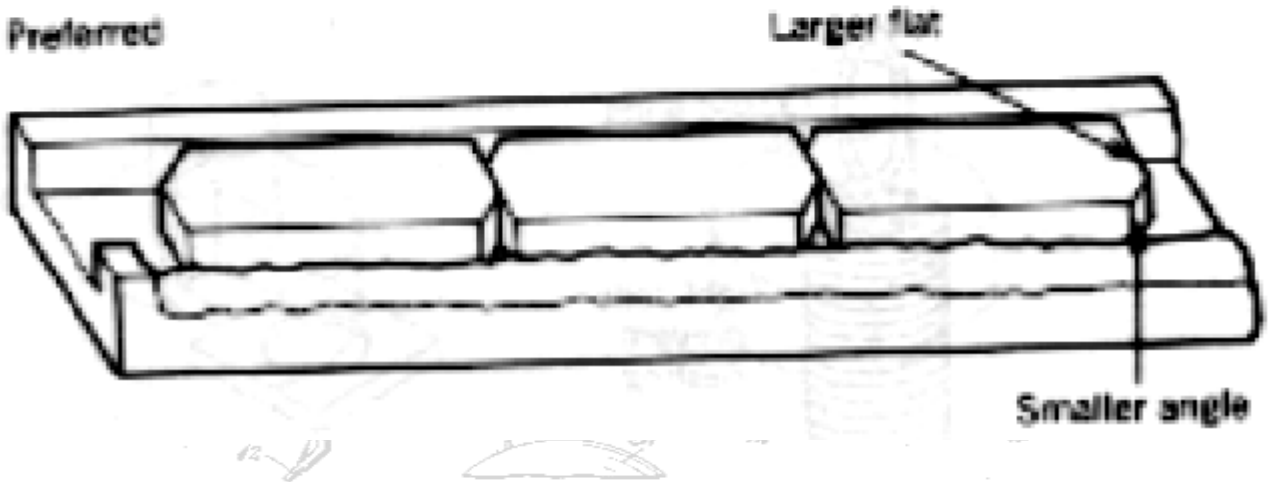

Difficult to feed
Preferred
Opening less than wire diameter prevents nesting
Difficult to feed
Preferred
Open ends
Closed ends
Tight coils prevent nesting
Larger tab
Smaller hole

Shingling



Wedging





Designing for Insertion