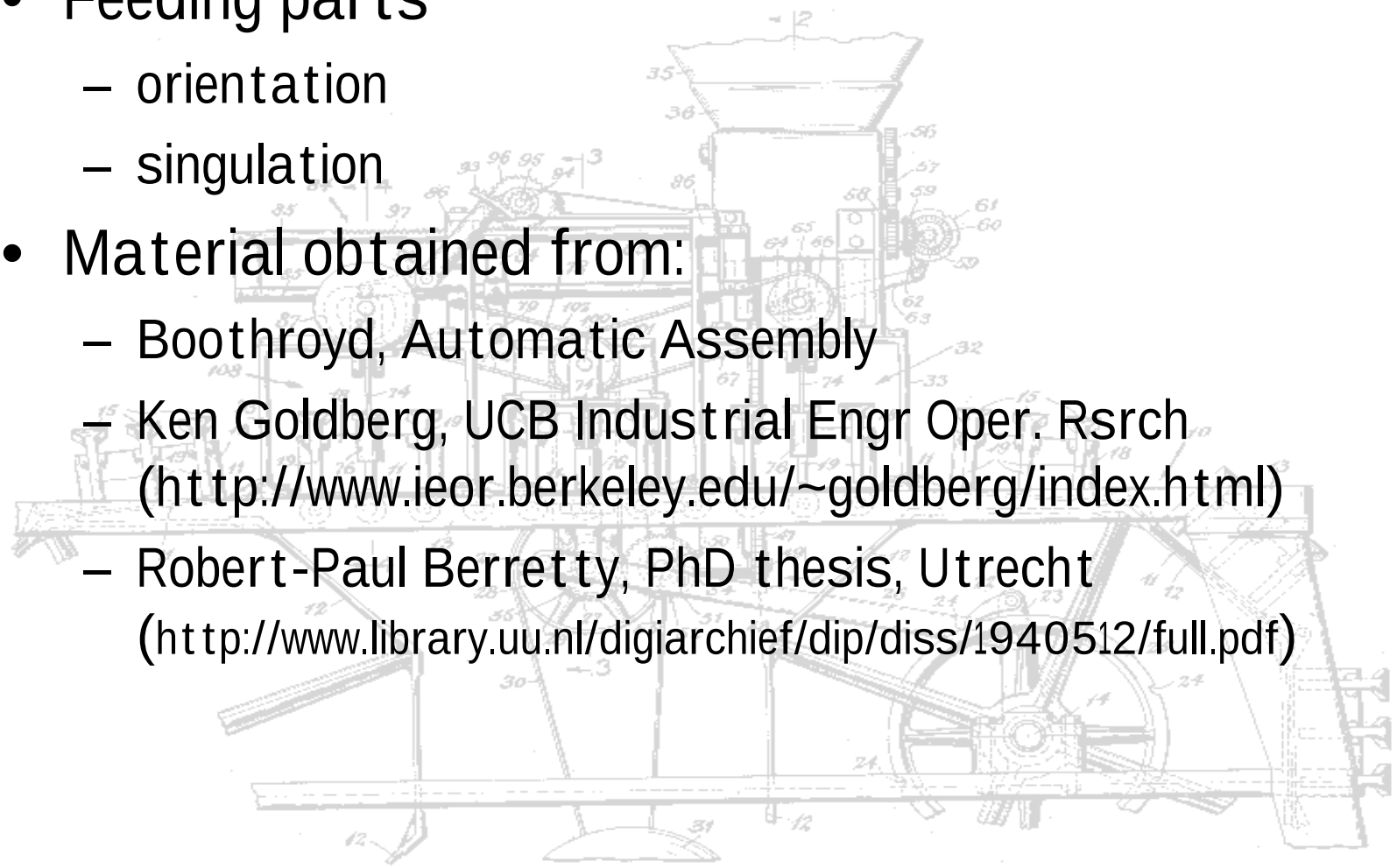
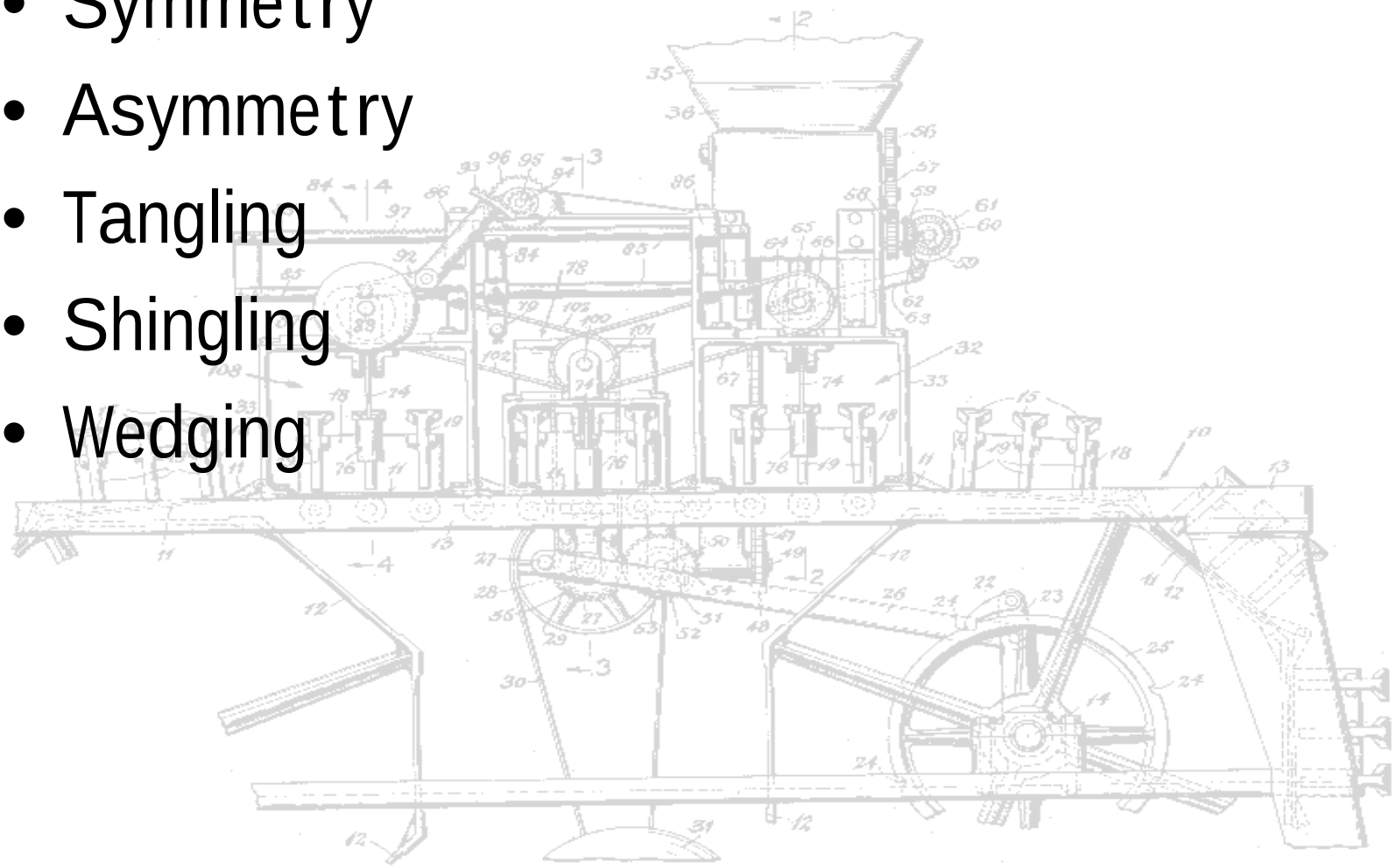
Care & Feeding of Machines

- Feeding parts
  - orientation
  - singulation
- 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)

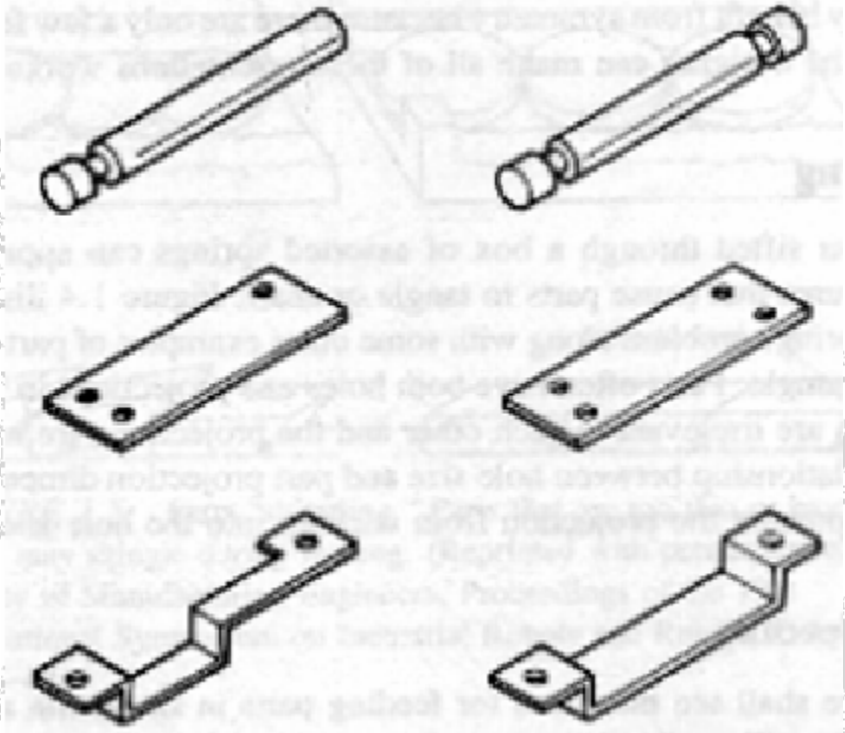


Designing Parts for Feeding

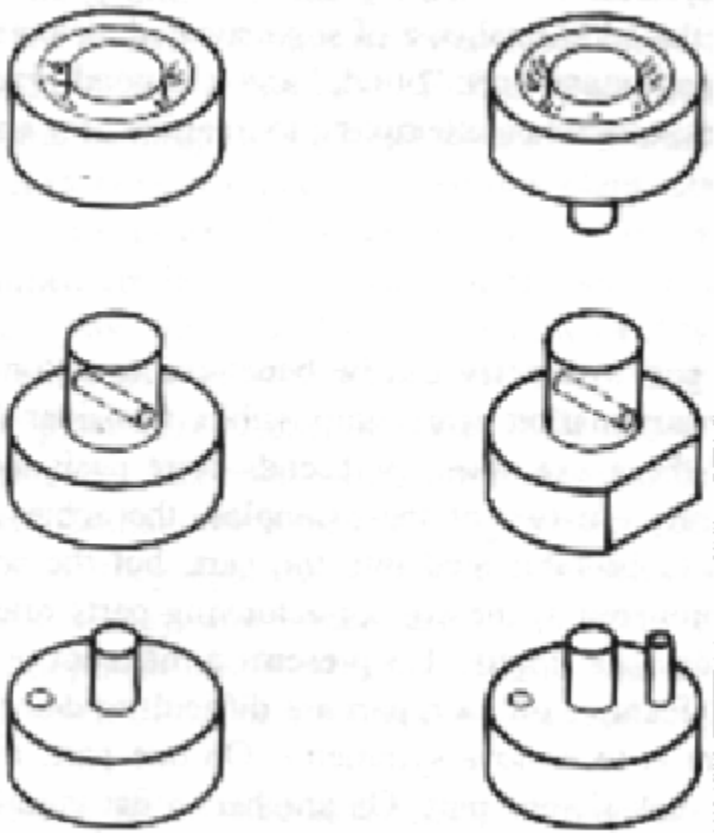
- Symmetry
- Asymmetry
- Tangling
- Shingling
- Wedging



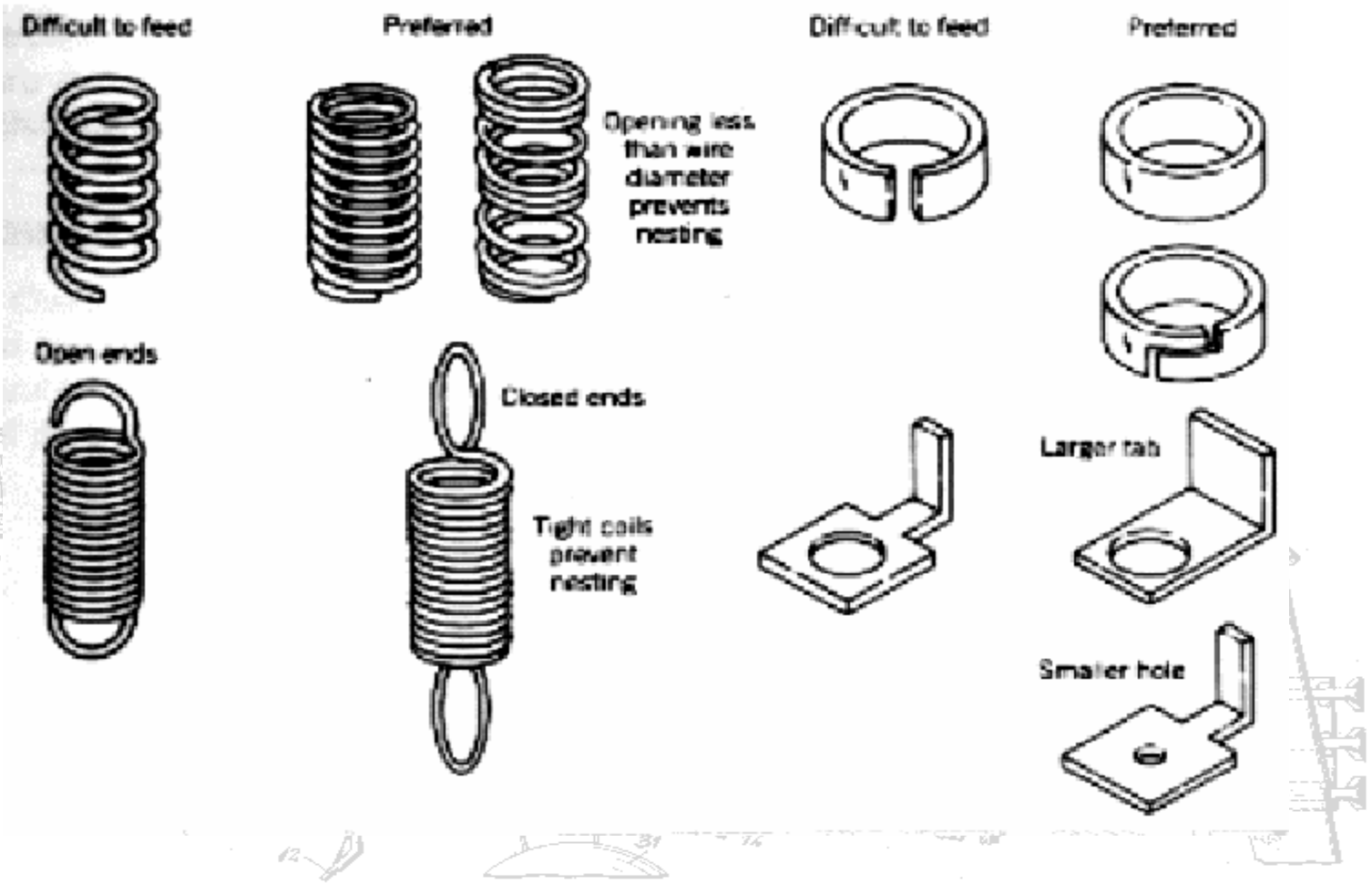
Symmetry



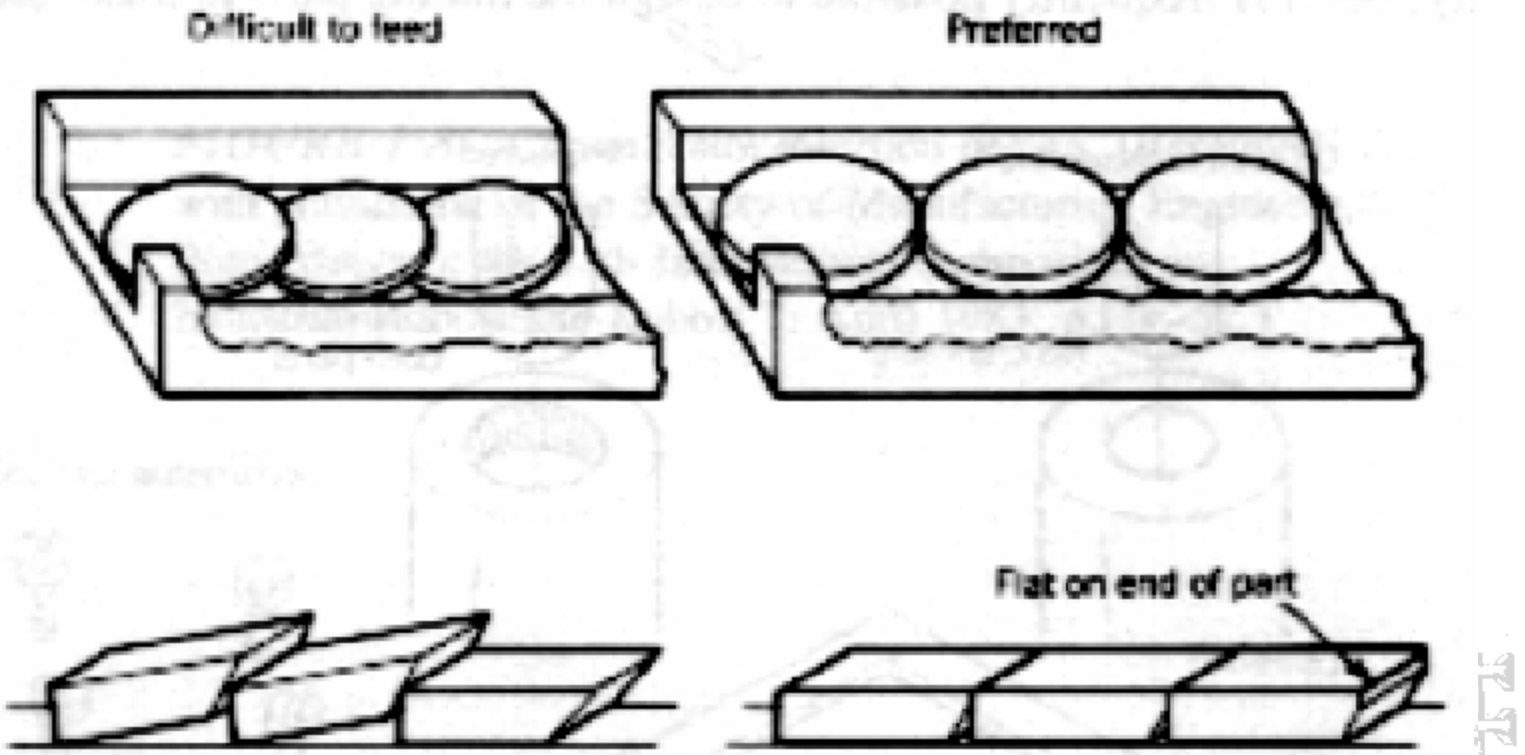
Asymmetry



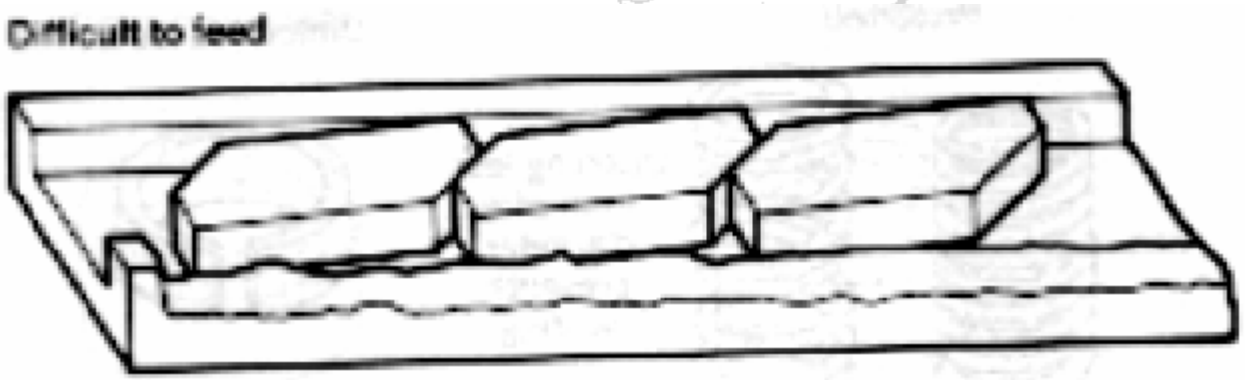
Tangling

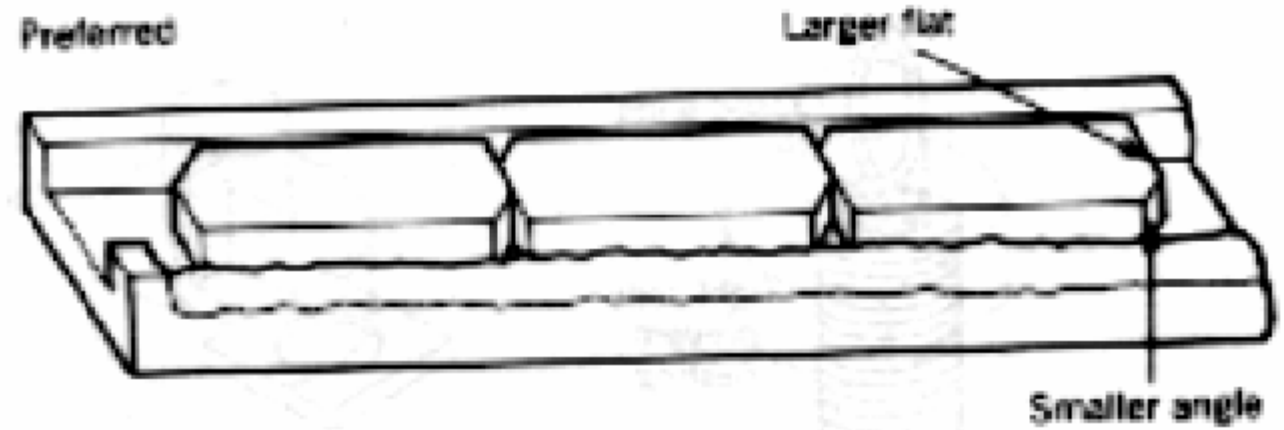

Difficult to feed
Preferred
Opening less than wire diameter prevents nesting
Open ends
Closed ends
Tight coils prevent nesting
Difficult to feed
Preferred
Larger tab
Smaller hole

Shingling

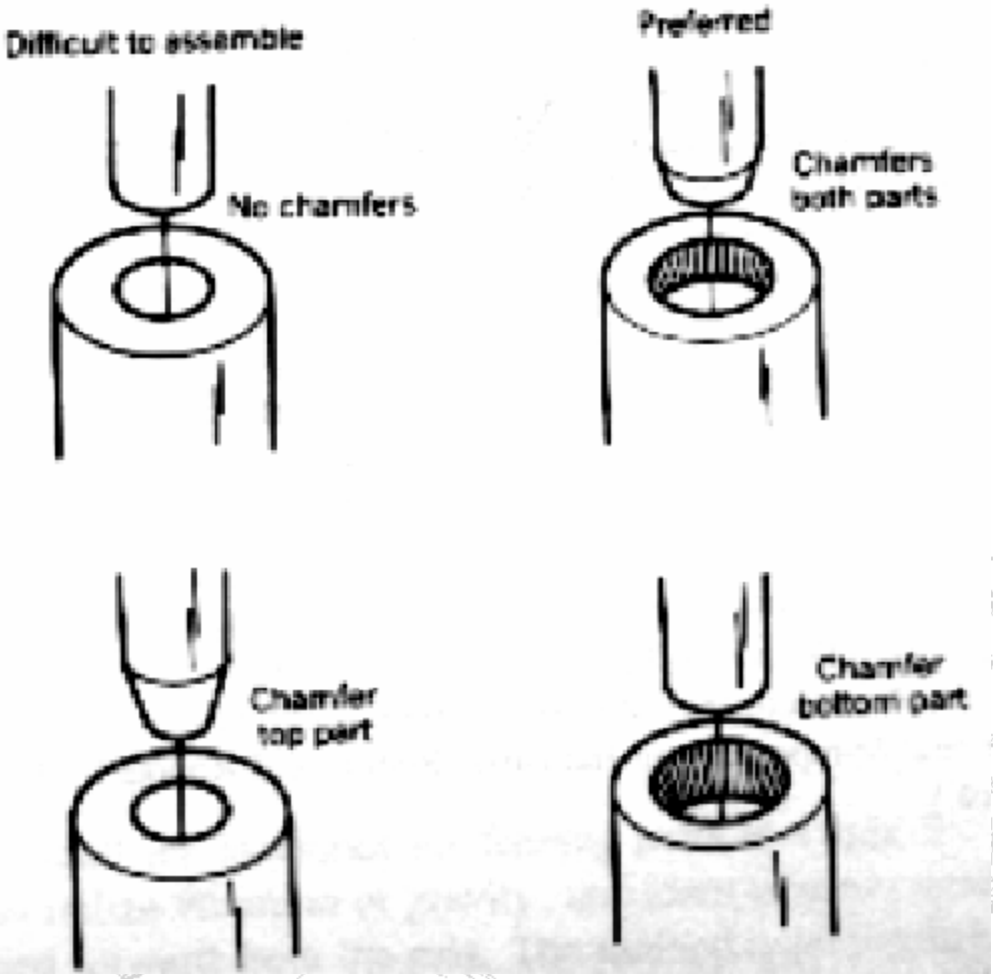


Wedging

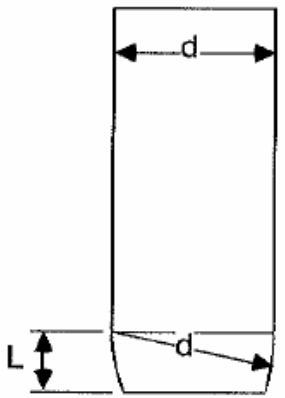


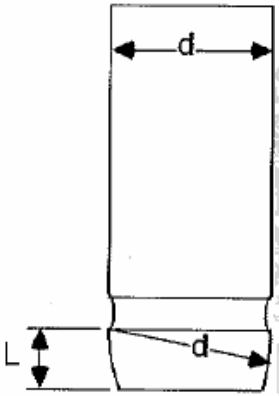


Designing for Insertion



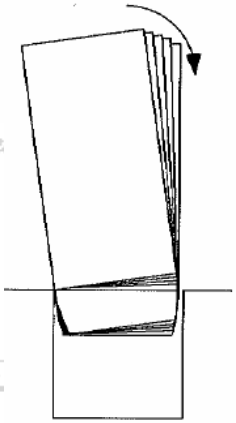
Inserting Pegs in Round Holes

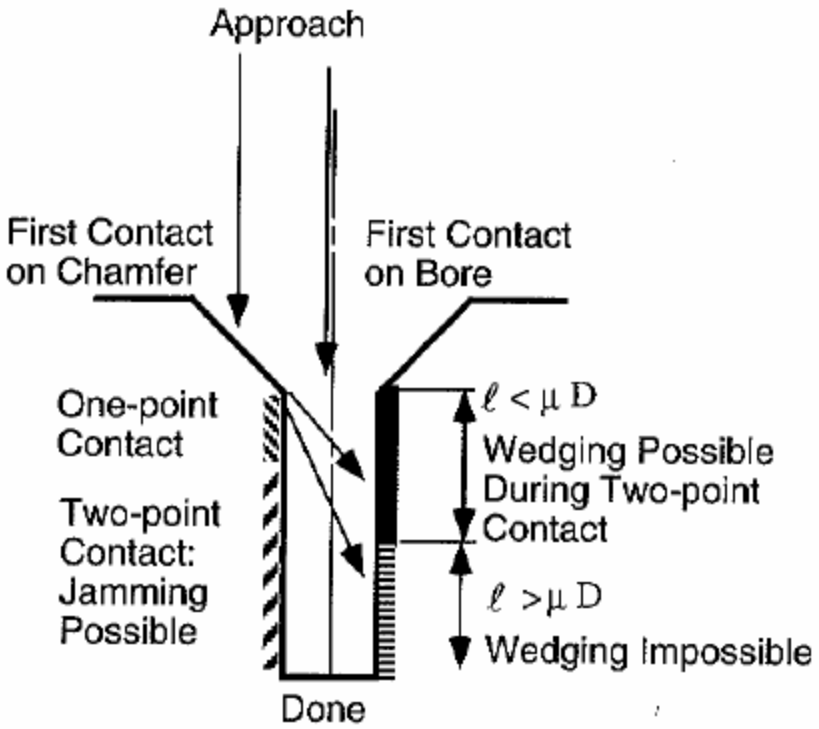




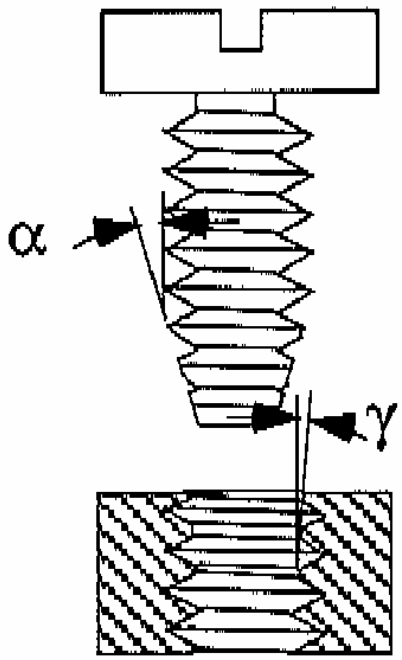
d = Diameter of Peg

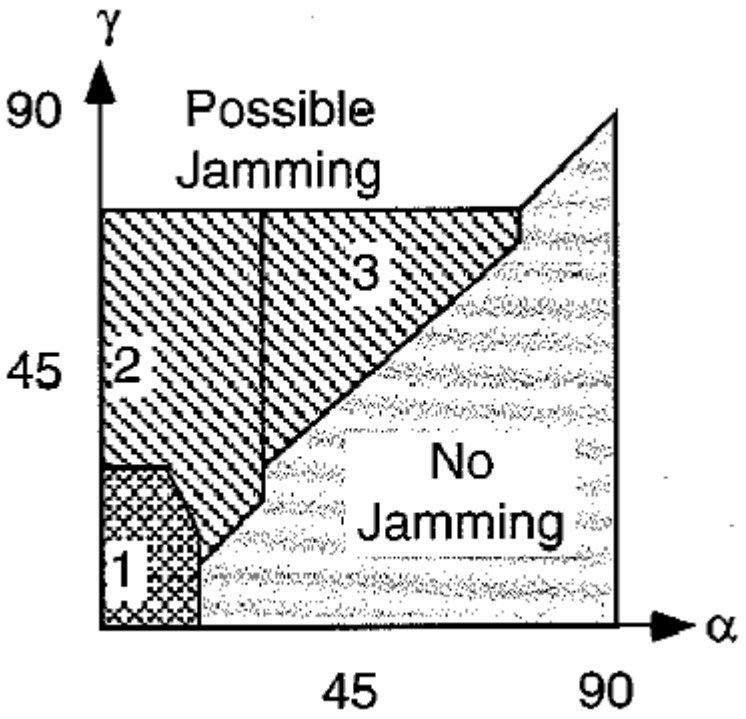
L > Wedging Depth = μd



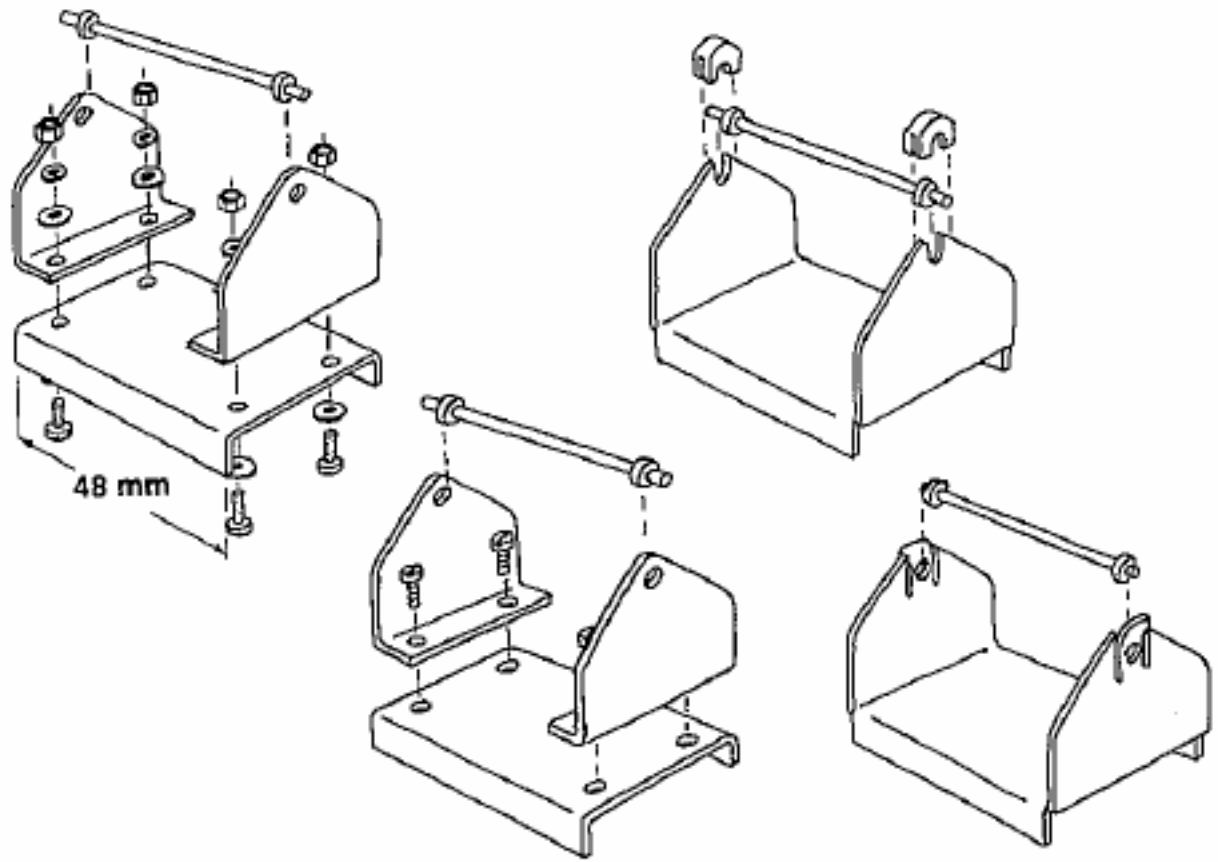


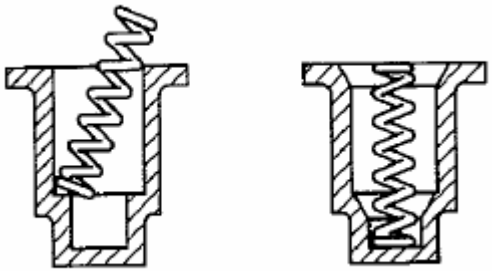
Screw Thread Mating





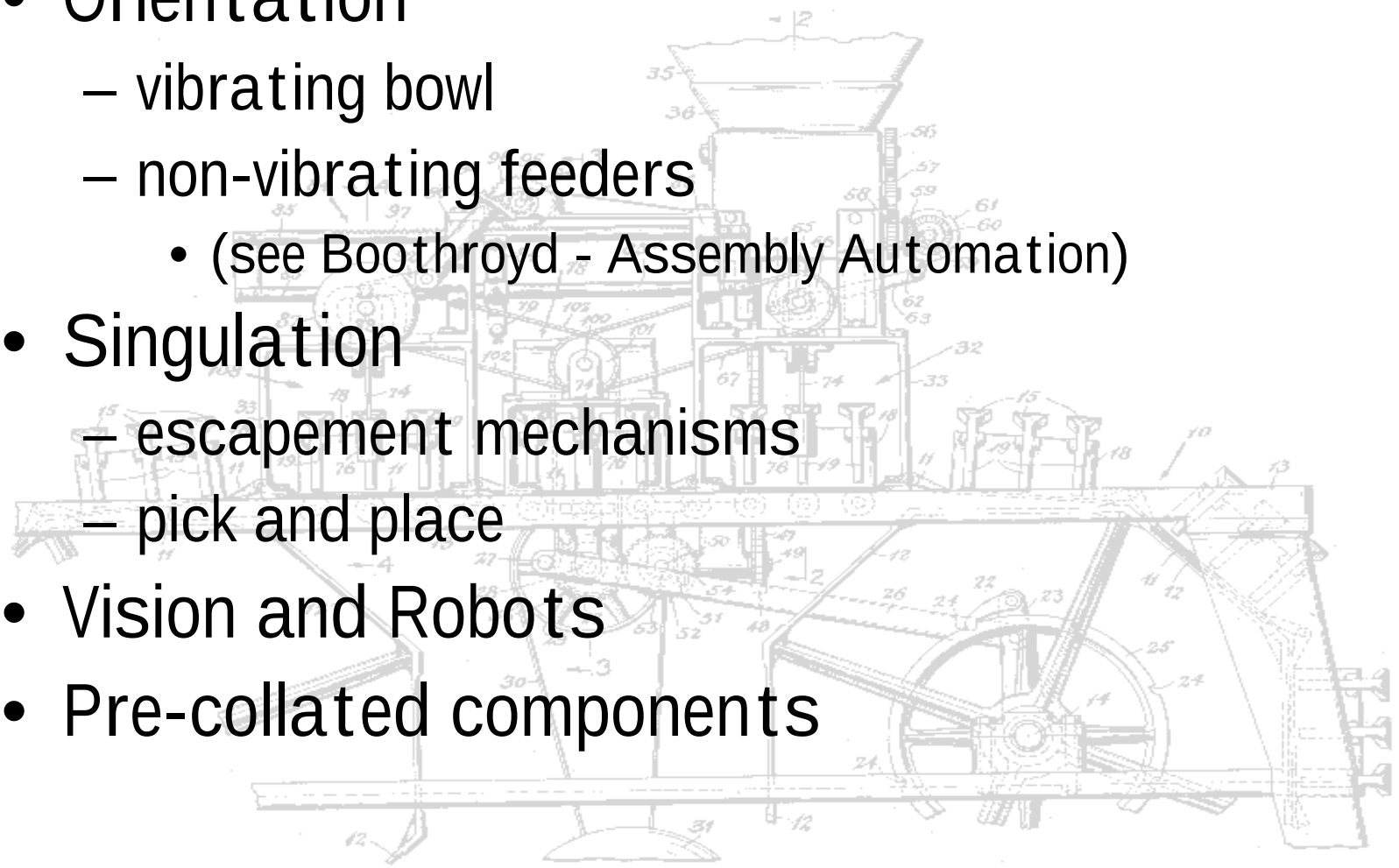
Simplifying the Design





Fastener Feeding Requirements

- Orientation
  - vibrating bowl
  - non-vibrating feeders
    - (see Boothroyd - Assembly Automation)
- Singulation
  - escapement mechanisms
  - pick and place
- Vision and Robots
- Pre-collated components



Singulation

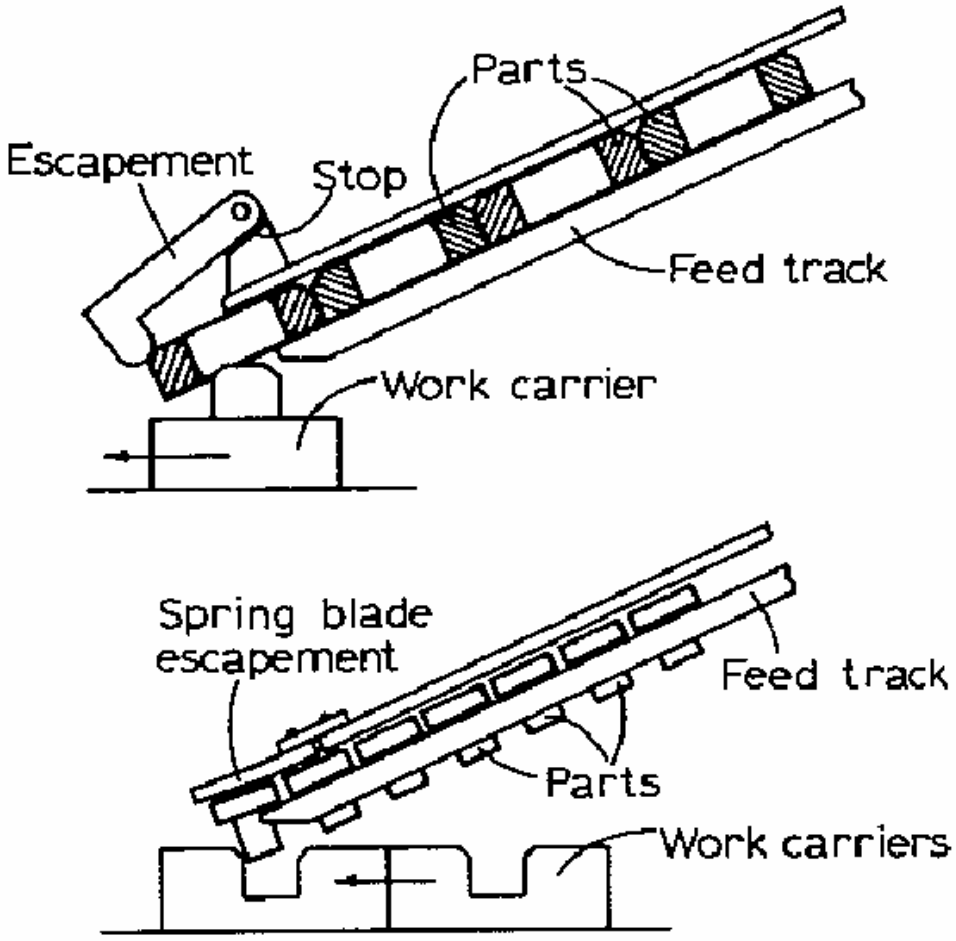


Fig. 5.24 Escapements actuated by the work carrier.

Singulation

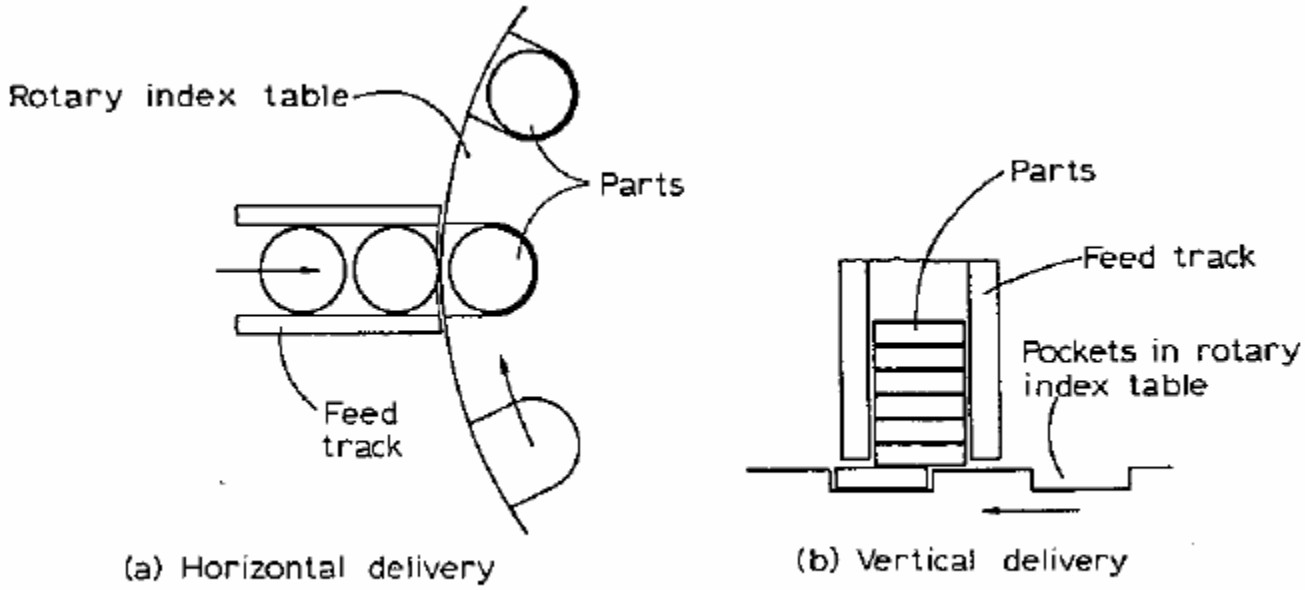


Fig. 5.25 Feeding of parts onto rotary index table.

Singulation

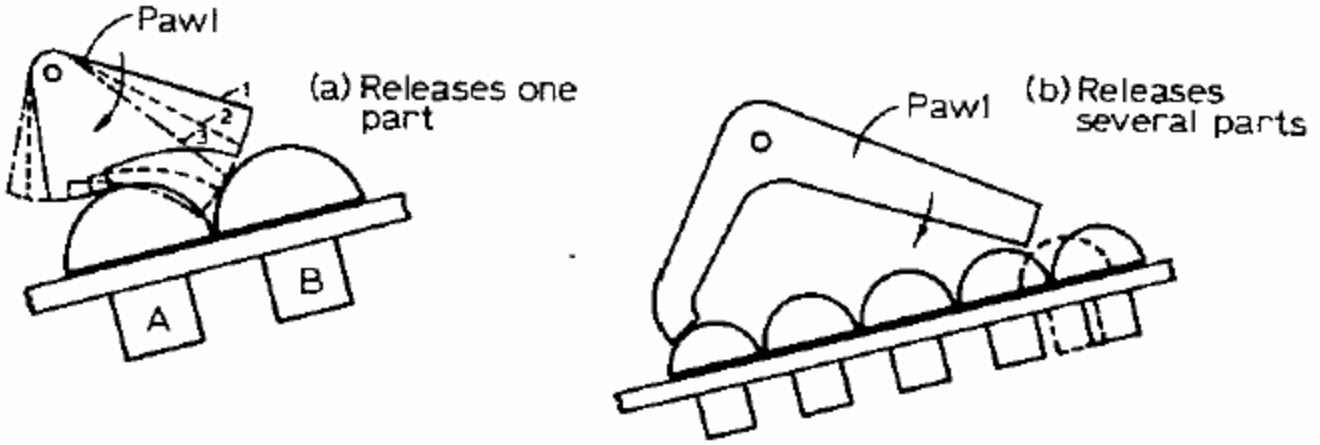


Fig. 5.26 Rachet escapements operated by rotary motion.

Singulation

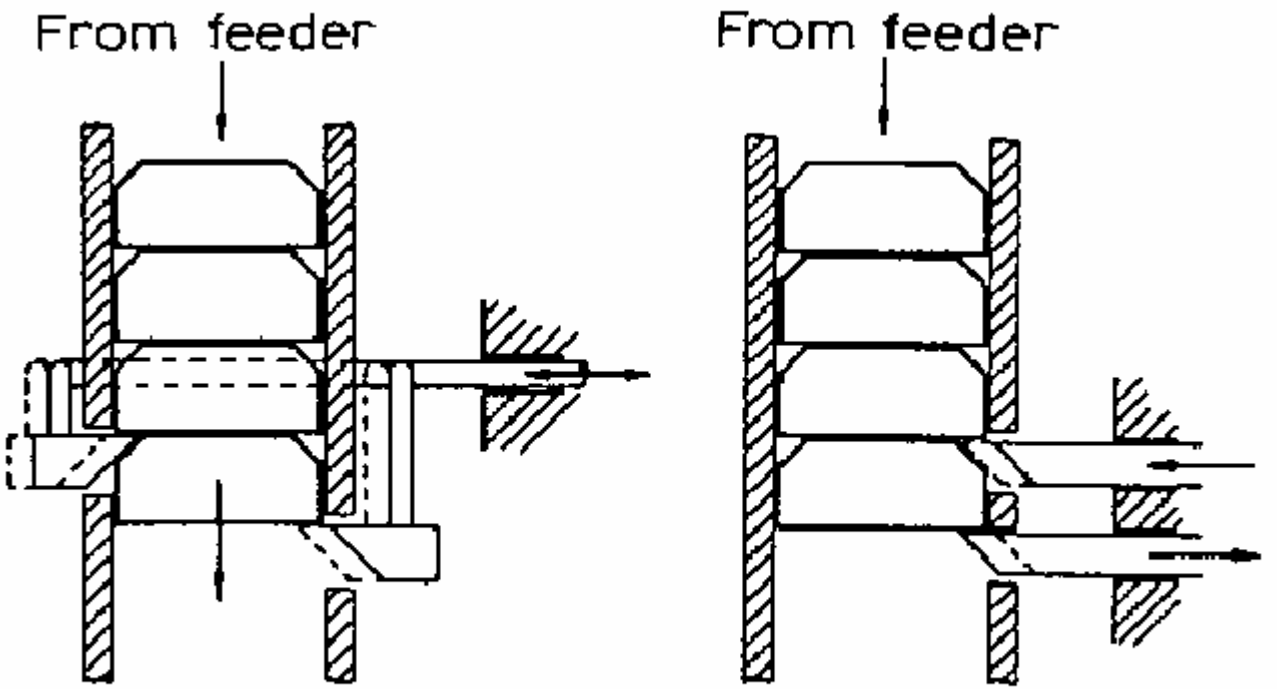
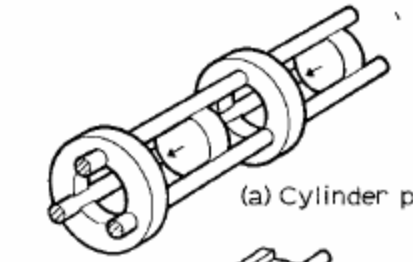
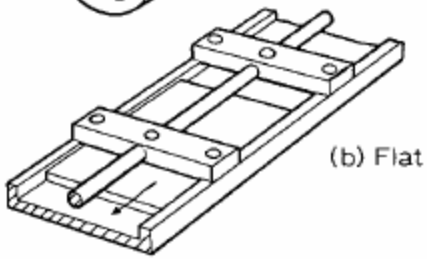


Fig. 5.27 Ratchet escapements operated by linear motion.

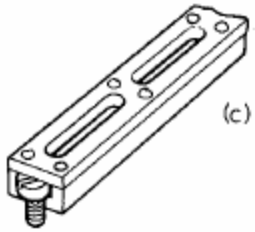
Gravity Feeders



(a) Cylinder part



(b) Flat parts

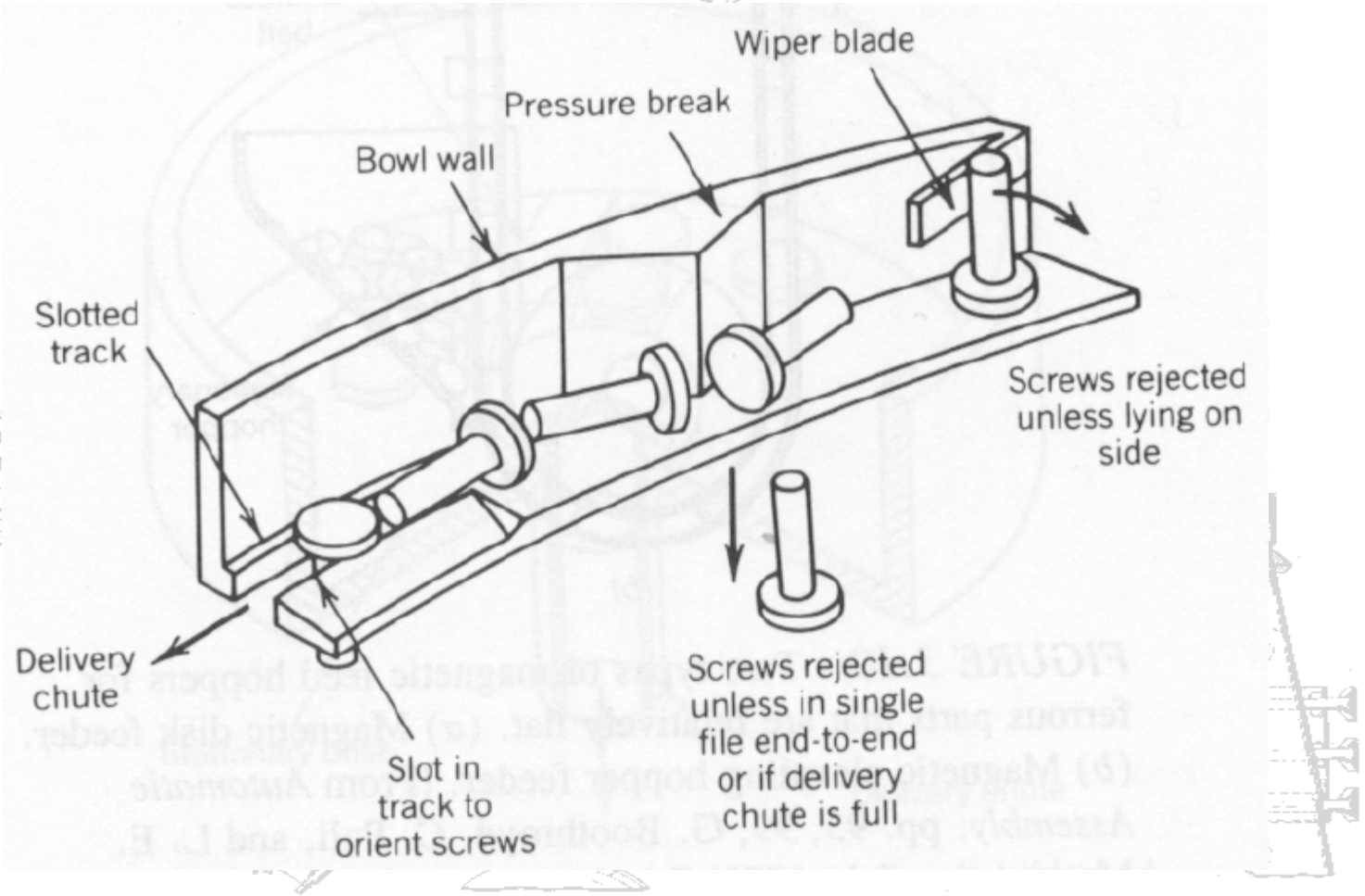


(c) Screws

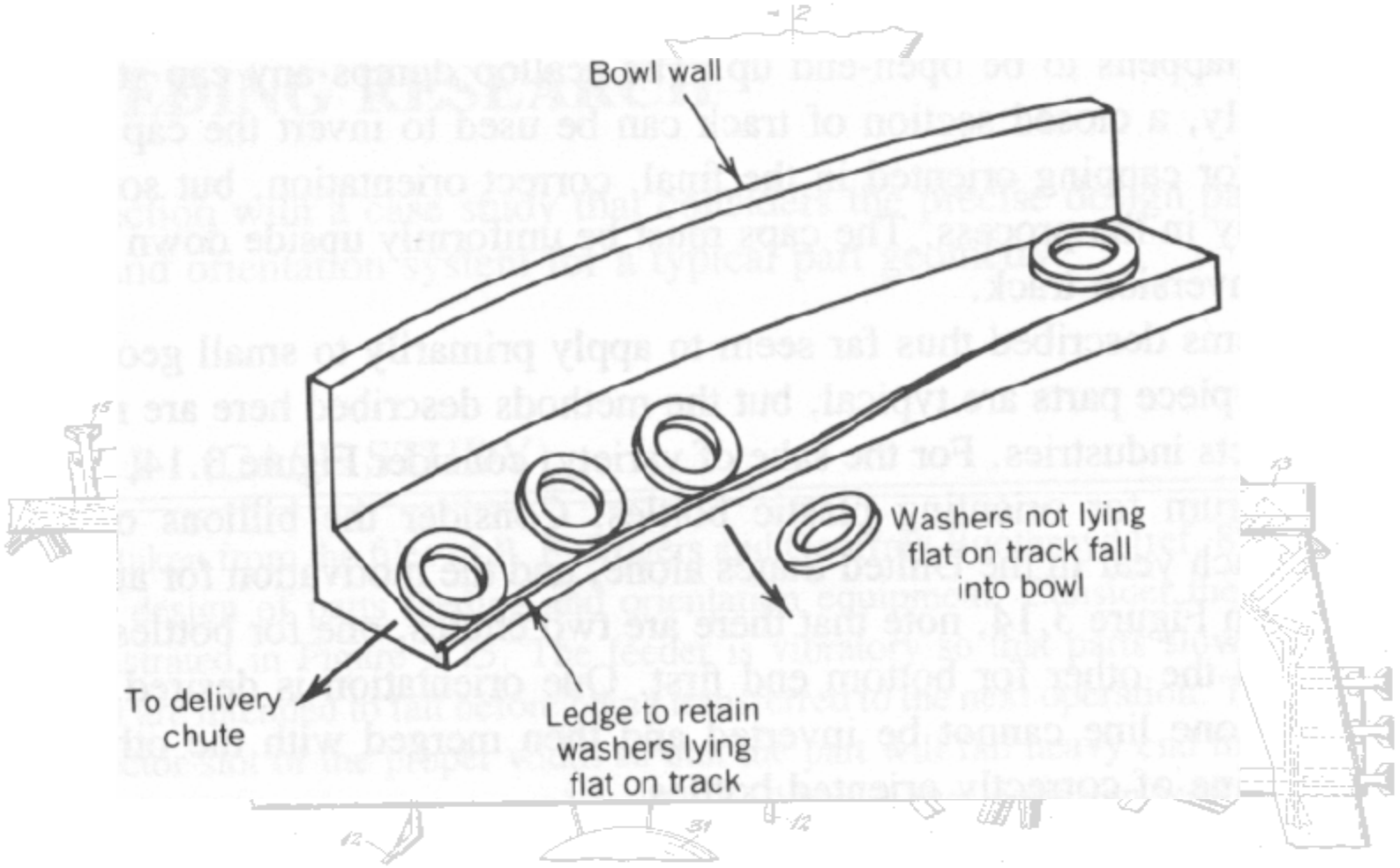
Bowl Feeders

Bowl Feeders

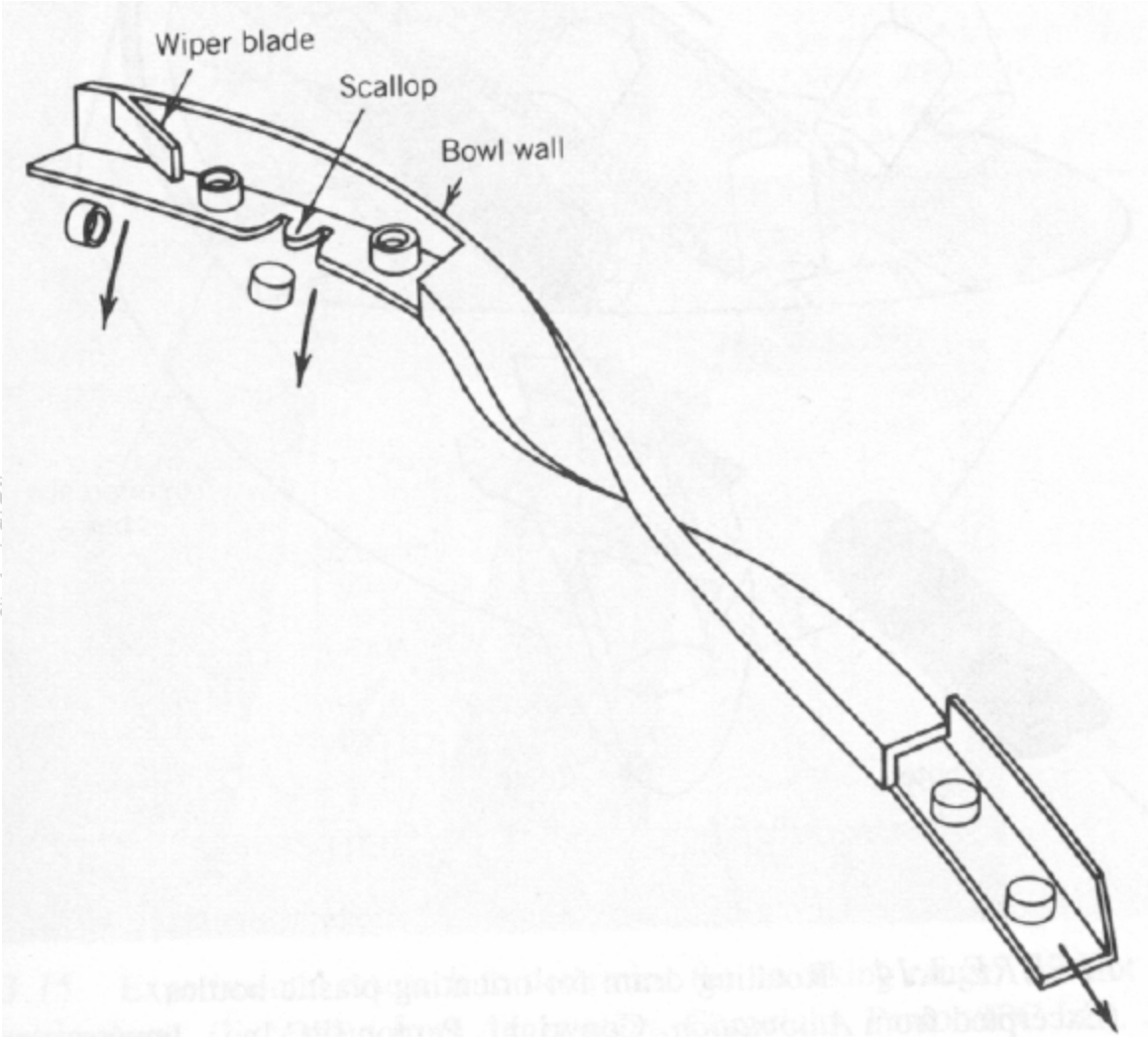
Bowl Feeders



Bowl Feeders



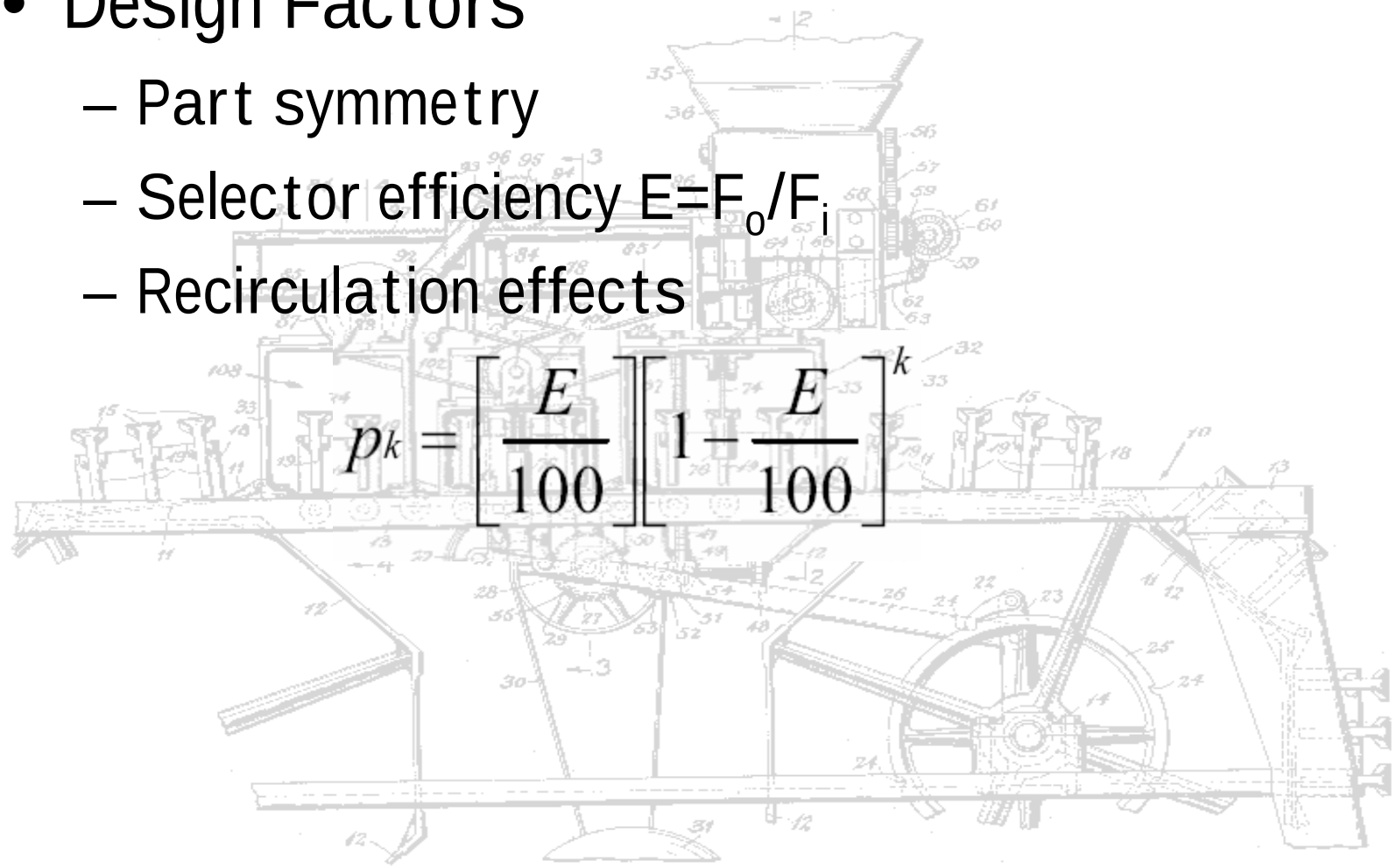
Bowl Feeders



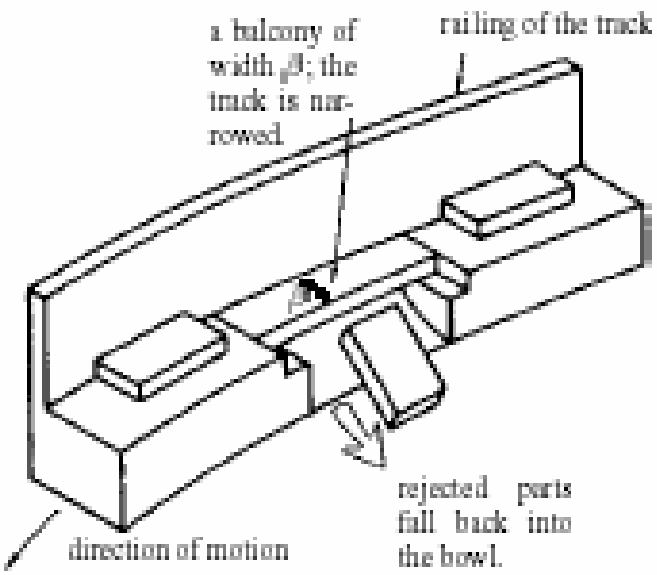
Bowl Feeders

- 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



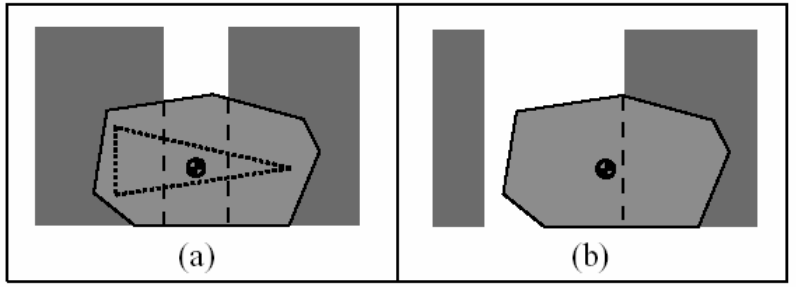


Figure 2: (a) A safe pose. The triangle is evidence of safeness. (b) An unsafe pose of the same part above a different trap.

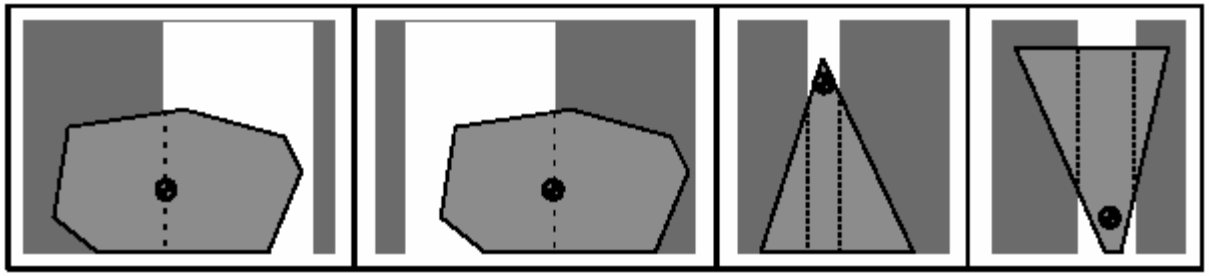


Figure 4: The types of rejected poses.

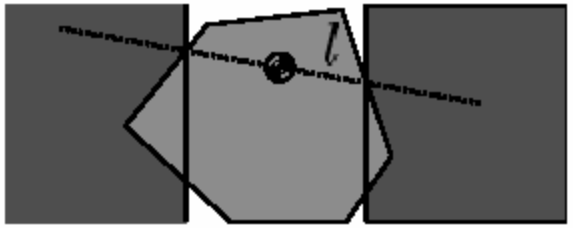
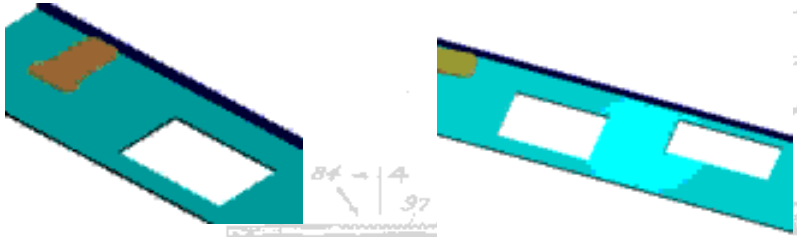
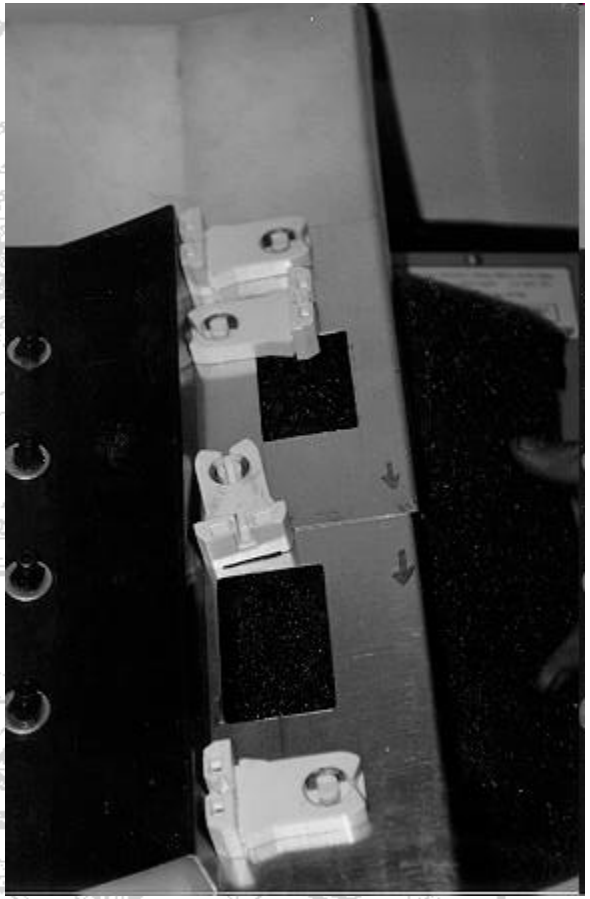


Figure 5: A critical pose.

Bowl Feeders - Trap Design





Non-vibrating Feeders

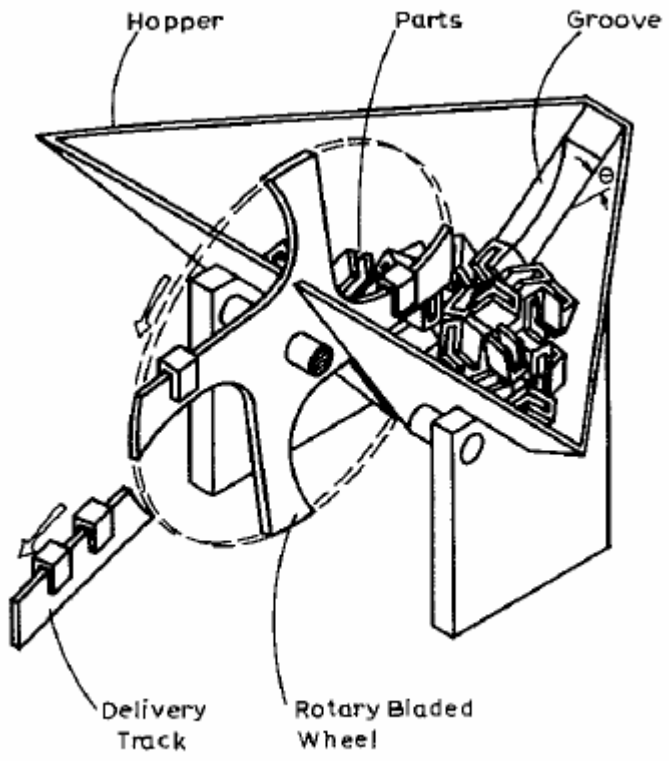
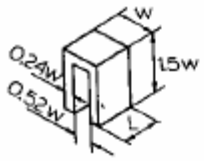
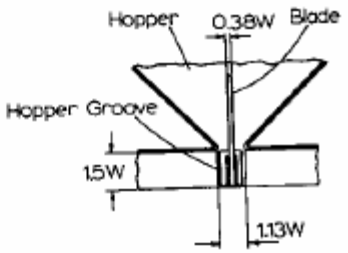
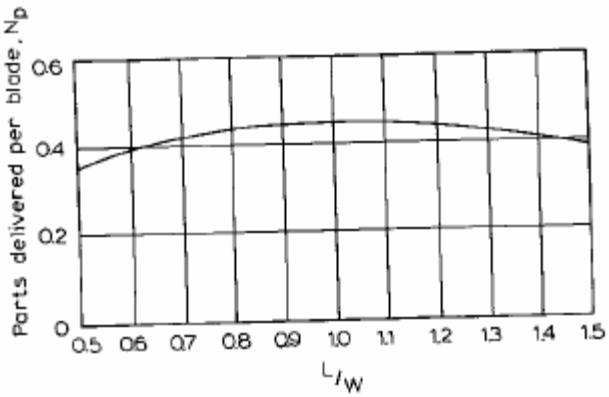


Fig. 4.34 Rotary centerboard hopper.







Non-vibrating Feeders

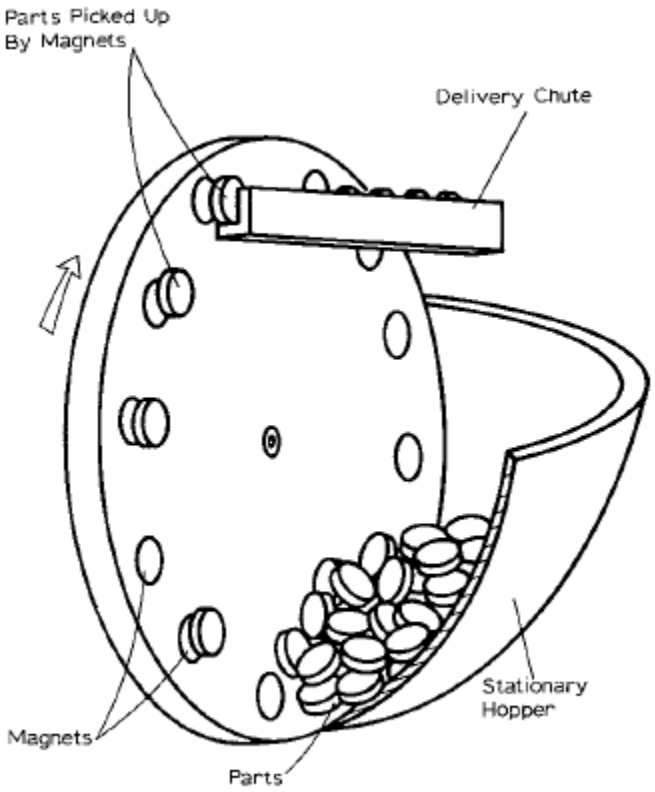
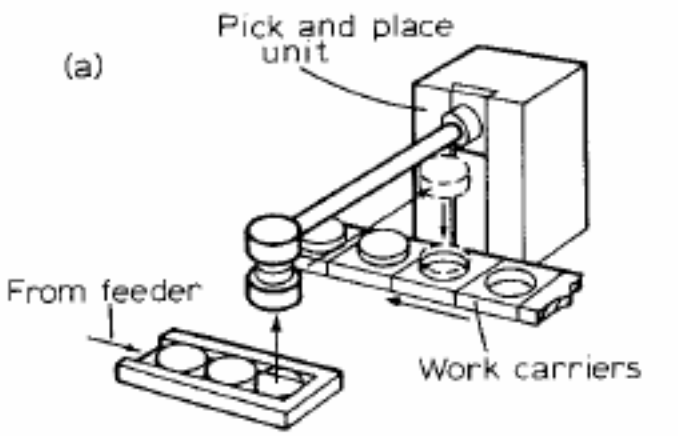
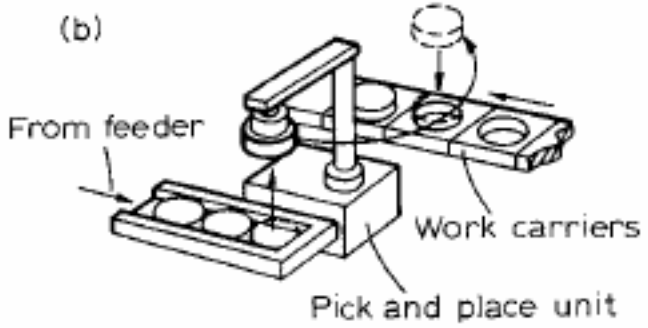
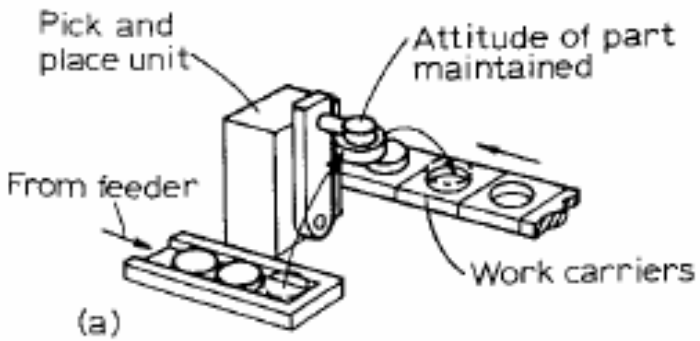


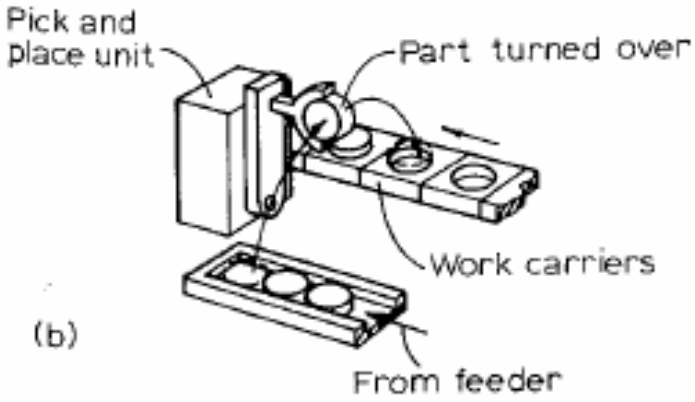
Fig. 4.36 Magnetic-disk feeder.

Pick & Place

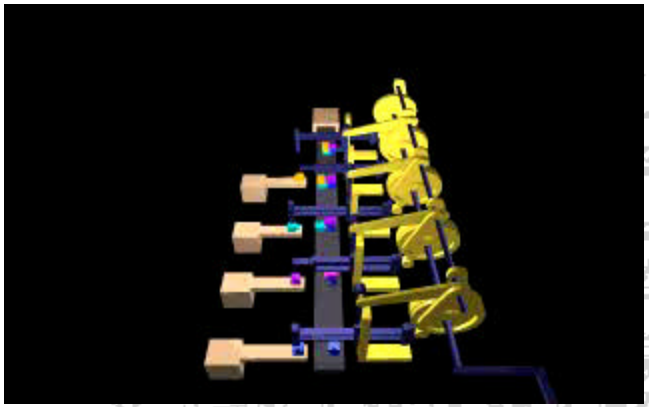

(a)
Pick and place unit
From feeder
Work carriers


(b)
From feeder
Work carriers
Pick and place unit


Pick and place unit
Attitude of part maintained
From feeder
Work carriers
(a)

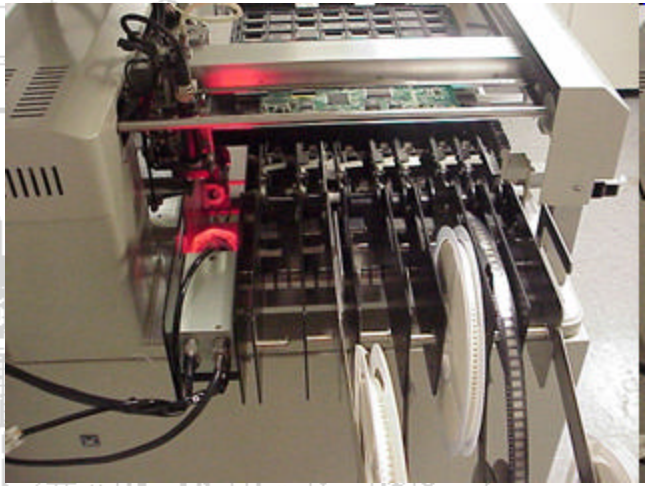

Pick and place unit
Part turned over
Work carriers
(b)
From feeder

Pick & Place

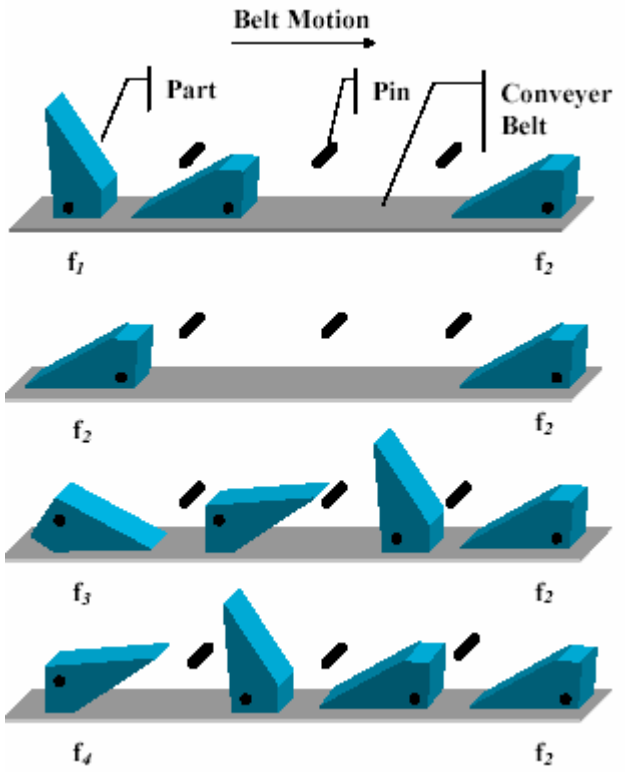


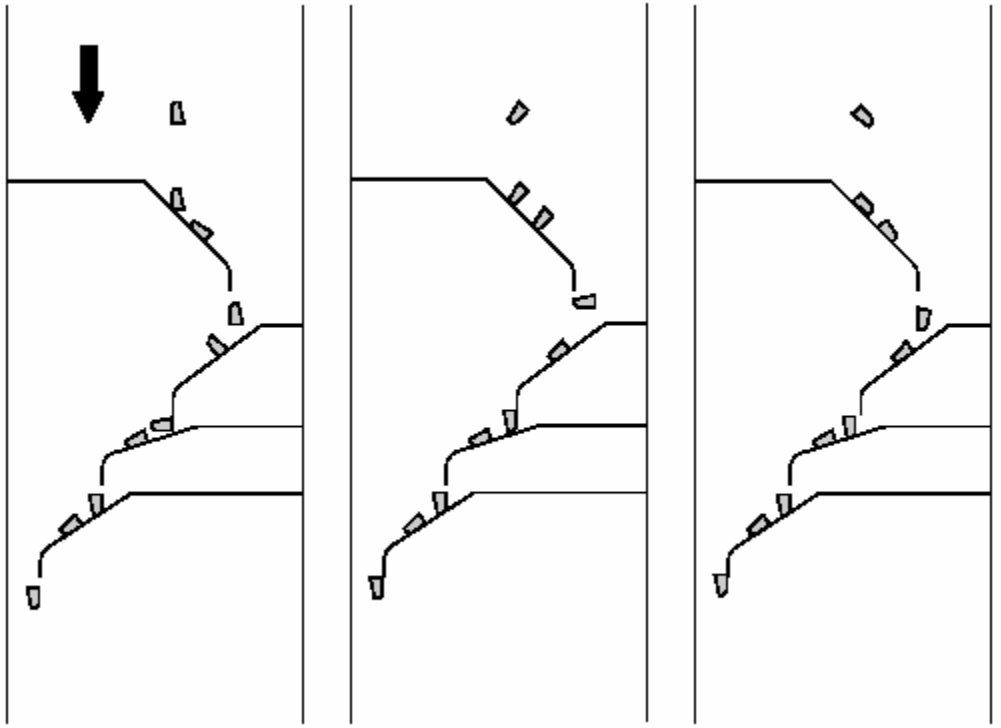

L SERIES
MODEL L60
Board sizes to 13.5 x 32"
& 96 feeder positions

Pre-collated Components



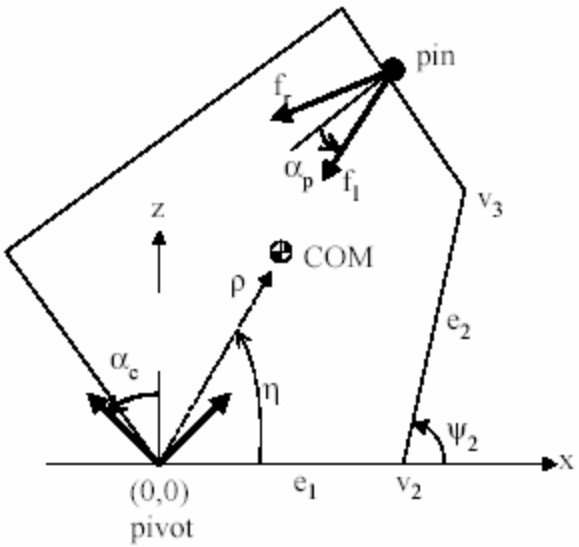
Conveyors





- Orienting with pins or fences

Conveyor part orientation - pins



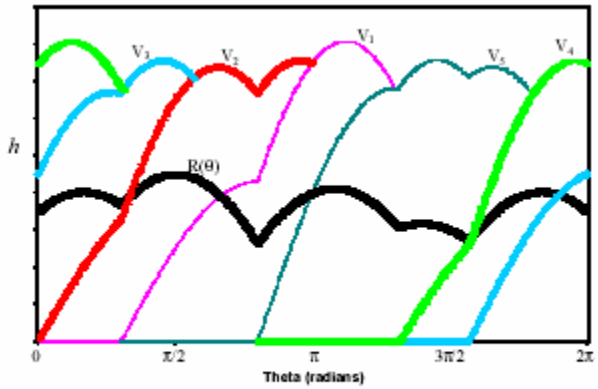


Figure 4. Radius function, $R(\theta)$, and vertex functions, $V_i(\theta)$.

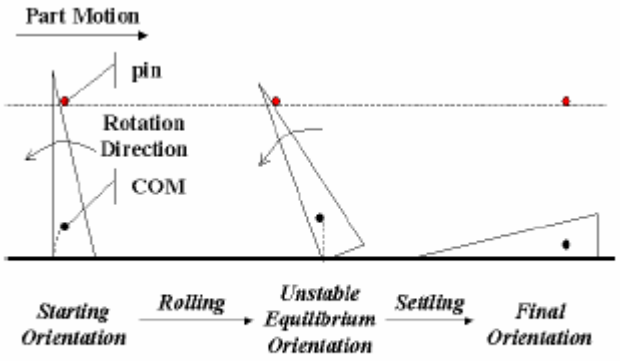


Figure 3. Two phases of toppling: *rolling and settling*.

Conveyor part orientation - pins

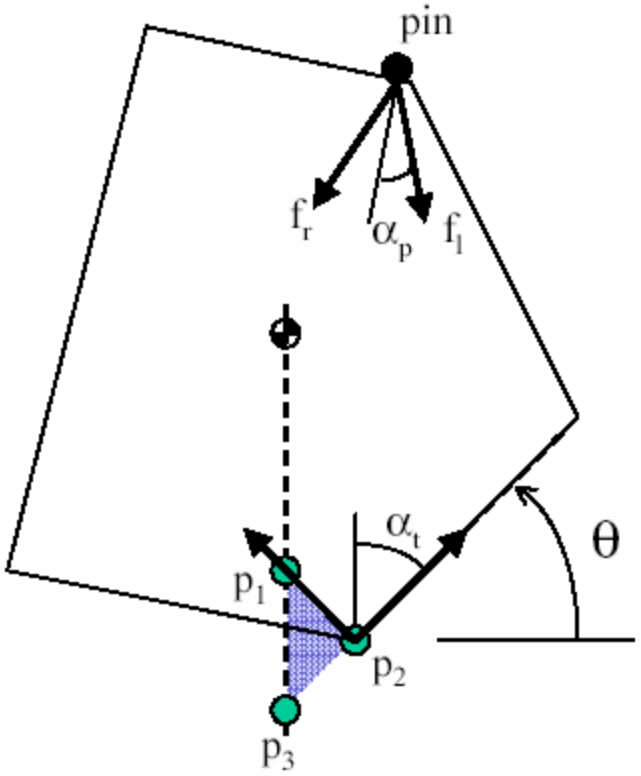


Figure 7. Jamming conditions.

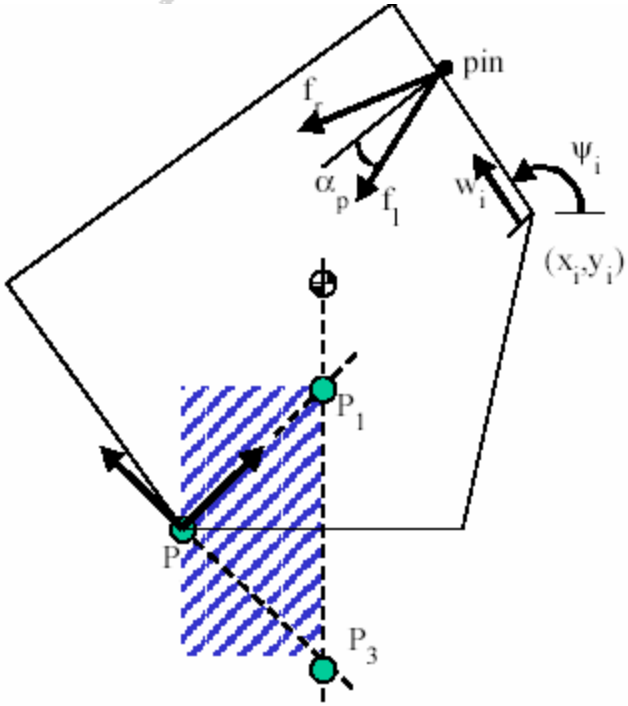
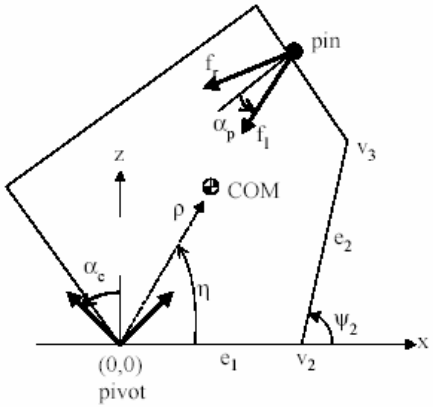
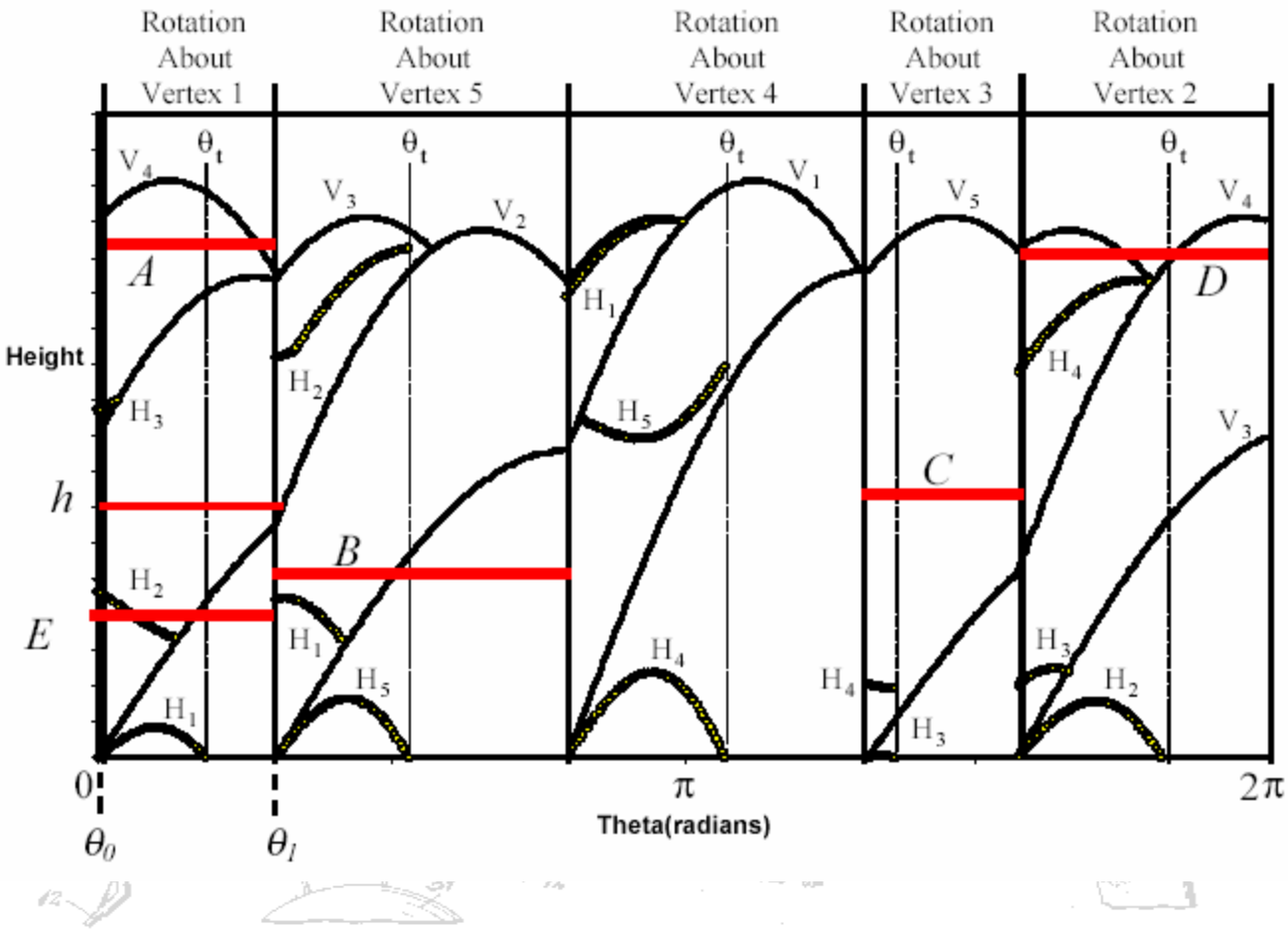


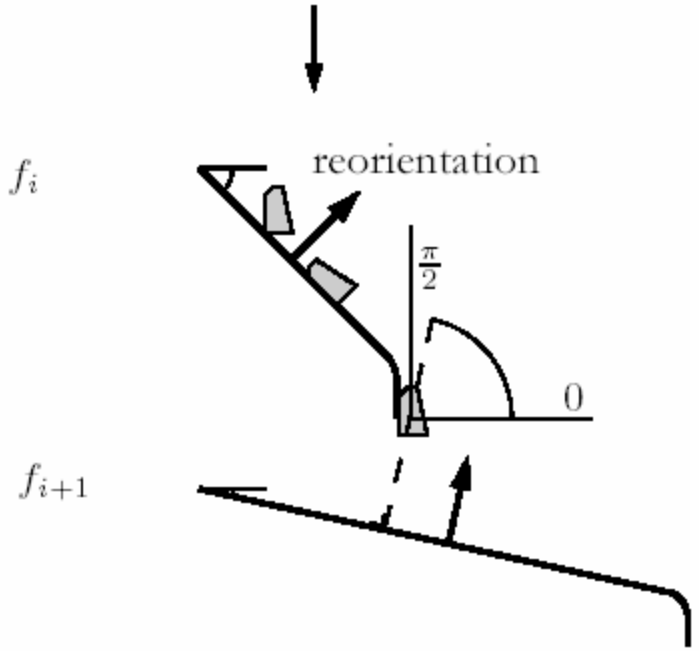
Figure 5. Conditions for the rolling phase.

Conveyor part orientation - pins





Conveyor part orientation - fences



(a)

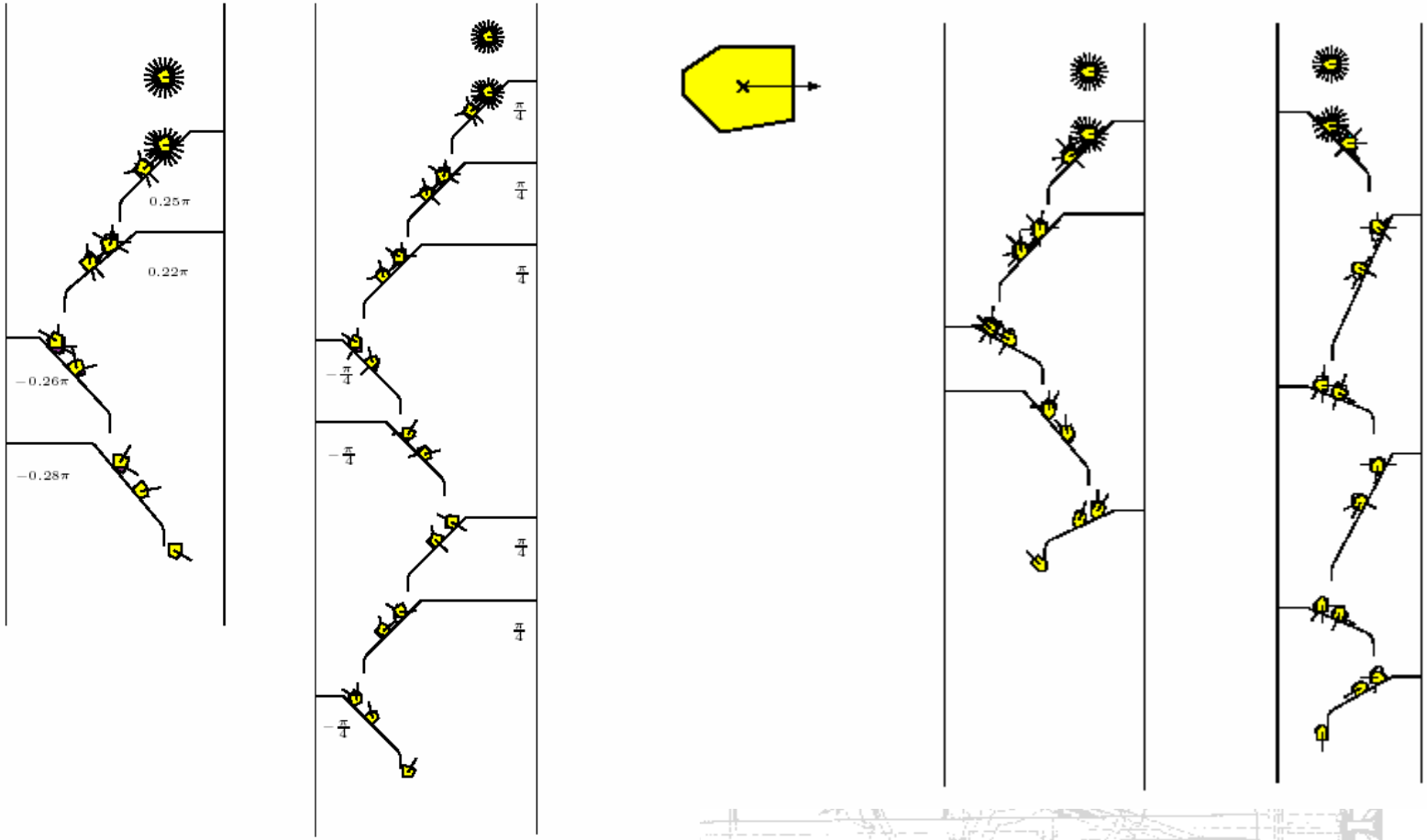
t_i	α_{i+1}	t_{i+1}
left	$(0, \pi/2)$	left
left	$(\pi/2, \pi)$	right
right	$(-\pi, -\pi/2)$	left
right	$(-\pi/2, 0)$	right

(b)

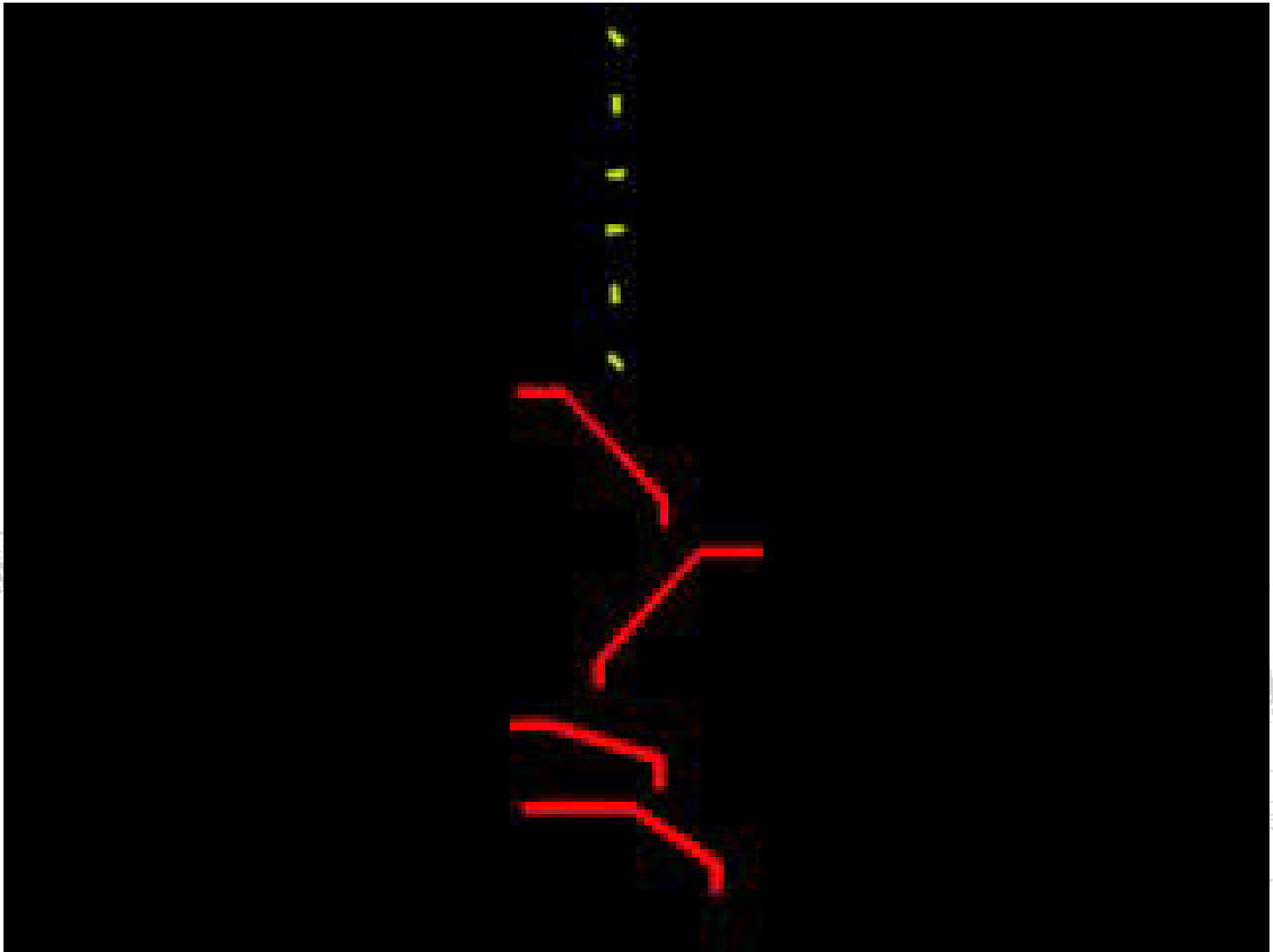
Figure 3.2 (a) For two successive left fences, the reorientation of the push direction lies in the range $(0, \pi/2)$. (b) The ranges op possible reorientations of the push direction for all pairs of fence types.

- 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

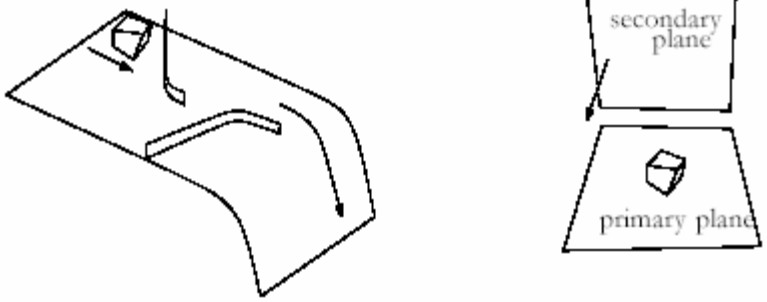


Figure 5.3 (a) A part sliding down a plate with fences. (b) The same part on the jaw.