Material Handling

Chapter 5

- Designing material handling systems
- Overview of material handling equipment
- Unit load design
- Material handling equipment selection

Material Handling Definitions

- Material handling is the combination of art and science of:
  - moving
  - storing
  - protecting
  - controlling the material

- Material handling means providing the
  - right amount
  - of the right material
  - in the right condition
  - at the right place
  - in the right position
  - in the right sequence
  - in the right time
  - for the right price
  - by the right method

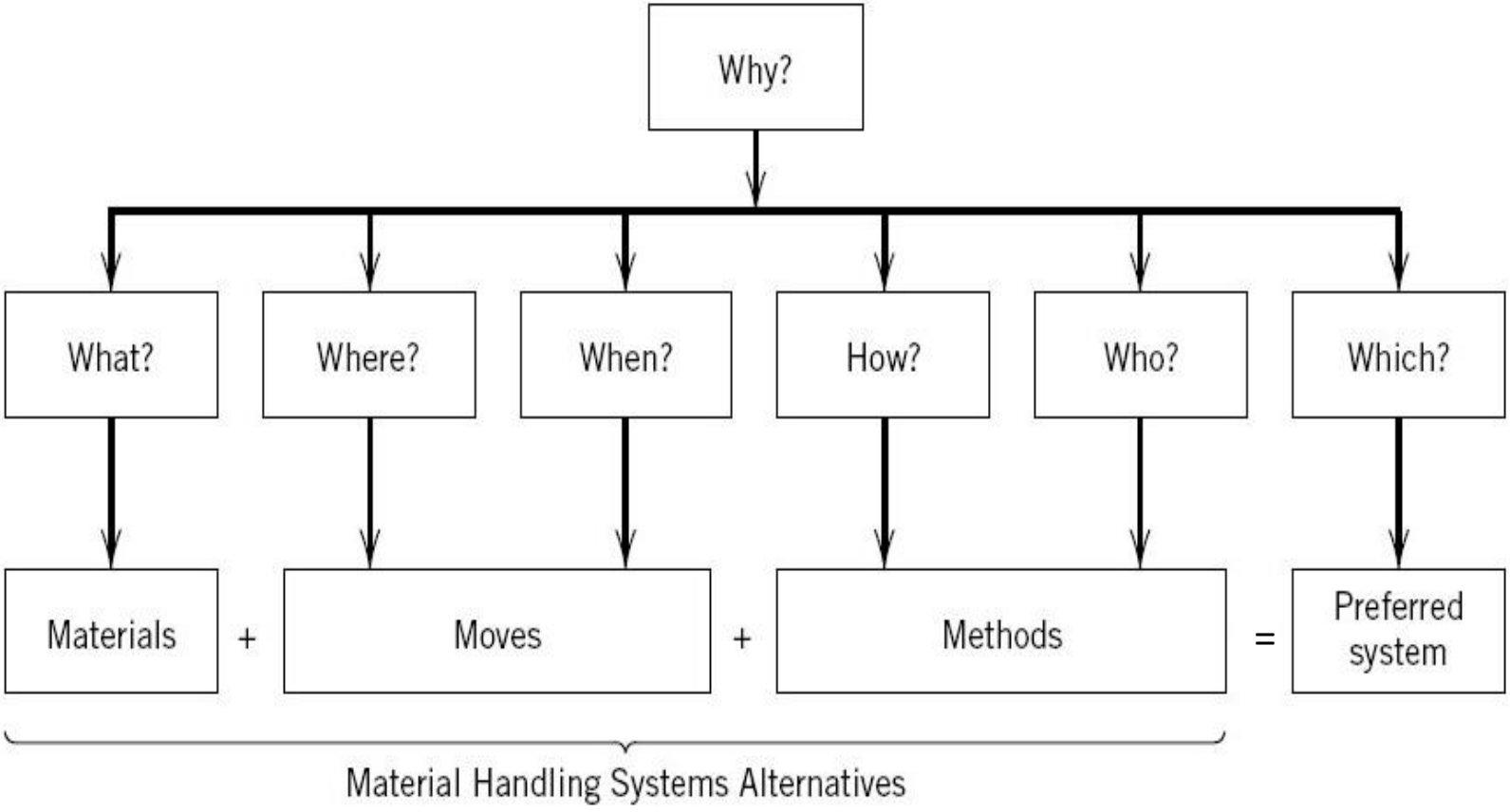
Goals of Material Handling

- In a typical manufacturing facility:
  - 25% of the work-force is used in material handling
  - 55% of the factory floor is reserved for it
  - **87% of the production time!**
  - It may represent 15% to 70% of the total cost generated in the company

- Goals of material handling:
  - **Reduce unit costs of production**
  - Maintain or improve product quality, reduce damages, and provide for protection of materials
  - Promote safety and improve working conditions
  - Promote productivity
  - Promote increased use of facilities
  - Control inventory

Material handling system equation

Materials + Moves + Methods = Preferred system



Material Handling Planning Chart

(1) to gather information pertaining to material handling and
(2) to analyze the data in order to develop alternative solutions.

WHERE **WHAT** **WHEN** **HOW**

Product Air Speed Control Value Date Sheet 1 of 8

Step No.	O	T	S	I	Description	Oper. No.	Dept.	Cont. Type	Size	Wt.	Qty. Per Cont.	Freq	Dist	Method of Handling
1			X		Bar stock in Storage (2200)		Stores.							
2		X			Profit Stores to Saw Dept.			LDDSE (FK.TRK)	2.5" × 3.5 × 16"	5 lb	to bars	3 times daily	16 ft	Fork lift
3			X		Store in Saw Department		Saw							
4	X				Cut to length	0101	Saw							
5		X			From Saw to Grinding			TOTE pan	15" × 12" × 7"	30 lb	30	Twice daily	10 ft	Platform hand truck
6			X		Store in Grinding		Grinding							
7	X				Grind to length	0201	Grinding							
8			X					TOTE pan	15" × 12" × 7"	30 lb	30	Twice daily	13 ft	Platform hand truck
9				X	Store in Deburring		Deburring							
10	X				Deburr	0301	Deburring							
11		X			From Deburring to Dr. Prs			TOTE pan	15" × 12" × 7"	30 lb	30	Twice daily	16 ft	Platform hand truck
12			X		Store in Drill Press		Drill Press							
13	X				Dr. CD holes tap. rean,dsk	0401	Drill Press							
14		X			From Dr. Press to Tur. Lathe			TOTE pan	15" × 12" × 7"	30 lb	30	Twice daily	33 ft	Platform hand truck

Figure 5.2 Material handling planning chart for an air flow regulator. Key: Operation—O. transportation—'I'. storage—S. inspection—I.

Handling systems classification

- Mechanized
- Semi-automated
- Automated
- Information-directed

Material handling equipment

- 4 categories:
  - I. Containers and unitizing equipment
  - II. Material transport equipment
  - III. Storage and retrieval equipment
  - IV. Automatic identification and communication equipment

I. Containers and unitizing equipment

- Containers
  - To facilitate the movement and storage of loose items
- Unitizers
  - Equipment for a formation of a unit load

Unit load design

- ***Unit load*** **–** amount of material that can be moved *as a single mass* between two locations
- Primary advantage of using unit loads is the capability of handling more items at a time and reducing the number of trips, handling cost, loading and unloading times, and product damage.
- Unit load and JIT

Unit load design

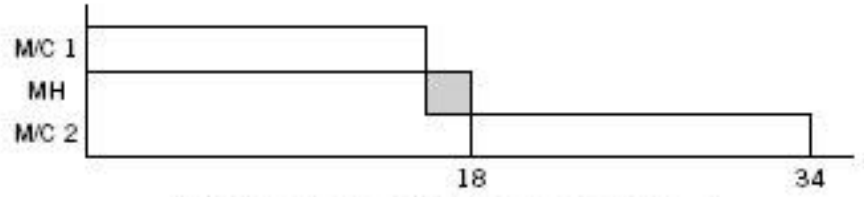
Determination of the load size

- Size (volume and weight) of the unit load has major impact on the specification and operation of the material handling

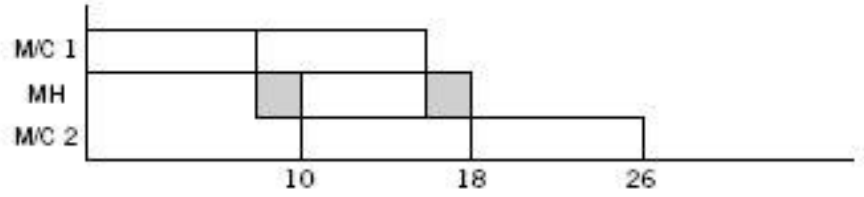
	LARGE unit loads	SMALL unit loads
Advantages	•Fewer moves •More efficient start & finish of processes (receiving, shipping, etc.)	•Lower WIP •Simpler material handling equipment (lower initial investment) •Support of JIT and continuous flow •Shorter completion time •Higher flexibility
Disadvantages	•Bigger heavier equipment •Wider aisles •Higher floor load capacity •Higher WIP	•Increases the transportation requirement

- The Optimal Unit Load is the quantity where the system idle time, WIP and transportation cost are minimized

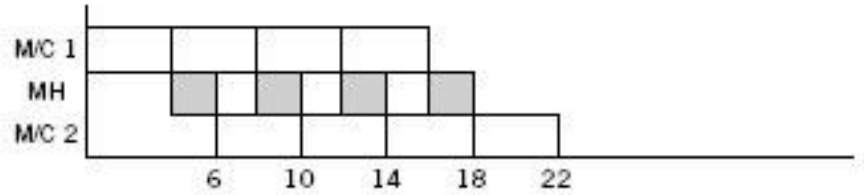
Processing time = 1 time unit per piece
Material handling time = 2 time units per move



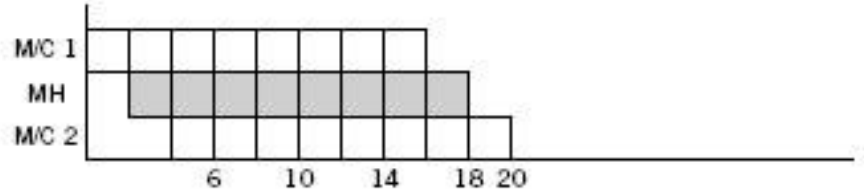
(a) Unit load size = 16 pieces; no. of transfers = 1



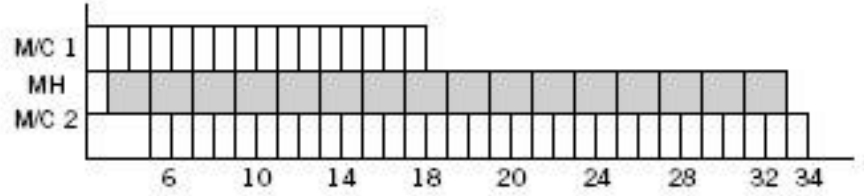
(b) Unit load size = 8 pieces; no. of transfers = 2



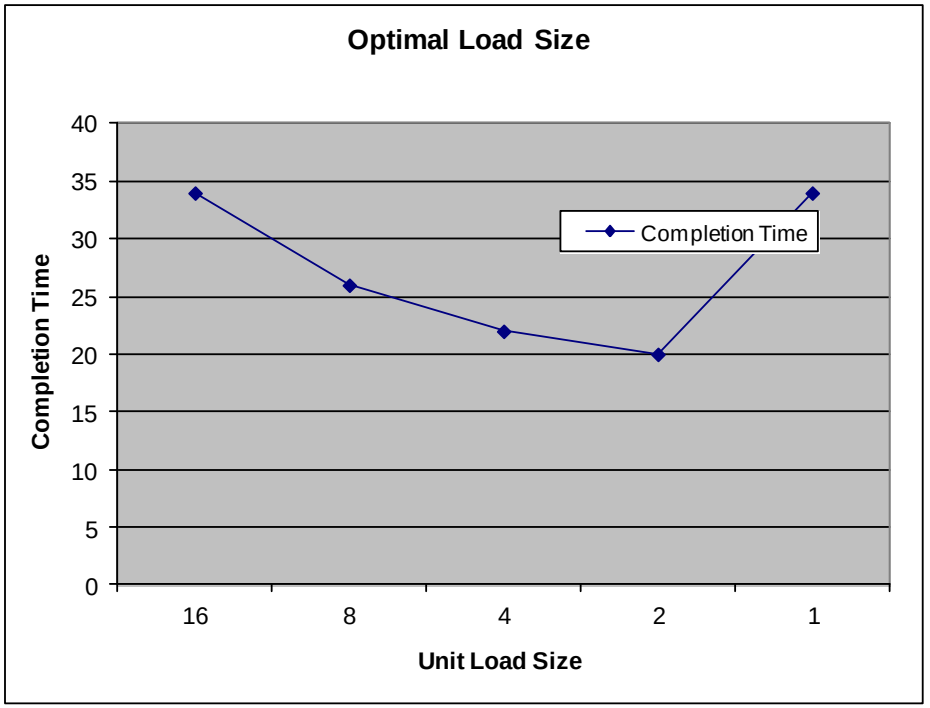
(c) Unit load size = 4 pieces; no. of transfers = 4



(d) Unit load size = 2; no. of transfers = 16



(e) Unit load size = 1; no. of transfers = 16



Unit Load Size:

L = Load Size

P_t = Unit Production time

T_t = Transportation time

$L*P_t = T_t \rightarrow L = T_t/P_t$

$P_t = 1, T_t = 2 \rightarrow L = T_t/P_t = 2/1 = \underline{2}$

Unit load design

- Common methods of unitizing a unit load
  - Containers
  - Platforms
    - Skids
    - Pallets
  - Sheets
    - Cardboard
    - Plywood
    - Polyethylene slip-sheets
  - Racks
  - Strapping
  - Wrapping
    - Stretch wrapping
    - Shrink wrapping

Pallet

Skids

Stretch wrapping

Shrink wrapping

Unit load design

- Moving of the unit load:

a) Lifting under the mass

b) Inserting the lifting element into the body of the unit load

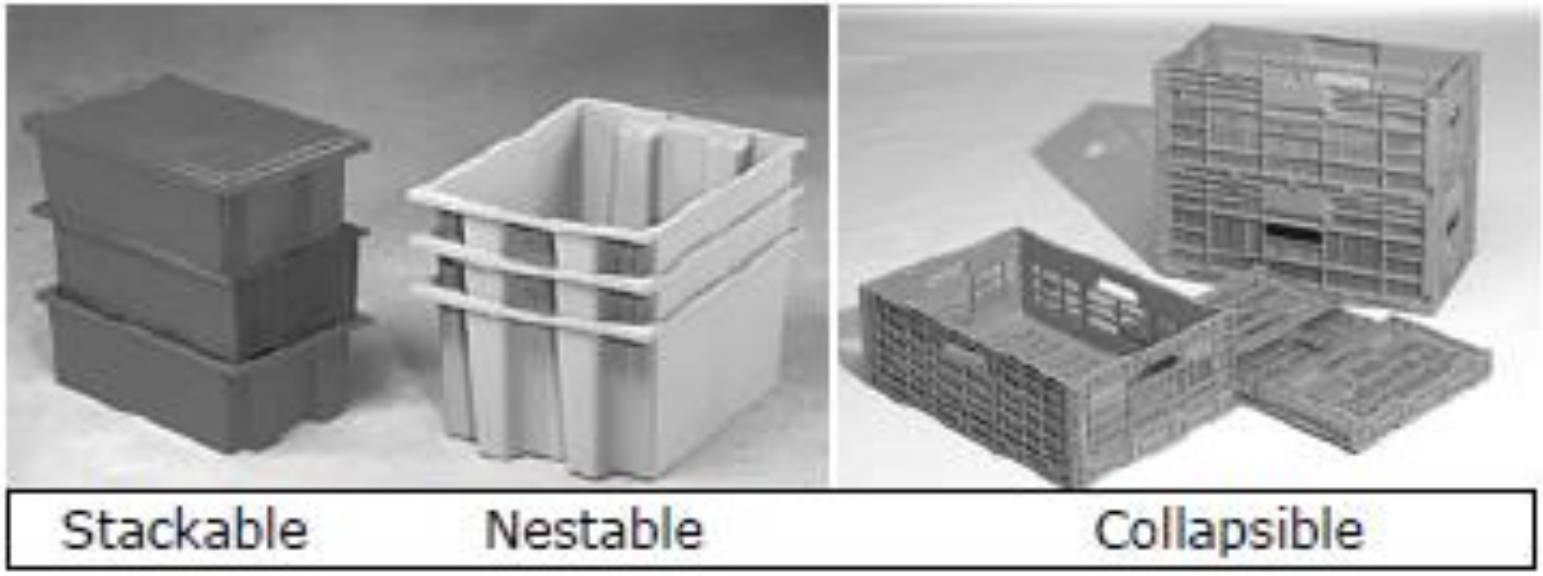
c) Squeezing the load between two lifting surfaces

d) Suspending the load

Unit load design

Efficiency of containers

- Containers with good stacking and nesting features can provide significant reduction in material handling costs
- ***Stackability***
  - A full container can be stacked on top of another full container in the same spatial orientation.
- ***Nestability***
  - Shape of the containers permits an empty container to be inserted into another empty container of the same type.



Unit load design

Efficiency of containers

- **Container Space Utilization:**
  - Usable space (interior) of the container divided by exterior envelope.
  - *Example:*

inside dimensions 18” x 11” x 11” (w x d x h)

outside dimensions 20” x 12” x 12”

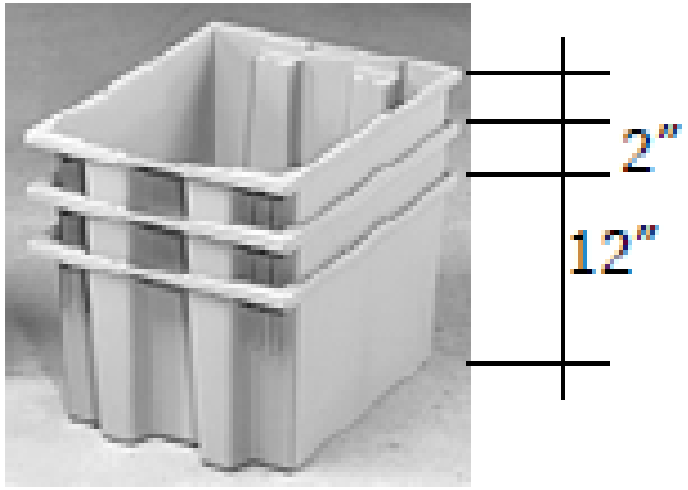
Container Space Utilization = (18x11x11)/(20x12x12) = 76%

- **Container Nesting Ratio:**
  - Exterior height divided by the nested height.
  - *Example:*

outside dimensions 20” x 12” x 12”

Each nested container 20” x 12” x 2”

Container nesting ratio = 12/2 = 6:1



Unit load design

Pallets

- Common method of containing a unit load
- **Pallet Sizes**

L x W
32″x40″
40″x48″
48″x40″
36″x48″
42″x42″
48″x48″

- Two-way and four-way
- Non-wooden pallets
- Pallet loading problem

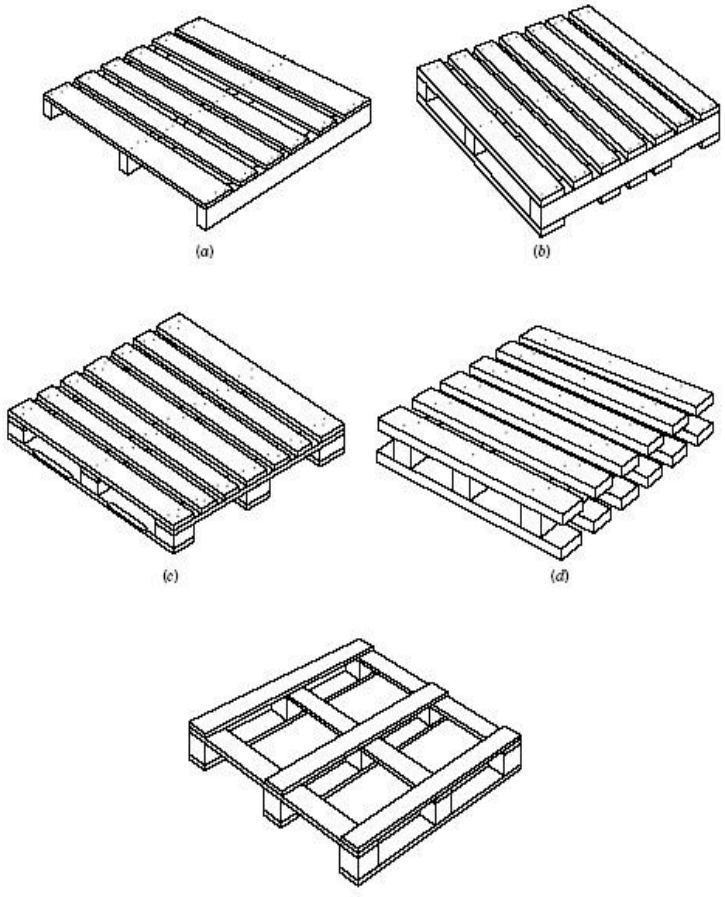


Figure 5.7 Types of wooden pallets.

Unit load design

Pallet loading problem

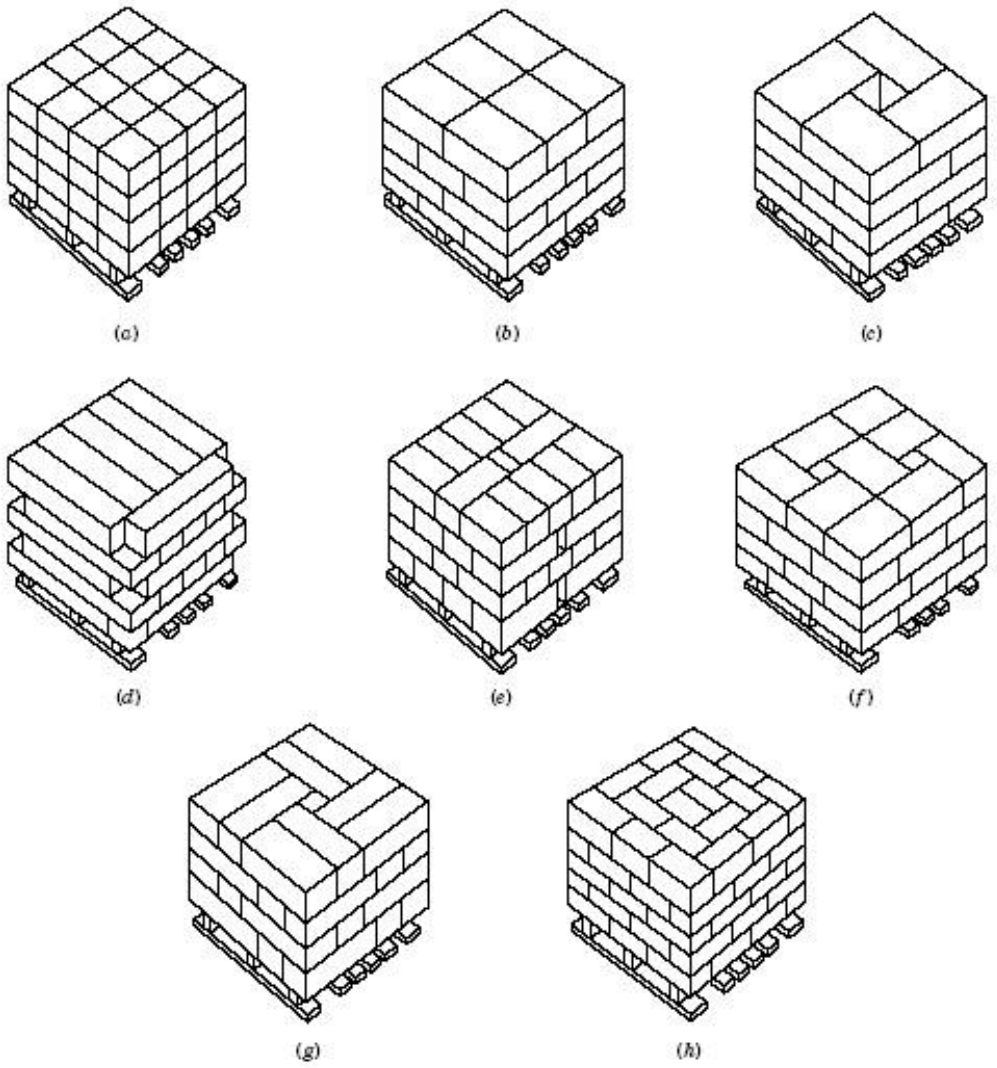


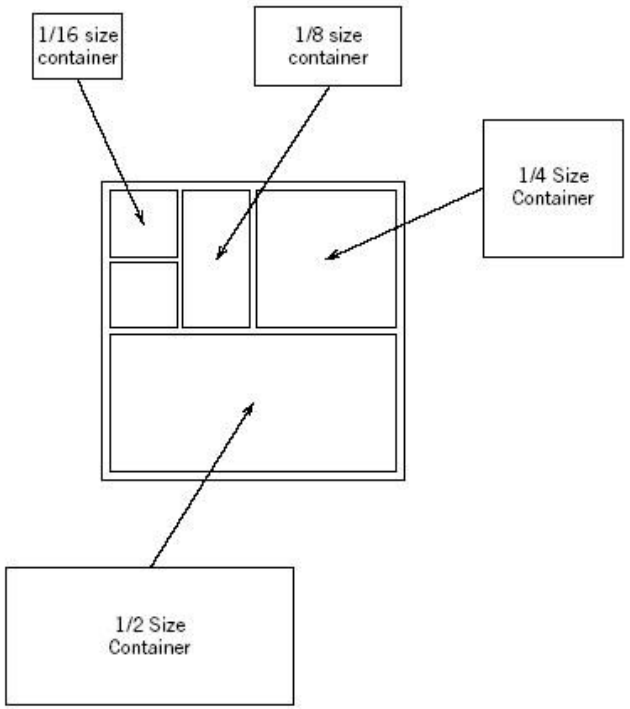
Figure 5.9 Stacking patterns for different pallet sizes. (*a*) Block pattern. (*b*) Row pattern. (*c*) Pinwheel pattern. (*d*) Honeycomb pattern. (*e*) Split-row pattern. (*f*) Split-pinwheel pattern. (*g*) Split-pinwheel pattern for narrow boxes. (*h*) Brick pattern. (*From [7] with permission.*)

- The relationship between the container and the pallet
- The objectives:
  - to maximize the use of space
  - to maximize load stability

Unit load design

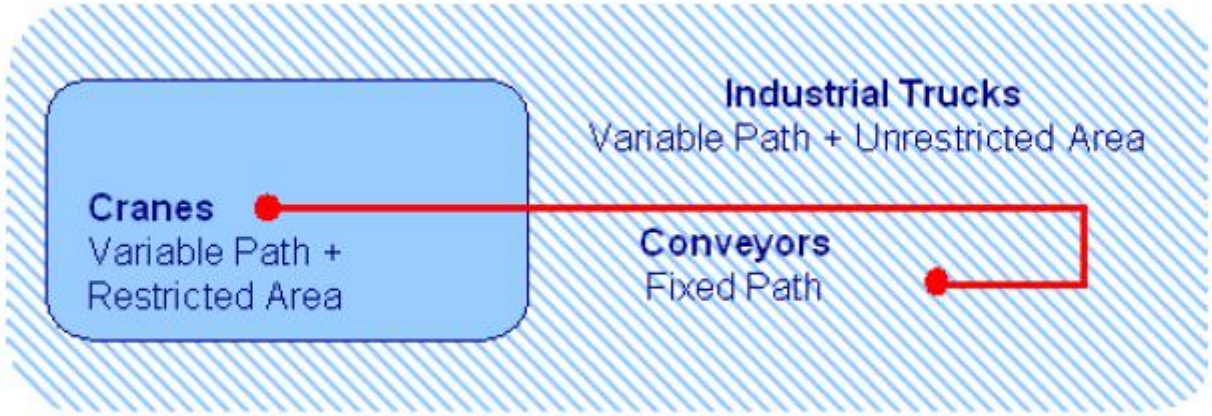
- Should the material handling system be designed around the unit load or should the unit load system be designed to fit the material handling system ?
  - Neither! It should be simultaneous

- Key element in the concurrent design is the specification of the *progressive size containers* that fit standard pallets.
  - Flexibility



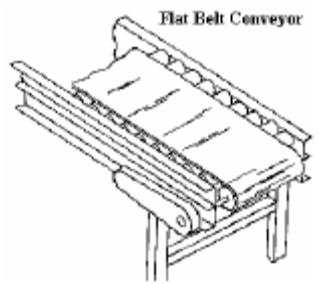
II. Material transport equipment

- To move material from one location to another (e.g., between workplaces, between a loading dock and a storage area, etc.) within a facility or at a site.
  - Conveyors
  - Industrial trucks
  - Cranes



Conveyors

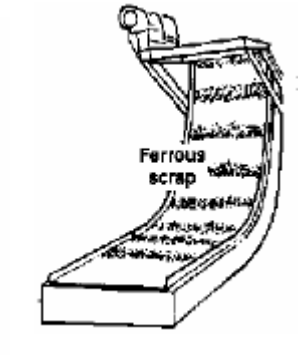
- Flat belt conveyor



- Roller conveyor

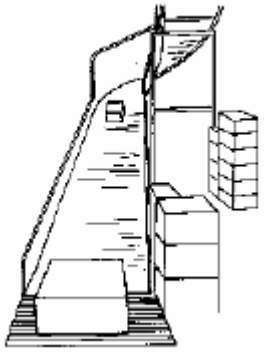
- Wheel conveyor

- Magnetic belt conveyor



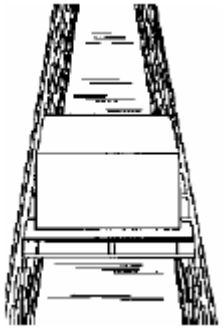
- Slat conveyor

- Chute conveyor

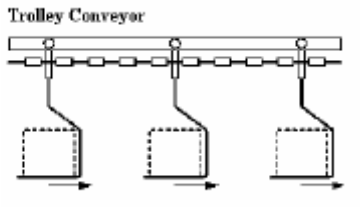


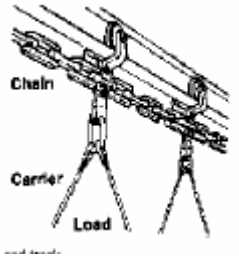
Conveyors

- Chain conveyor

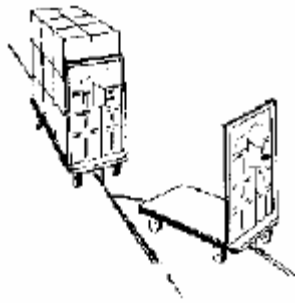


- Trolley conveyor

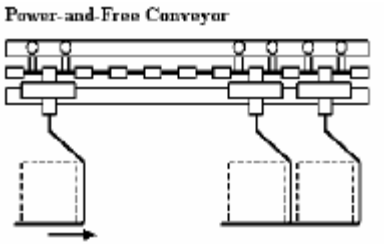


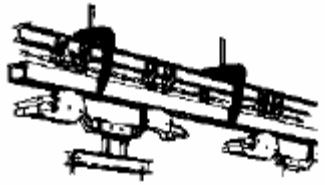


- Tow line conveyor



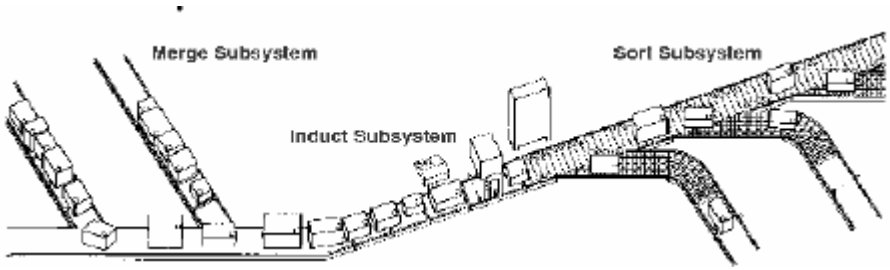
- Power-and-free conveyor



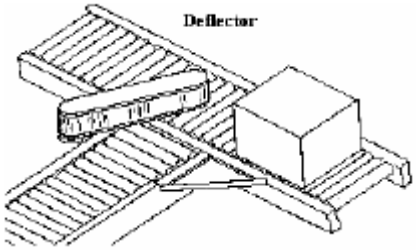


Sorting conveyors

- Sortation conveyor

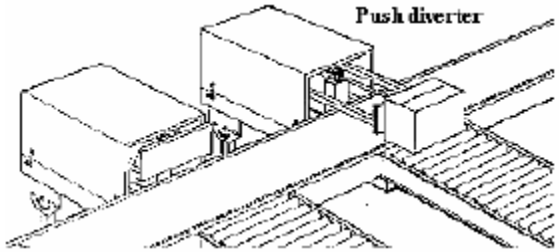


- Deflector



- Sliding shoe sorter

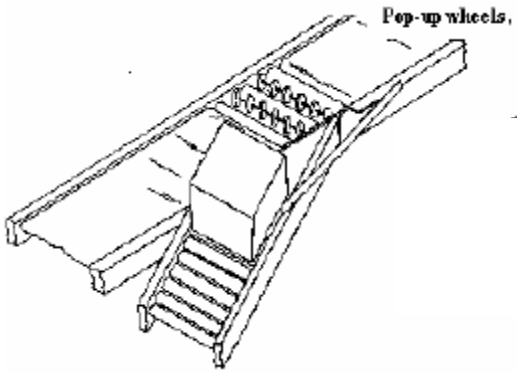
- Push diverter



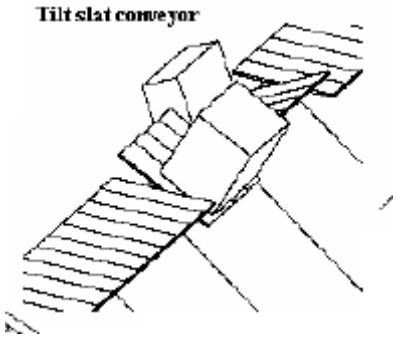
Sorting conveyors

- Tilt tray sorter

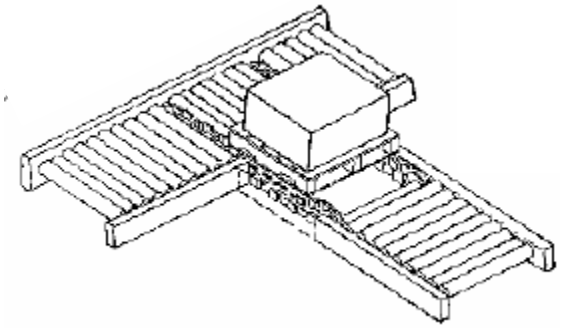
- Pop-up wheels



- Tilt slat conveyor

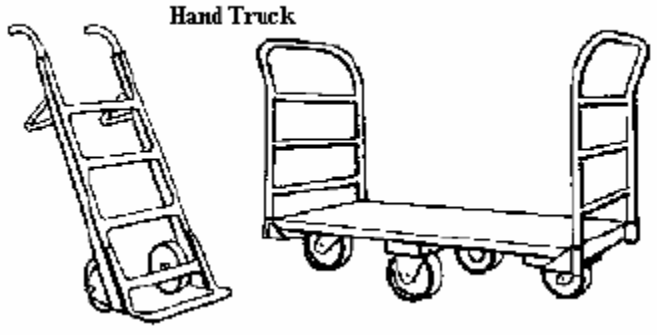


- Pop-up rollers

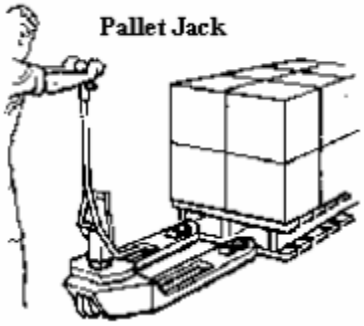


Industrial vehicles - walking

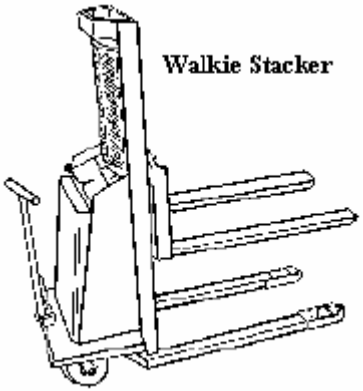
- Hand truck and hand cart



- Pallet jack

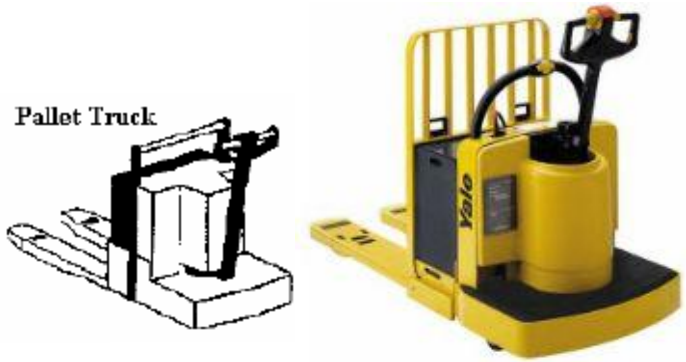


- Walkie stacker

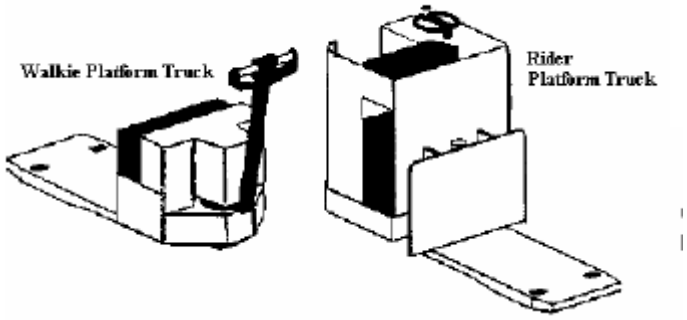


Industrial vehicles - riding

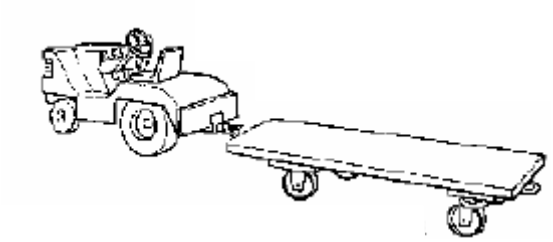
- Pallet truck



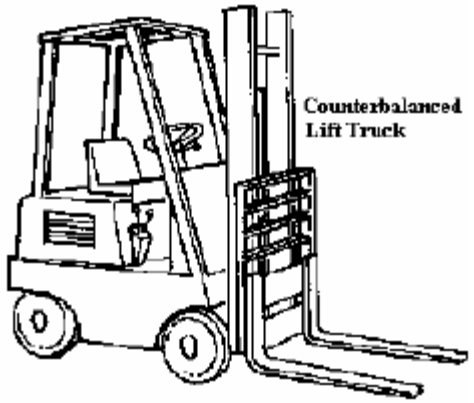
- Platform truck



- Tractor-trailer



- Counterbalanced lift truck



Industrial vehicles – Lift truck

- Very popular, very flexible
- Careful lift truck selection to optimize utilization of space and labor while maintaining a high safety factor
  - Fuel types (electric, gasoline/diesel, LPG Liquid Propane, fuel cell technology)
  - Tire types (cushion or pneumatic)
  - Lift capacity and lift height
  - Aisle types (wide, narrow, very narrow aisles)
  - Truck types
  - Attachments / options

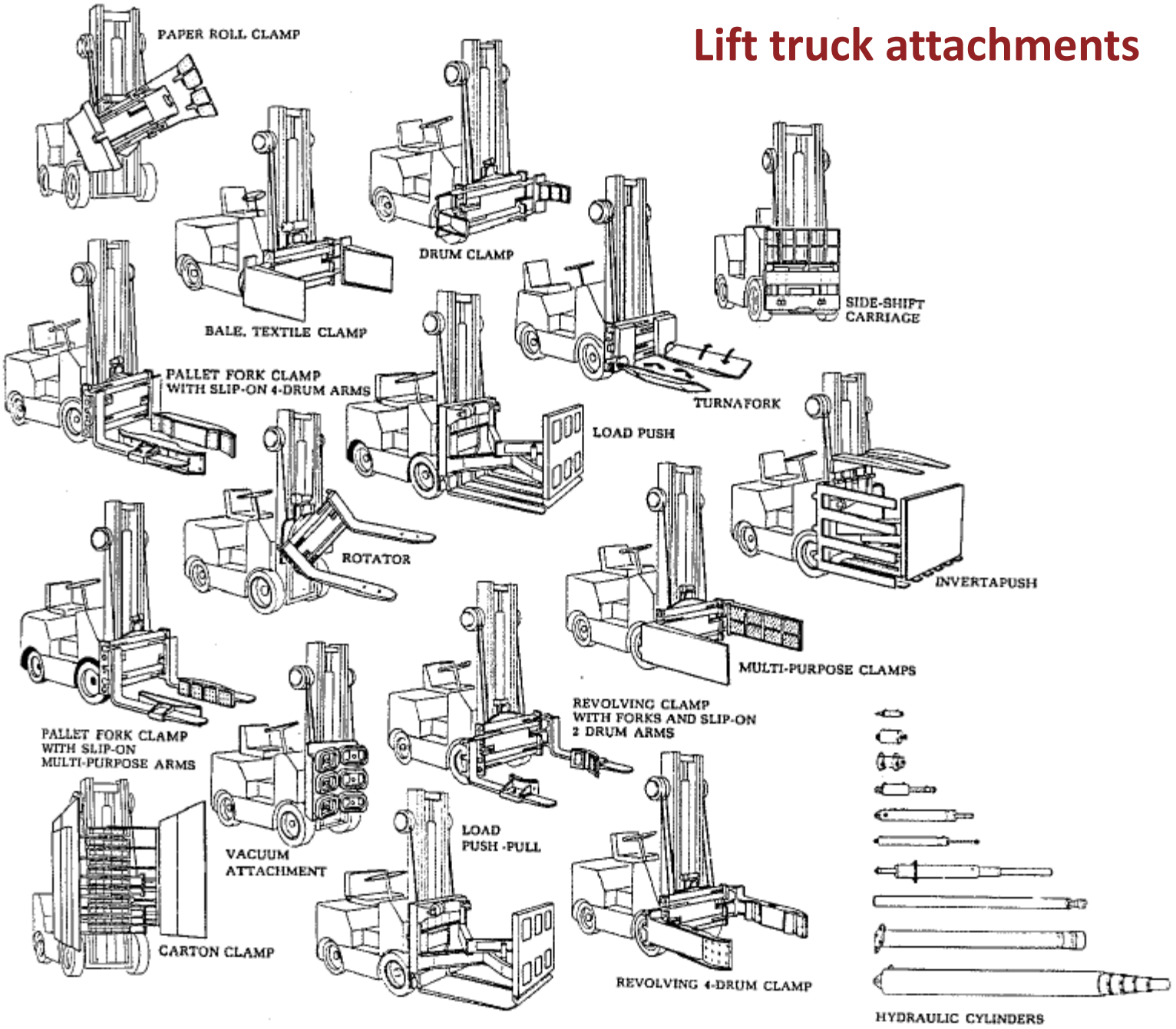
Industrial vehicles – lift truck

- Standard forklift
  - Lift heights under 6 meters
  - Wide aisles

- Reach truck
  - Lift heights up to 10 meters
  - Narrow aisles

- Order selector truck
  - Lift heights up to 12 meters
  - Very narrow aisles

Lift truck attachments



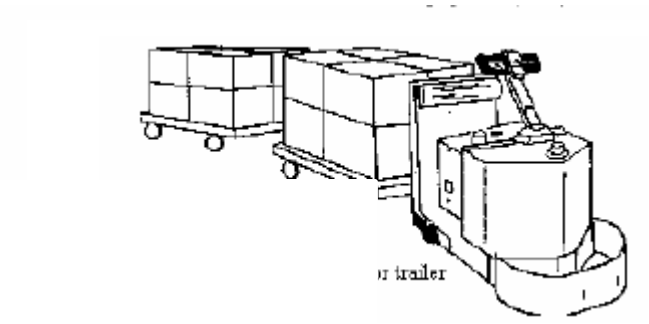
Industrial vehicles – Automated Guided Vehicles

- Battery-powered, driverless vehicle system
- Destination, path selection, positioning capabilities can be programmed
- Used to transport material from various loading locations to unloading locations
- Include intelligent collision avoidance capabilities
- Communication with the vehicle sustained by
  - Wires installed on the floor
  - Radio signals

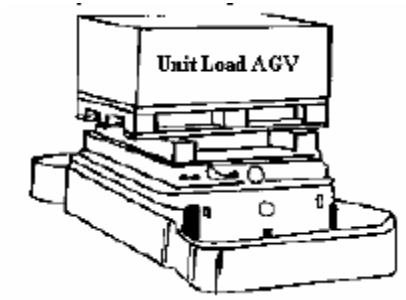
Industrial vehicles – Automated Guided Vehicles

- The type of AGVSs
  - Towing vehicle
  - Unit load transporter
  - Pallet trucks
  - Forklift trucks
  - Light-load transporters
  - Assembly-line vehicles

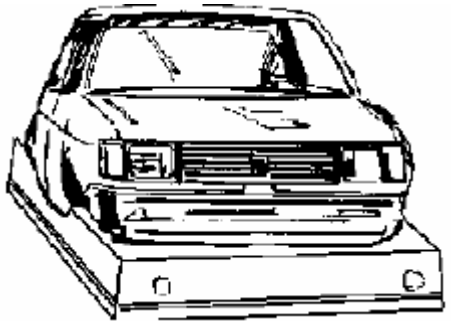
- Tow AGV



- Unit load AGV

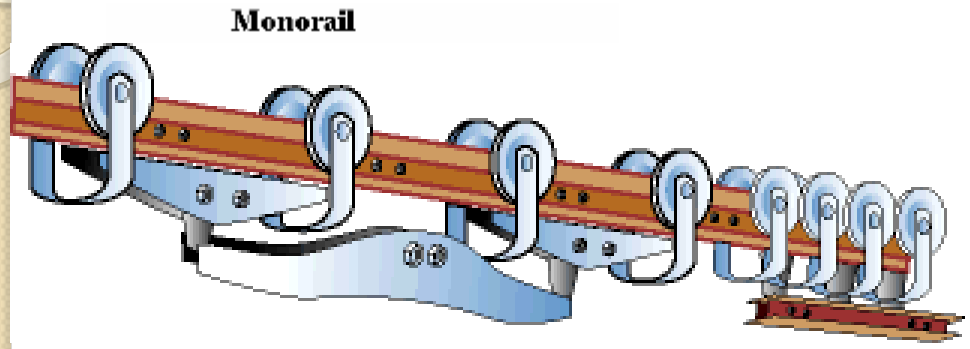


- Assembly AGV



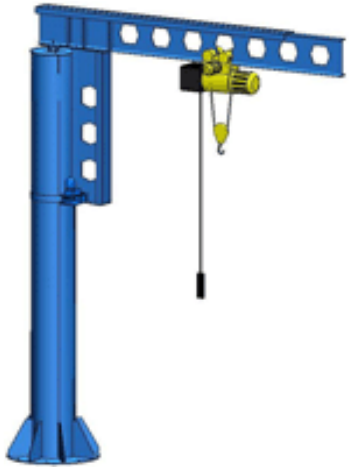
Monorail, hoists and cranes

- Monorail



- Hoist

- Jib crane

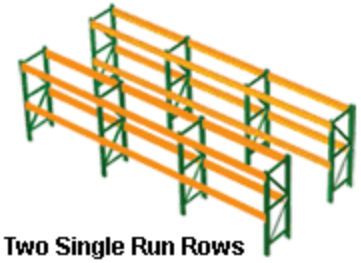


- Bridge crane

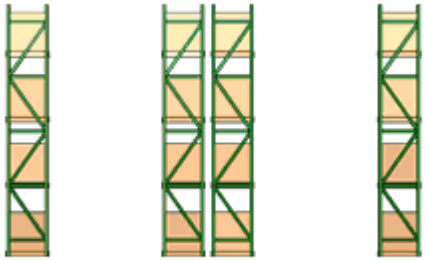
- Gantry crane

III. Storage and retrieval equipment

- Pallet racks

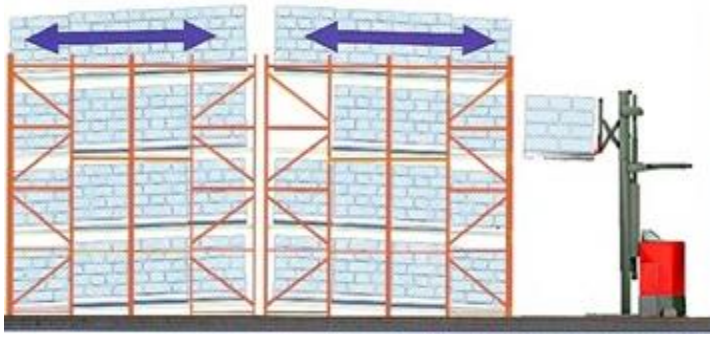


Two Single Run Rows

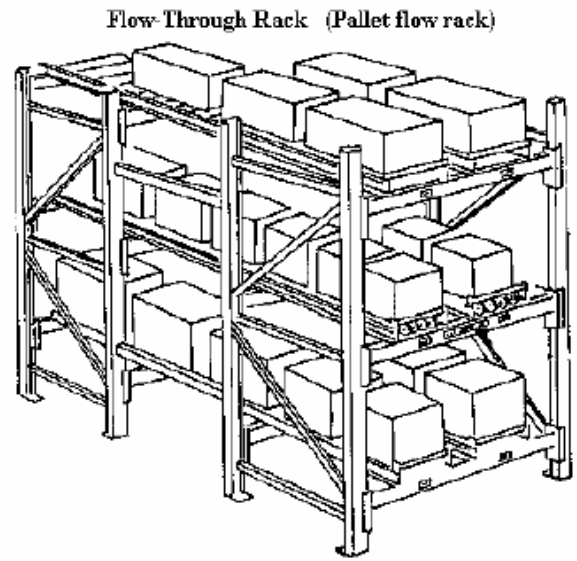


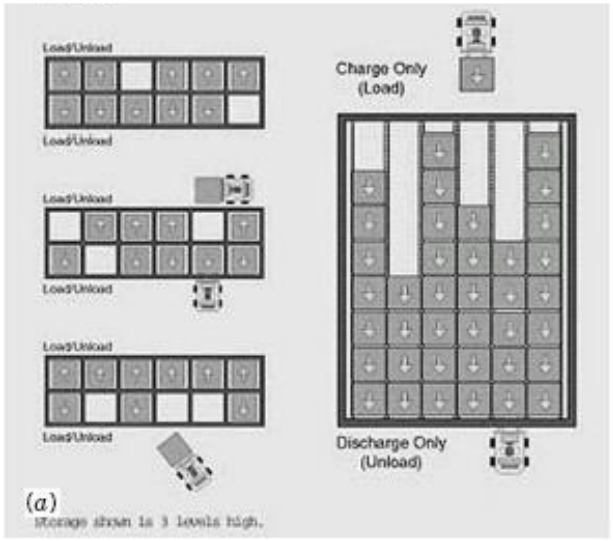
Two Single & One Double Run Rows

- Push-back rack
  - LIFO (Last in – First out)



- Flow-through rack
  - FIFO (First in – First out)



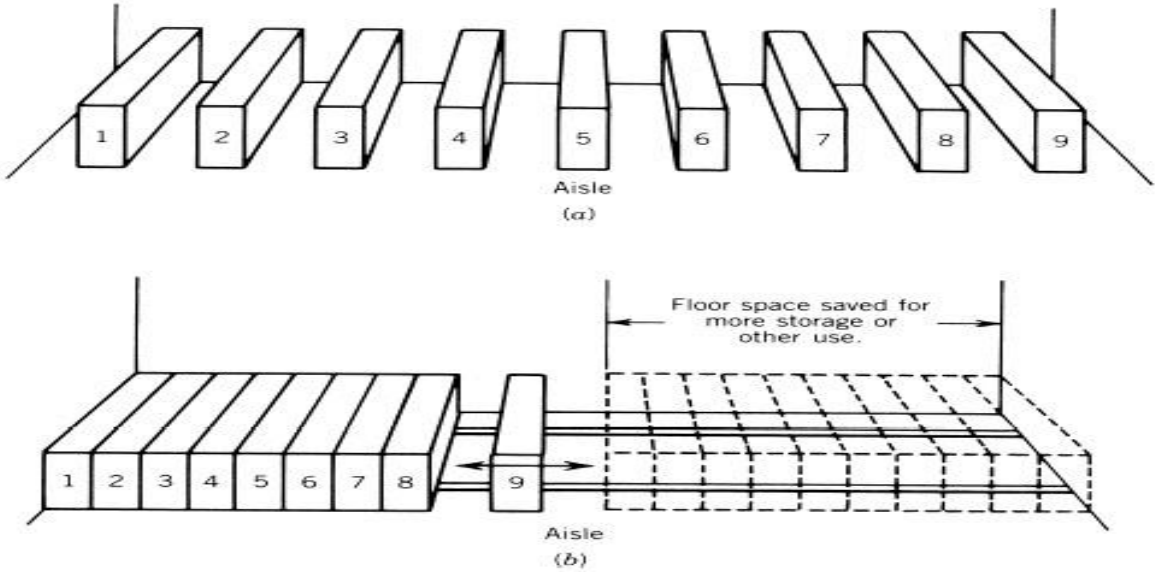


III. Storage and retrieval equipment

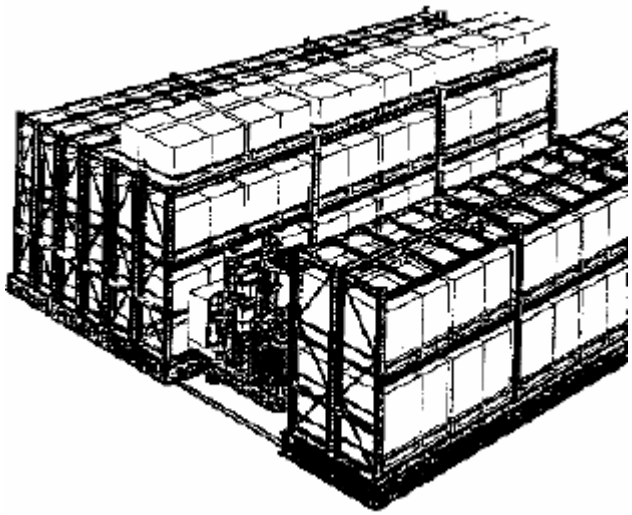
- Drive-in or Drive-through rack
  - Drive-in: LIFO
  - Drive-through: FIFO

- Cantilever rack

III. Storage and retrieval equipment

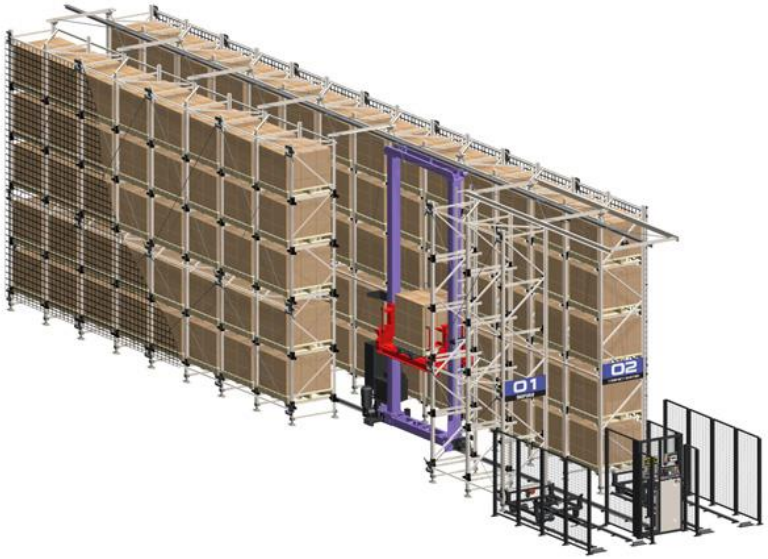


- Sliding rack

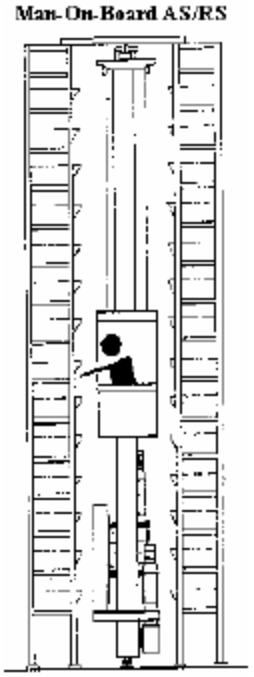


III. Automated storage and retrieval systems

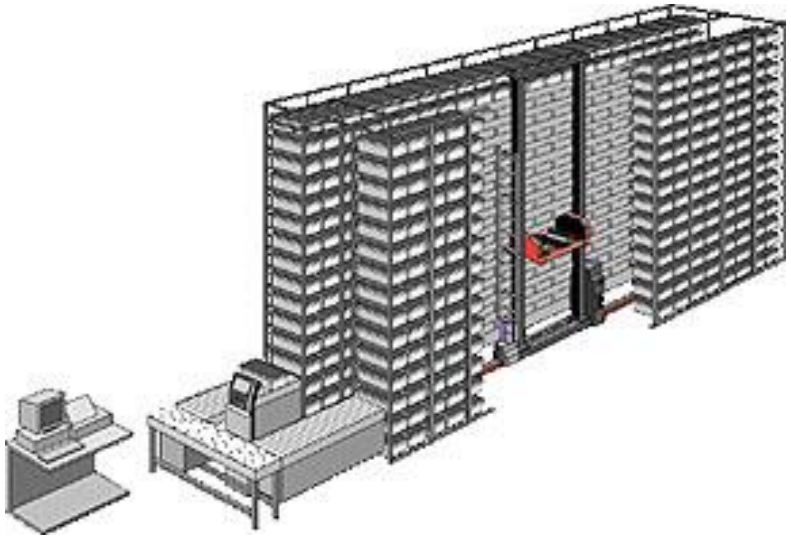
- Unit load AS/RS



- Man-on-board AS/RS

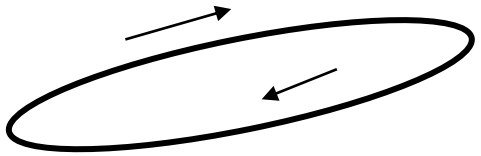


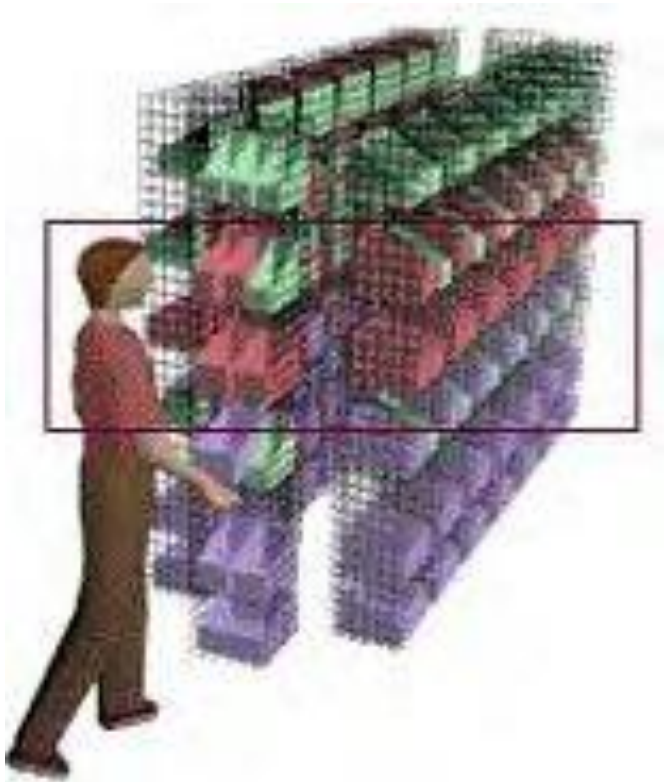
- Miniload AS/RS

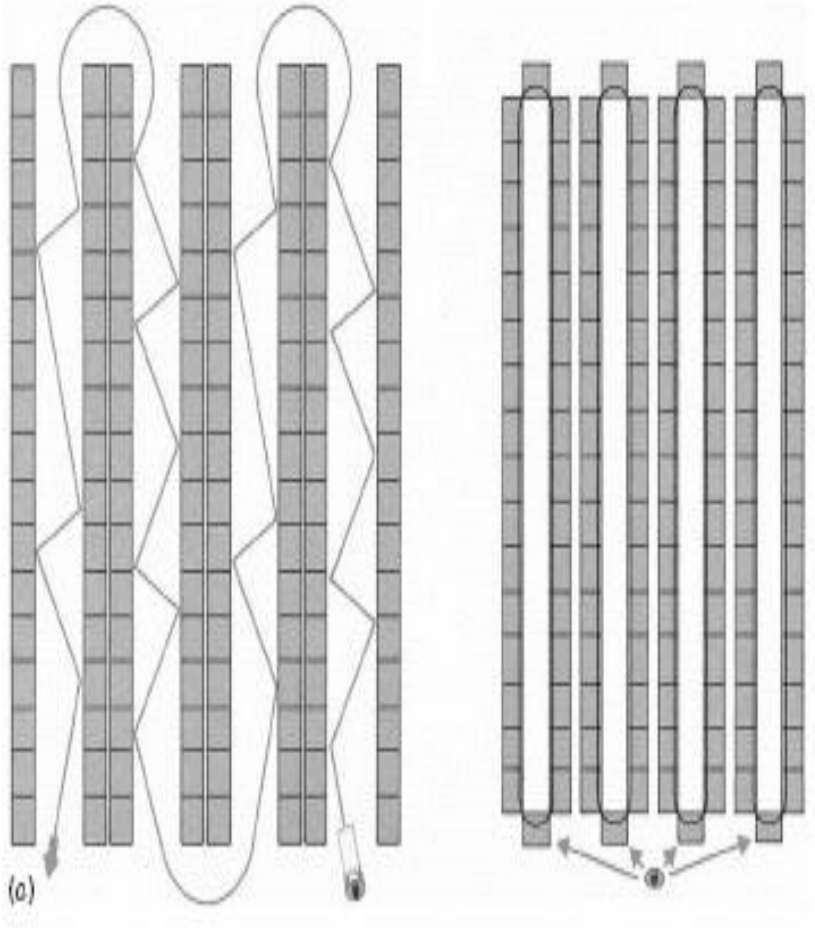


III. Small load storage and retrieval equipment

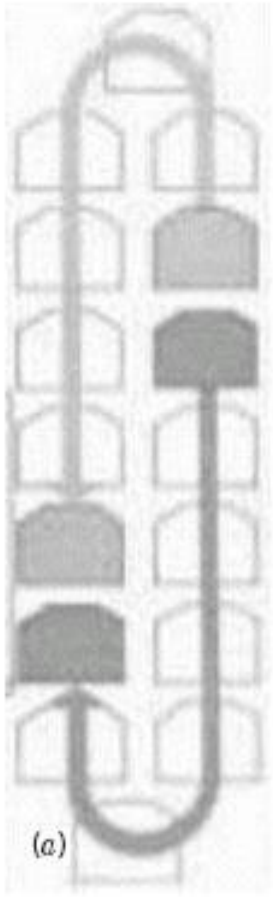
- Horizontal carousel



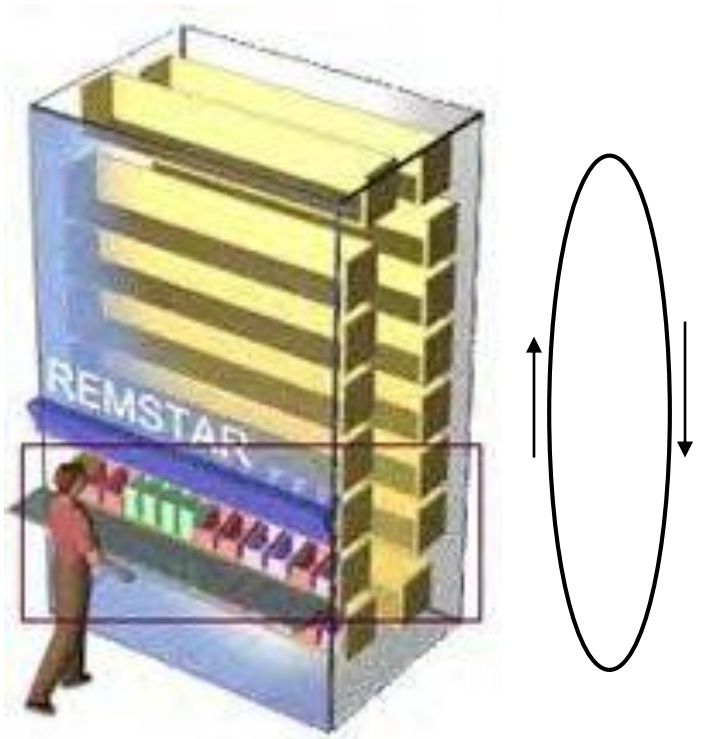




III. Small load storage and retrieval equipment



- Vertical carousel



IV. Automatic identification and communication equipment

- Automatic identification and recognition
  - Bar coding
  - Optical character recognition
- Automatic paperless communication
  - Radio frequency data terminal
  - Voice headset
  - Light and computer aids
  - Smart card

Equipment selection

- Balance between the production problem, the capabilities of the equipment available, and the human element involved
- Objective is to arrive at the lowest cost per unit of material handled
- Depends on:
  - Material to be moved
  - Movement
  - Storage
  - Costs
  - Equipment factors: adaptability, flexibility, load capacity, power, speed, space requirements, supervision required, ease of maintenance, environment

Equipment selection

- Conveyors:
  - Large capacity over considerable distance
  - Materials or parts can be added
  - Permanent position
  - Various packages, individual items, bulk material
- Trucks:
  - Delivery in batches
  - Flexibility
  - Portable power supply
  - Load usually on a pallet
- Cranes:
  - Lifting heavy pieces
  - Limited mobility
  - Very expensive
  - Foundation requirements

Next lecture

- Quiz II. (based on Assignments #3 and #4)