Material Transport Systems

L-12

Categories of material transport equipment

1. Industrial Trucks
2. Automated guided vehicles
3. Monorails and other rail guided vehicles
4. Conveyors
5. Cranes and hoists

1) Industrial Trucks

- They are divided into two categories : i) nonpowered ii) powered
- The nonpowered types are often referred to as hand trucks because they are pushed or pulled by human workers
- Quantites of material moved and distances are relatively low when this type of equipment is used to transport materials
- Hand trucks are classified as either two wheel or multiple-wheel
- Two wheel hand trucks are generally easier to manipulate by worker
- Multi-wheeled hand trucks are available in several types and sizes
- Two common types are dollies and pallet trucks.
- Dollies are simple frames or platforms.
- Various wheel configurations are possible, including fixed wheels and caster-type wheels
- Pallet trucks have two forks that can be inserted through the openings in a pallet

Non –Powered Industrial Truck

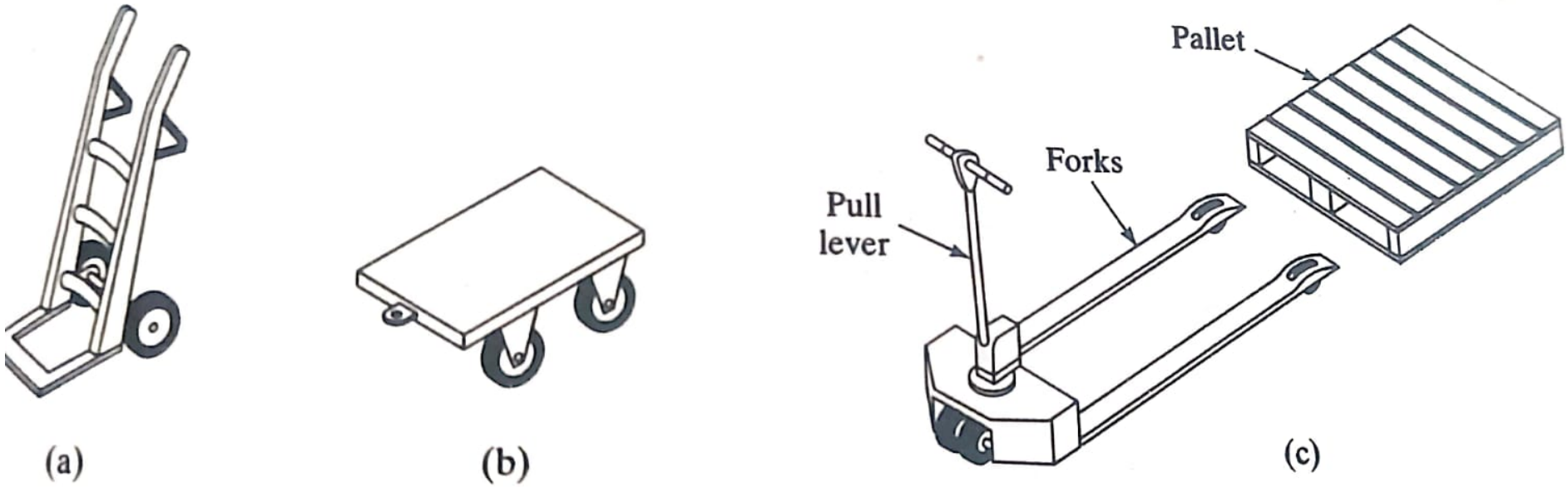

Figure 10.1 Examples of non-powered industrial trucks (hand trucks): (a) two-wheel hand truck, (b) four-wheel dolly, and (c) hand-operated low-lift pallet truck.

Powered Industrial Trucks

- Powered trucks are self-propelled to relieve the worker of manually having to move the truck

Three common types are used in factories and warehouses

a) Walkie trucks b) forklift rider trucks c) towing tractors

--Walkie trucks: i)They are battery powered vehicles equipped with wheeled forks for insertion into pallet openings but with no provision for a worker to ride on the vehicle. ii) the truck is steered by a worker using a control handle at the front of the vehicle. The forward speed of a walkie truck is limited to around 5 km/hr.

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Forklift rider trucks: (i)They are distinguished from walkie trucks by the presence of a modest cab for the worker to sit in and drive the vehicle. (ii) Load carrying capacity is about 450 Kg to 4500 kg. (iii) these include trucks with high reach capacities for accessing pallet loads on high rack systems and trucks capable of operating in the narrow aisles of high-density storage racks. (iv) Power sources for forklift trucks are either internal combustion engines (gasoline, liquefied petroleum gas, or compressed natural gas) or electric motors (using on-board batteries).

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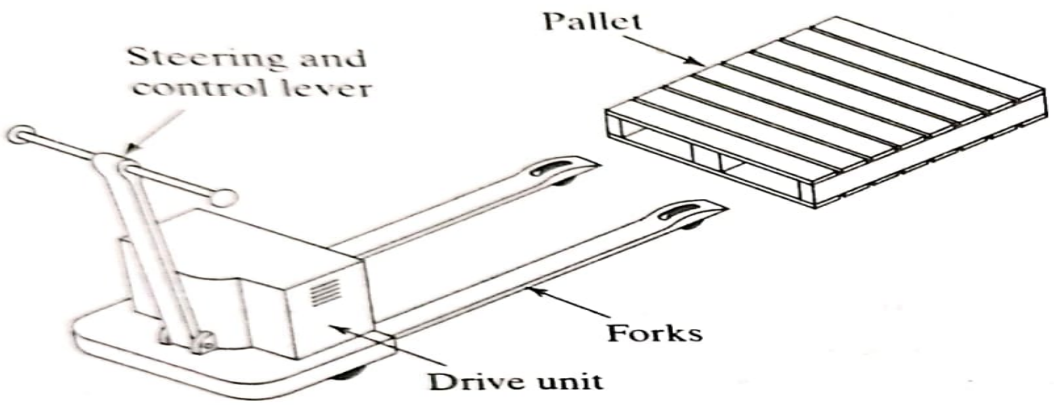
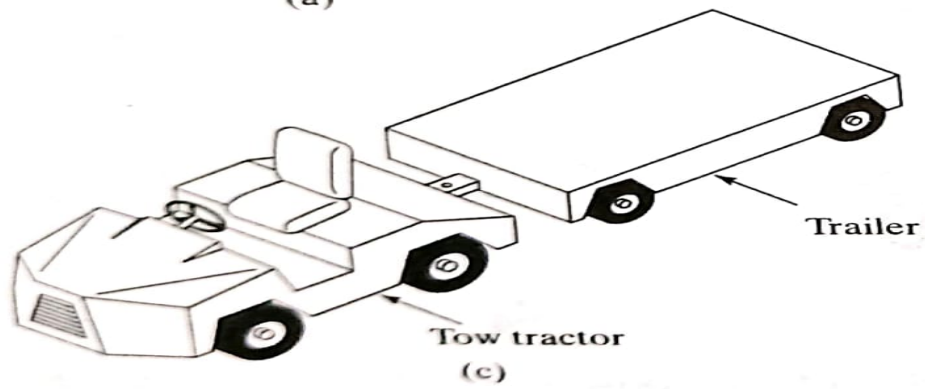
Towing tractors: (i) They are designed to pull one or more trailing carts over relatively smooth surfaces found in factories and warehouses.

(ii) They are generally used for moving large amounts of materials between major collection and distribution areas.

(iii) Power is supplied either by electrical motor (battery-powered) or internal combustion engine. Tow tractors also find significant applications in air transport operations for moving baggage and air freight in airports.

Powered Industrial Trucks





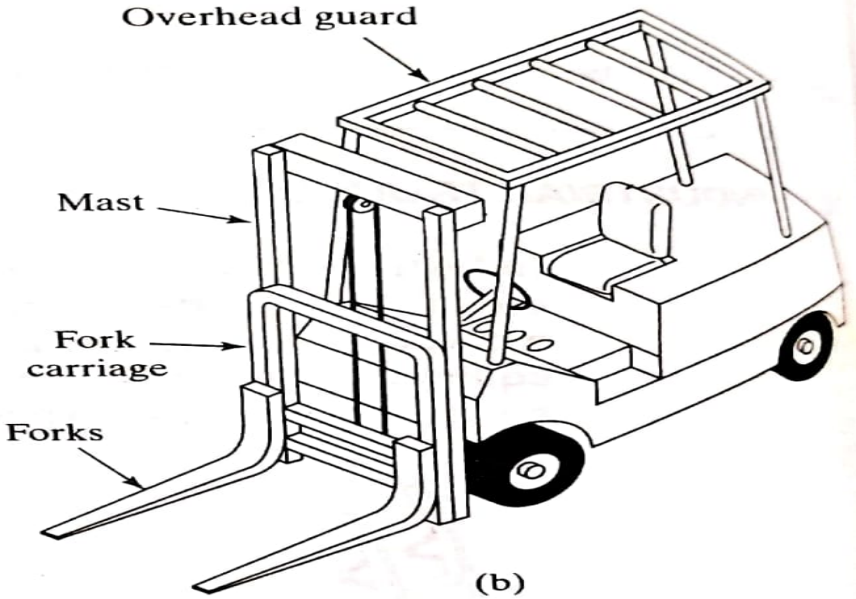


Figure 10.2 Three principal types of powered trucks: (a) walkie truck, (b) fork lift truck, and (c) towing tractor.

2) Automated Guided Vehicle Systems

- An automated guided vehicle system (AGVS) is a material handling system that uses independently operated, self propelled vehicles guided along defined pathways.
- The vehicles are powered by on-board batteries that allow many hours of operation (8-16 hr) between recharging.
- The distinguished feature is that pathways are unobtrusive
- It is appropriate where different materials are moved from various load points to various unload points.
- AGVs are suitable for batch production and mixed model production.

Types of Vehicles used

a) Driver-less trains
b) Pallet trucks
c) Unit load carriers

a) Driverless trains

- A driverless train consists of a towing vehicle (AGV) that pulls one or more trailers to form a train.
- A common application is moving heavy payloads over large distances in warehouses or factories with or without intermediate pickup and drop-off points along the route

b) Automated guided pallet trucks

- Are used to move palletized loads along predetermined routes.
  In typical application the vehicle is backed into the loaded pallet by a human worker who steers the truck and uses its forks to elevate the load slightly.
- Then the worker drives the pallet truck to the guidepath, programs its destination, and the vehicle proceeds automatically to the destination for unloading
- The capacity of an AGVS pallet truck ranges up to several thousand kilograms, and some trucks are capable of handling two pallets rather than one.
- A more recent introduction related to the pallet truck is the fork lift AGV.

c) AGV unit load carriers

- It is used to move unit loads from one station to another.
- They are often equipped for automatic loading and unloading of pallets or tote pans by means of powered rollers, moving belts, mechanized lift platforms, or devices built into the vehicle deck.

Vehicles Used

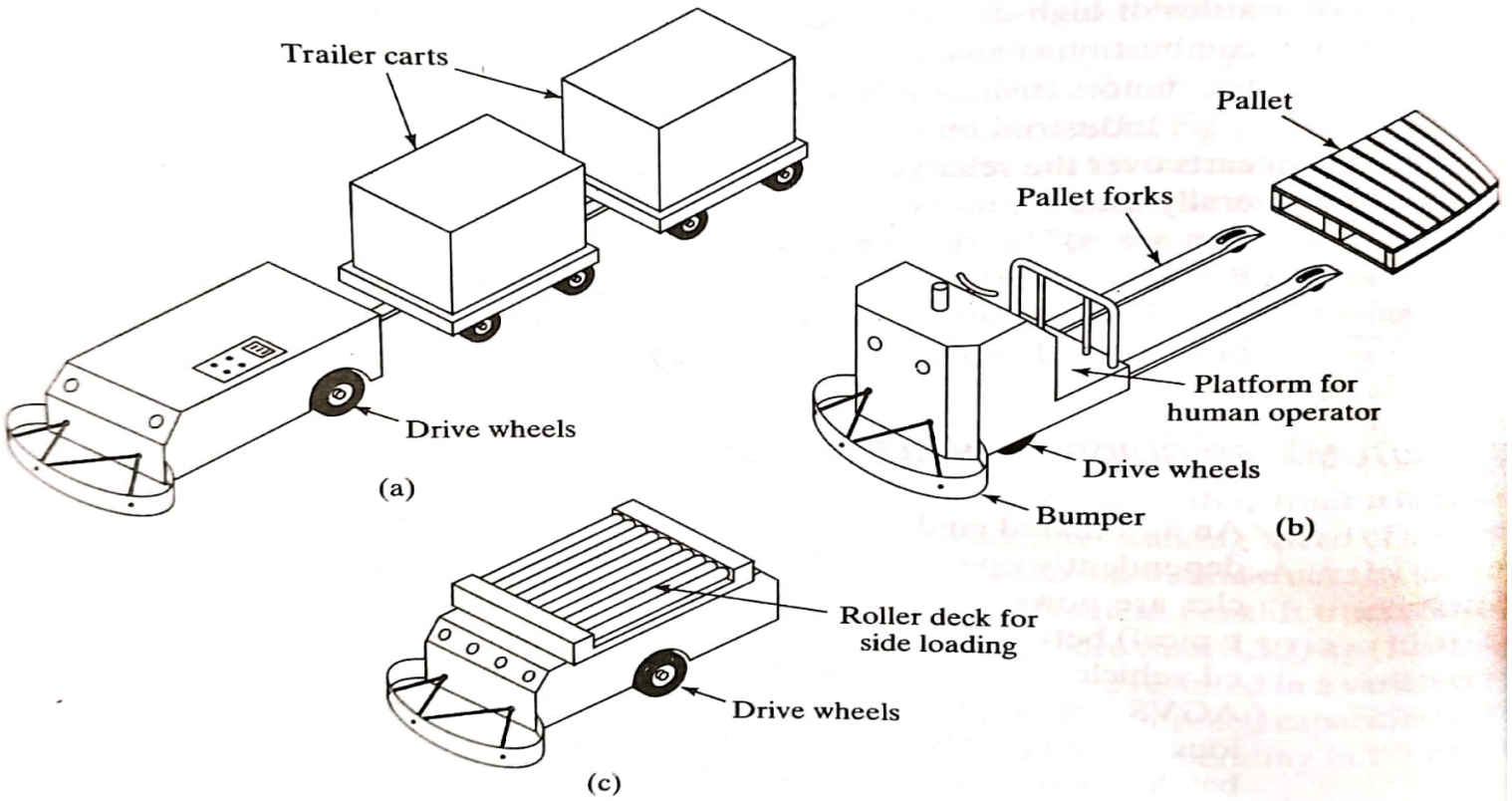


Figure 10.3 Three types of automated guided vehicles: (a) driverless automated guided train, (b) AGV pallet truck, and (c) unit load carrier.

AGVS Application

1)AGVS system used in movement of large quantities of material over relatively large distances through driverless train operations.

2) Storage and distribution : Unit load carriers and pallet trucks are typically used in these applications, which involve movement of material unit loads.

3) AGV systems are used in assembly line applications

4) AGVS are used in flexible manufacturing systems

5) Office mail delivery and hospital material transport

Vehicle Guidance Technology

Methods

i) Imbedded Guide Wires : In this method, electrical wires are placed in a small channel cut into the surface of the floor. The channel is typically 3-12 mm wide and 13-26 mm deep. After the guide wire is installed, the channel is filled with cement to eliminate, the discontinuity in the floor surface. The guide wire is connected to a frequency generator, which emits a low-voltage low-current signal with a frequency in the range 1-15 KHz. This induces a magnetic field along the pathway that can be followed by sensors on-board each vehicle. Two sensor coils are mounted on the vehicle on either side of the guide wire. When the vehicle is located such that the guide wire is directly between the two coils, the intensity of the magnetic field measured by each coil will be equal. If the vehicle strays to one side or the other, or if the guide wire path changes direction, the magnetic field intensity at the two sensors will be different. This difference is used to control the steering motor, which makes the required changes in vehicle direction to equalize the two sensor signals, thereby tracking the guide wire.

ii) Paint strips: The vehicle uses an optical sensor system capable of tracking the paint. The strips can be taped, sprayed, or painted on the floor. One system uses a 1-in-wide paint strip containing fluorescent particles that reflect the ultraviolet (UV) light source from the vehicle. An on-board sensor detects the reflected light in the strip and controls the steering mechanism to follow it.

iii) Self Guided Vehicles: Self-guided vehicles (SGVs) operate without continuously defined pathways. Instead they use a combination of dead reckoning and beacons located throughout the plant, which can be identified by on-board sensors.

Operation of On-board sensor system

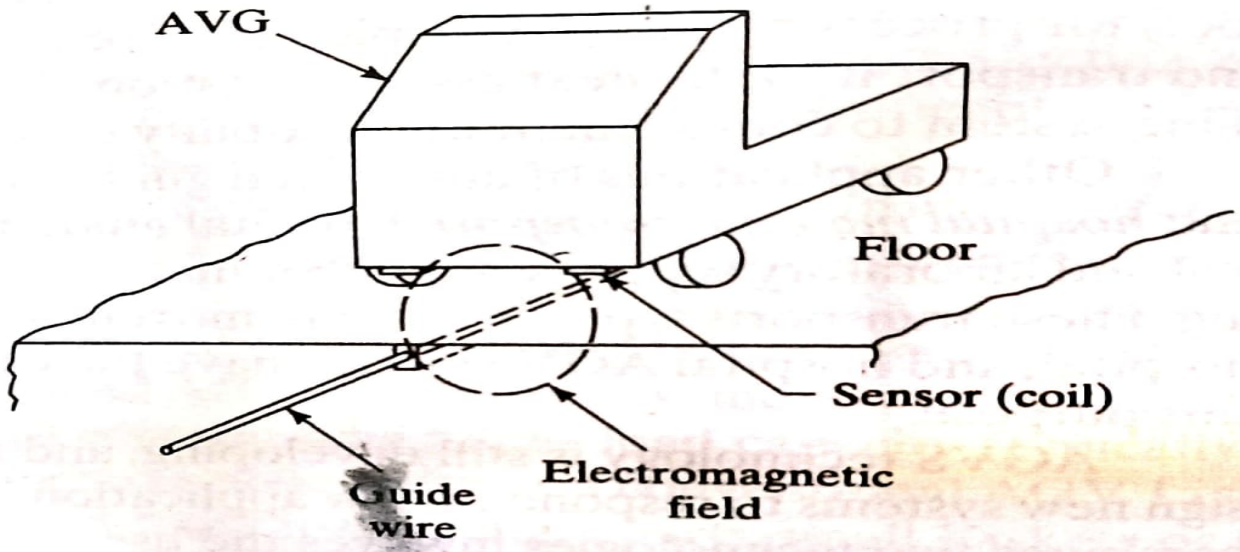


Figure 10.4 Operation of the on-board sensor system that uses two coils to track the magnetic field in the guide wire.

Vehicle Management and safety

1) Traffic Control: The purpose is to minimize interference between vehicles and to prevent collisions

Two method of traffic control used in commercial AGV systems are: a) on-board vehicle sensing b) Zone control

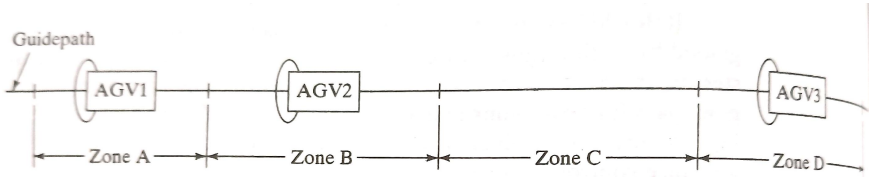


Figure 10.5 Zone control to implement blocking system. Zones A, B, and D are blocked. Zone C is free. Vehicle 2 is blocked from entering Zone A by Vehicle 1. Vehicle 3 is free to enter Zone C.

2) Vehicle Dispatching:

Methods used are

a) on-board control panel b)remote call stations c)Central computer control

3) Monorails and other rail guided vehicles

- It is consists of motorized vehicles that are guided by a fixed rail system. The rail system consists of either one rail (called monorail) or two parallel rails. Monorails in factories and warehouses are typically suspended overhead from the ceiling.
- The rail guided vehicles pick up electrical power from an electrified rail. This relieves the vehicle from periodic recharging of its battery; however, the electrified rail system introduces a safety hazard not present in an AGVS.

4) Conveyor Systems

- Conveyors are used when material must be moved in relatively large quantities between specific locations over a fixed path. The fixed path is implemented by track system, which may be in-the-floor, above-the –floor, or overhead
- Conveyors divide into two basic categories (1) : Powered (2) non-powered.
- In Powered conveyors , the power mechanism is contained in the fixed path, using chains, belts, rotating rolls or other devices to propel loads along the path.
- In Non-powered, materials are moved either manually by human workers who push the loads along the fixed path or by gravity from one elevation to a lower elevation.

Types of Conveyors

1) Rollers conveyors and Skate Wheel conveyors
2) Belt Conveyors
3) Conveyors Driven by Chains and Cables
4) Other types of conveyors

1) Roller and skate conveyors

- In Roller conveyors, the pathway consists of a series of tubes (rollers) that are perpendicular to the direction of travel.
- In skate wheel, the operation is similar to roller conveyors. Instead of rollers, they use skate wheels rotating on shafts connected to a frame to roll pallets or tote pans or other containers along the pathway

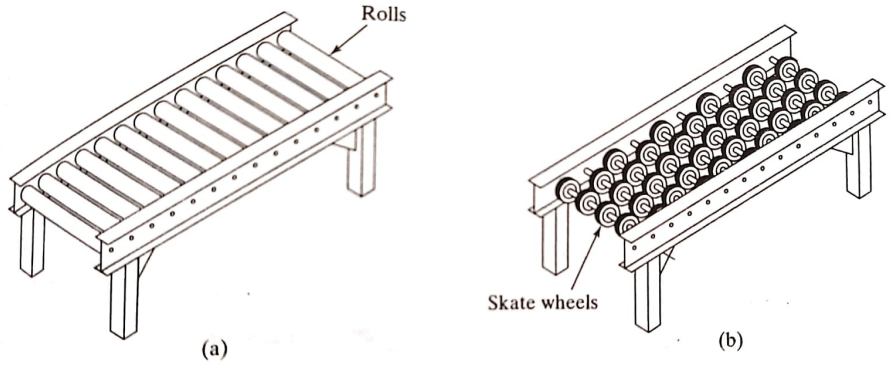


Figure 10.6 (a) Roller conveyor and (b) skate wheel conveyor.

2) Belt conveyors

- It consist of continuous loop: Half its length is used for delivering materials, and the other half is the return run.
- The belt is made of reinforced elastomer (rubber), so that it possesses high flexibility but low extensibility. At one end of the conveyor is a drive roll that powers the belt.
- Belt conveyors are available in two common forms (a)flat belts for pallets, individual parts, or even certain types of bulk materials

(b) Troughed belts for bulk materials

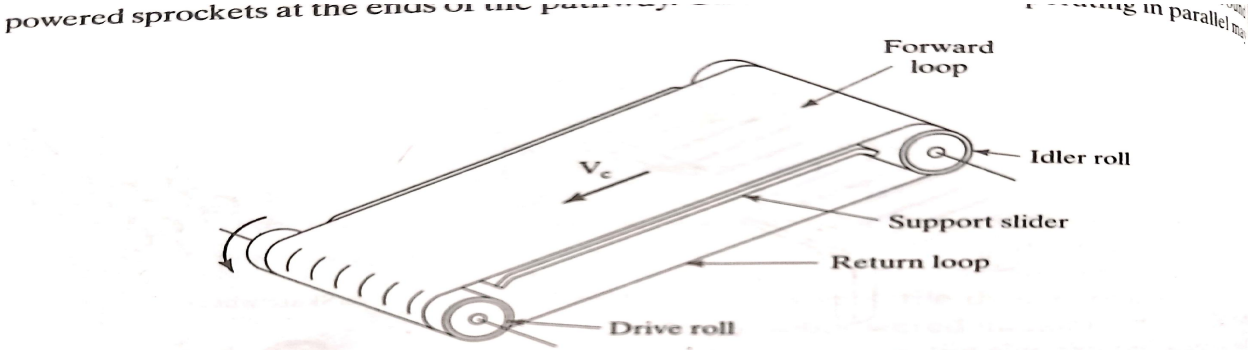


Figure 10.7 Belt (flat) conveyor (support frame not shown).

3) Conveyors driven by chains and cables

- The conveyors in this group are driven by a powered chain or cable that forms an endless loop. In some cases, the loop forms a straight line, with a pulley at each end.

The following conveyors are of this category

(i) Chain

(ii) Slat

(iii) in-floor towline

(iv)Overhead trolley

(v) Power and free over head trolley

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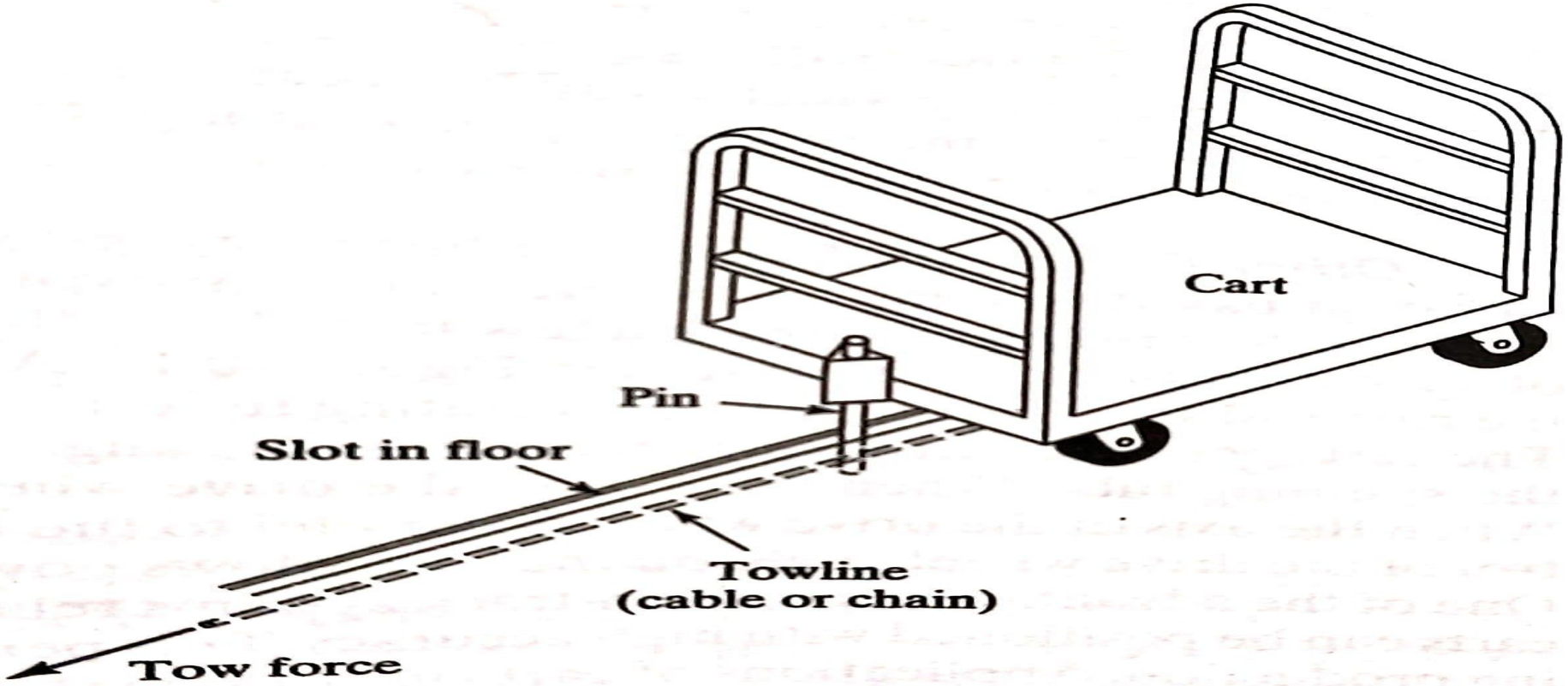
(i) Chain conveyors : It consist of loops in an over and under configuration around powered sprockets at the ends of the pathway. One or more chains operating in parallel may be used to form the conveyor

(ii) Slat conveyors: It uses individual platforms, called slats, connected to a continuously moving chain. Although the drive mechanism is a powered chain, it operates much like a belt conveyor. Loads are placed on the slats and are transported along with them. Straight line flows are common in slat conveyor systems. However, because of chain drive and the capability to alter the chain direction using sprockets, the conveyor pathway can have turns in its continuous loop.

(iii) In-floor towline conveyor: These conveyors make use of four-wheel carts powered by moving chains or cables located in trenches in the floor

In-floor towline conveyor



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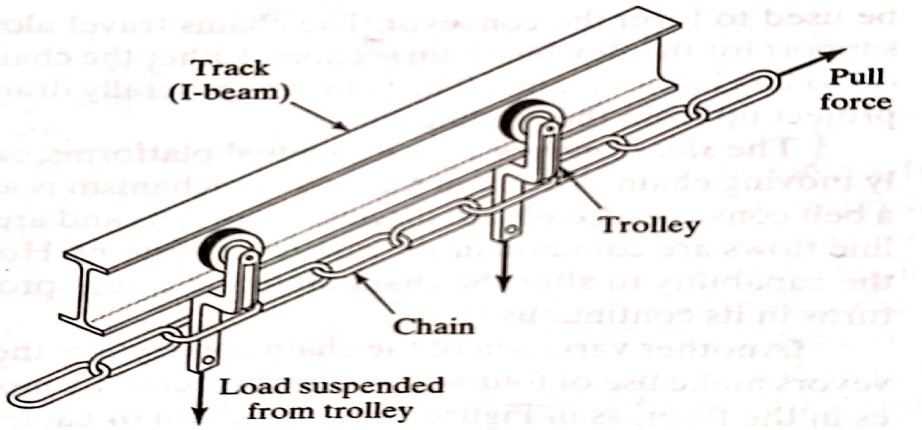
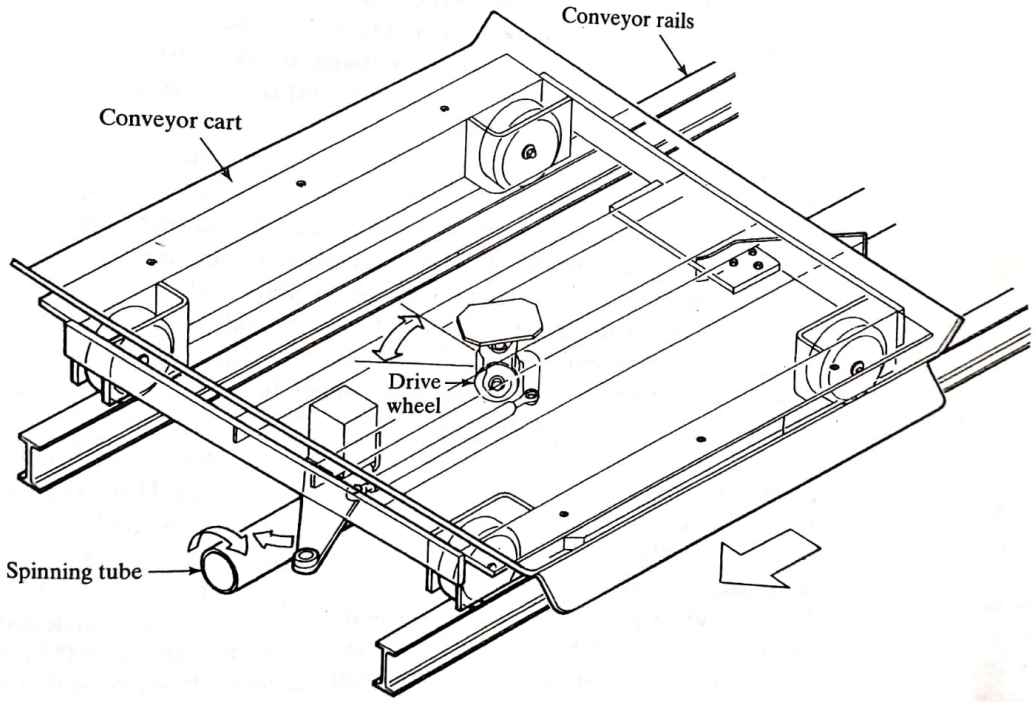
(iv) Overhead trolley : A trolley in material handling is a wheeled carriage running on an overhead rail form which loads can be suspended. An overhead trolley conveyor consists of multiple trolleys, usually equally spaced along a fixed track. The trolleys are connected together and moved along the track by means of a chain or cable that forms a complete loop.



(v) Power and free overhead trolley: It is similar to the overhead trolley conveyor,, except that the trolleys are capable of being disconnected from the drive chain, providing this conveyor with an asynchronous capability. This is usually accomplished by using two tracks, one just above the other.

Other conveyors types

(i) Cart-on-track conveyors: It consist of individual carts riding on a track a few feet above floor level. The carts are driven by means of rotating shaft. A drive wheel, attached to the bottom of the cart and set an angle to the rotating tube, rests against it and drives the cart forward.



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(ii) Screw Conveyors: they are based on Archimedes screw, the water raising device devised in ancient times (circa 236 B.C), consisting of a large screw inside a cyclinder, turned by hand to pump water up-hill for irrigation purposes

(iii) Vibration-based conveyors: They use a flat track connected to an electromagnet that imparts an angular vibratory motion to track to propel items in the desired direction.

(iv) Vertical lift conveyors: It includes a variety of mechanical elevators designed to provide vertical motion, such as between floors or to link floor-based conveyors with overhead conveyors. Other conveyor types include nonpowered chutes, ramps and tubes which are driven by gravity.

Conveyor operation and features

- Conveyors system divides into two parts (i) Continous (ii) asynchronous
- Continous motion conveyors move at a constant velocity along the path. They include belt, roller, skate-wheel, overhead trolley and slat conveyors
- Asynchronous conveyors operate with stop-and –go motion in which loads usually contained in carriers (hooks, baskets, carts), move between stations and then stop and remain at the station until released. Asynchronous handling allows independent movement of each carrier in the system. Examples of this type include overhead power and free trolley, infloor towline and cart on track conveyors.
- Reasons. for using asynchronous conveyors include: (i) to accumulate loads (ii) temporary storage (iii) to allow for differences in production rates between adjacent processing areas (iv) to smooth production when cycle times vary at stations along the conveyor (v) To accommodate different conveyor speeds along the pathway

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Conveyors can also be classified as:

(i) Single direction : They are used to transport loads one way from origination point to destination point. Single direction powered conveyors include roller, skate wheel, belt and chain in floor types. In addition all gravity conveyors operate in one direction.

(ii) Continous loop conveyors: An overhead trolley conveyor is an example of this conveyor type. However, any conveyor type can be configured as a loop even those previously defined as single direction conveyors, simply by connecting several single direction conveyor sections into a closed loop. A continuous loop system allows material to be moved between any two stations along the pathway.

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- Diagram

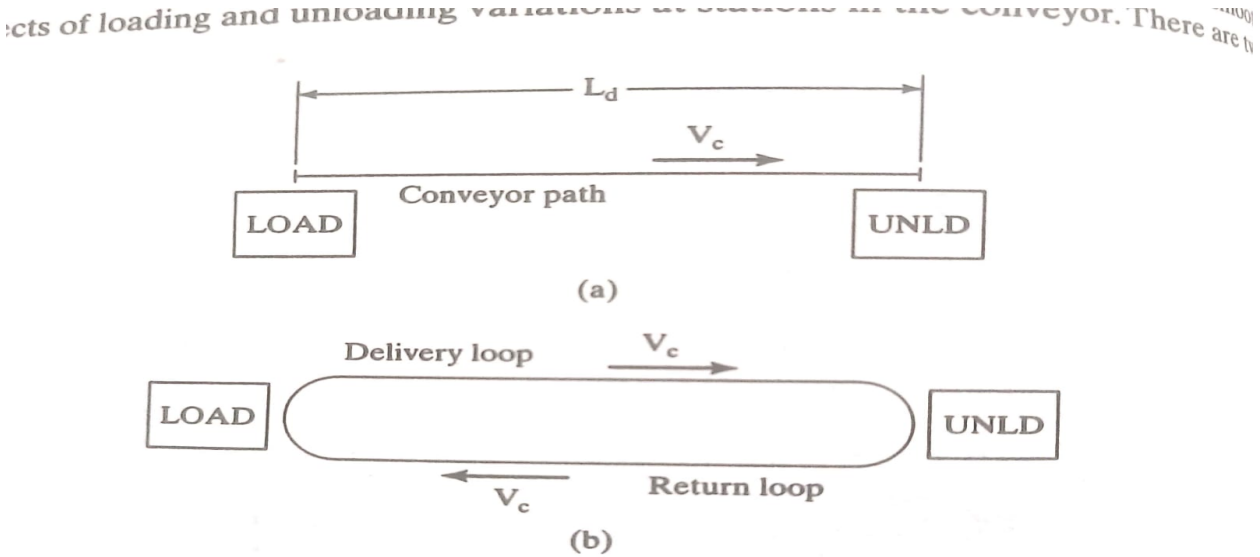


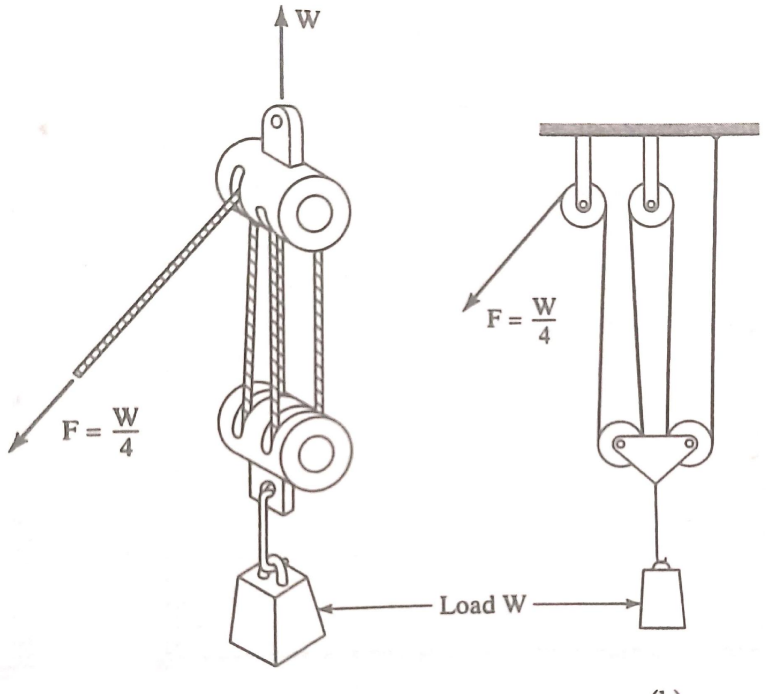
Figure 10.11 (a) Single direction conveyor and (b) continuous loop conveyor.

(iii) Recirculating conveyors: The conveyor systems that allows parts to remain on the return loop for one or more revolutions

5) Cranes and Hoists

- Cranes: cranes are used for horizontal movement of materials in a facility and hoists are used for vertical lifting
- Types of cranes: a) Bridge type (b) gantry cranes c) jib cranes
- Hoists: They are a mechanical device that can be used to raise and lower loads. A hoist consists of one or more fixed pulleys, one or more moving pulleys and rope, cable or chain strung between the pulleys. A hook or other means for attaching the load is connected to the moving pulley.

Diagram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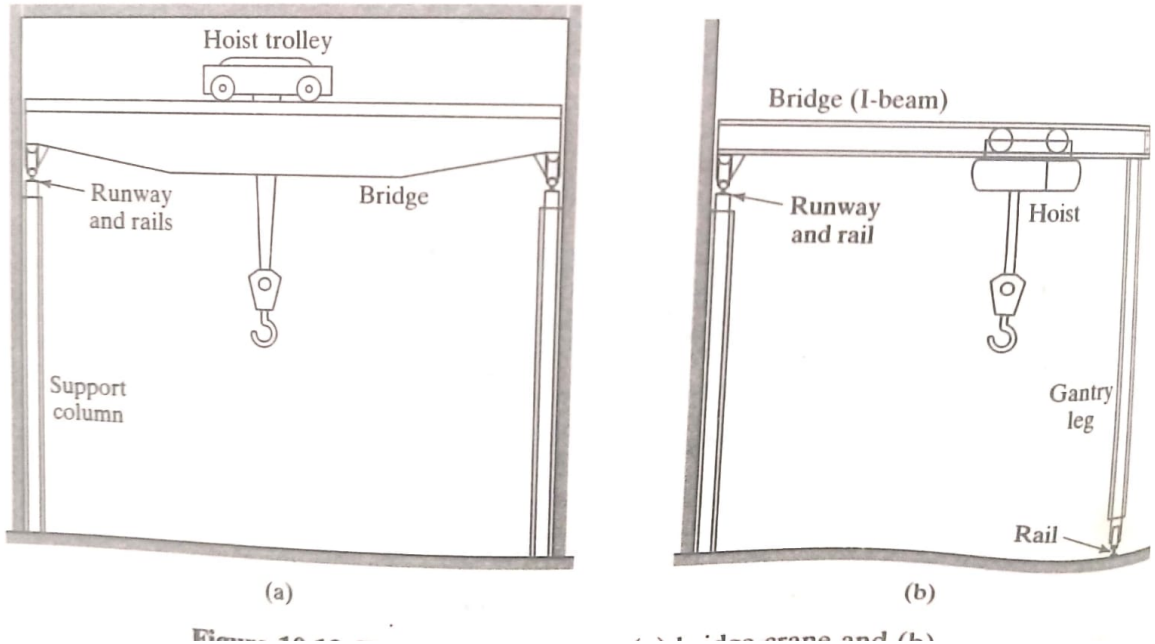
F = W/4
Load W


Hoist trolley
Runway and rails
Bridge
Support column
(a)
Bridge (I-beam)
Runway and rail
Hoist
Gantry leg
Rail
(b)