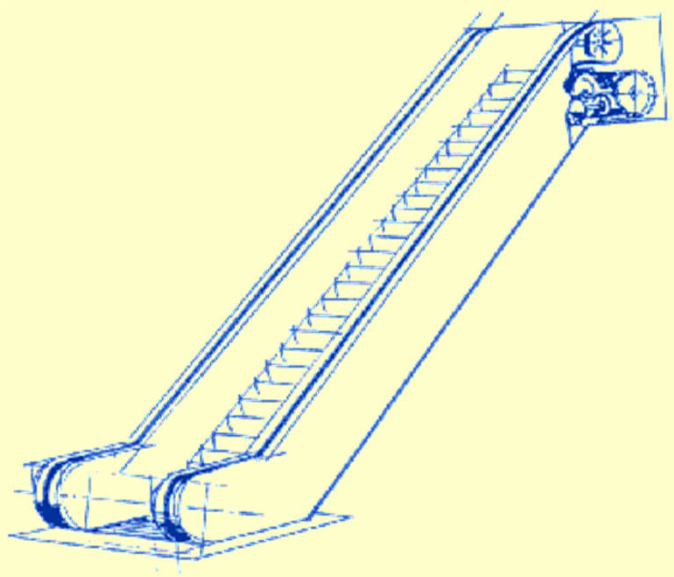
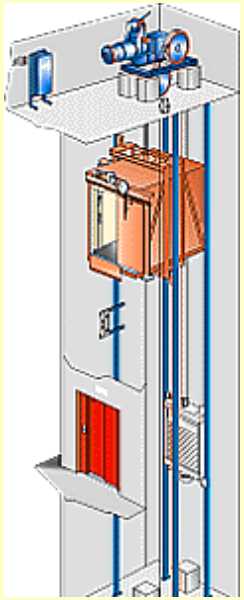
IBTM6010H Utility Services

http://ibse.hk/IBTM6010H/





Vertical Transportation (II)

Ir Dr. Sam C. M. Hui

E-mail: sam.cmhui@gmail.com

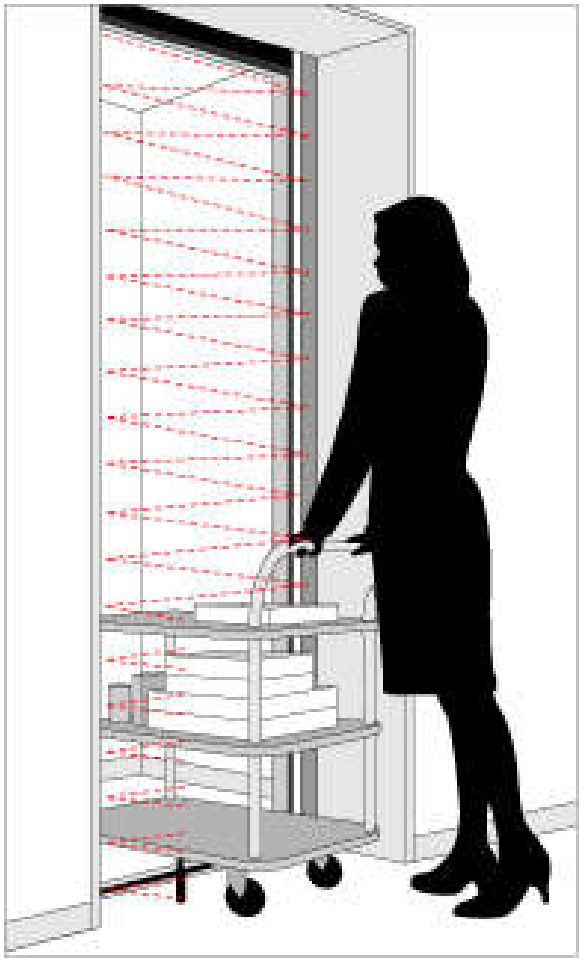
http://ibse.hk/cmhui/

Feb 2021

Contents

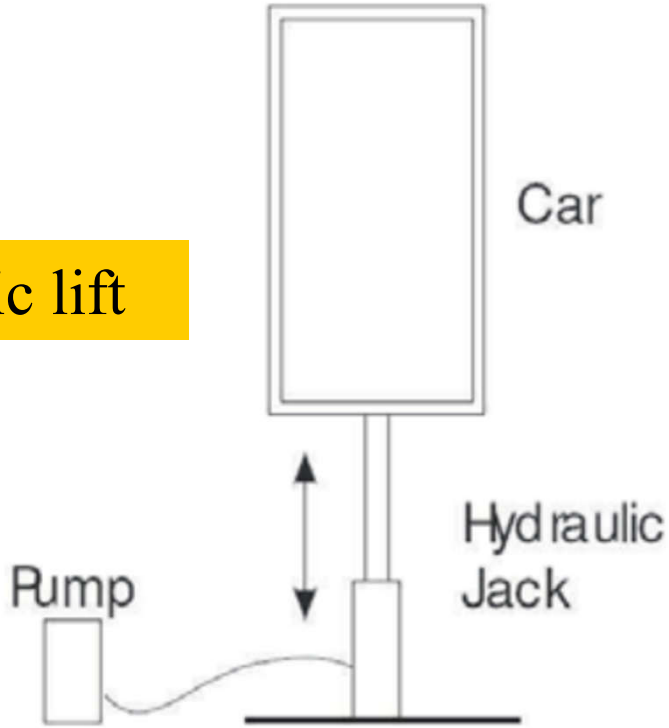


- Lift Components
- Lift Drive Operation
- Lift Traffic Control
- Operation of Escalators
- Safety Issues
- Energy Efficiency
- Modernisation

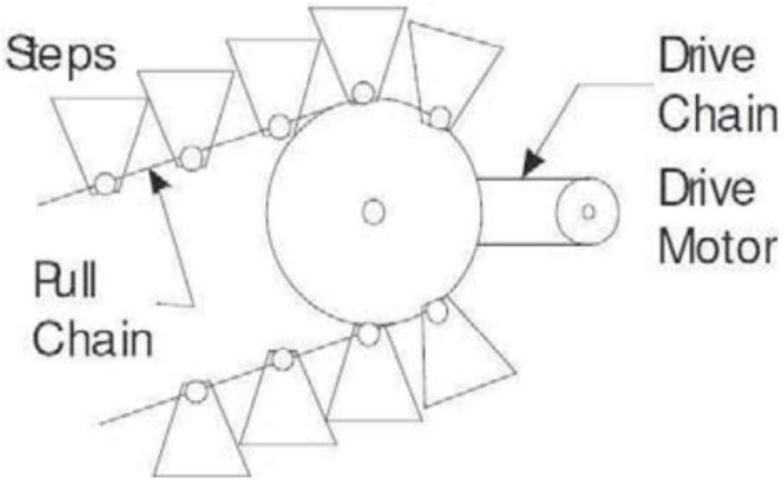


Basic components of hydraulic lift, electric traction lift and escalator

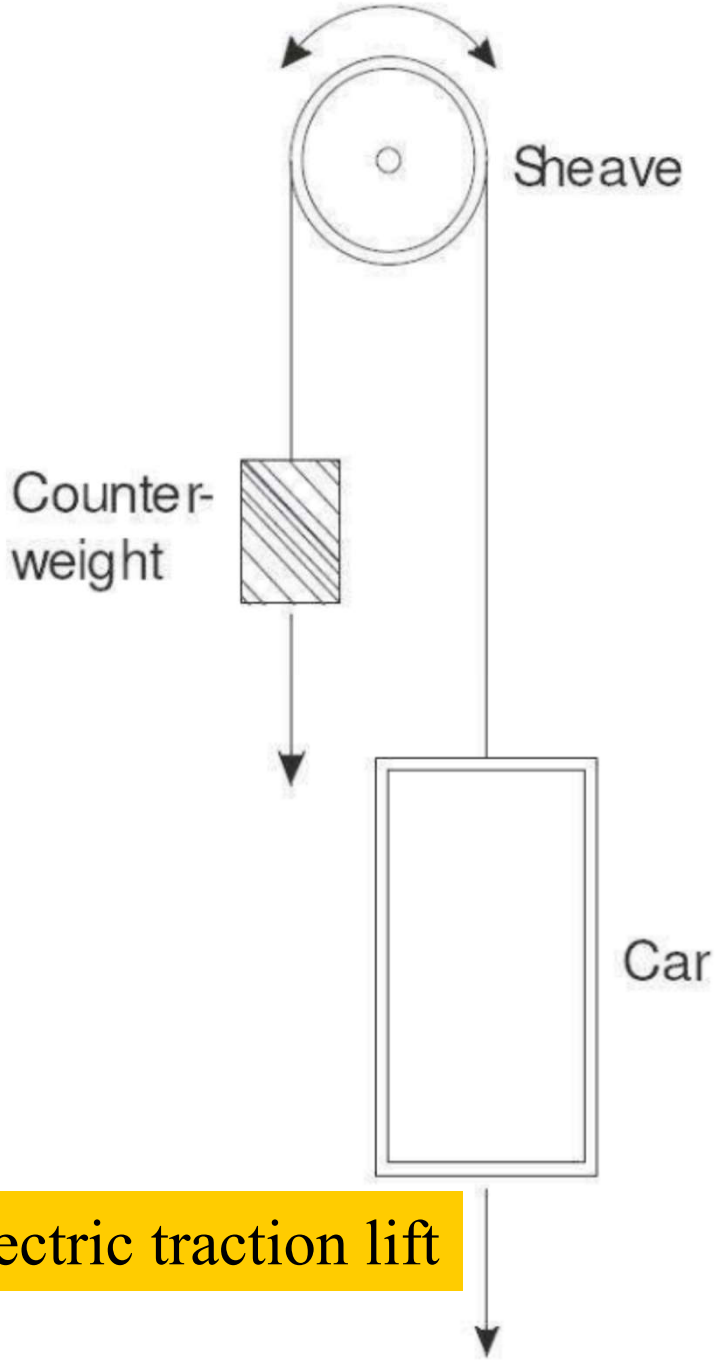
Hydraulic lift



Escalator

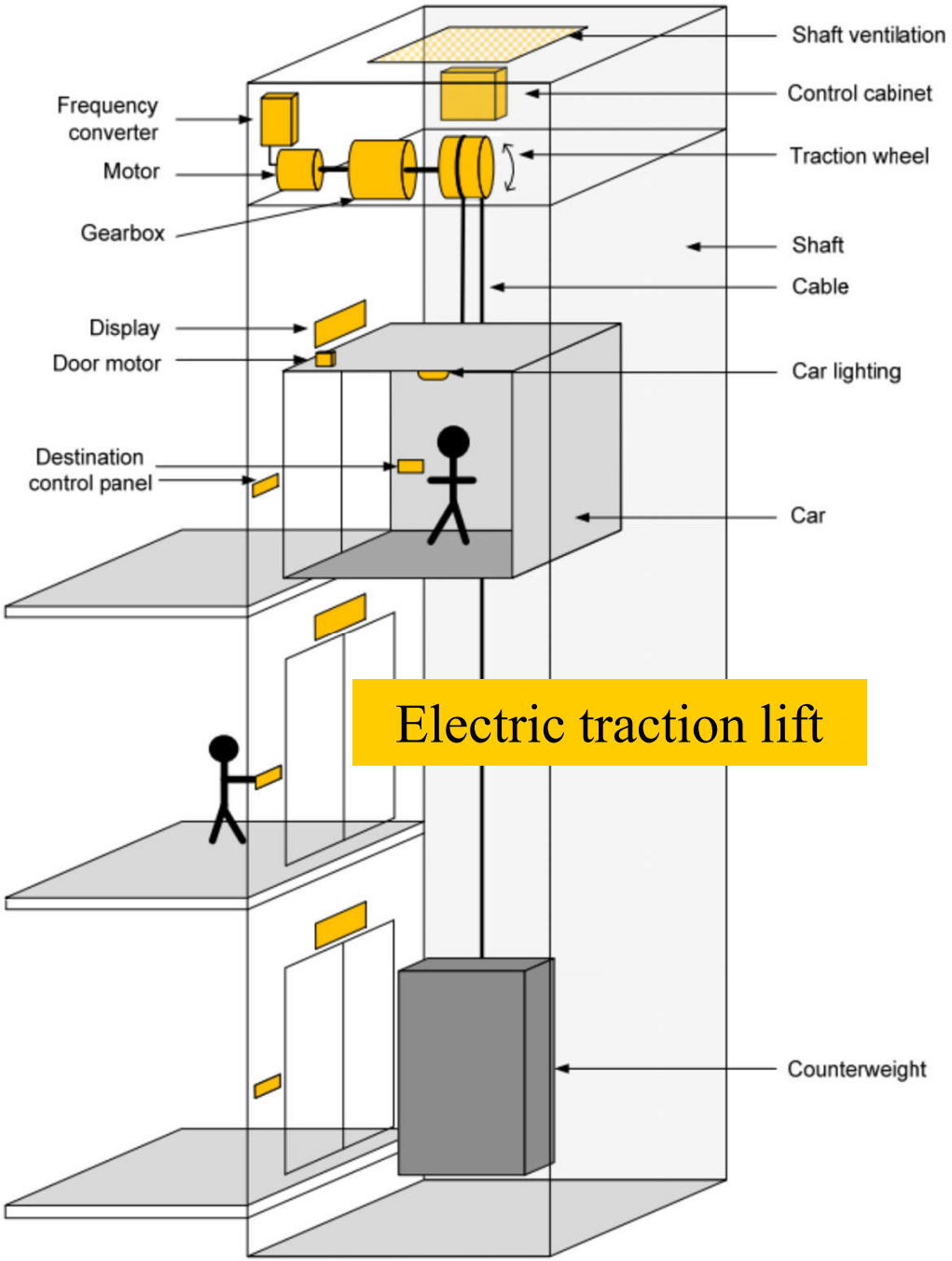


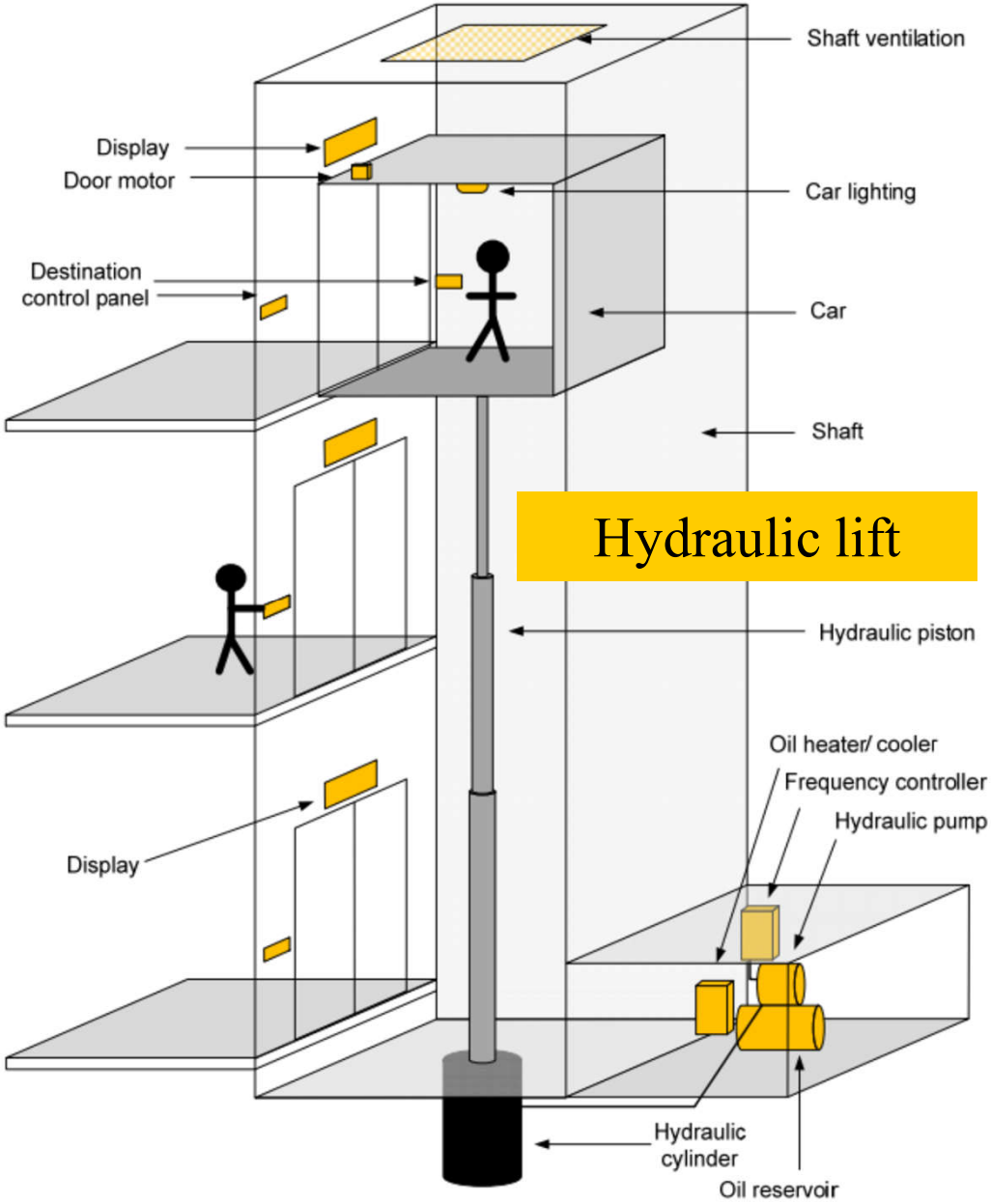
Electric traction lift



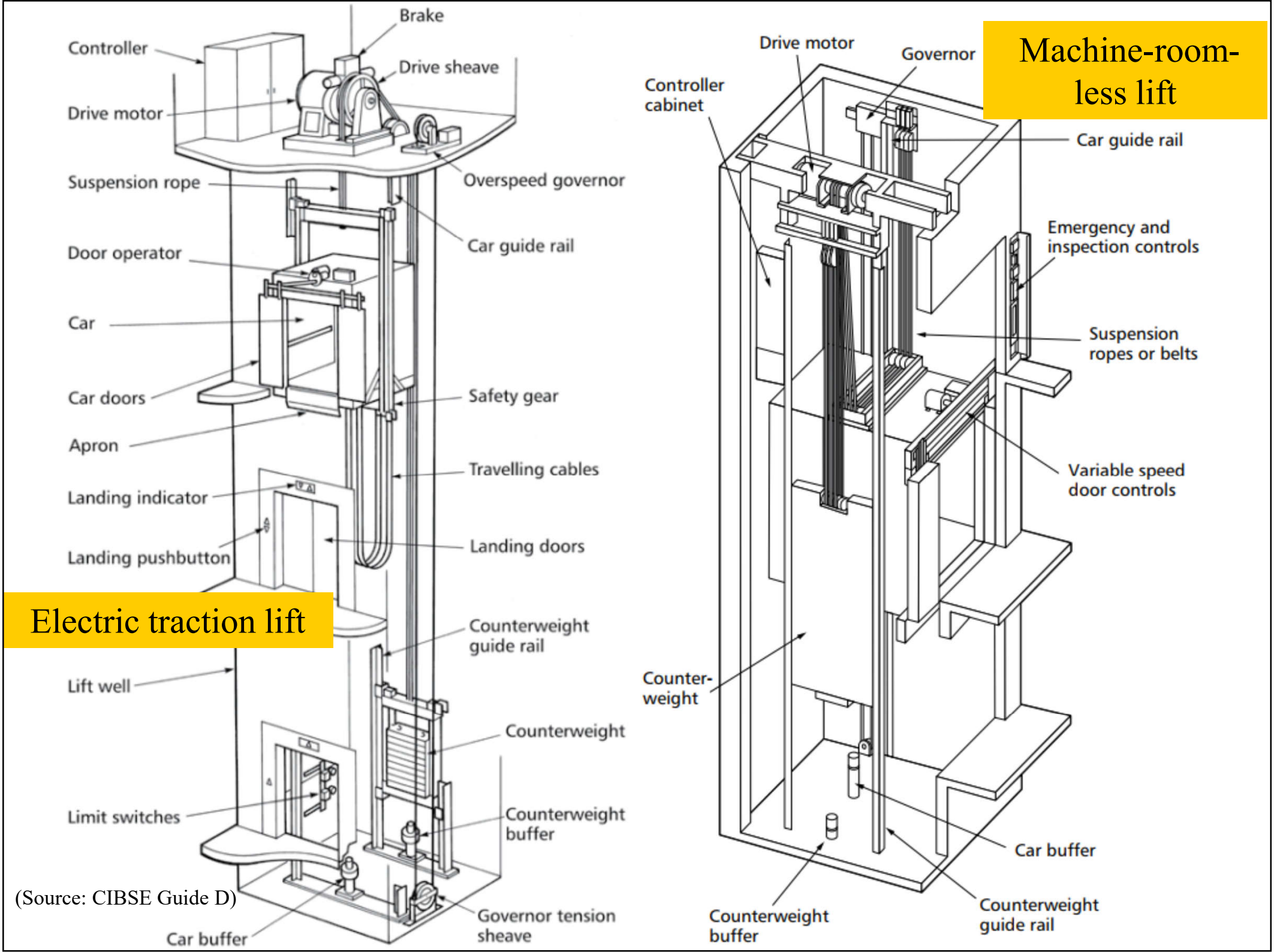
(Image source: https://www.eceee.org/static/media/uploads/site-2/library/conference_proceedings/eceee_Summer_Studies/2009/Panel_4/4.037/paper.pdf)

Simplified representation of electric traction lift & hydraulic lift



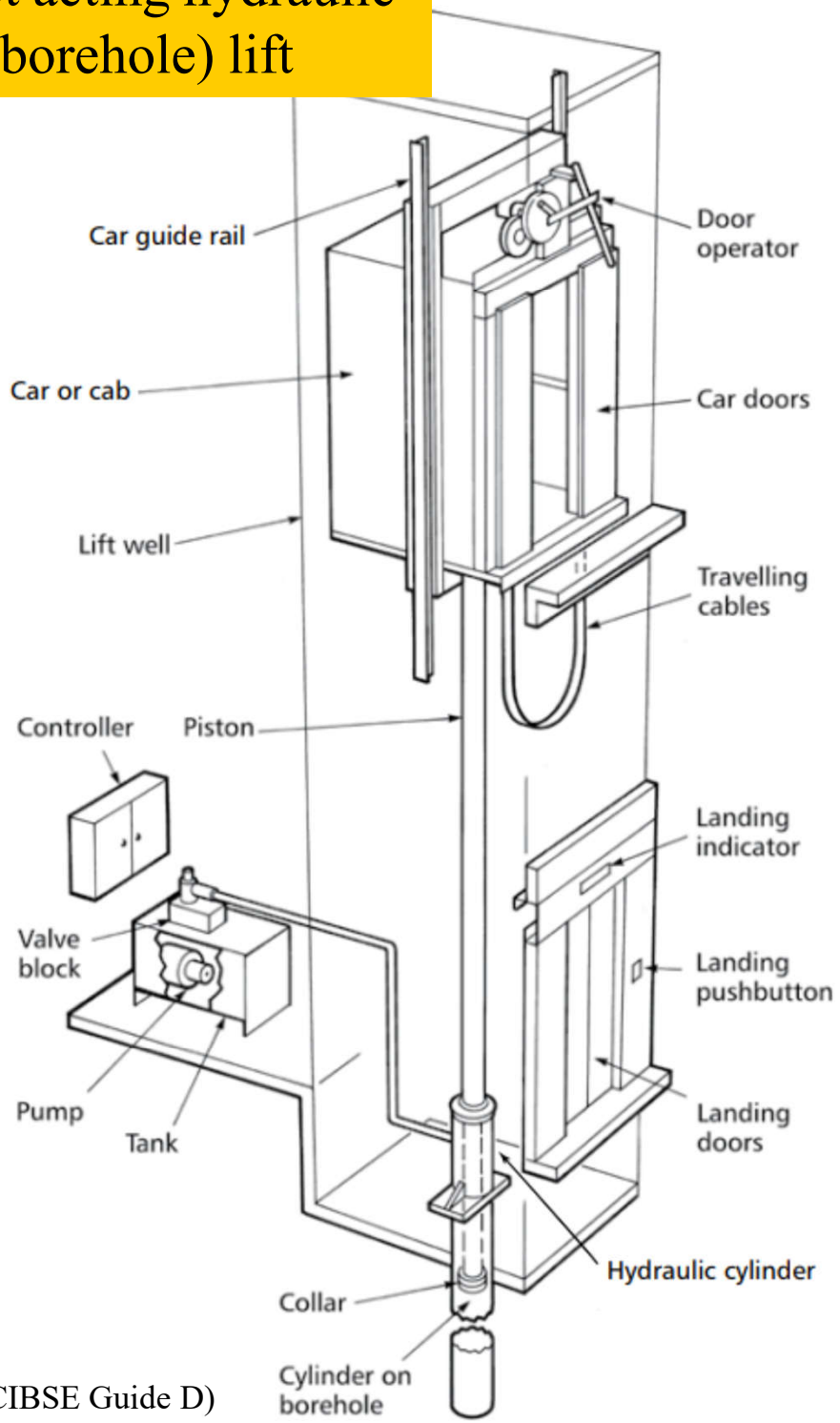


(Source: Fraunhofer ISI)

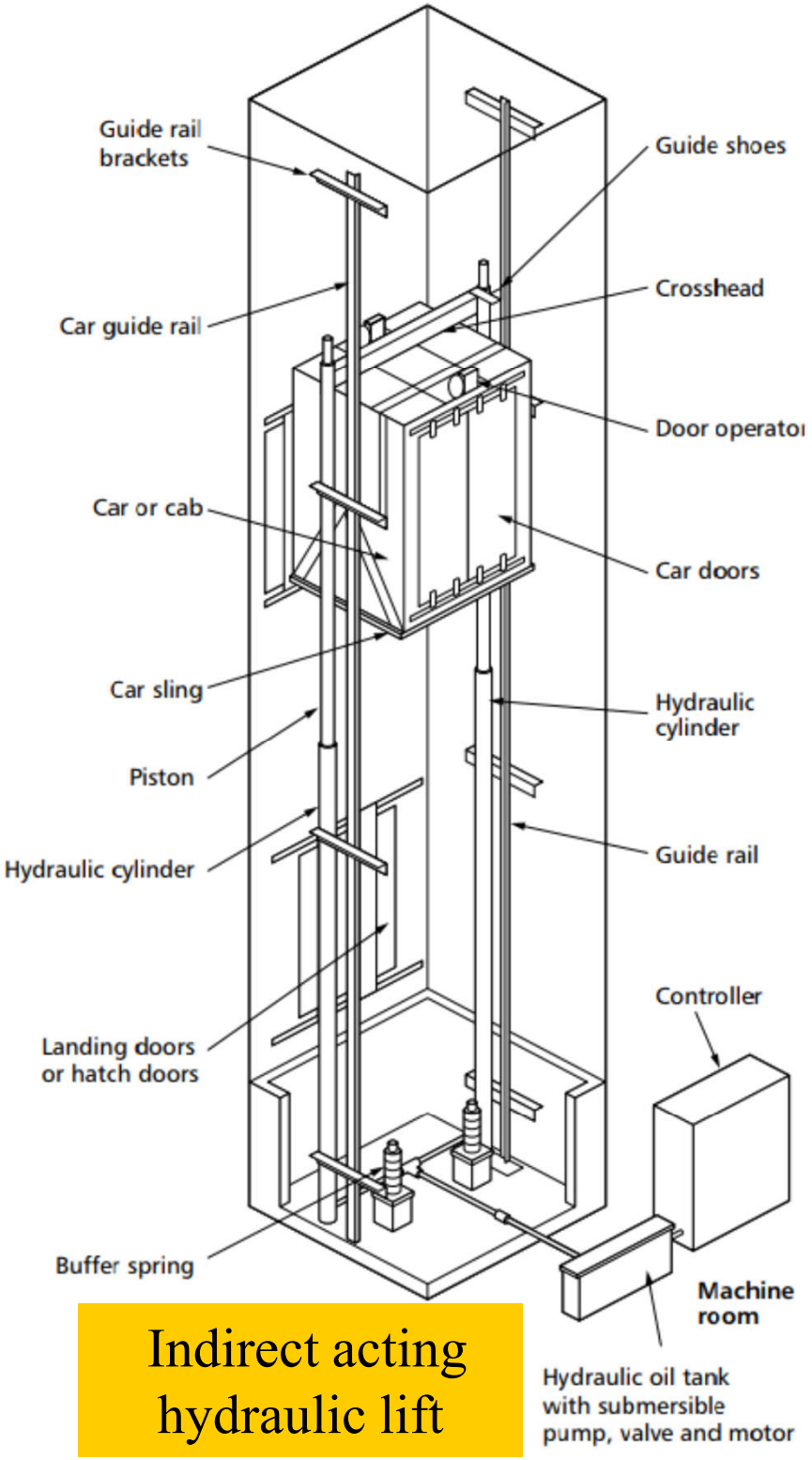


(Source: CIBSE Guide D)

Direct acting hydraulic (borehole) lift



(Source: CIBSE Guide D)



Indirect acting hydraulic lift

Lift Components

- Major lift components:
  - Prime mover (electric machine or hydraulic pump)
  - Lift car (car frame, the car itself)
  - Counterweight (if used)
  - Guide rails
  - Entrances/Doors
  - Safety gear & overspeed governor
  - Buffers (energy accumulation, energy dissipation)
  - Roping systems (compensating ropes, traction systems)
  - Car & landing fixtures (buttons, indicators & switches)

Lift Components

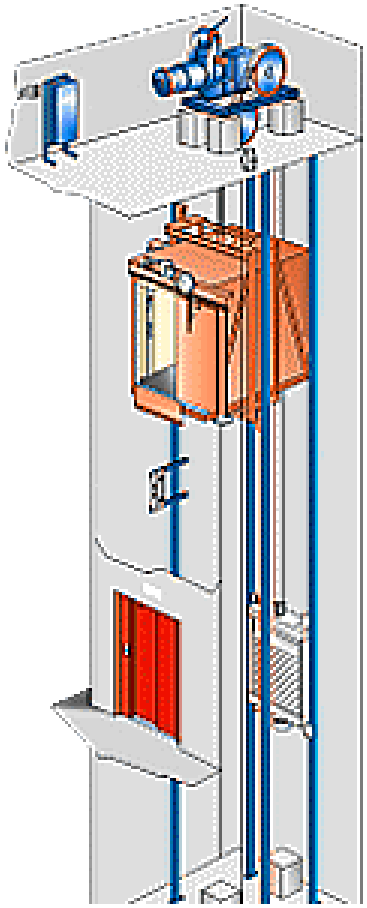
- Videos for demonstration:



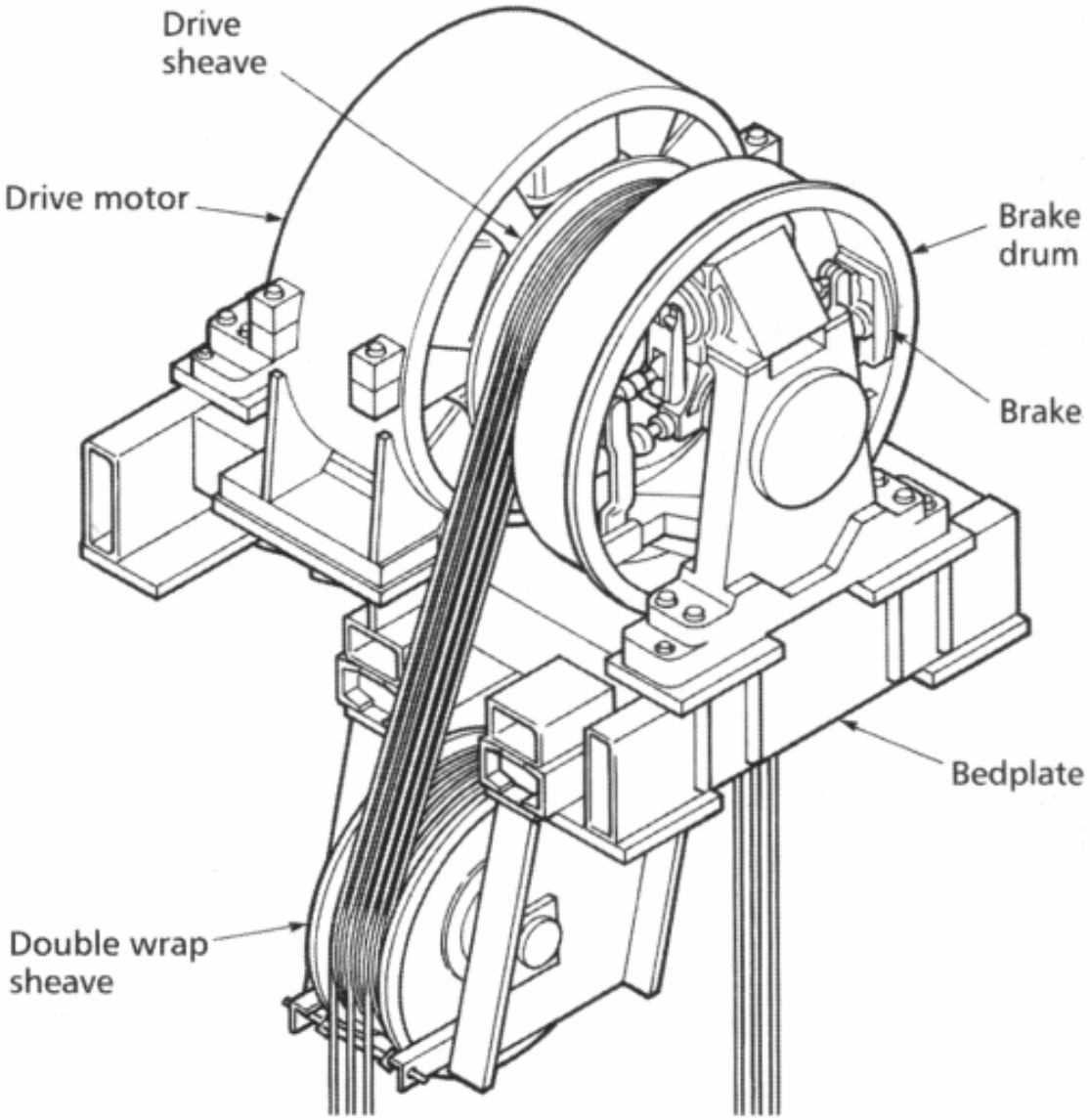
  - Elevator Project Animation - UC Berkeley (10:25)
    https://youtu.be/vuhQnO8HXZc
  - Components of Elevator (8:06)
    https://youtu.be/_PoAwHJkS_8
  - Components of Elevator Part 2 (7:29)
    https://youtu.be/Z6tYRoJtza0

Lift Components

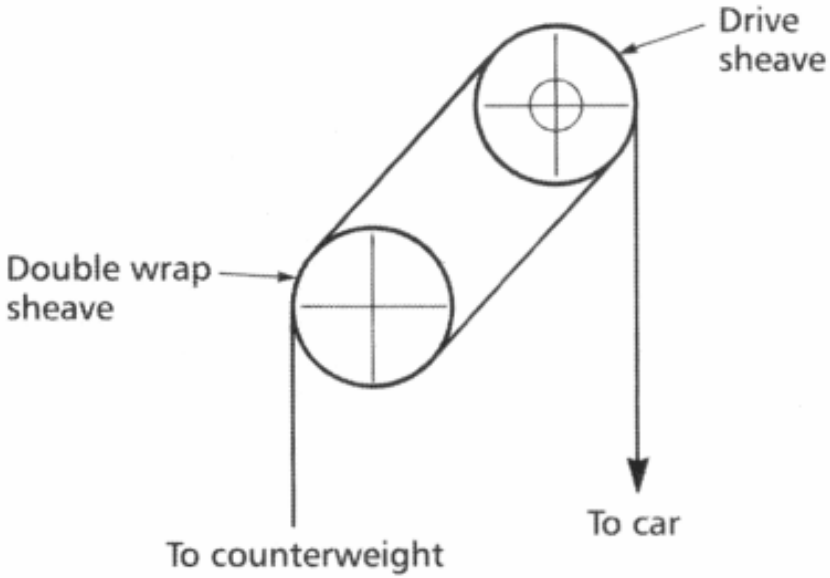
- Electric traction lift
  - Motor (AC or DC; gear or gearless)
  - Roping
  - Emergency brake
  - Lift doors
  - Constructional dimensions
  - Machine room position
  - Controller cabinet
  - Lift pit & shaft



Typical gearless machine

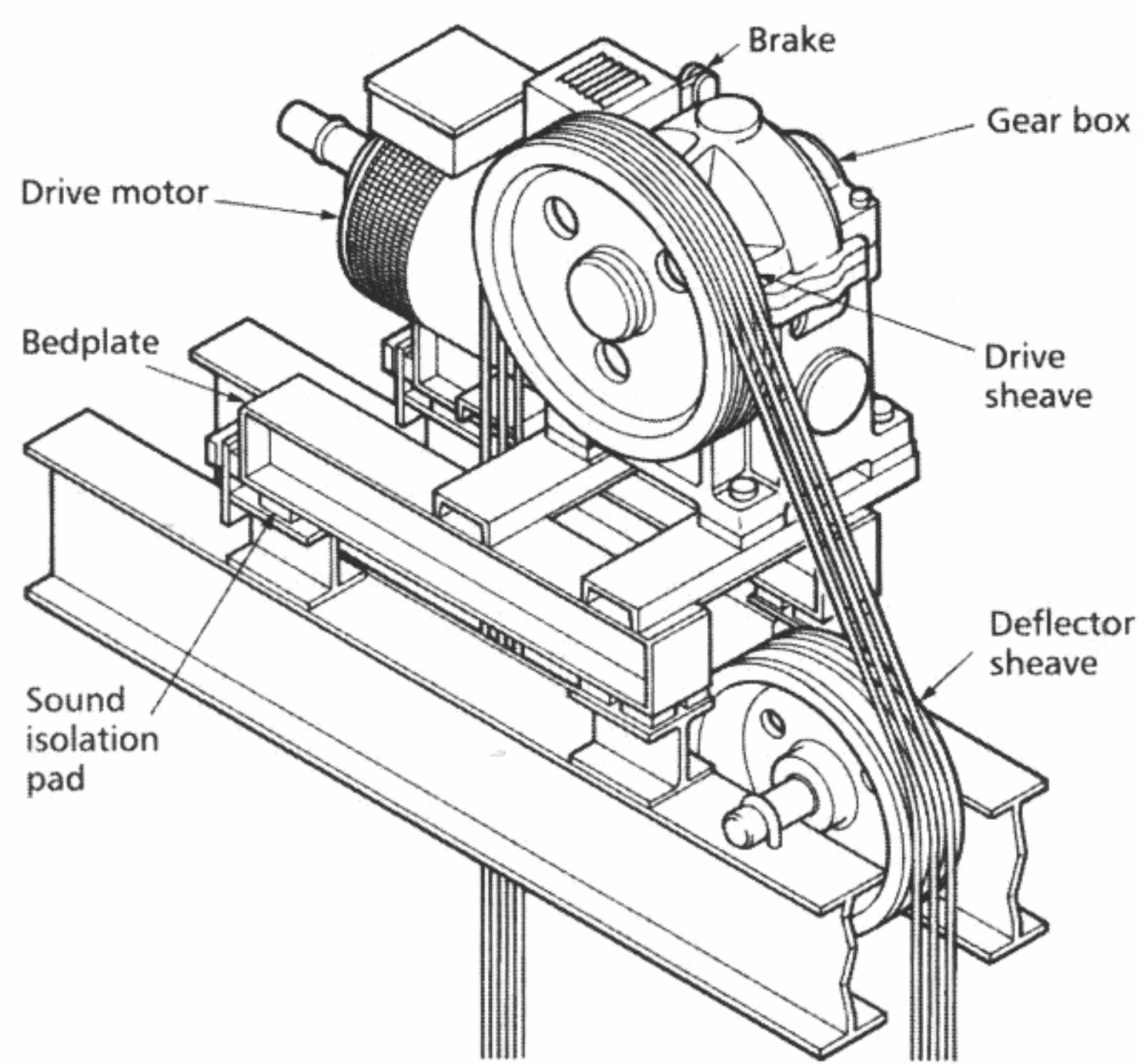






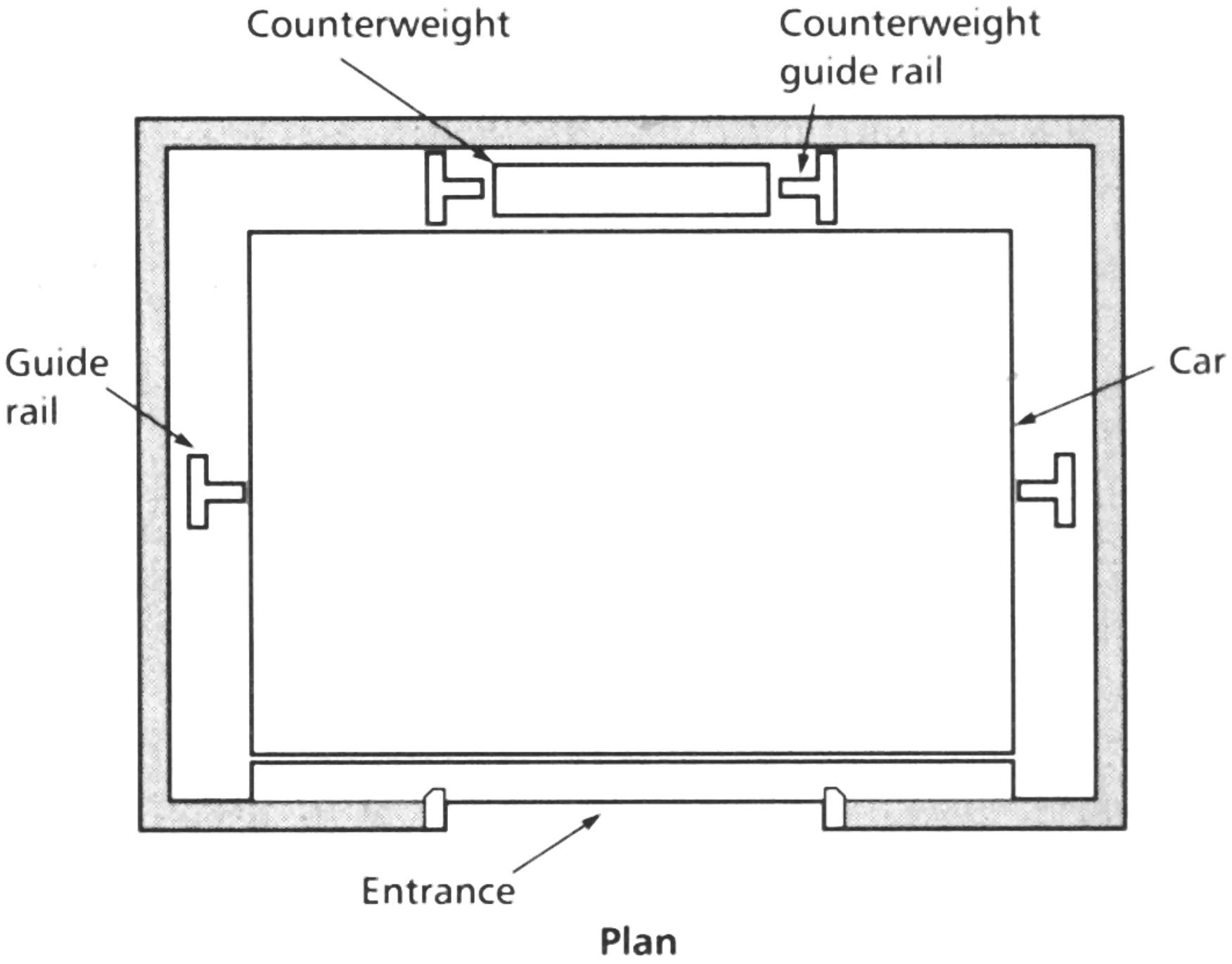
[Source: CIBSE Guide D]

Typical geared machine

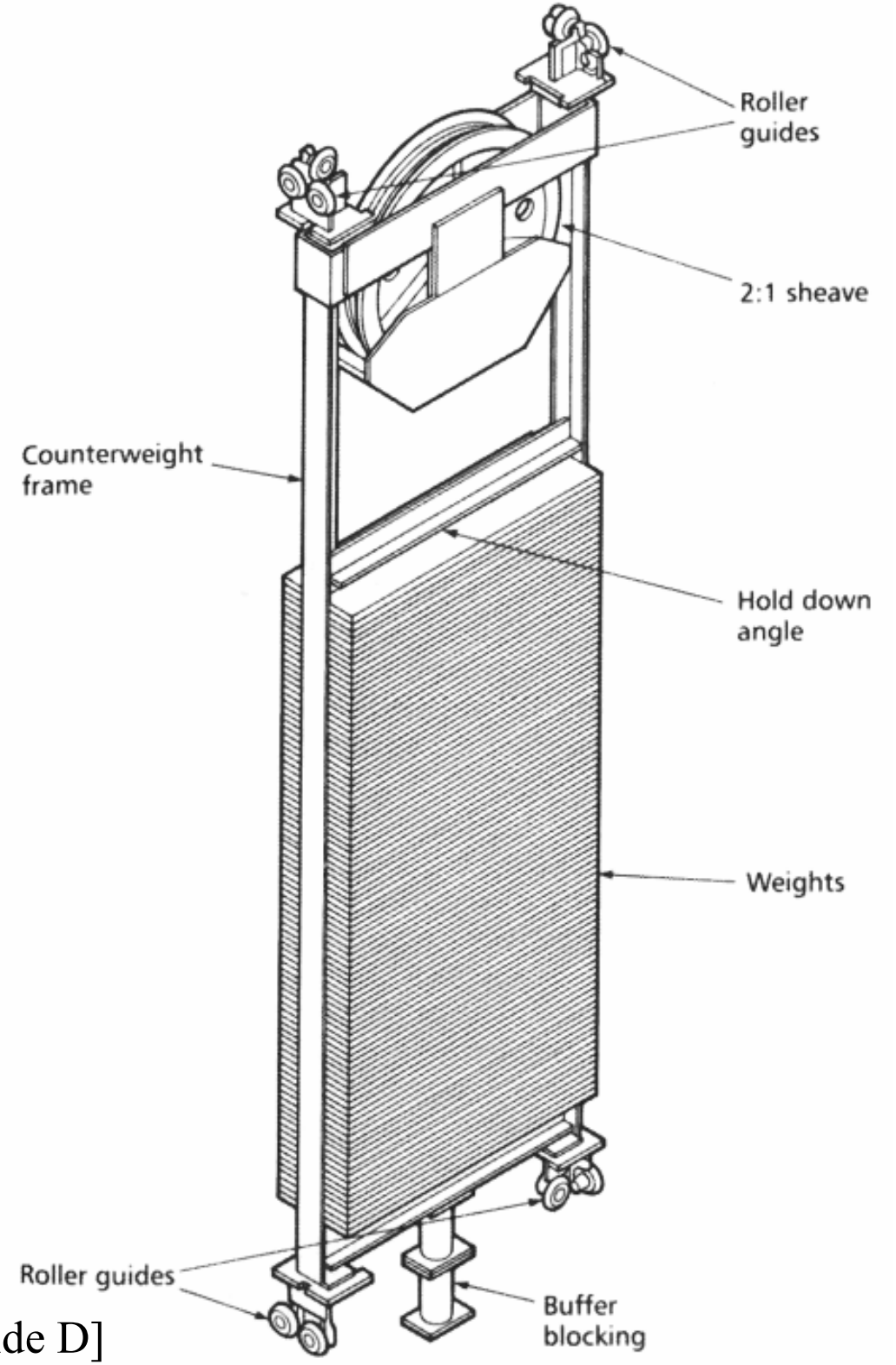


[Source: CIBSE Guide D]

Position of guide rails

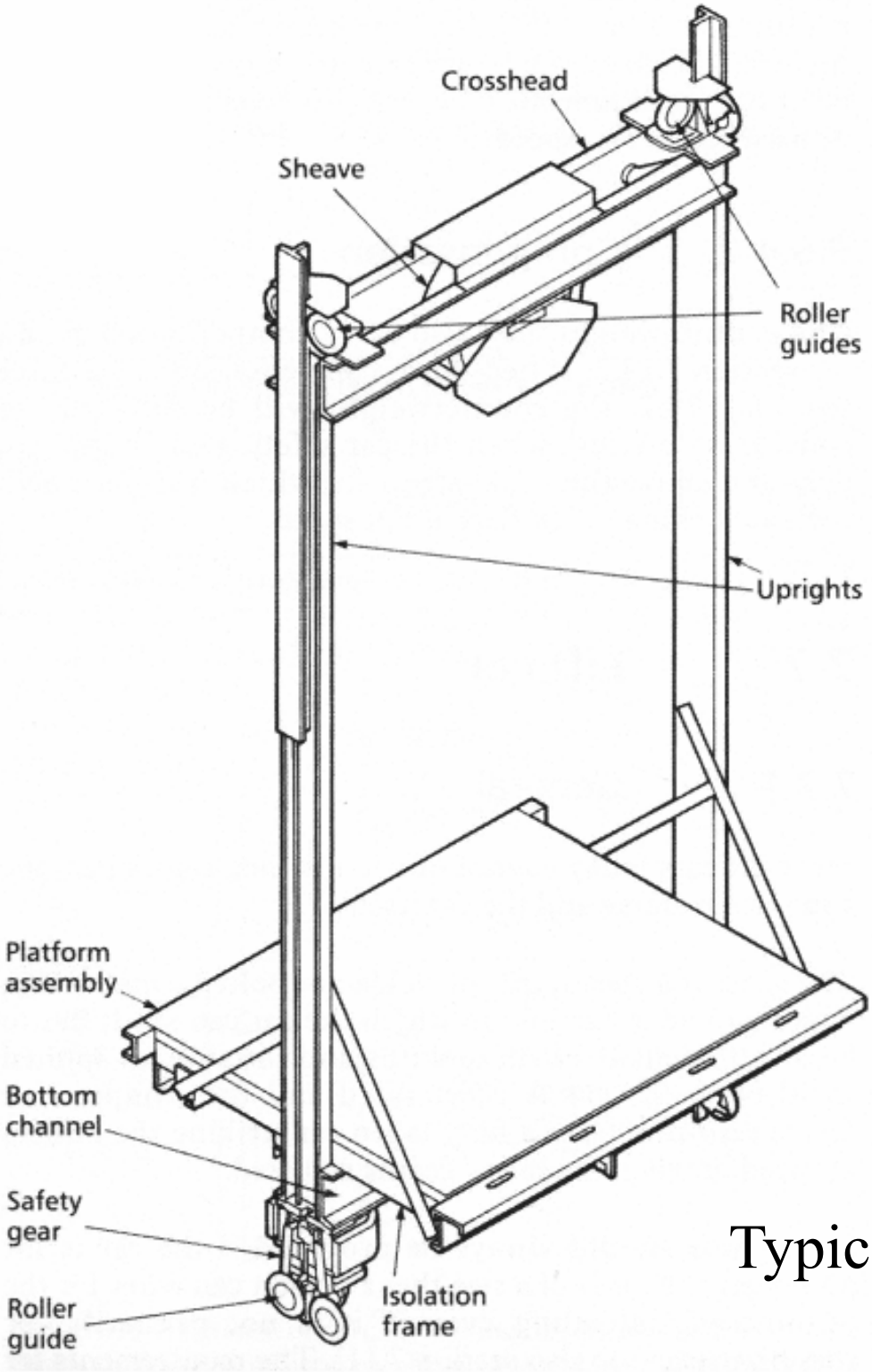


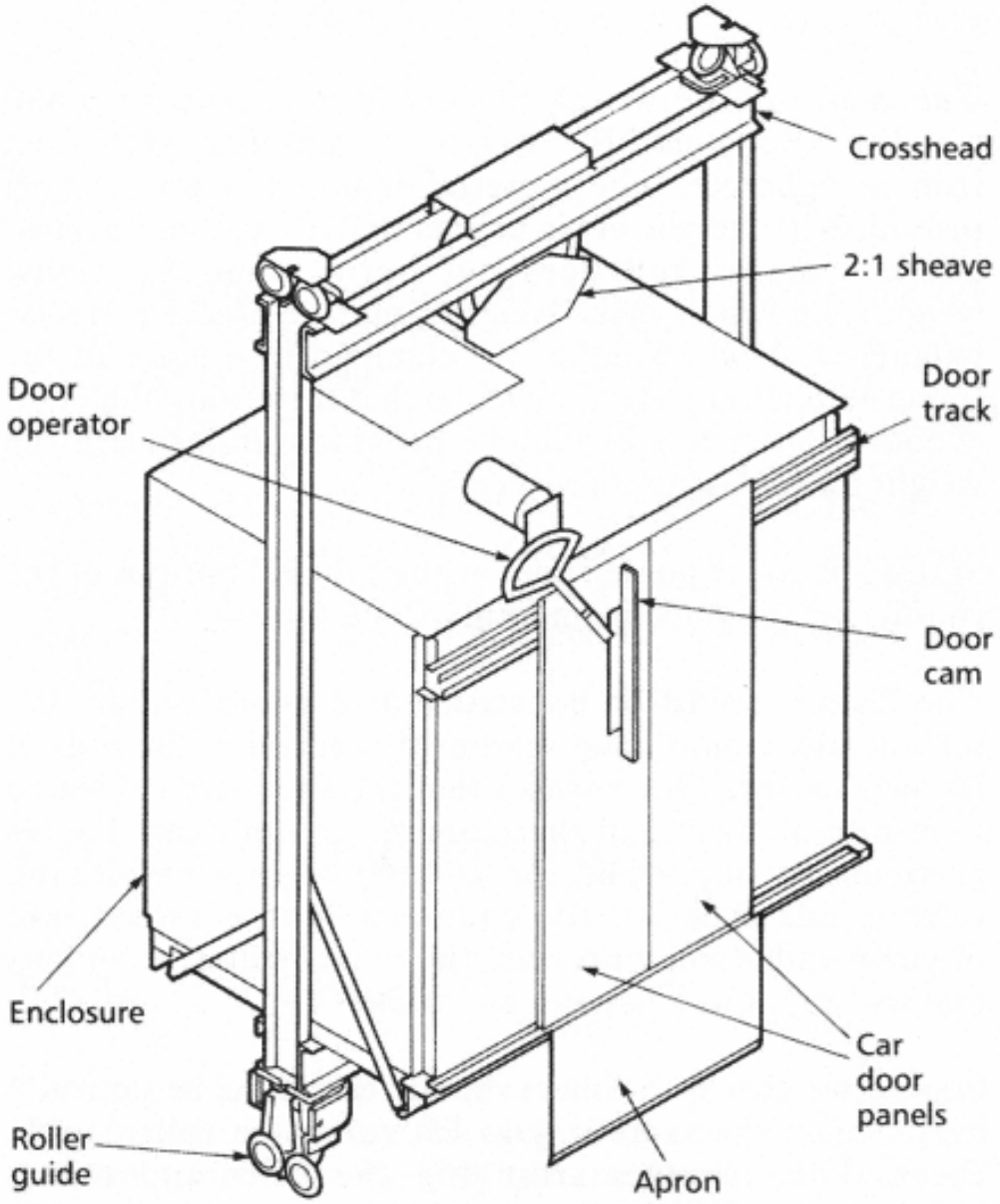
[Source: CIBSE Guide D]



Typical counterweight

[Source: CIBSE Guide D]

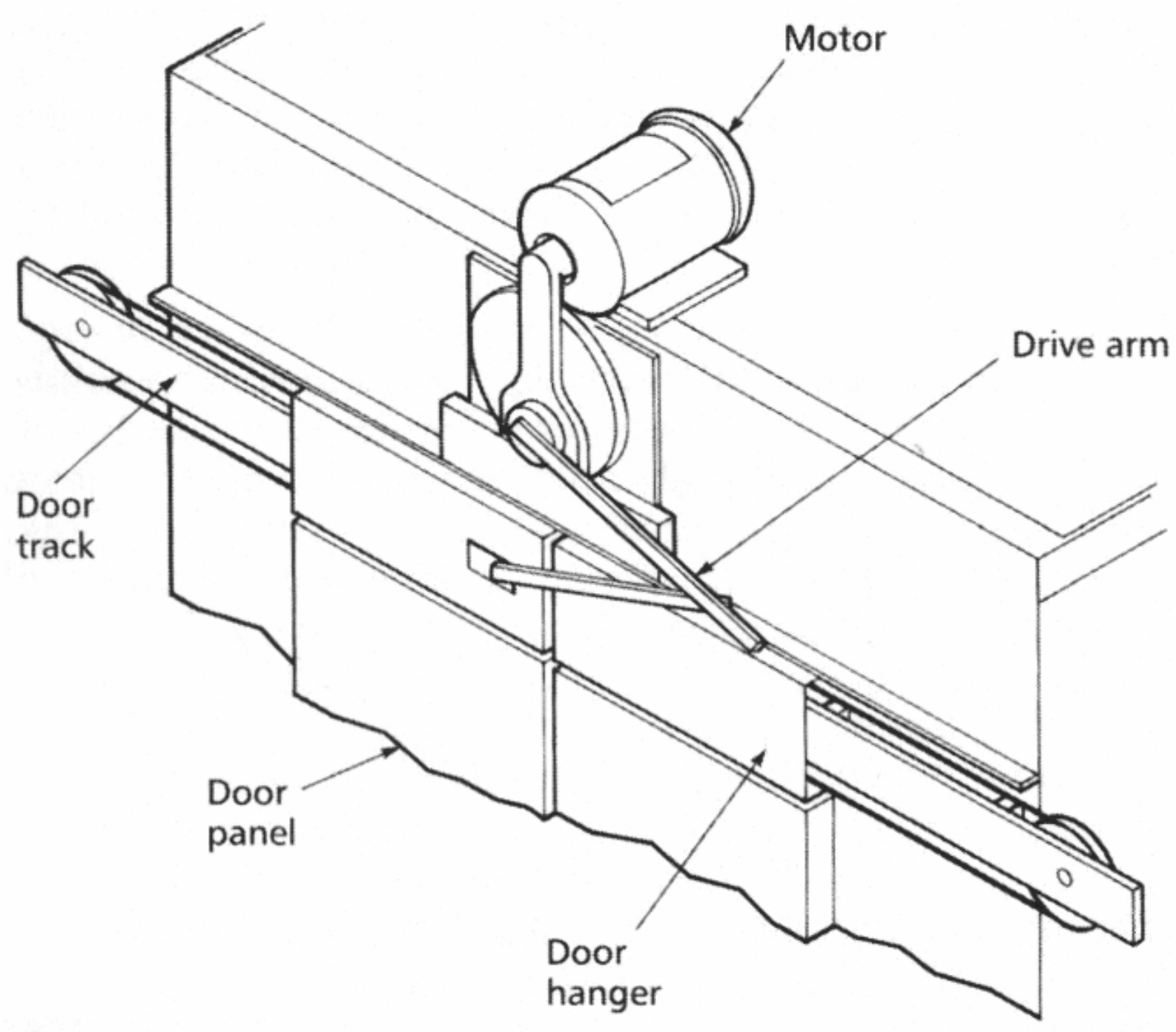




Typical car frame and lift car construction

[Source: CIBSE Guide D]

Typical door operator

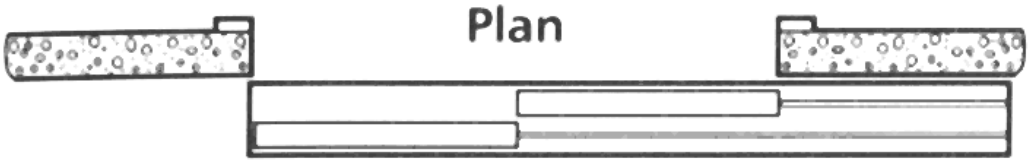


[Source: CIBSE Guide D]

Horizontal power-operated sliding doors



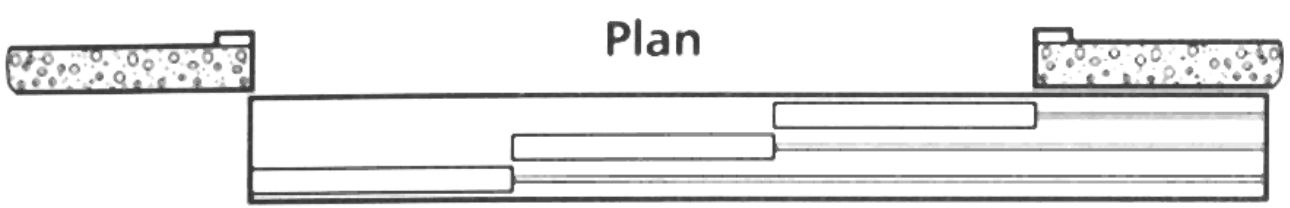
Single slide



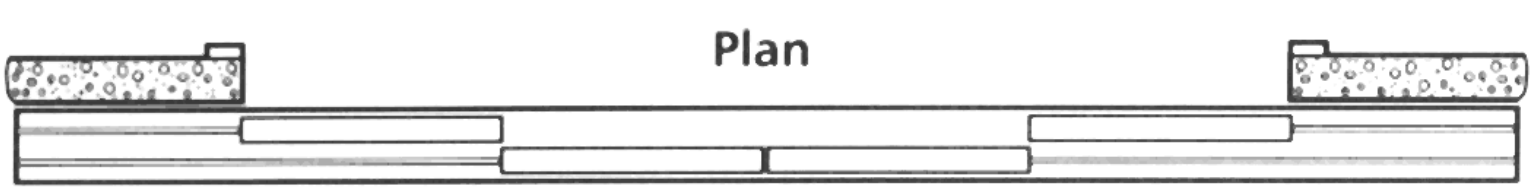
Two-speed side opening



Single-speed centre opening



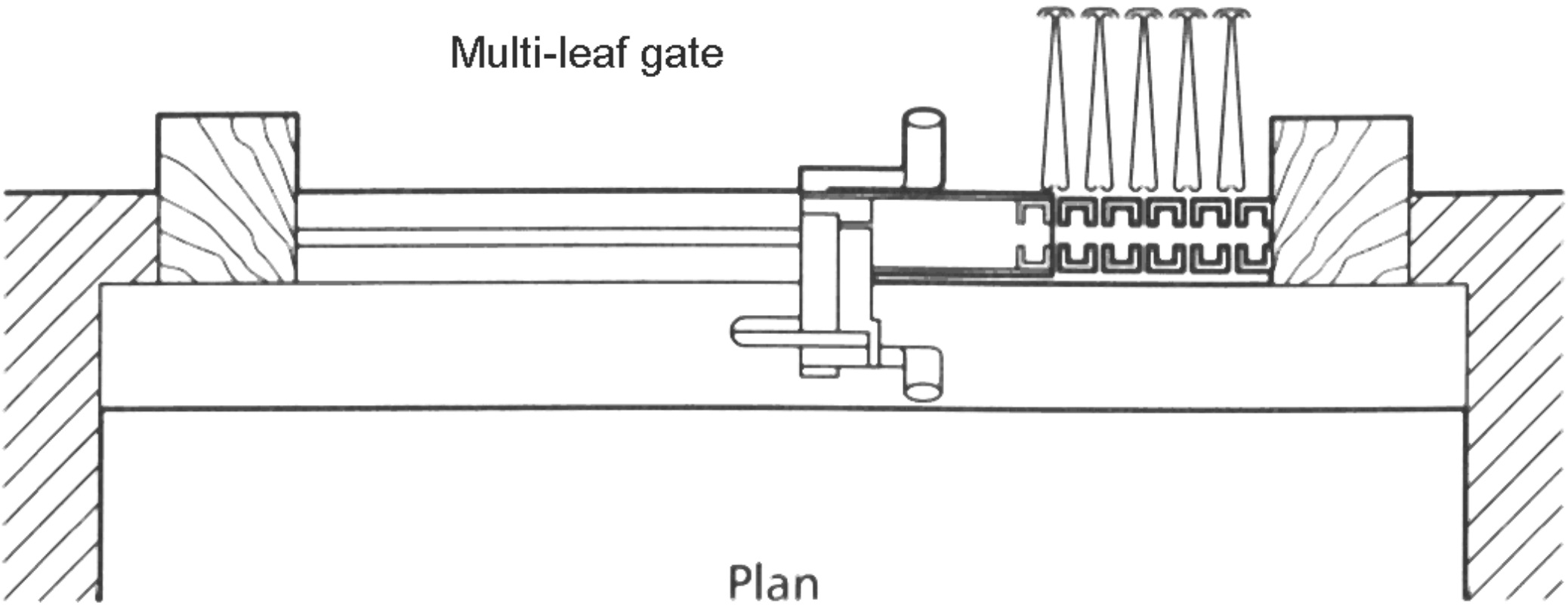
Three-speed side opening



Two-speed centre opening

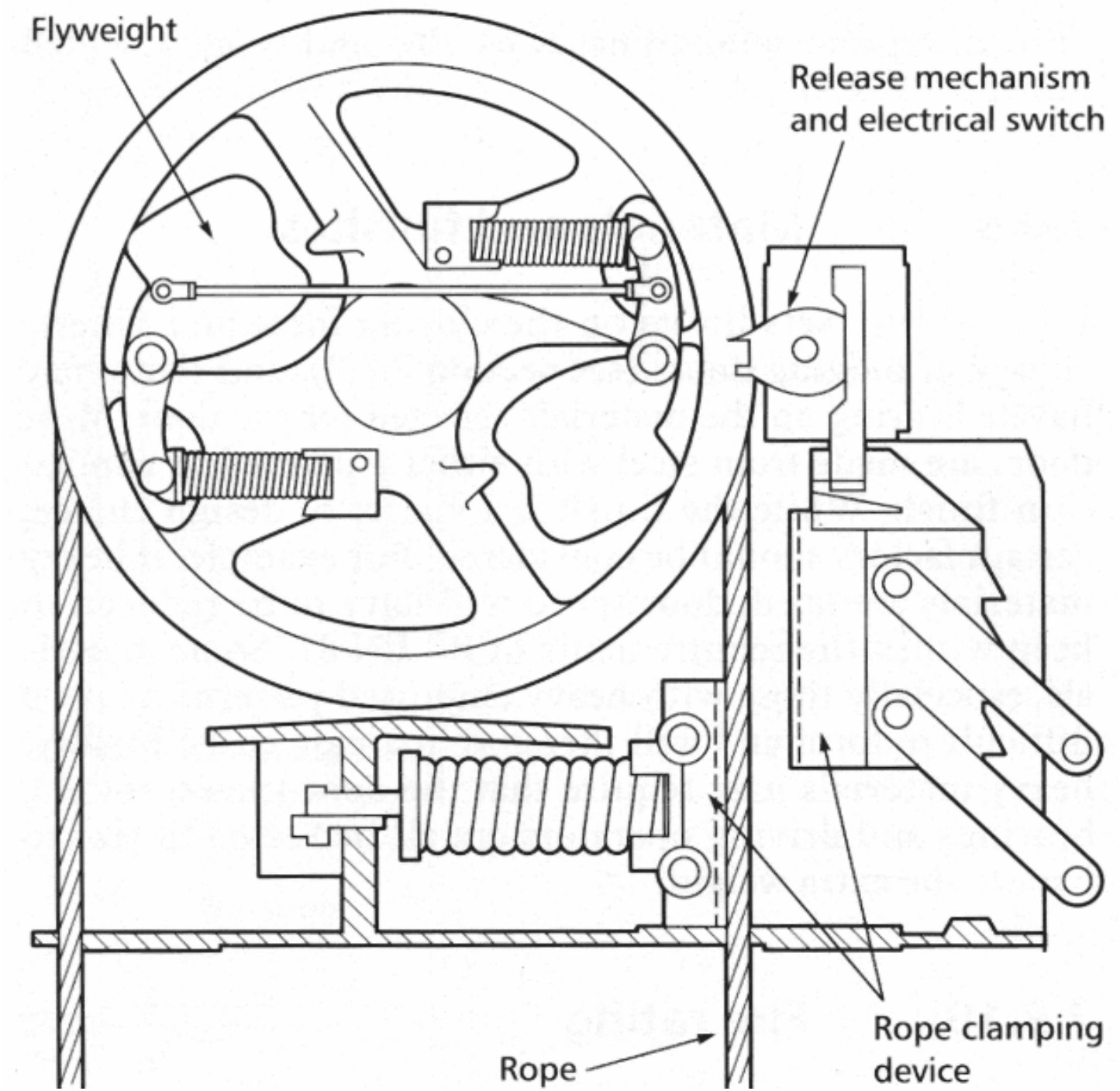
[Source: CIBSE Guide D]

Multi-leaf gate sliding door

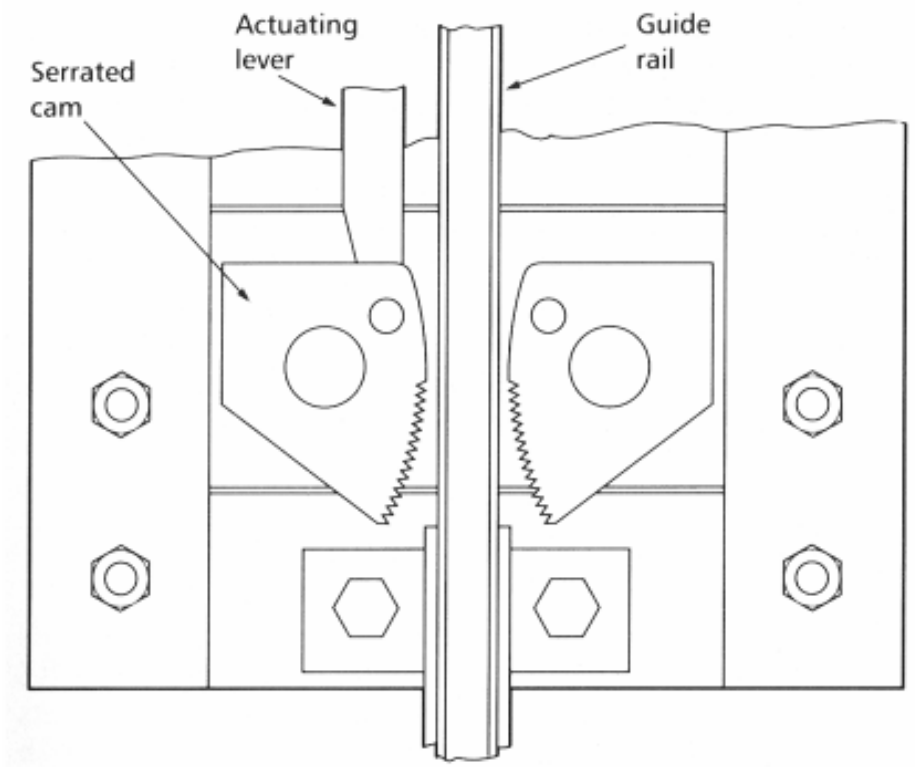


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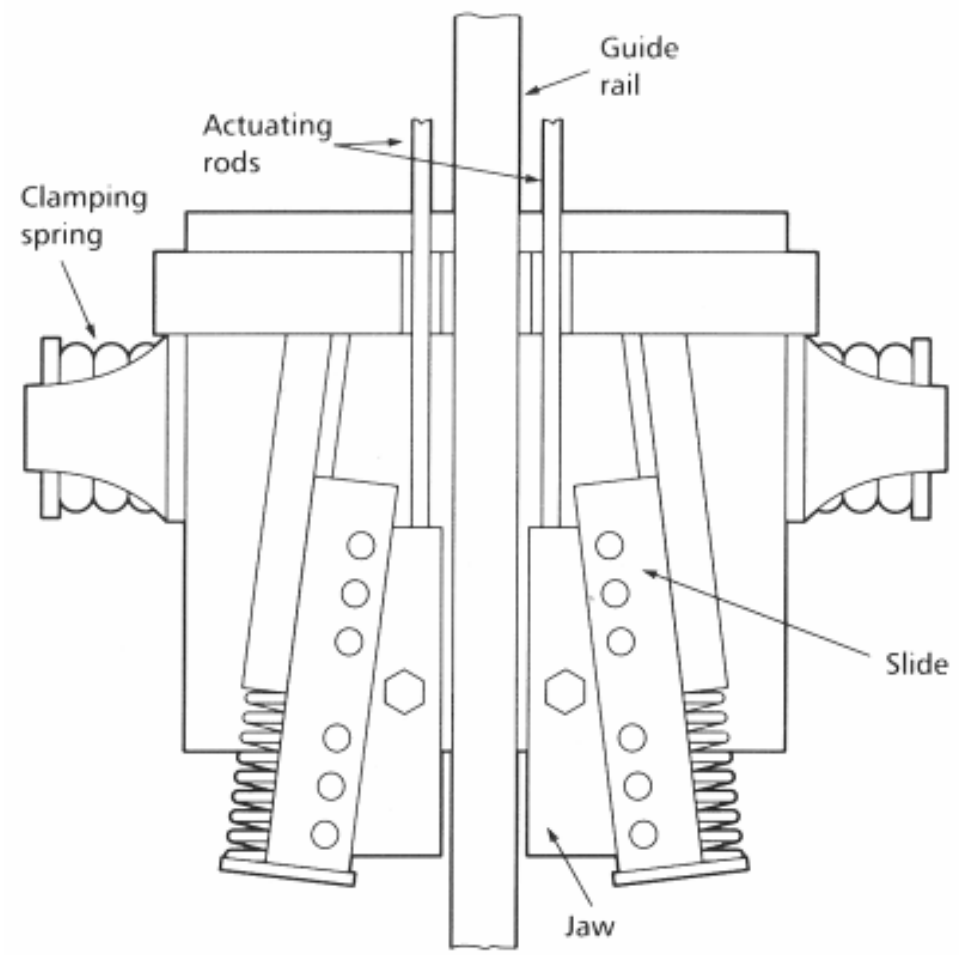
Centrifugal governor



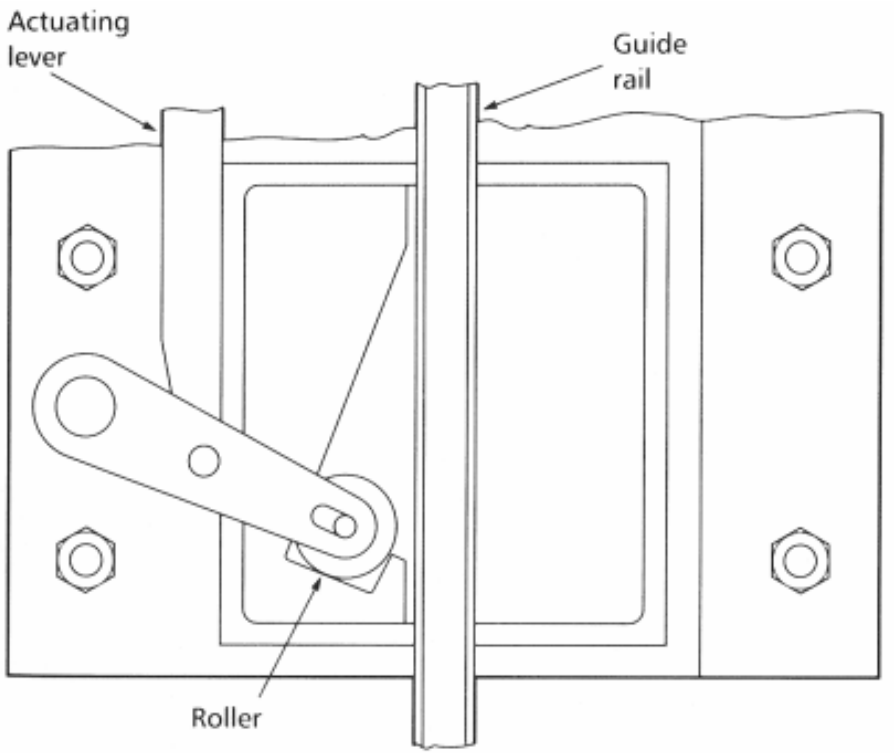
[Source: CIBSE Guide D]



Instantaneous safety gear: serrated cam

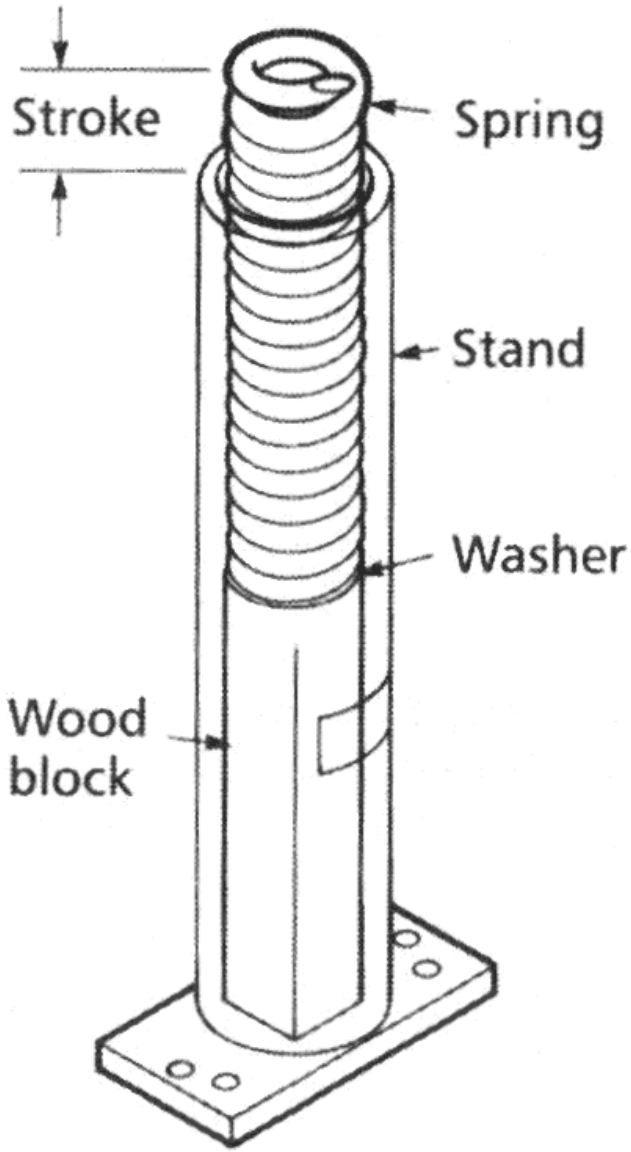


Progressive safety gear

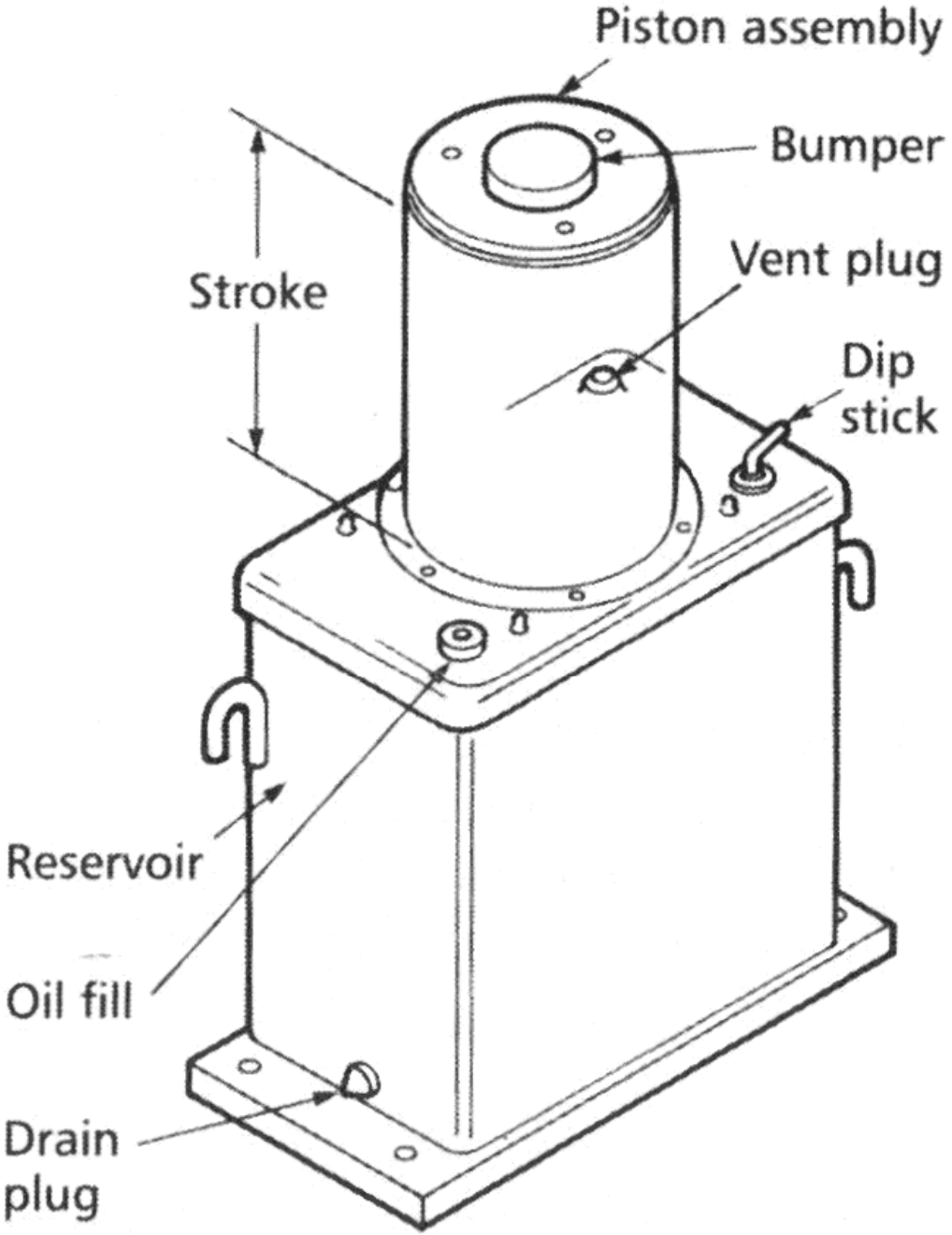


Instantaneous safety gear: roller type

[Source: CIBSE Guide D]



Energy accumulation type buffer

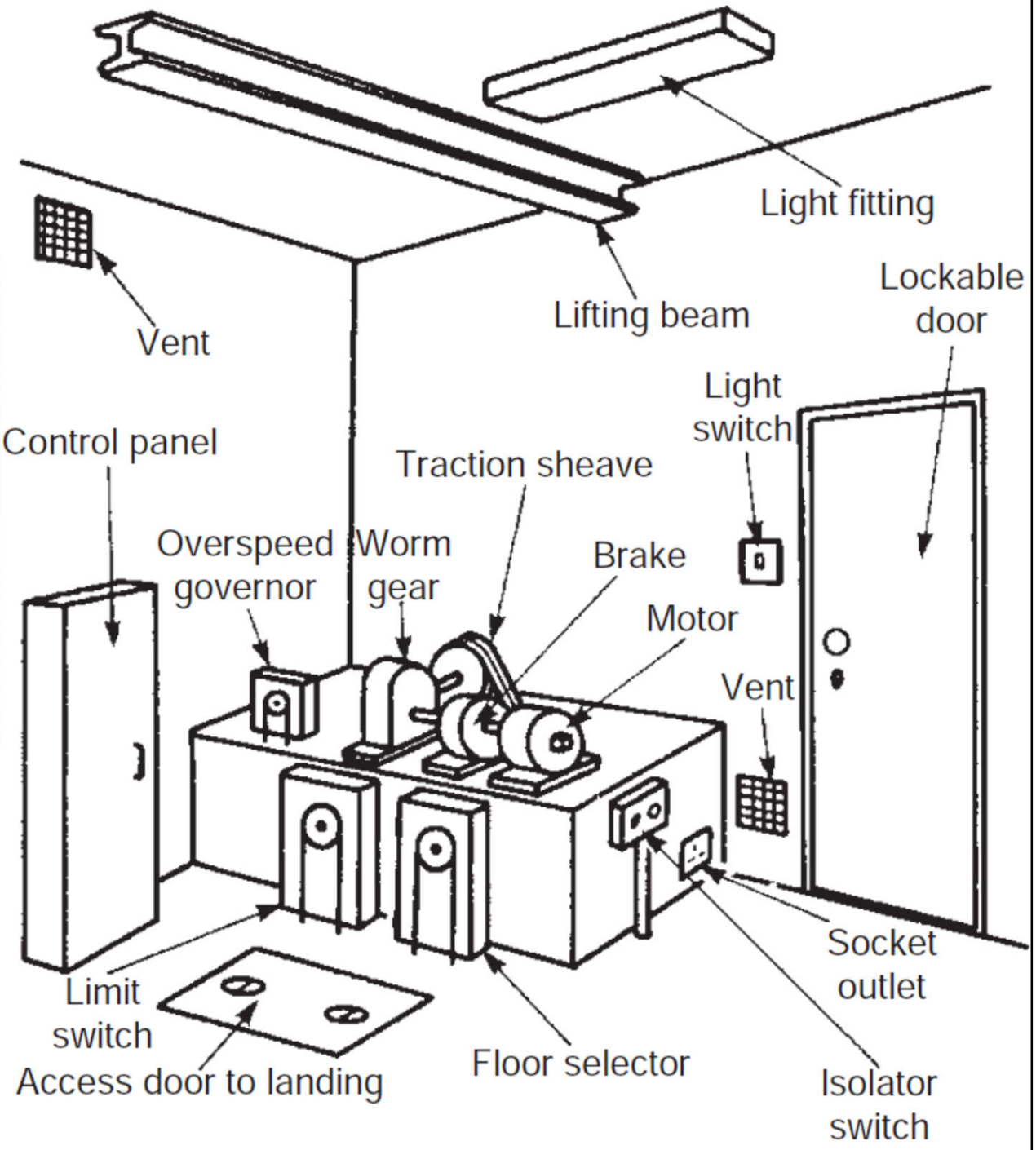


Energy dissipation type buffer

[Source: CIBSE Guide D]

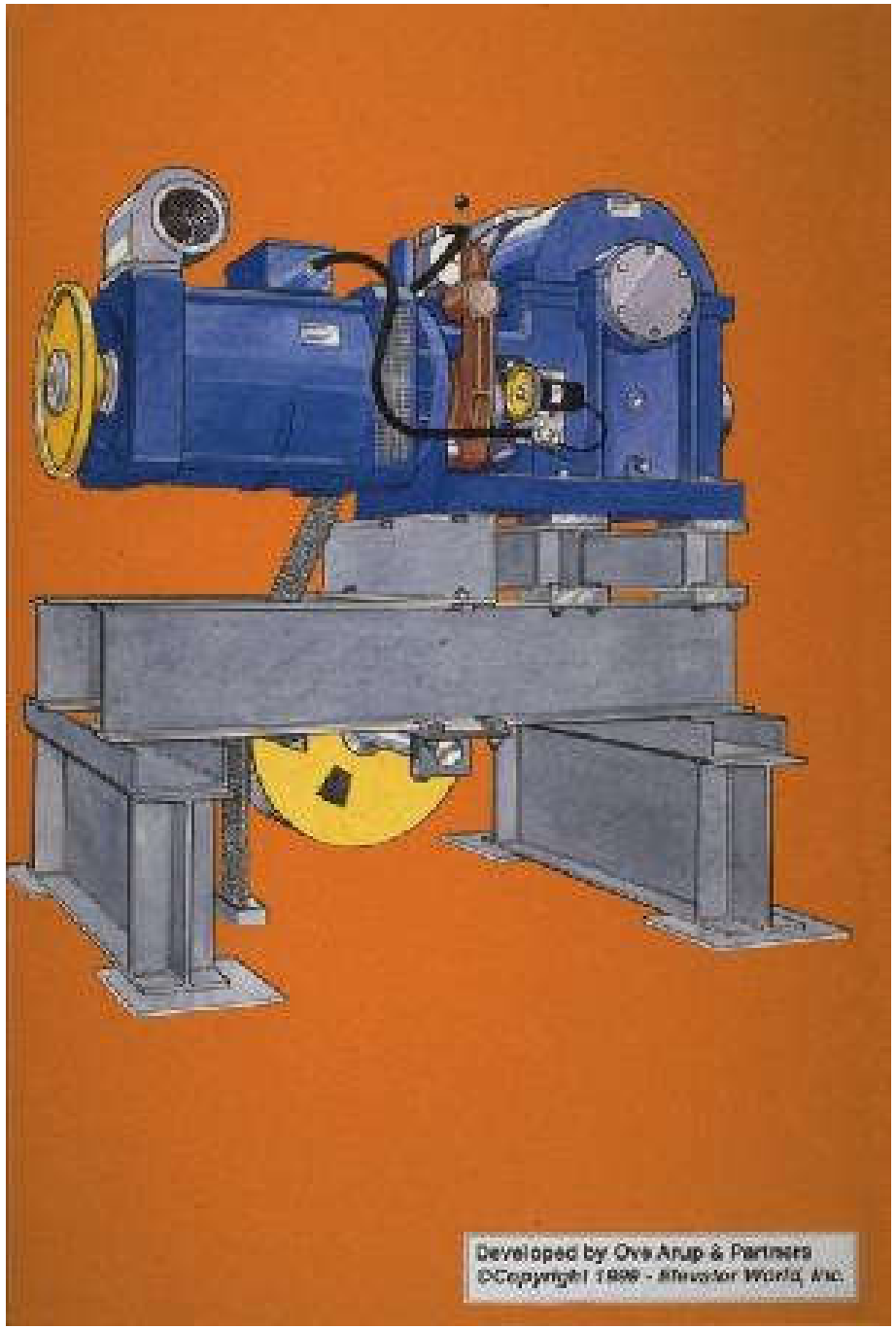
Typical lift machine room

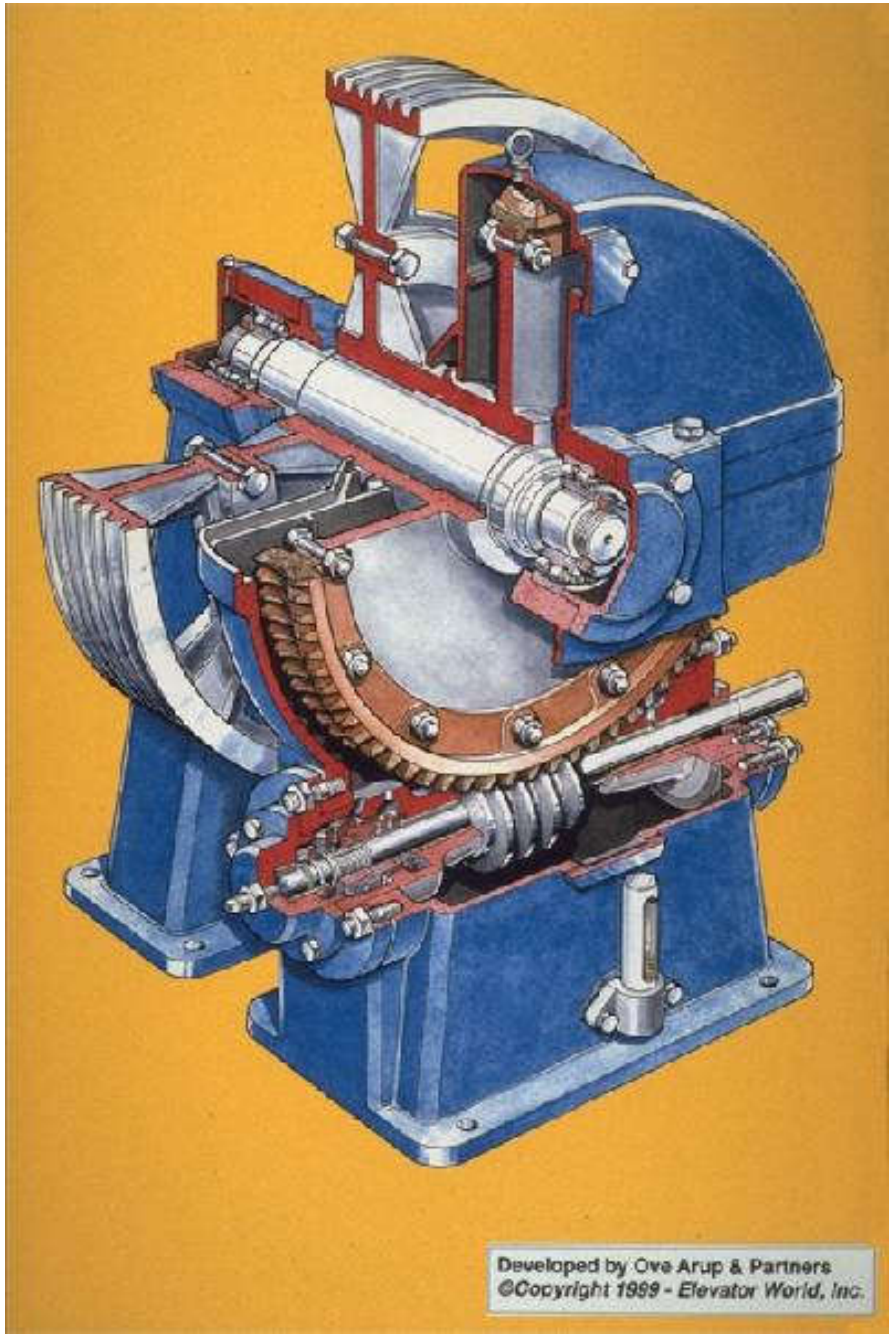




[Source: http://www.elevator-world.com and *Building Services Handbook*]

Geared machine and baseplate assembly



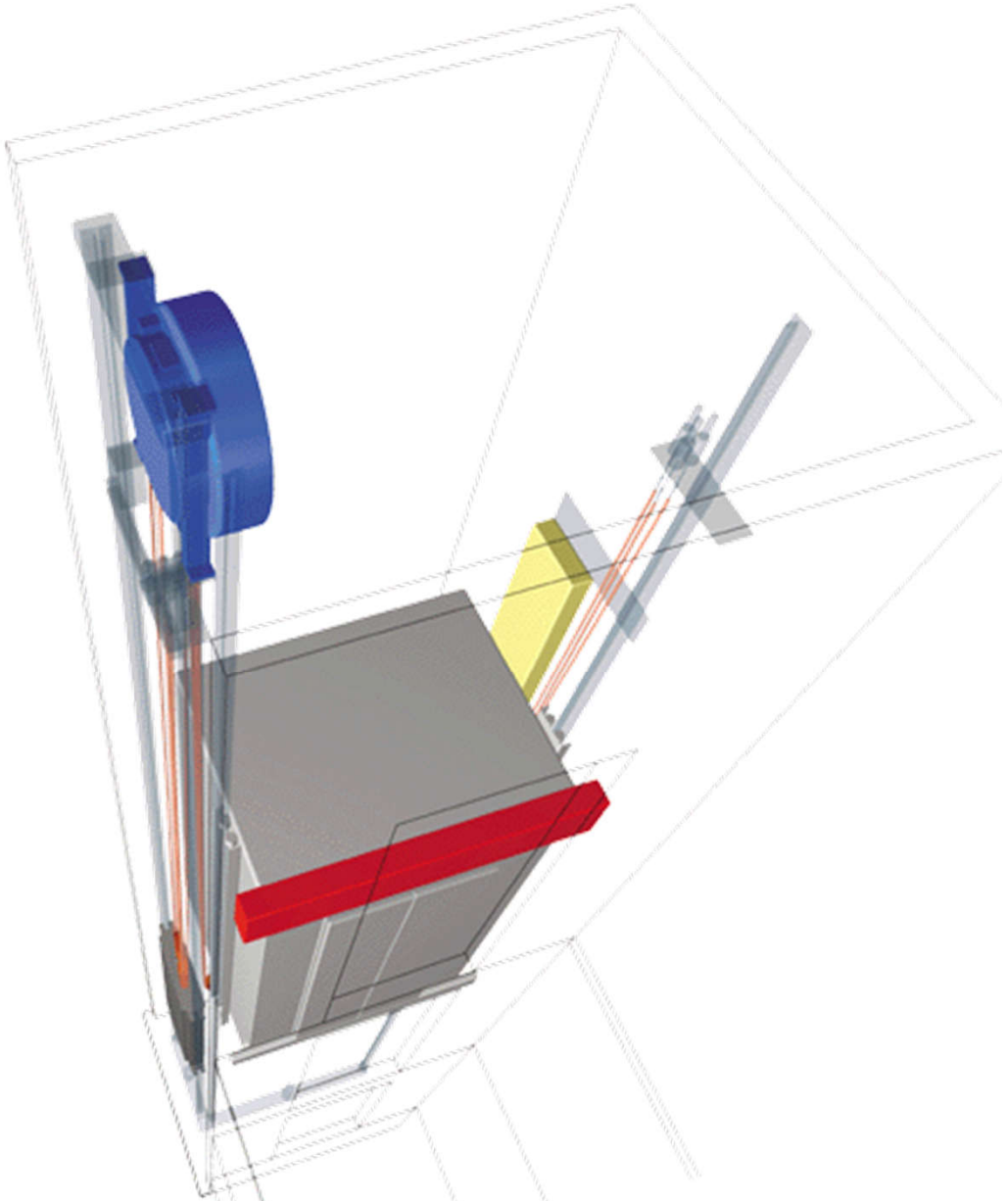


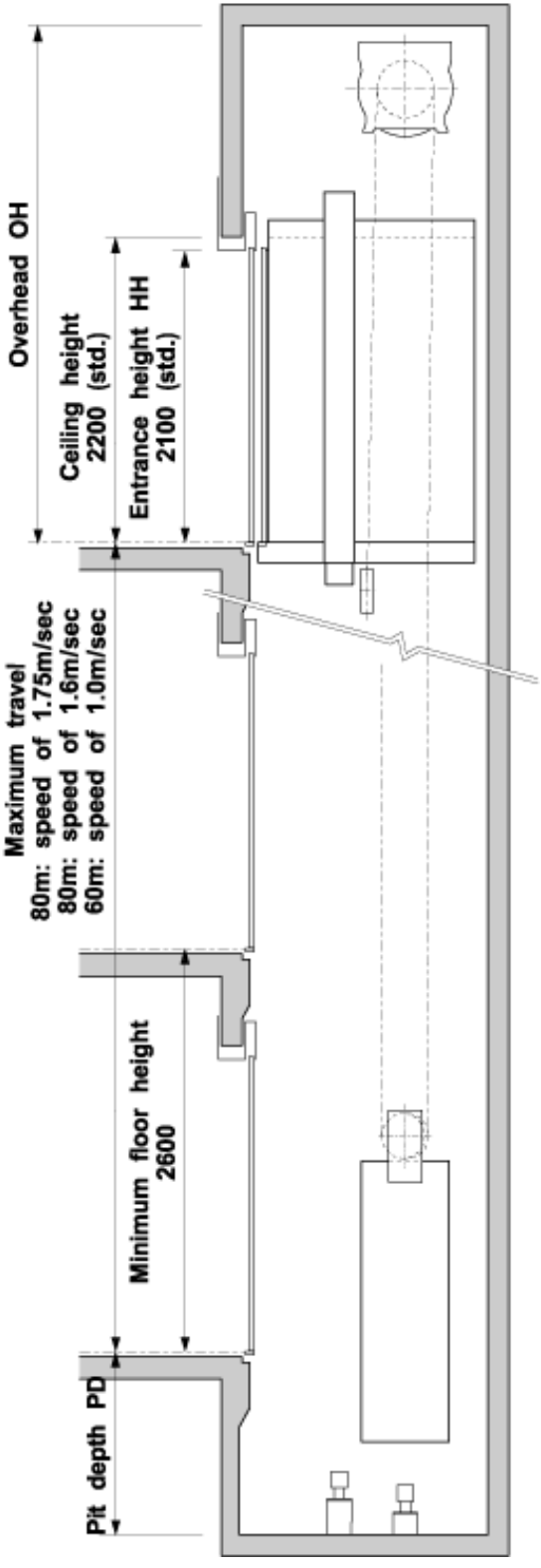
[Source: http://www.elevator-world.com]

Machine-room-less lift system



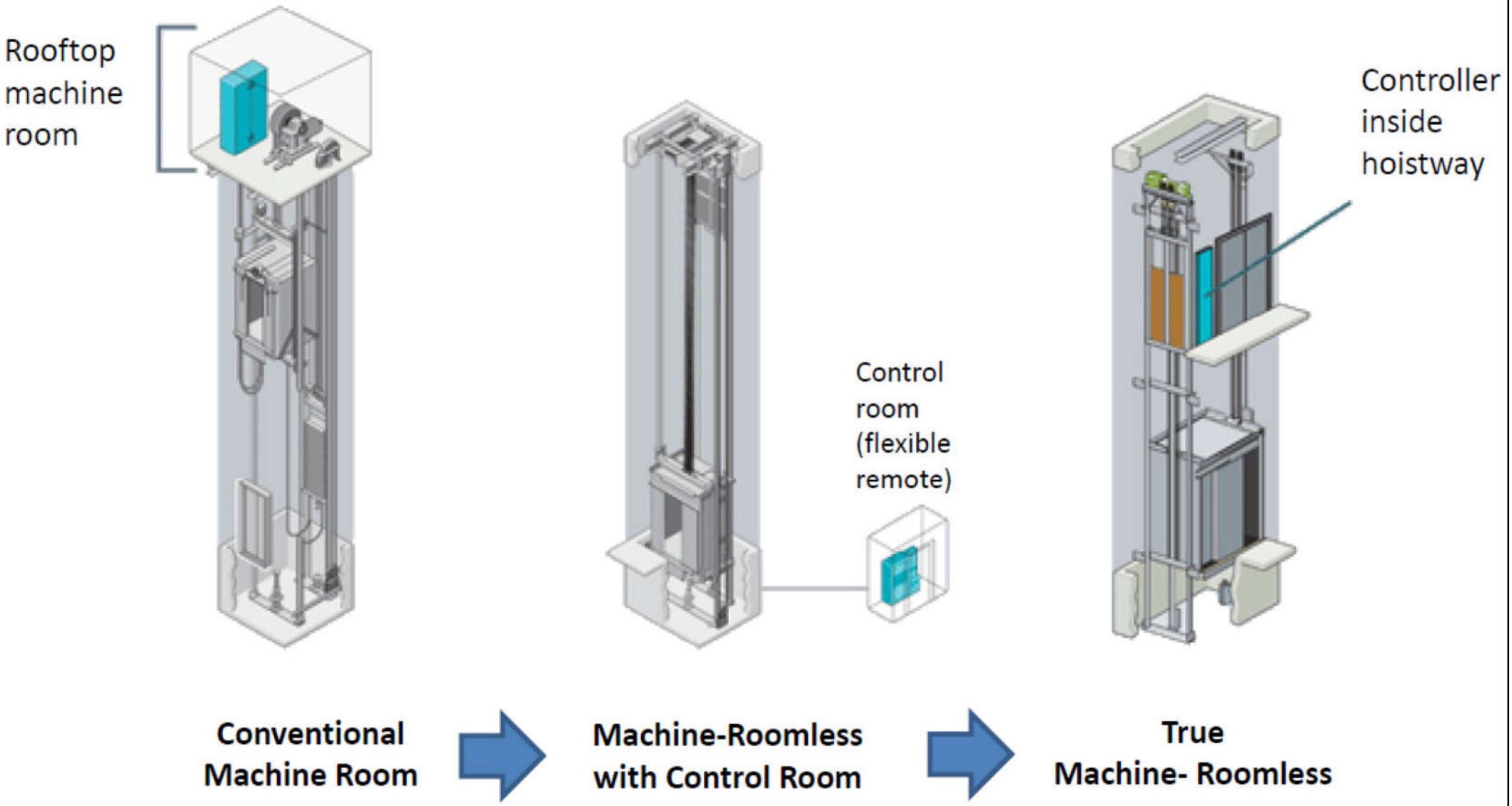






What are the advantages?

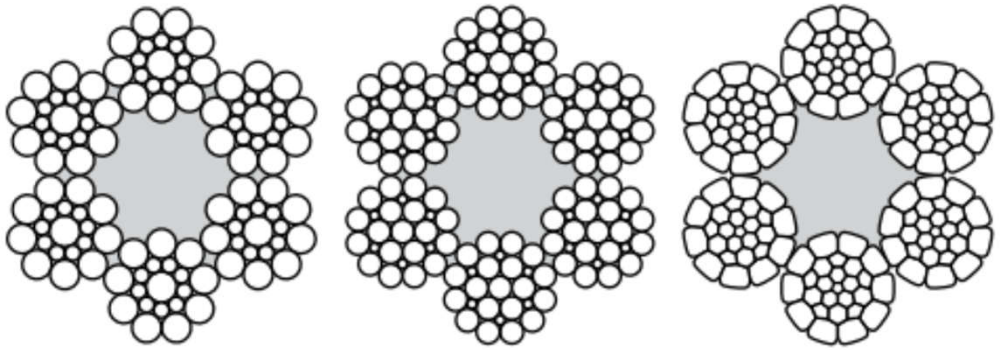
Gearless machine-roomless technology

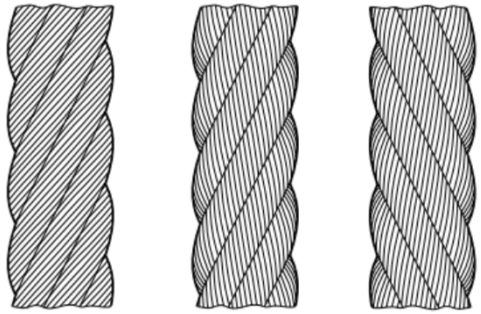


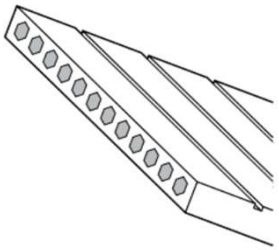
(Source: http://www.otisworldwide.com)

Lift Components

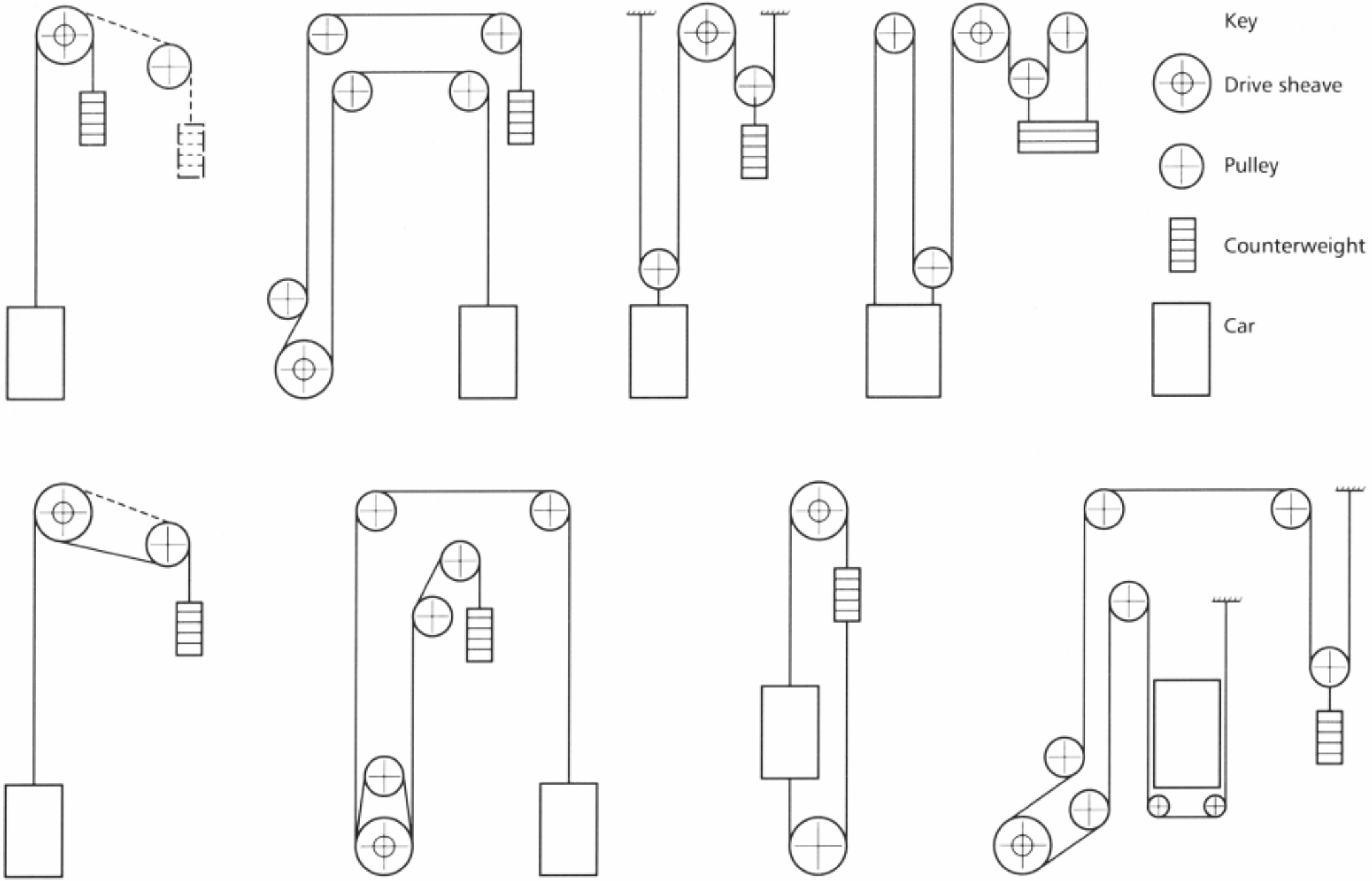
- Electric traction lift
  - Roping systems
    - Single wrap
      - 1:1 roped
      - 1:1 roped with diverter pulley
      - 1:1 roped with machine room below roof level
      - 2:1 roped
      - 3:1 roped
    - Double wrap
      - 1:1 roped (for high speed & medium to heavy duty loads)
      - 1:1 roped with compensating rope
    - Drum drive
    - Flat belt construction







Roping systems



[Source: CIBSE Guide D]

Lift Components

- Electric traction lift: motor drives
  - Gear
    - Single-speed or two-speed AC motor
    - Variable voltage AC motor
    - VVVF (variable voltage, variable frequency) AC motor
    - Variable voltage DC motor
  - Gearless
    - Variable voltage DC motor
    - VVVF (variable voltage, variable frequency) AC motor
  - Linear induction drive

Lift Components

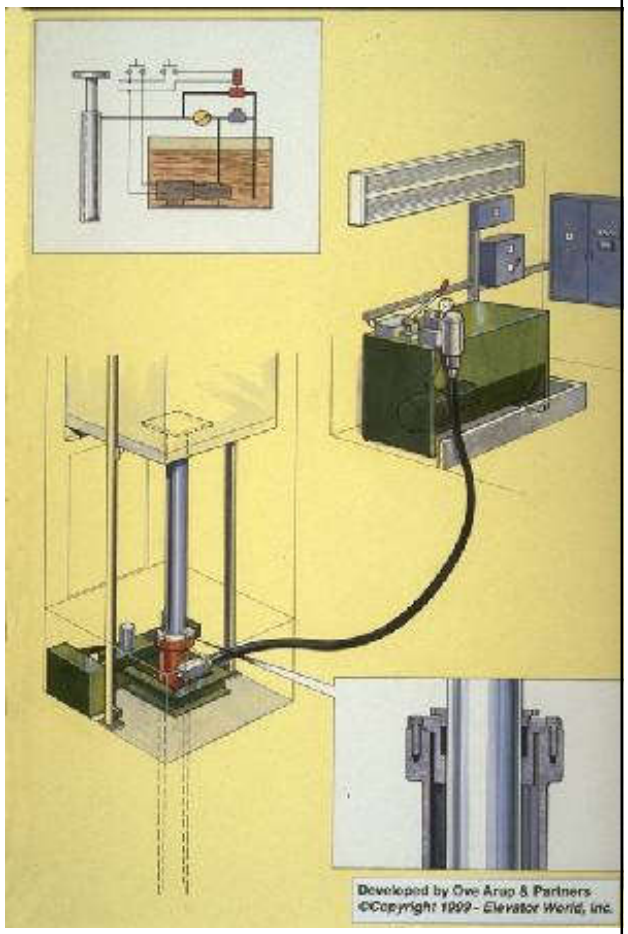
- Hydraulic lift
  - Maximum travel of 21 m; speed up to 0.75 m/s
  - Advantages:
    - Capacity for very heavy loads
    - Accuracy in floor leveling
    - Smooth ride characteristics
    - Low-level plant room
    - No structural loads from winding gear
    - Pump room can be located up to 10 m from the shaft





Lift Components

- Hydraulic lift
  - Jack arrangements
    - Direct-acting
    - Single side-acting: direct or indirect
    - Twin side-acting: direct or indirect
  - Power units
    - Tank or oil reservoir
    - Pump
    - Pump motor (e.g. single-speed AC induction type)
    - Flow control valve block



Lift Components



- Firefighting or fireman's lift
  - Specific provisions include
    - Break-glass key switch (at G/F to control the lift)
    - Min. duty load, say 630 kg (for firefighting equipment)
    - Min. internal dimensions (m), 1.1(W) x 1.4(D) x 2.0(H)
    - An emergency hatch in the car roof
    - Manufactured from non-combustible material
    - A two-way intercom
    - 1 hour fire-resisting doors of 0.8 m (W) x 2 m (H)
    - A max. of 60 sec to run full building height
    - Dual power supplies (normal + emergency)

Can you explain why we need each of them?

Lift Components

- Lift shaft should have the following features:
  - Water-tightness
  - Means of drainage
  - Plumb, vertical sides
  - Smooth painted finish
  - Ventilation void for emission of smoke
  - Permanent inspection lights
  - Have no other services (except this for the lift)





Lift Drive Operation



- Lift controllers
  - Power control: car motion, door
  - Traffic control: passenger demand
  - Controller input
    - Car calls, landing calls, door safety device, lift well safety, passenger detection device
  - Controller output
    - Door control signals, life drive control signals, passenger signalling
  - Lift control options: normal & various operation modes
  - Fail-safe operation: to ensure safety

Examples of passenger controls and signals



(a) Landing call pushbuttons



(c) Direction indicators



(d) LED position and direction indicators



(b) Car operating panels



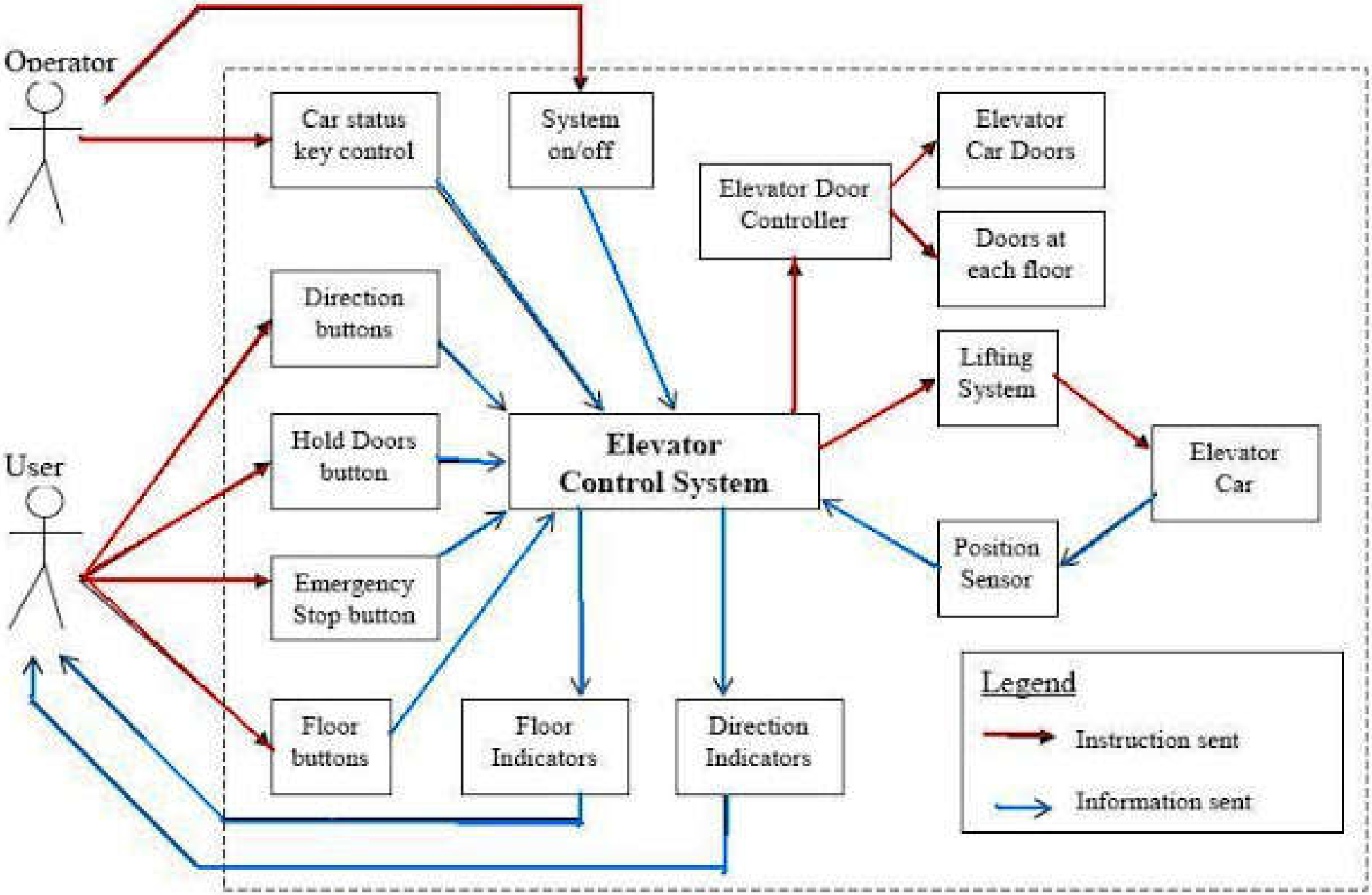
(e) Destination control panel



(f) LCD/TFT information panels

[Source: CIBSE Guide D]

Simple lift/elevator control system inputs and outputs



[Source: http://www.electrical-knowhow.com/2012/04/elevator-control-system.html]

Lift Drive Operation



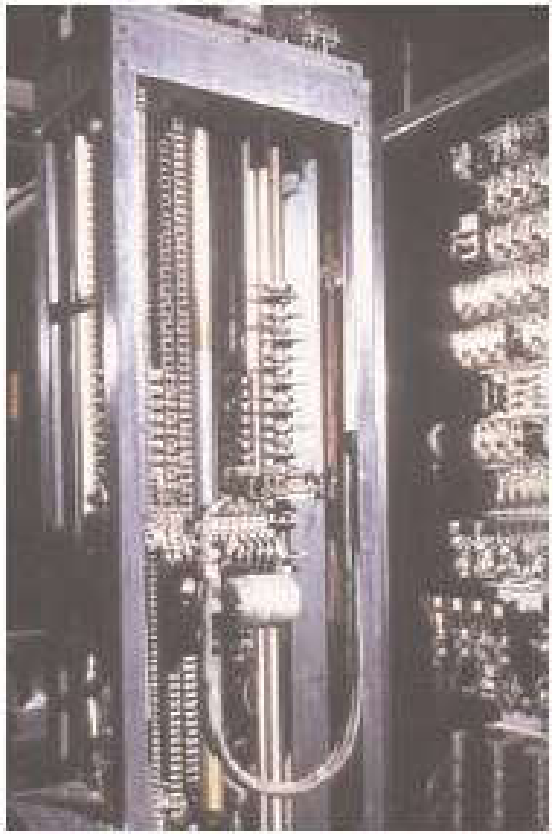
- Lift control system
  - Coordinating all aspects of lift service e.g. travel, speed, accelerating, decelerating, door opening speed and delay, leveling and hall lantern signals
- Main aims of lift control system:
  - To bring the lift car to the correct floor
  - To minimize travel time and maximize passenger comfort by providing a smooth ride
  - To accelerate, decelerate and travel within safe speed limits

Lift Drive Operation



- Controller technology
  - Electromechanical switching
    - Electromagnetic relays & mechanically driven selectors
    - Limited operation life, maintenance problems, noisy
  - Solid-state logic technology
    - Discrete transistors circuits & integrated circuit boards
    - Improved reliability, lower power consumption & easier fault detection
  - Computer-based (‘intelligent’) systems
    - Enable complex & adaptable functions

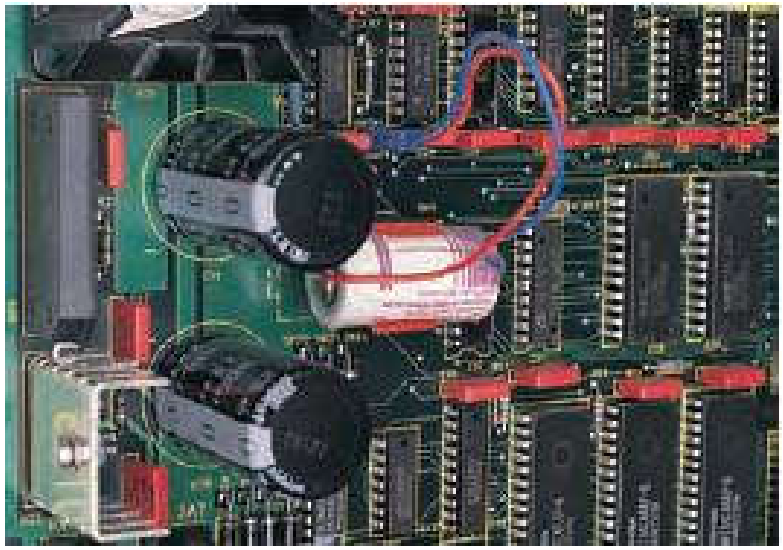
Development of lift controller technology



Electromechanical relays



Solid-state logic



Computer-based electronic

[Source: Otis]

Controller cabinets



Relay based controller



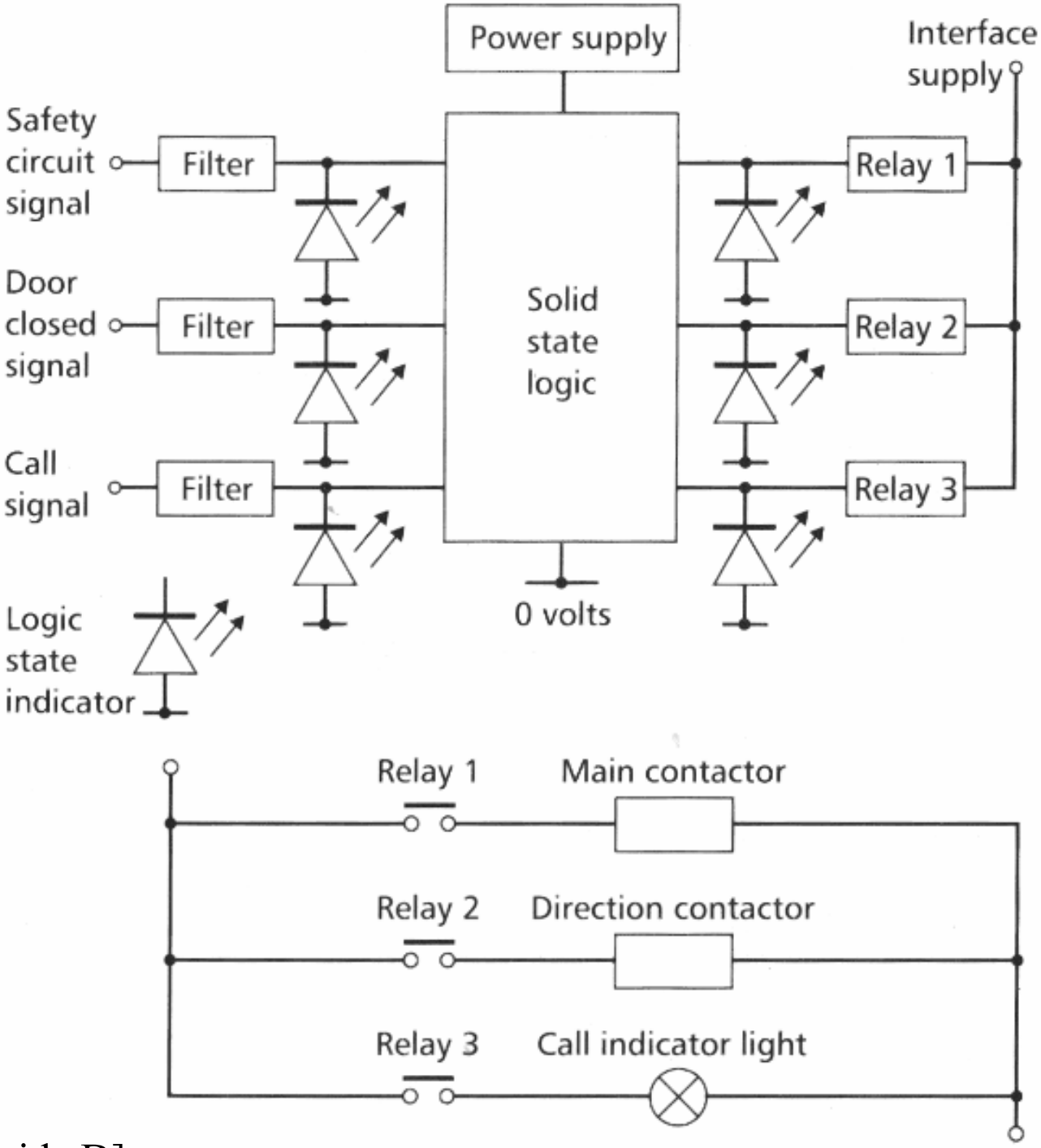
Solid-State Logic Technology



computer based technology

[Source: http://www.electrical-knowhow.com/2012/04/elevator-control-system-part-two.html]

Schematic of typical solid-state logic controller



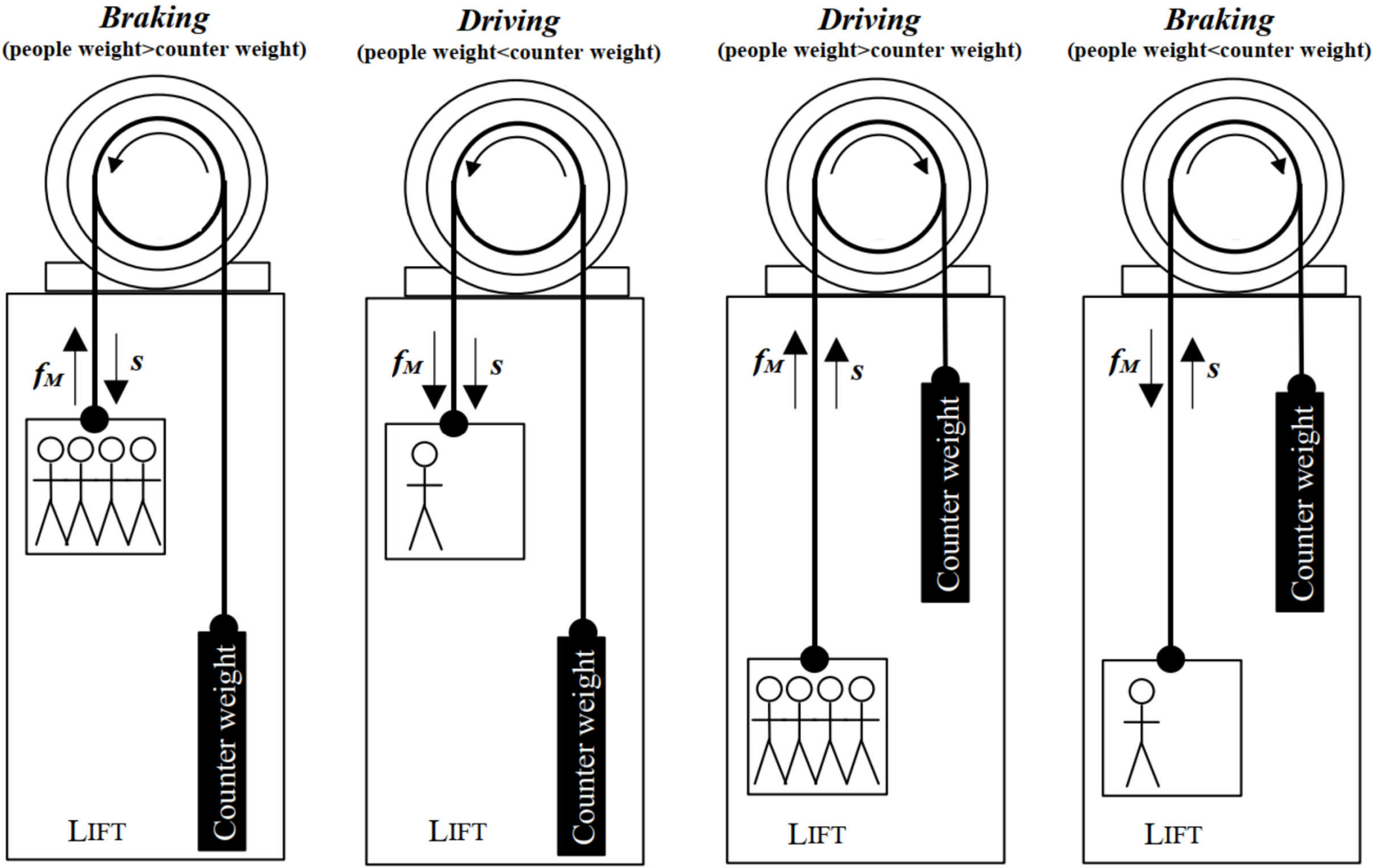
[Source: CIBSE Guide D]

Lift Drive Operation

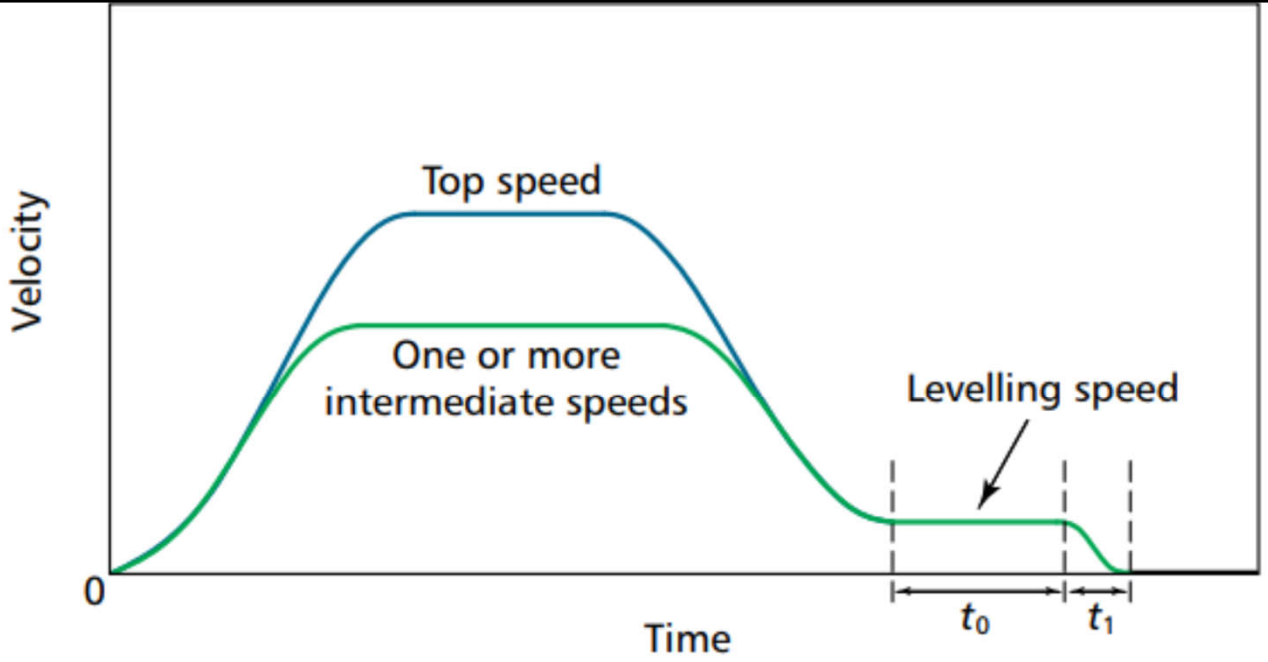


- Types of lift drive control
  - Motor speed reference
    - Time-based speed reference
    - Distance-based speed reference
  - Protection against failure of feedback systems
  - DC motor control, e.g. static convertors
  - AC motor control: variable voltage/frequency
  - Control of hydraulic lifts
- Control of door operators (DC/AC)

Lift motor operating modes (f_M - Motor force ; s - Speed)



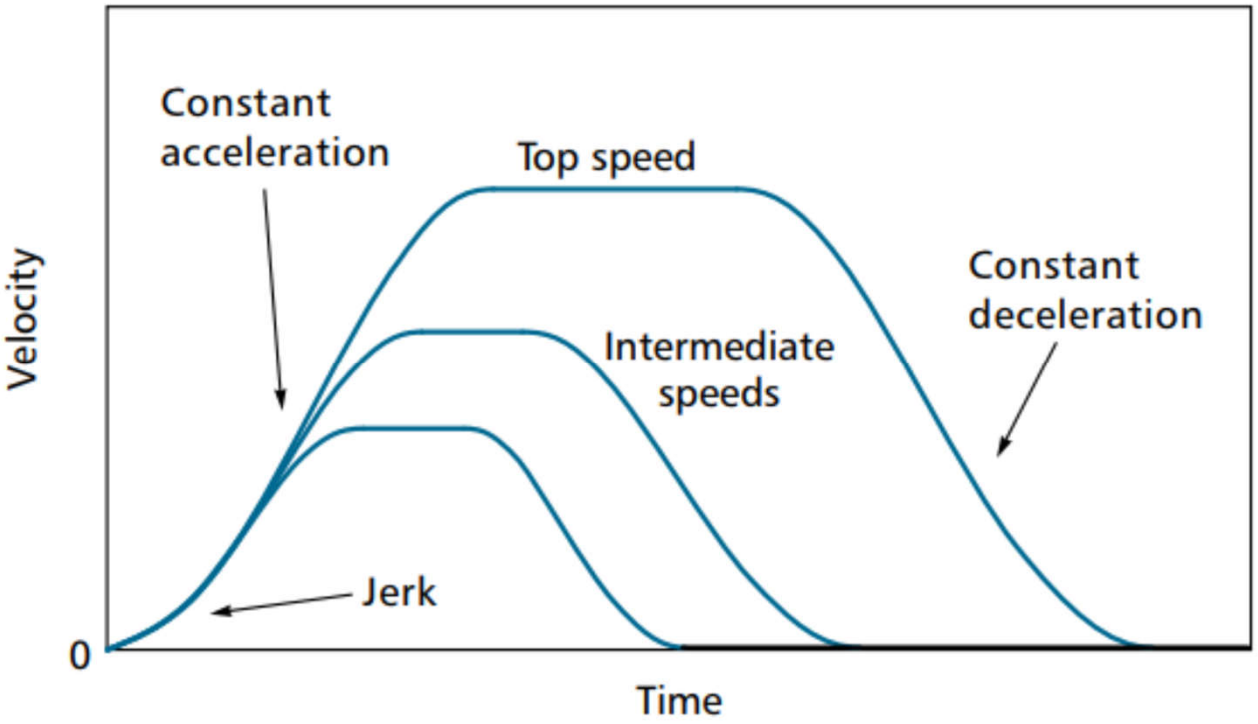
(Source: ISR-University of Coimbra, 2010. E4 Energy-Efficient Elevators and Escalators, brochure prepared for the Intelligent Energy of European Commission, University of Coimbra, Portugal. https://ec.europa.eu/energy/intelligent/projects/sites/iee-projects/files/projects/documents/e4_publishable_report_en.pdf)



t_0 = levelling time (typically 2–3 seconds)
t_1 = levelling to zero time (typically 150 ms)

Time-based
speed reference

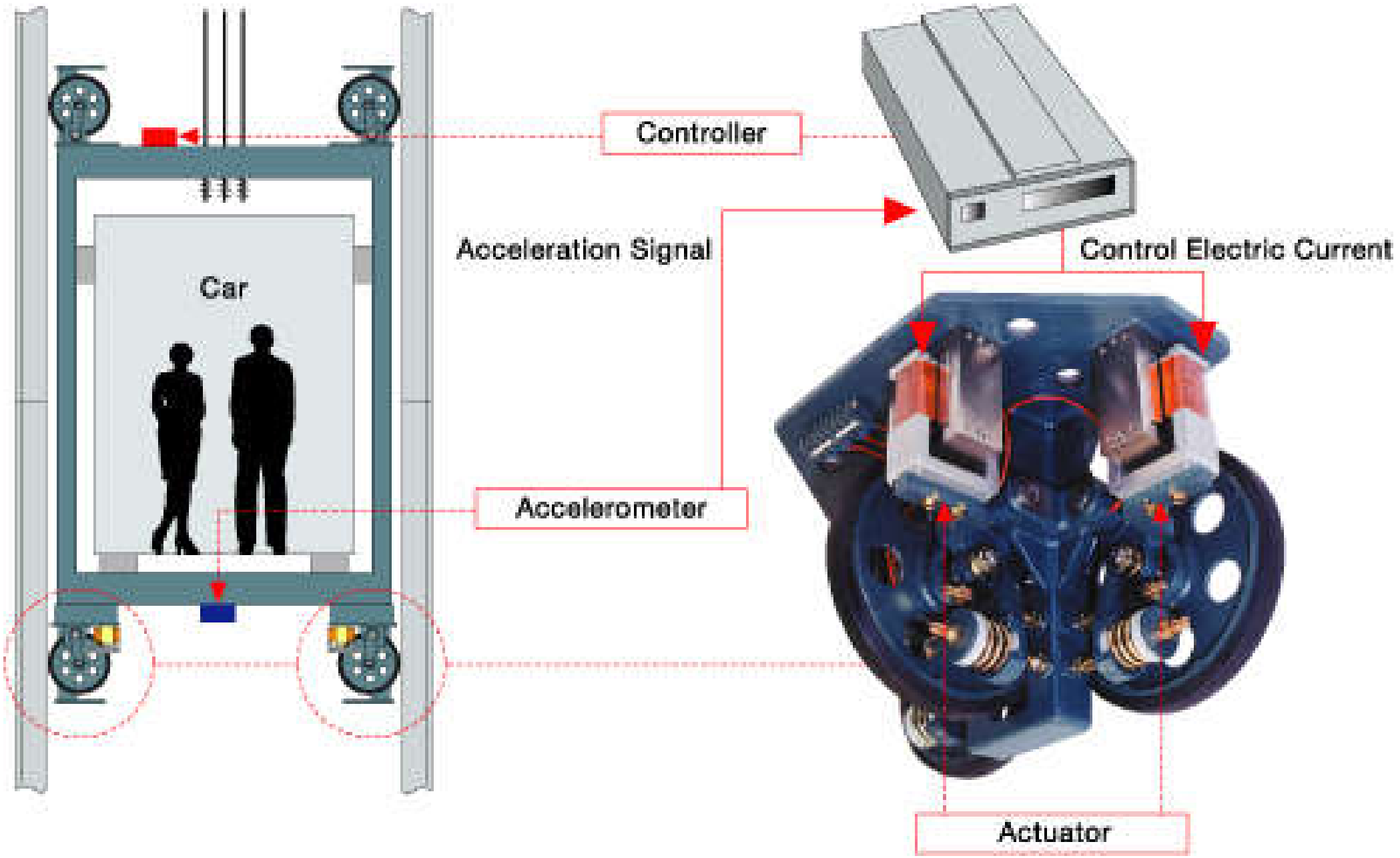
Do you feel
comfortable
when travelling
on a lift?



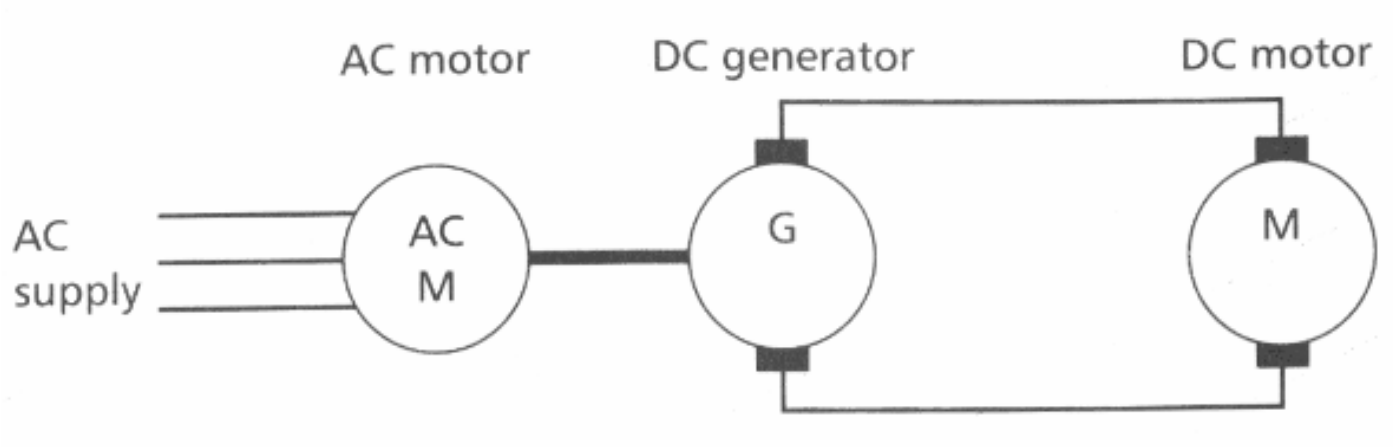
Distance-based
speed reference

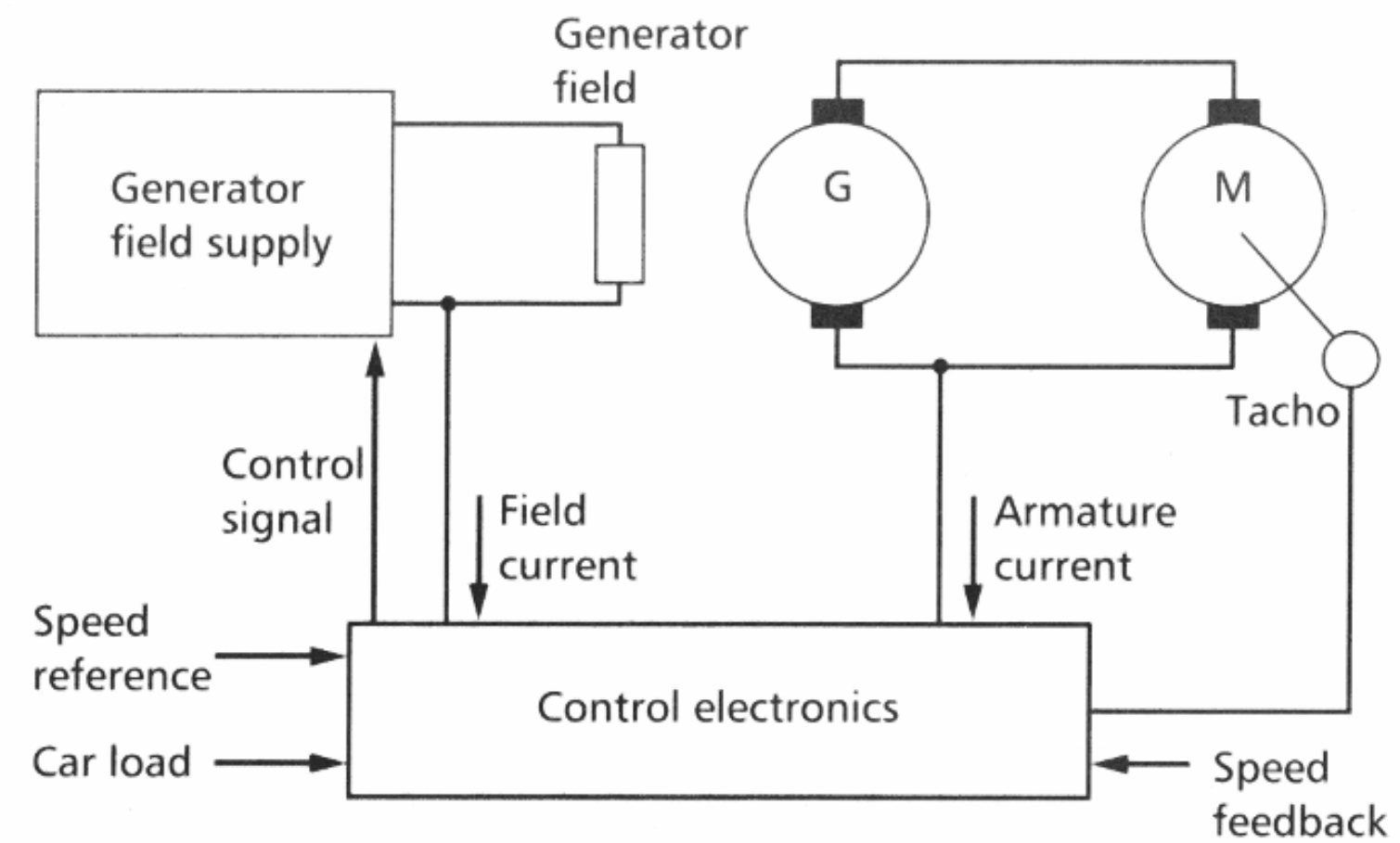
[Source: CIBSE Guide D]

Lift controller, accelerometer and actuator



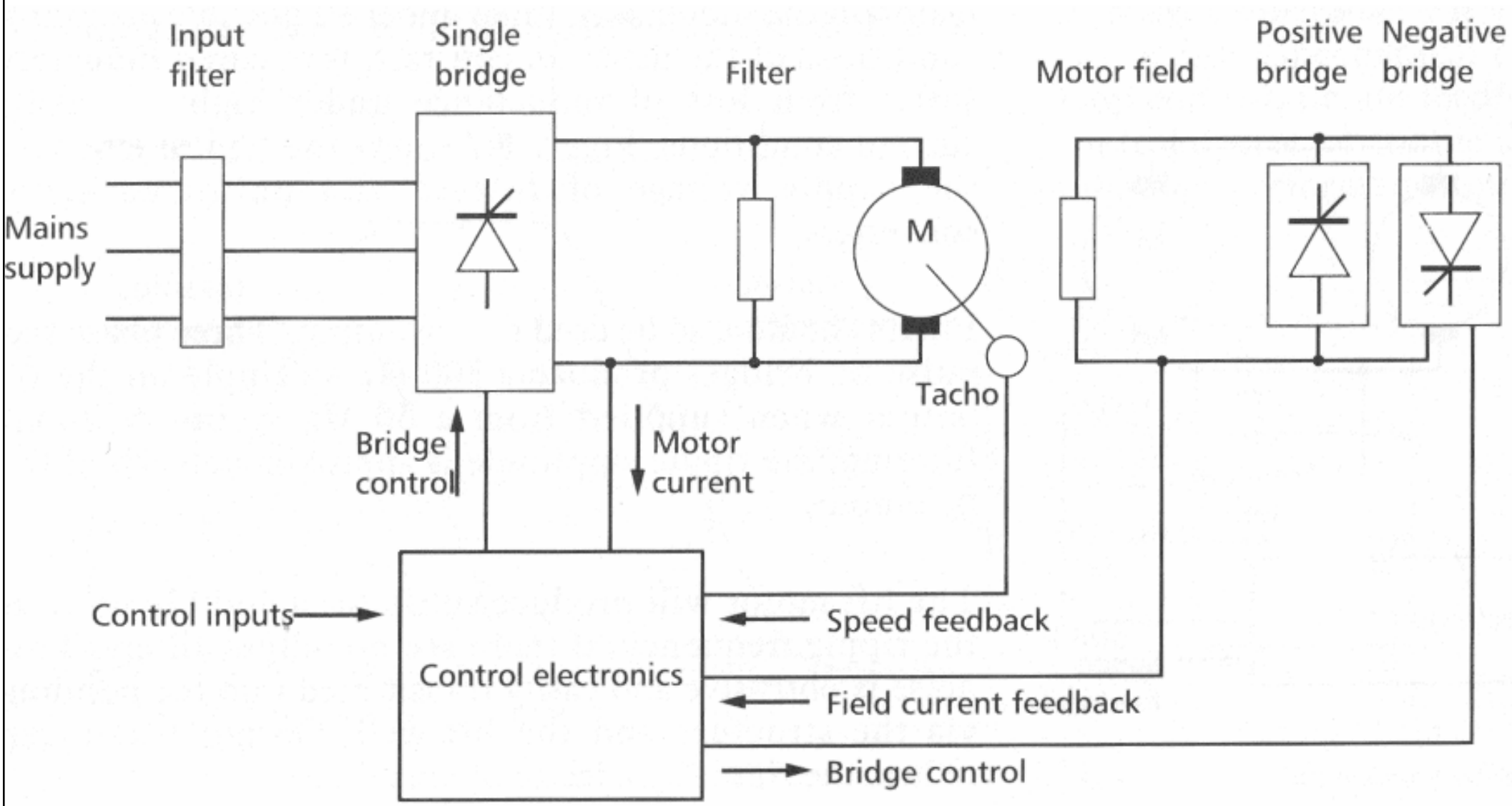
Generator control using feedback techniques





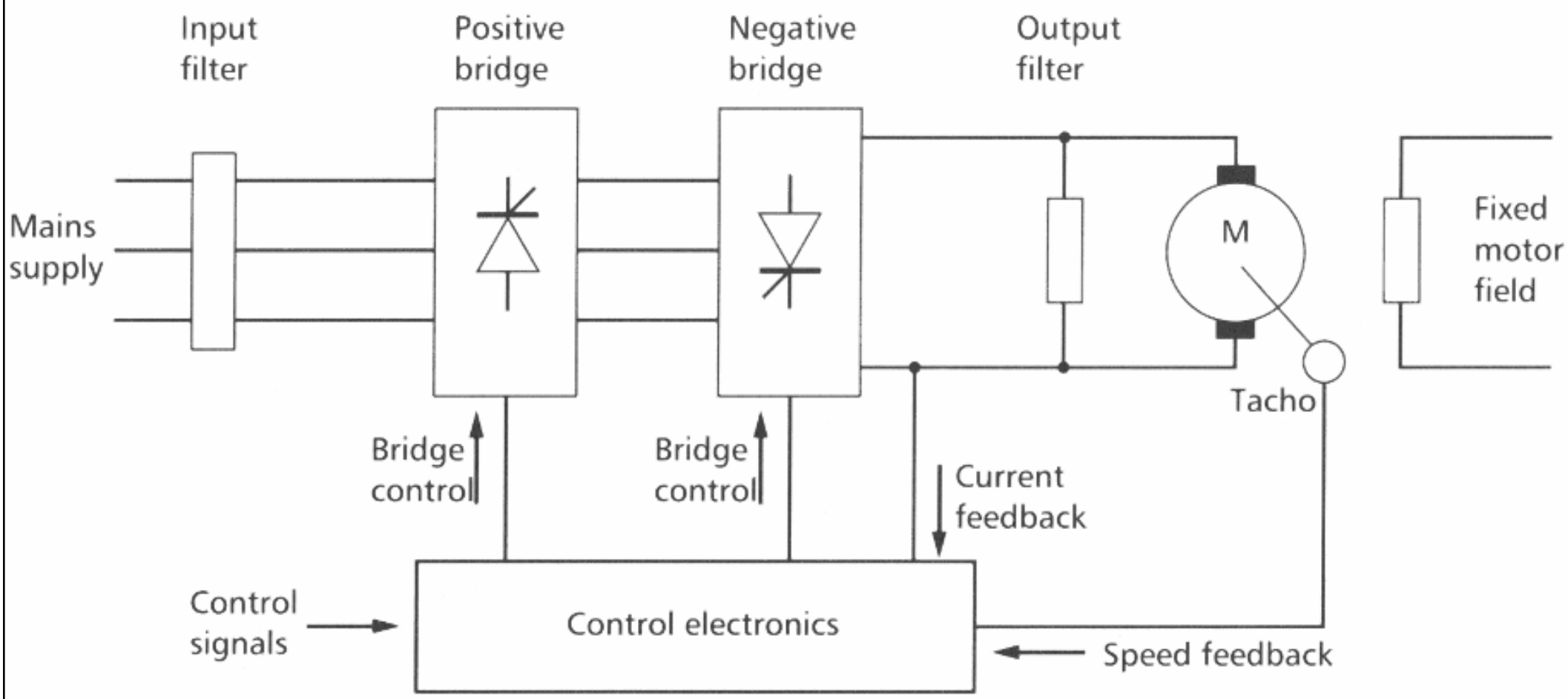
[Source: CIBSE Guide D]

Schematic of single-bridge static converter with motor field control



[Source: CIBSE Guide D]

Schematic of two-bridge static converter with fixed motor field



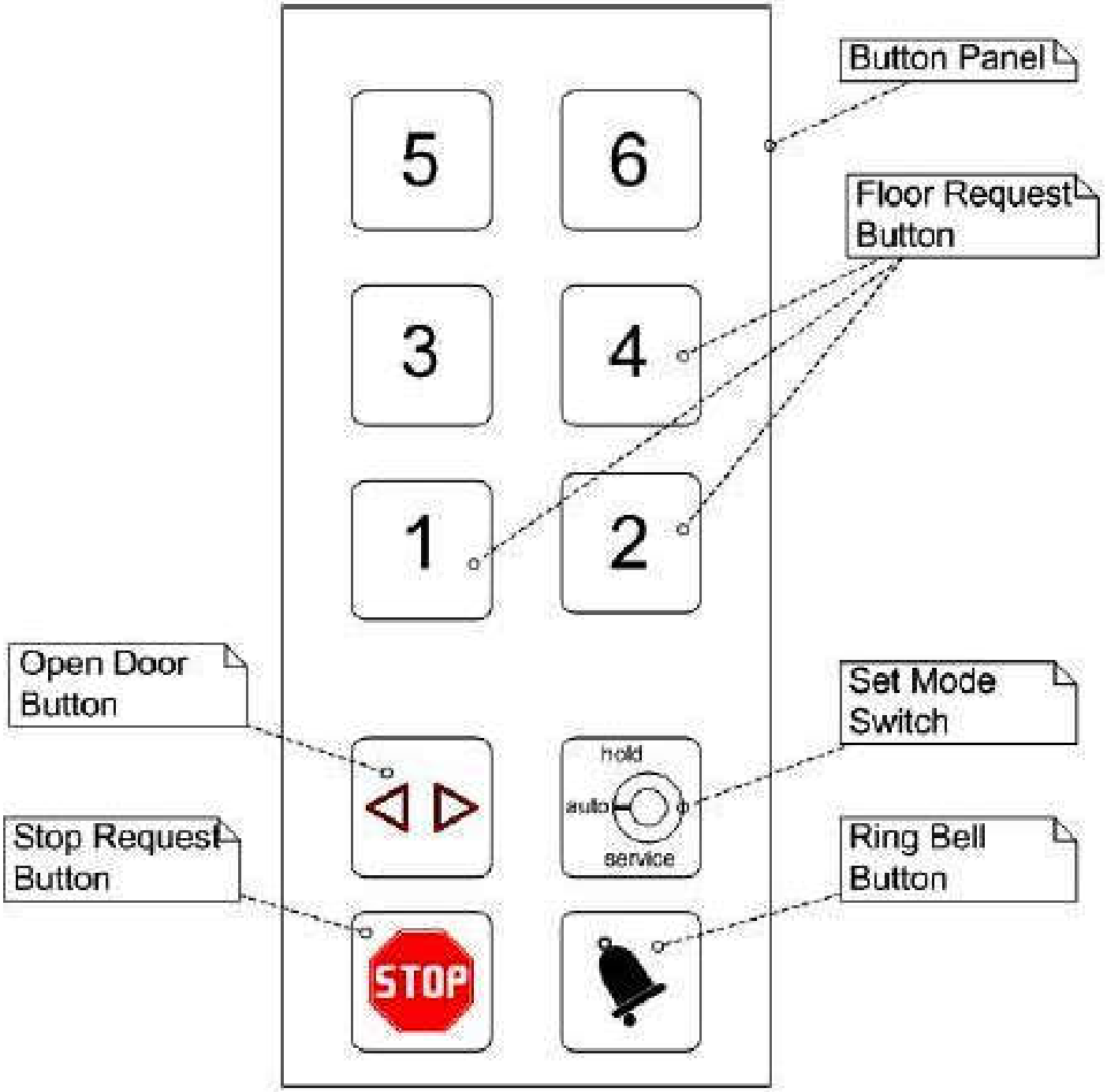
[Source: CIBSE Guide D]

Lift Drive Operation



- Monitoring of lift operation
  - Basic information
    - Lift position, actual & intended travel direction, lift-in use indication
  - Other features, e.g.
    - Fault detection & diagnosis
    - Statistics on call handling & lift usage
    - Communication capability (transmit info to remote pt.)
    - Video monitor displays of real-time lift operation
    - Voice annunciation of lift position & other messages

Car operating panel (COP) buttons



[Source: http://www.electrical-knowhow.com/2012/04/elevator-control-system-part-two.html]

Lift Drive Operation



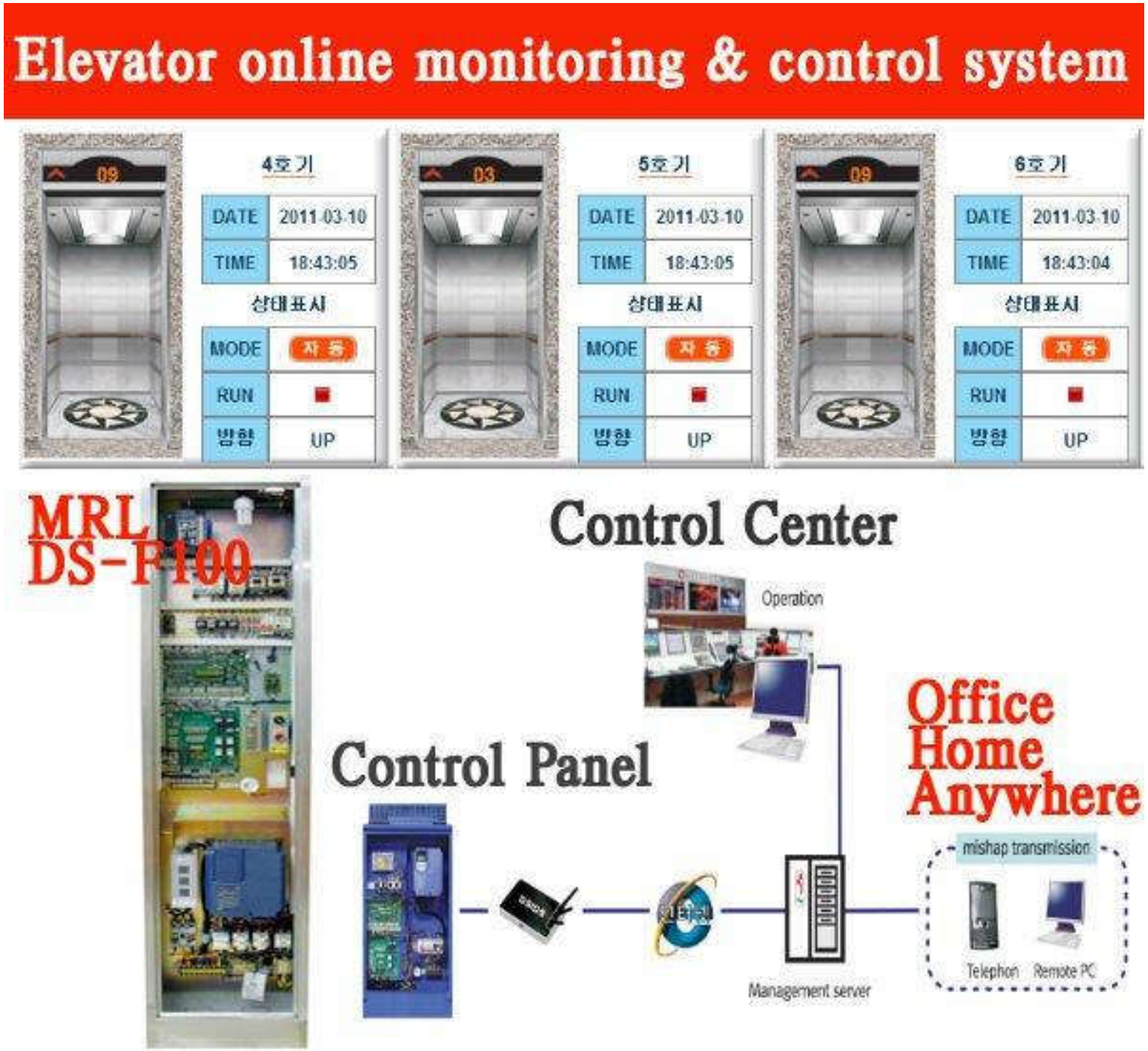
- Other lift operation features
  - Loaded car bypass
  - Automatic dispatching of loaded car
  - Emergency fire services operation
  - Nudging (to push gently)
  - Anti-nuisance operation
  - Preferential service operation
  - Auto adjustment of door open hold time
  - Learning function

Lift Drive Operation



- Other lift operation features (cont'd)
  - Emergency hospital operation
  - Earthquake emergency operation
  - Hoistway access operation
  - Card reader access
  - VIP operation
  - Freight service operation
  - Audio visual (info) system
  - Remote monitoring & interfacing with BAS/BMS

Supervisory control panel with remote online monitoring and control



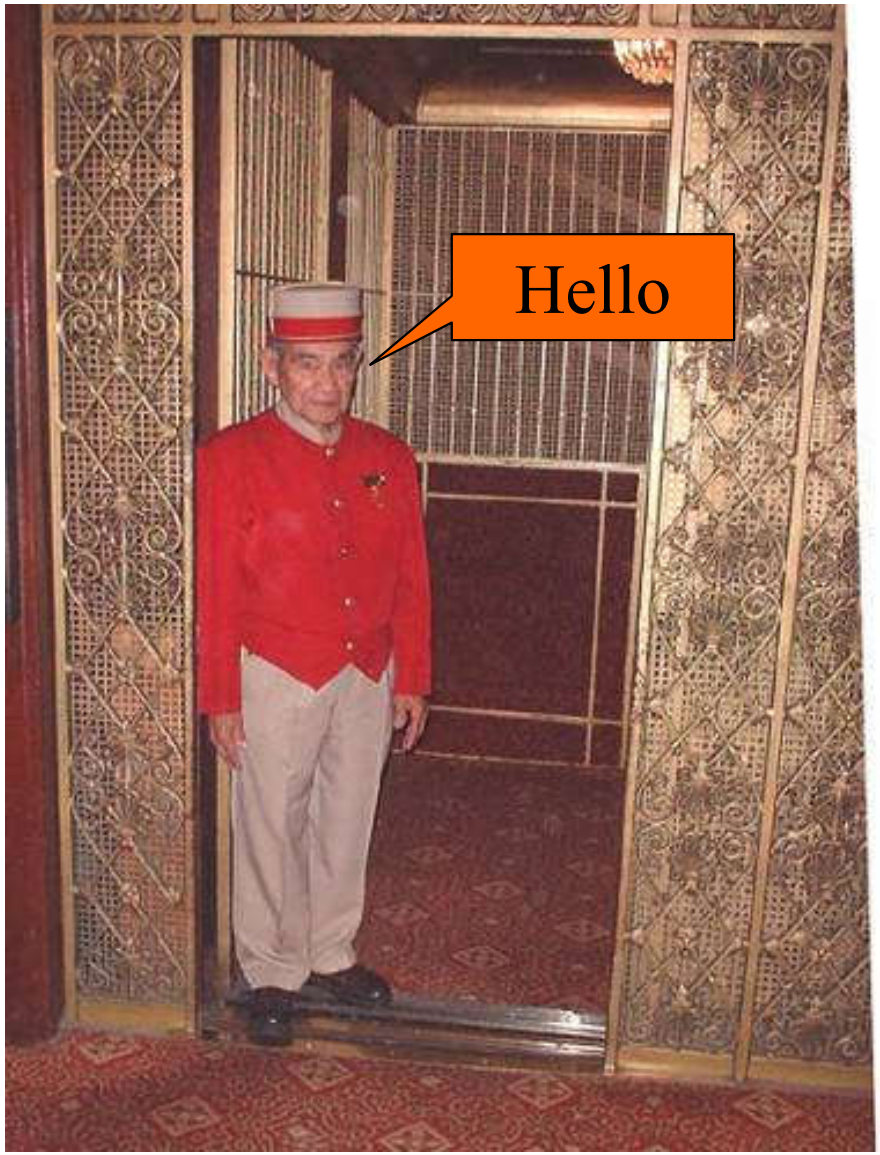
[Source: http://www.electrical-knowhow.com/2012/04/elevator-control-system-part-two.html]

Generations of lift traffic control

Era	Dates	Traffic control type
I	1850-1890	Simple mechanical control (mechanical)
II	1890-1920	Attendant and electrical car switch control (electro-mechanical)
III	1920-1950	Attendant/dispatcher and pushbutton control (electro-mechanical)
IV	1950-1975	Group control: (electrical) IVa scheduled traffic control to 1960 IVb demand traffic control from 1960
V	1975-	Computer group control (electronic)

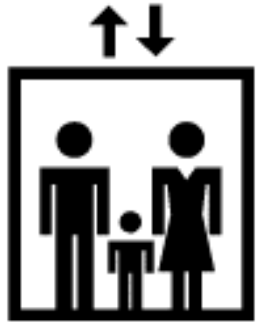
[Source: Barney, G., 2003. *Elevator Traffic Handbook*]

“Lift operator”





Lift Traffic Control



- Lift (group) control arrangements
  - Operator
  - Single automatic
  - Down or up collective
  - Directional (up & down) collective
  - Group collective
  - Programmed control
  - AI (artificial intelligence) assisted control

Single automatic control

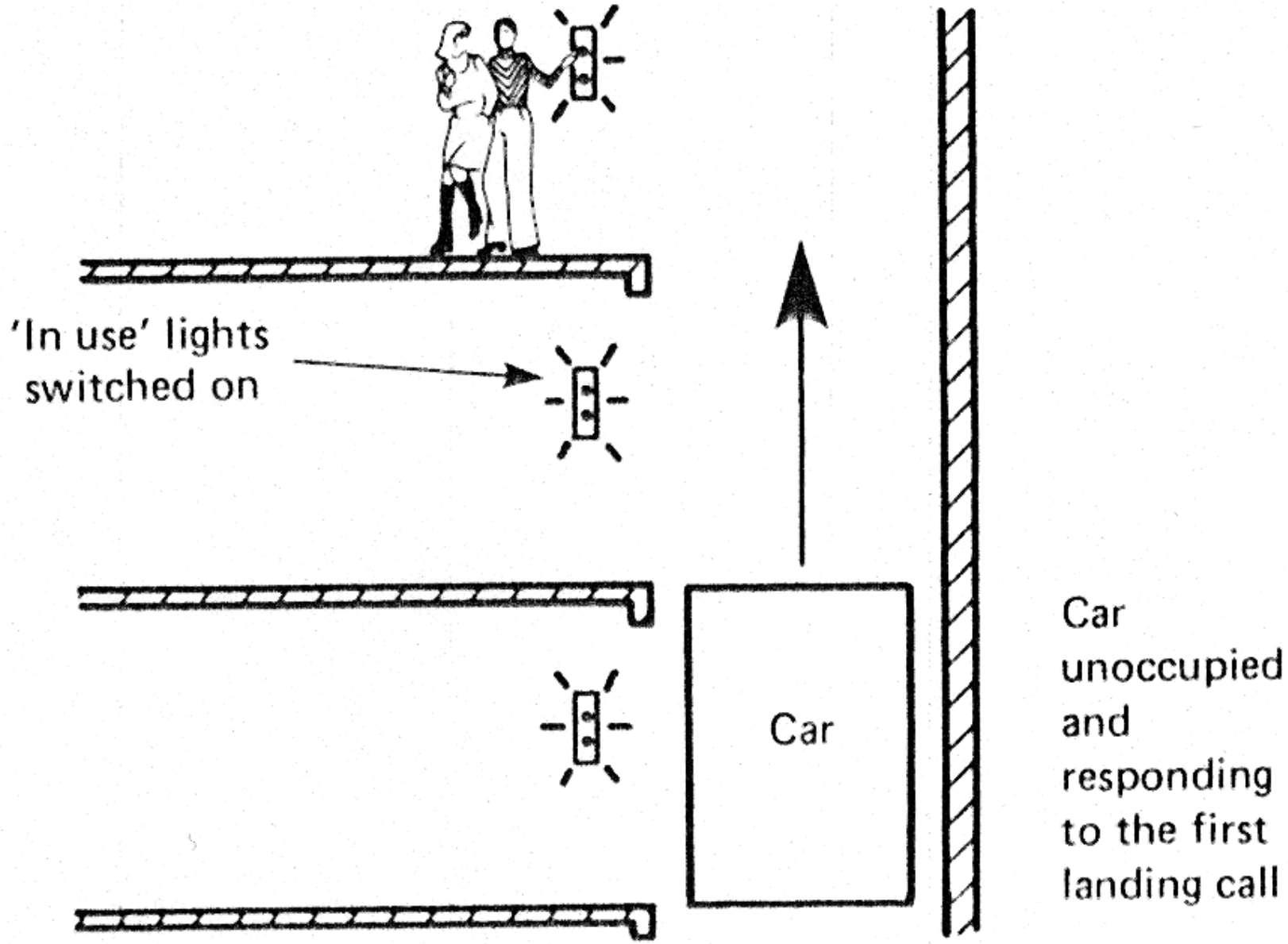


Fig 14 Lift car called to a floor. 'In use' lights switched on

[Source: Hall, F. and Greeno, R., 2005. *Building Services Handbook*]

Single automatic control

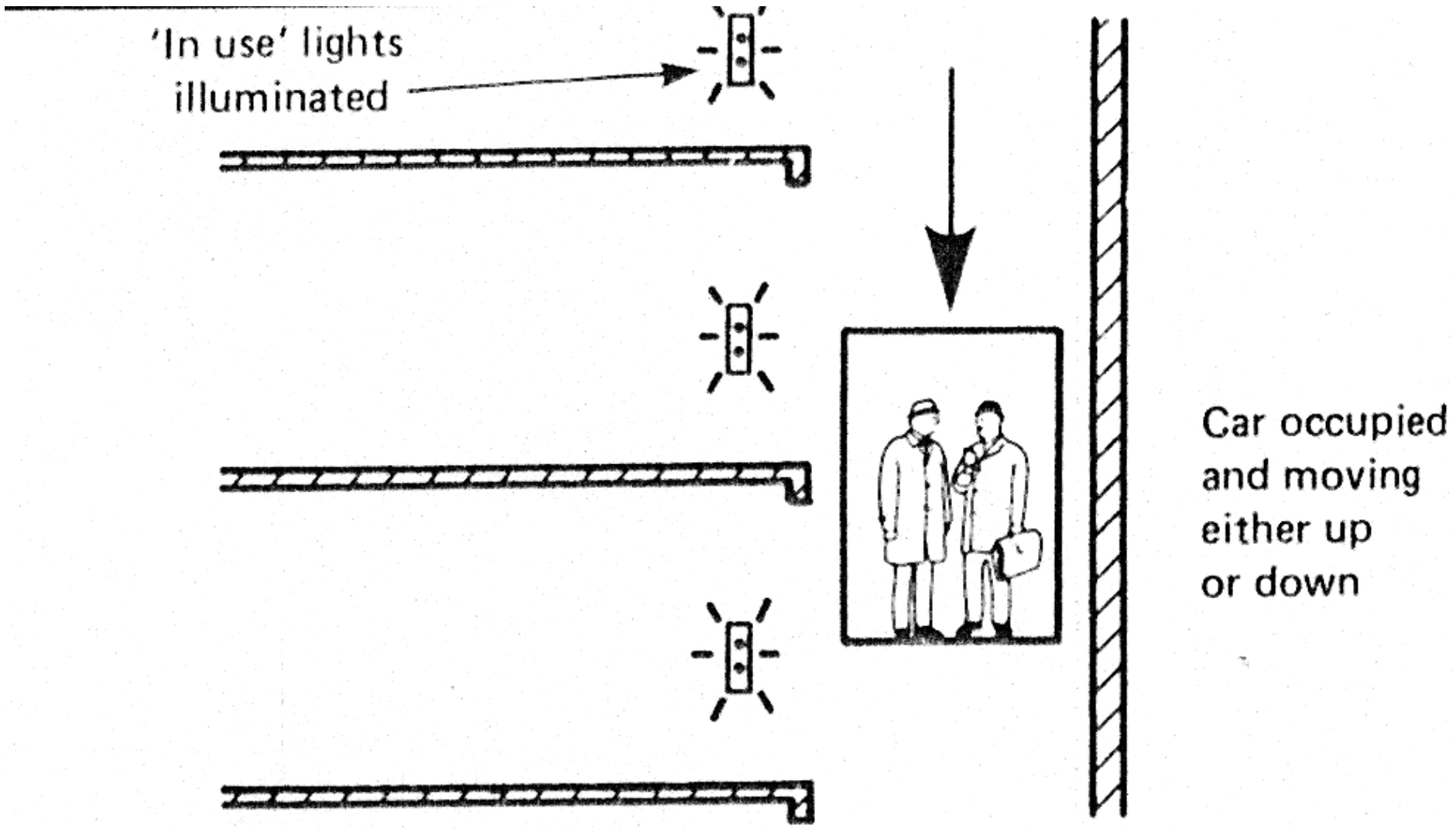


Fig 15 Lift car in control of occupant and cannot be called by other passengers

[Source: Hall, F. and Greeno, R., 2005. *Building Services Handbook*]

Single automatic control

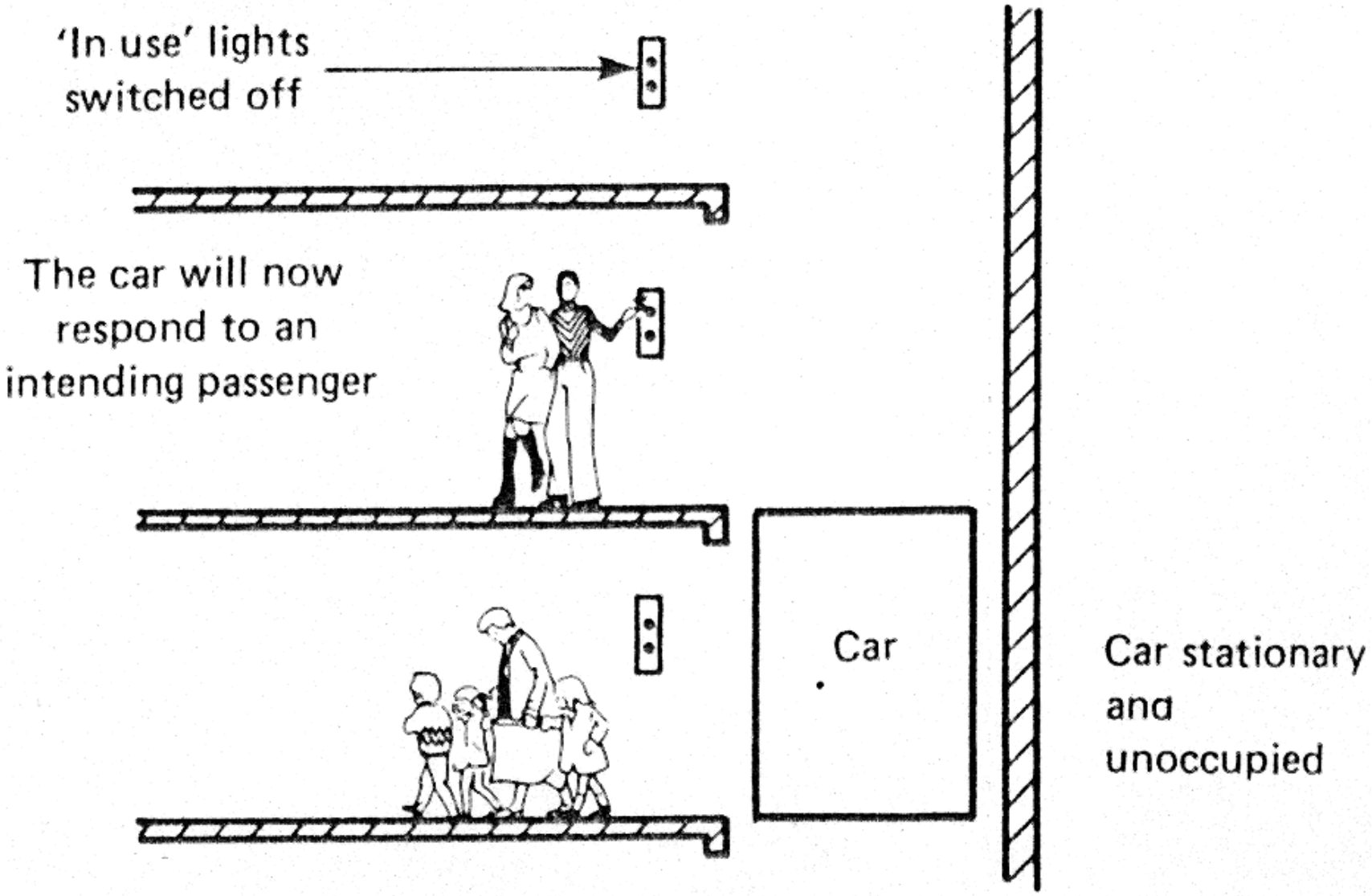


Fig 16 Lift car vacated. 'In use' lights switched off. Lift can now be called by other passengers

[Source: Hall, F. and Greeno, R., 2005. *Building Services Handbook*]

Down collective control

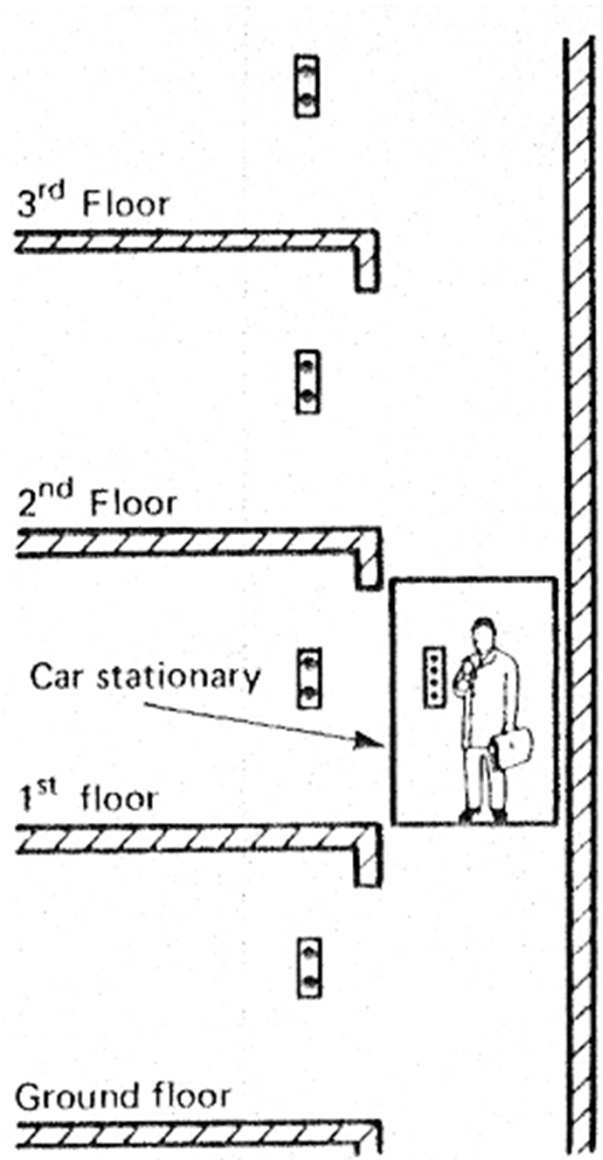


Fig 17 Passengers enter the car and press buttons to travel upwards

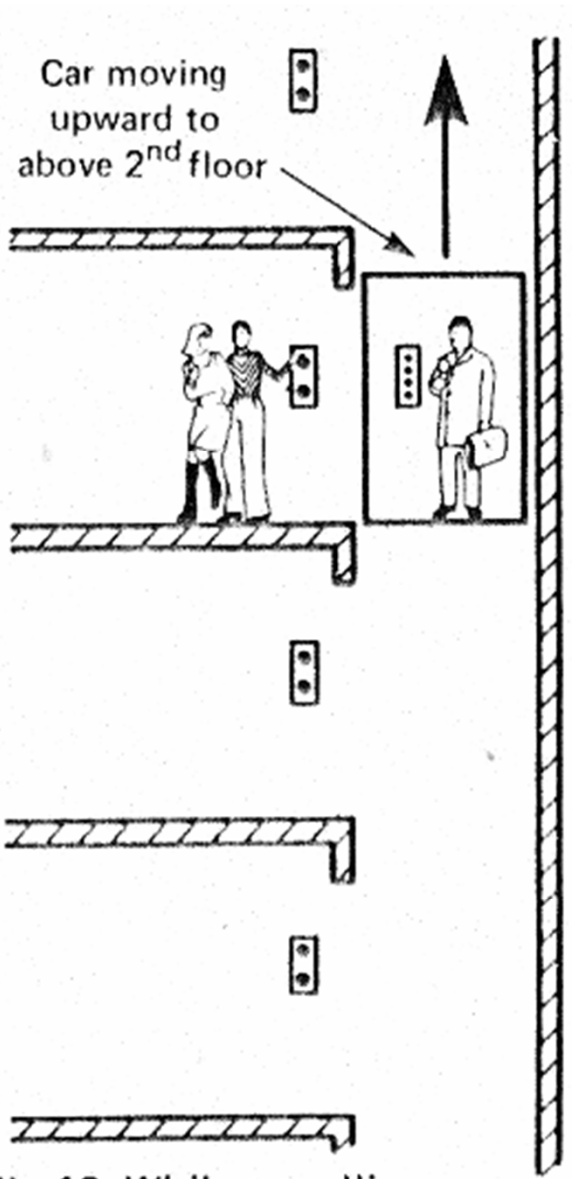


Fig 18 While travelling upwards all the landing calls are by-passed

[Source: Hall, F. and Greeno, R., 2005. *Building Services Handbook*]

Down collective control

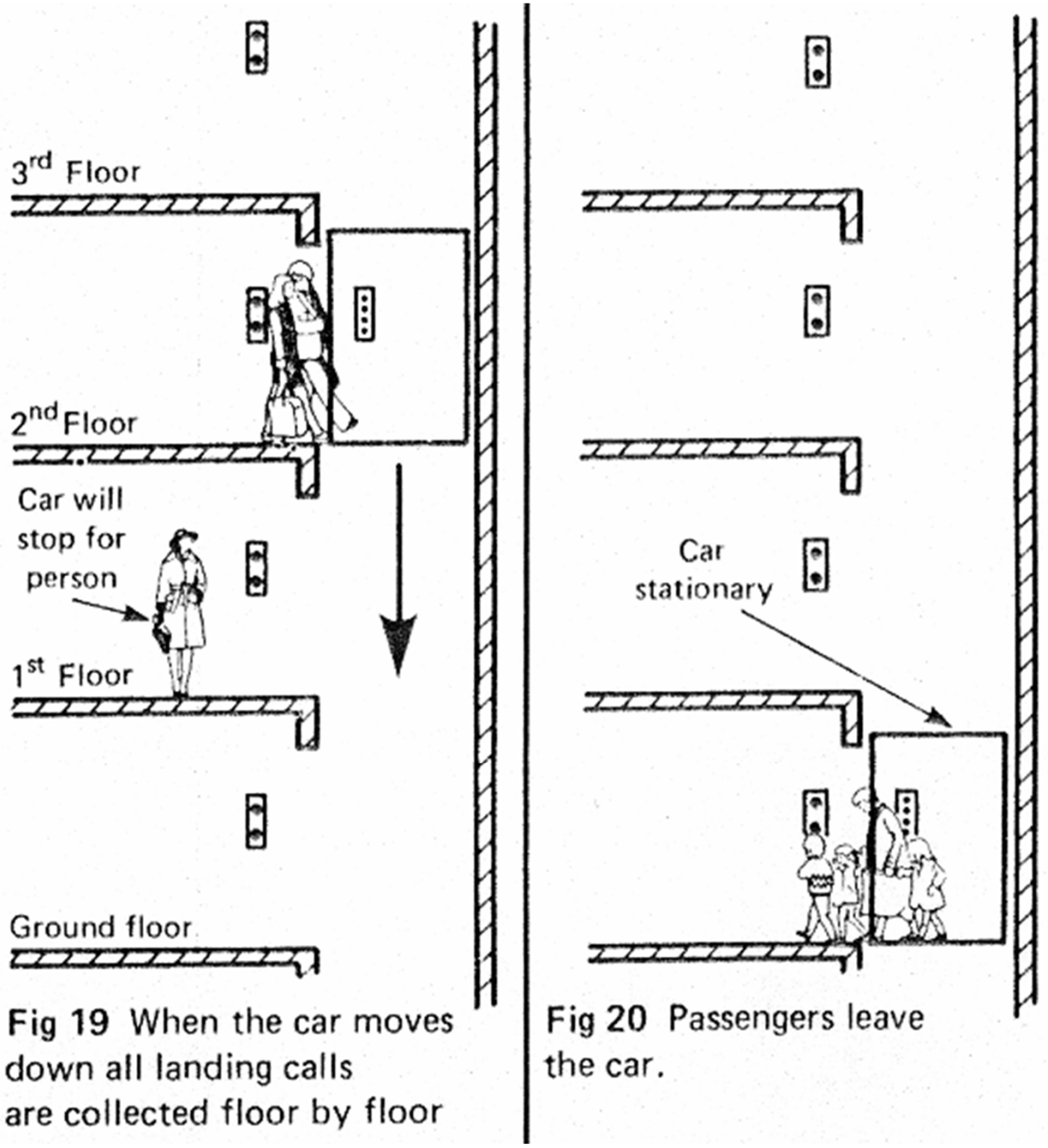
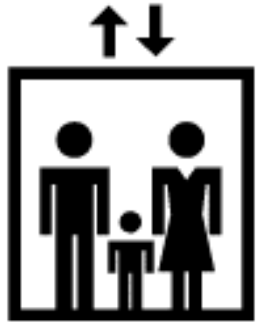


Fig 19 When the car moves down all landing calls are collected floor by floor

Fig 20 Passengers leave the car.

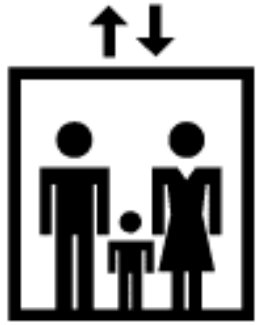
[Source: Hall, F. and Greeno, R., 2005. *Building Services Handbook*]

Lift Traffic Control



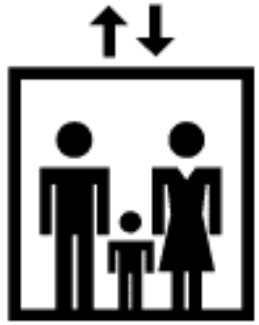
- Group of lifts
  - A number of lifts placed physically together, using a common signalling system and under the command of a group lift control system
- Group traffic control algorithms
  - From simple 2 lift control to very sophisticated
  - Landing call allocation: assign a lift to service a particular landing call

Lift Traffic Control



- Purpose:
  - To allocate the landing calls in an optimum way to individual lifts in the group
    - Minimise passenger waiting time
    - Minimise system response time
    - Minimise passenger journey time
    - Reduce ‘bunching’ (lifts move around together, instead of being evenly separated, e.g. by sudden heavy traffic)
    - Minimise the variation in passenger waiting time

Lift Traffic Control



- Up peak service
  - Focus on main terminal; zone assignments; dynamic zoning
- Down peak service
  - Similar to up peak but down direction
- General group control
  - Static sectoring (assign & park car(s) to each building 'sector')
  - Dynamic sectoring (sectors change with position & direction of car)
  - Hall call allocation systems (every passenger register his/her call, an indication of which car is allocated, no car button)

Hall call allocation system

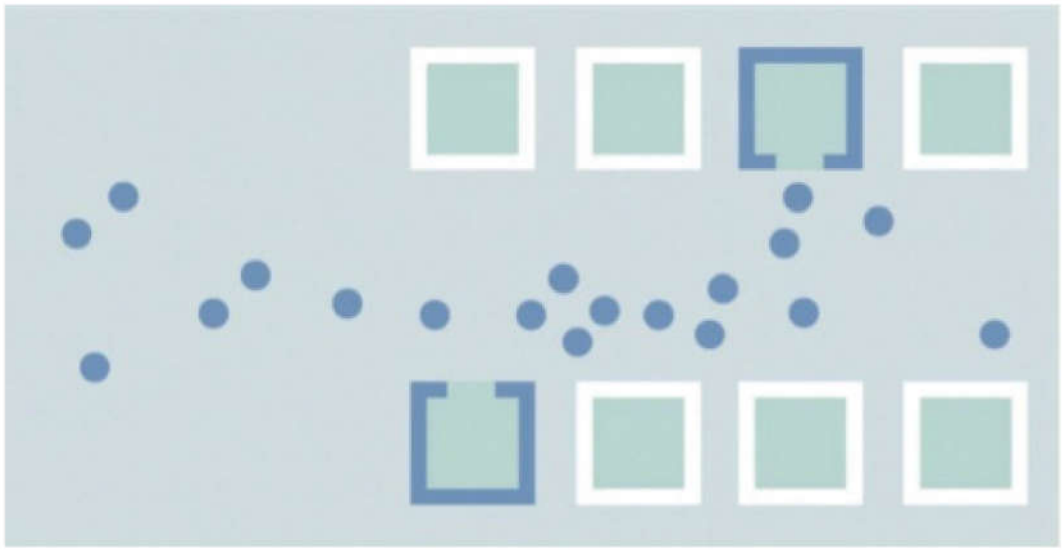






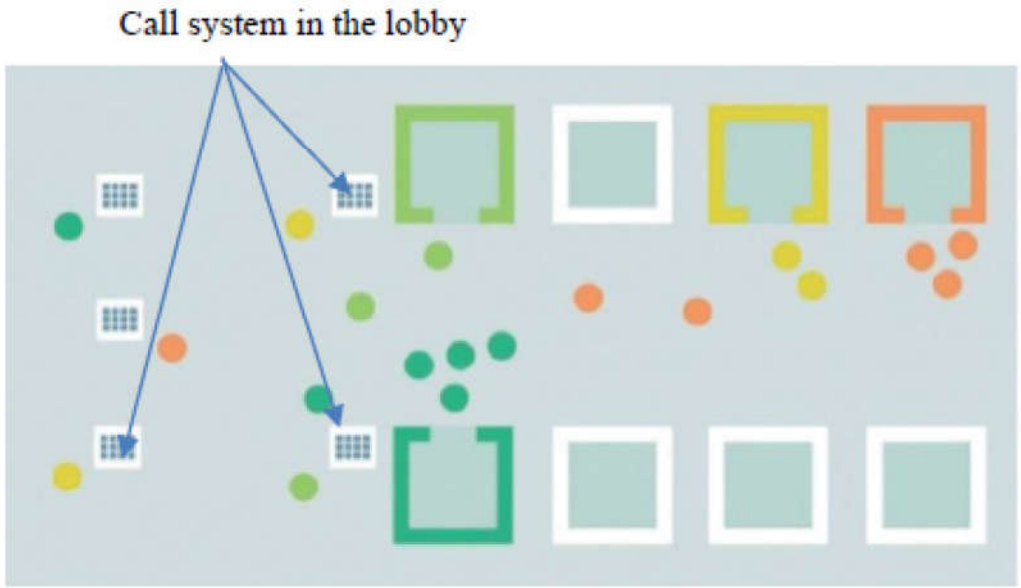
[Source: Schindler https://www.schindler.com/]

Conventional versus destination dispatching system

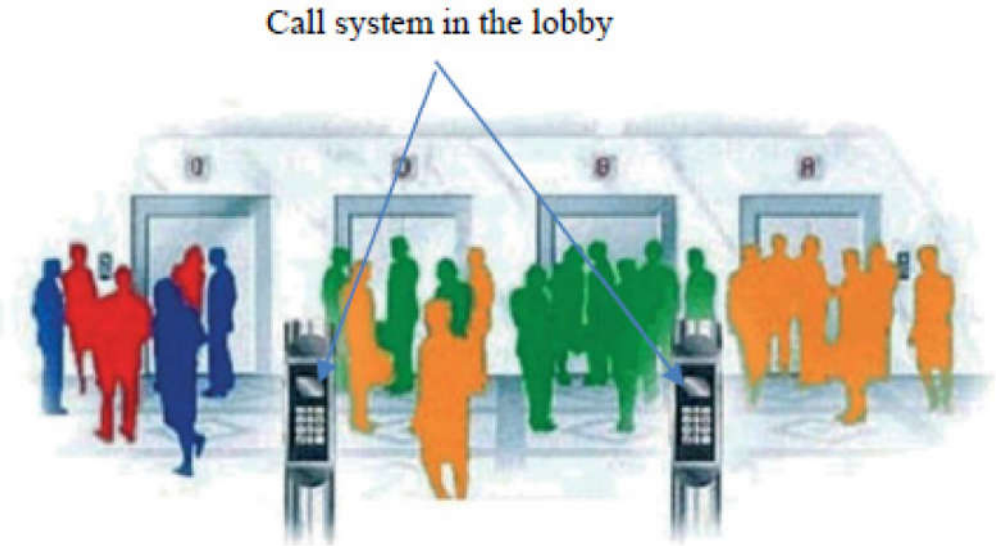


Conventional dispatching system



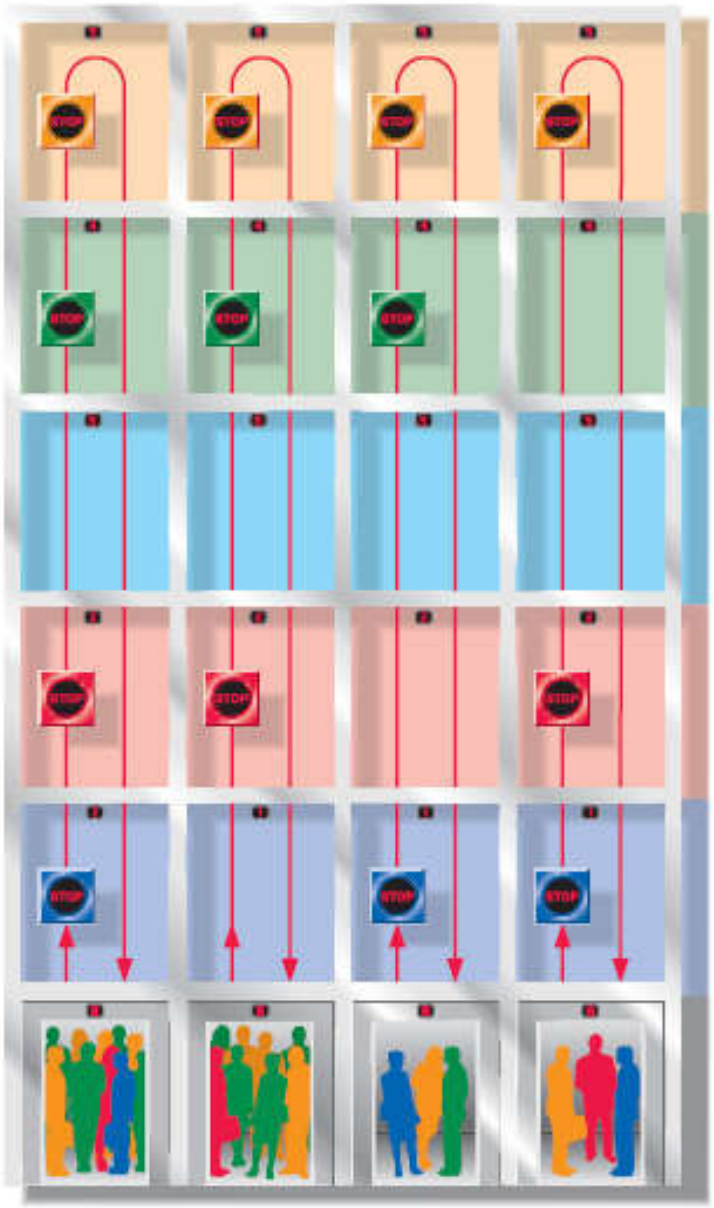


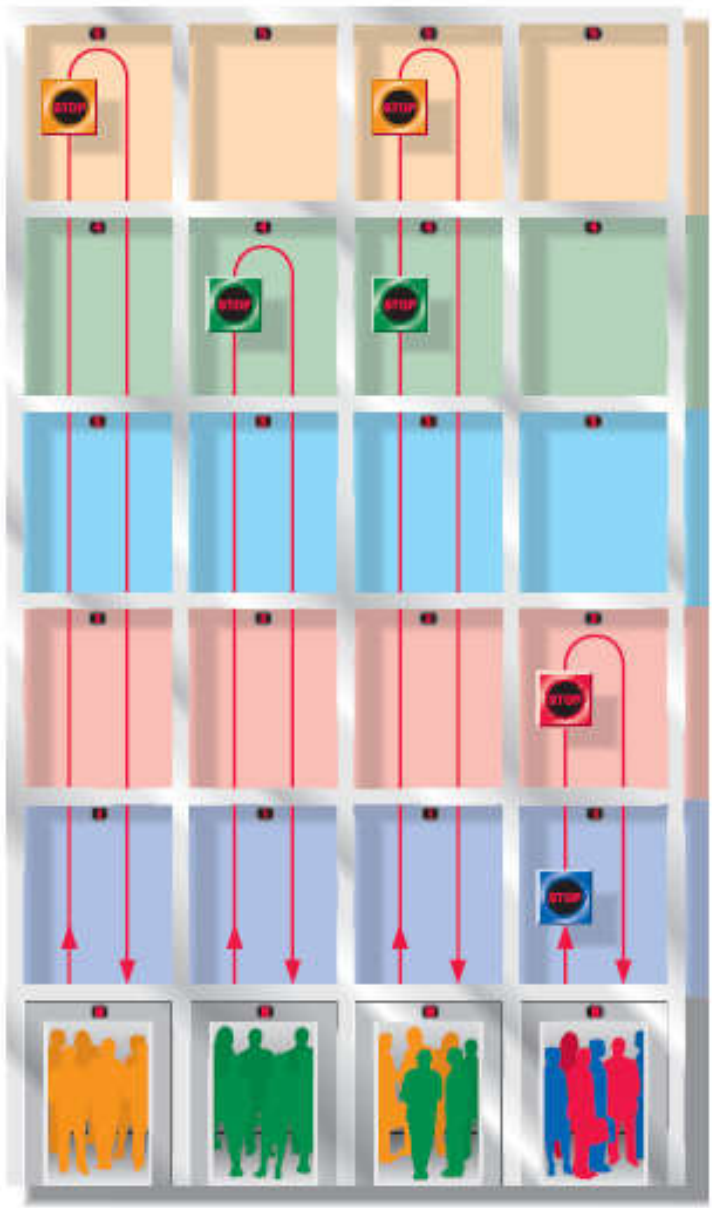
Destination dispatching system



(Source: http://www.ThyssenKrupp.com)

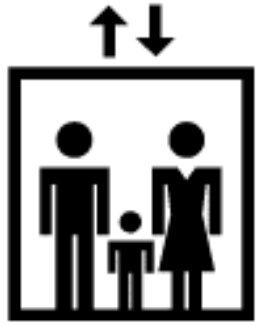
Hall call allocation system: comparison





[Source: Schindler https://www.schindler.com/]

Lift Traffic Control



- Other features
  - Load bypass (when a lift fills up)
  - Heavy demand floors
  - Lobby & preferential floor
  - Lift parking (to main terminal)
  - Basement service
  - Car preference
  - Automatic shut down
- Future trends: use of artificial intelligence
  - Such as expert system control, fuzzy control, artificial neural network control, optimal variance method

Operation of Escalators



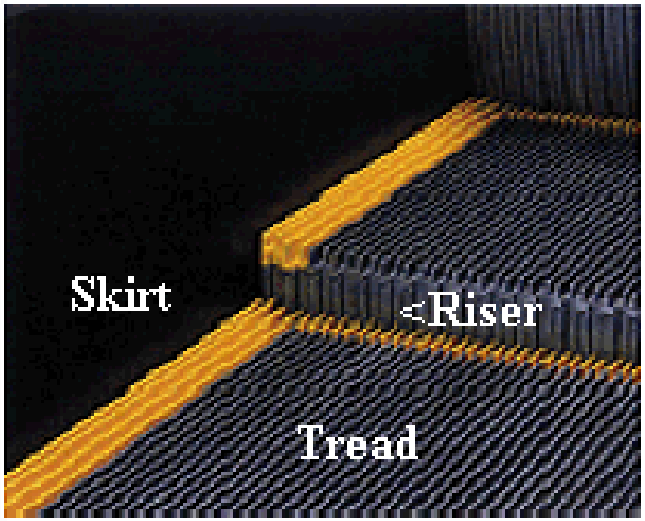
- Basic applications of escalators
  - Commercial (e.g. shopping centres)
  - Transportation (airport terminals, railway stations)
  - Mass transit (subway, MTR)
- Safety features
  - Yellow lines on steps
  - Brushguards
  - Yellow spots on handrails
  - Lighting at the landings

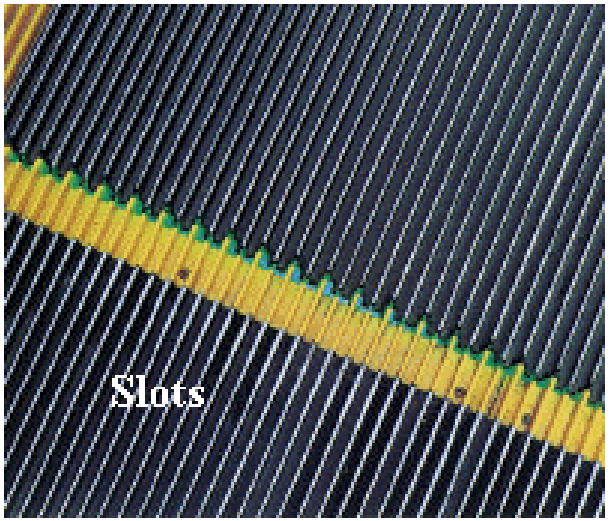
Terminal Railway Station



Escalator components & safety features













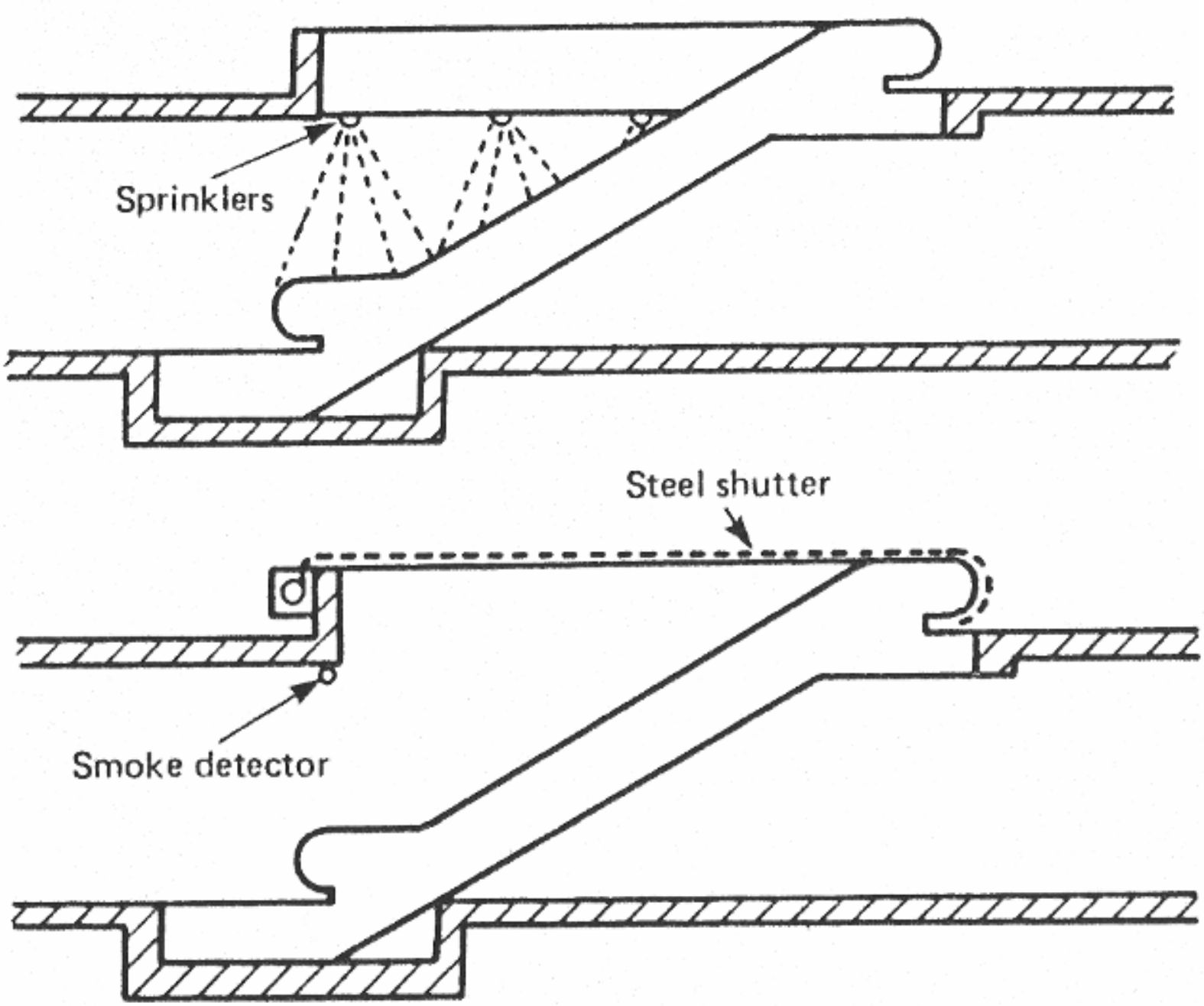
[Image source: http://www.elevator-expert.com]

Operation of Escalators



- Prevent spread of fire
  - Void containing escalators encourage fire/smoke to spread
  - Precautions needed:
    - Sprinklers to provide a continuous water curtain
    - Fire curtains or shutter released by fusible smoke link or smoke relay to seal the top of the escalator shaft
    - Compartmentation or separation of escalators

Fire/Smoke precautions for escalators



[Source: Hall, F. and Greeno, R., 2005. *Building Services Handbook*]

Operation of Escalators



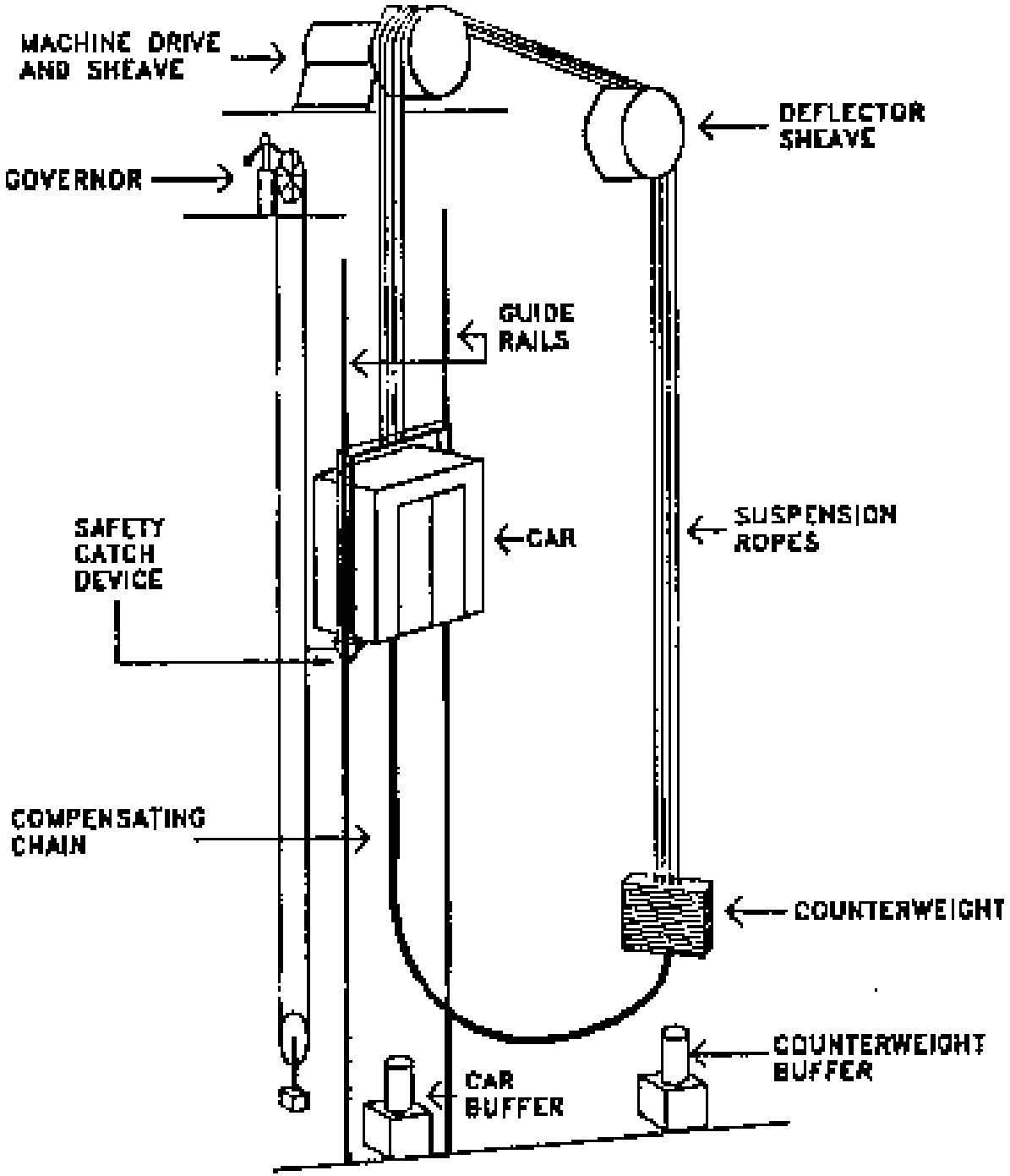
- Motor drives & methods of starting
  - Star delta starter
    - Requires a non-standard pole changing motor & high value of starting current
  - Soft start (by using thyristors)
  - Inverter start (standard motor can be used)
    - Also allow speed to be varied
  - Modular drives
    - Employ 2 or 3 motors coupled to the gear box

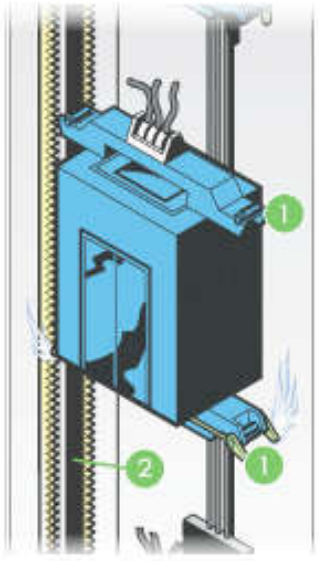
Safety Issues



- Lifts & Escalators Safety (EMSD)
  - https://www.emsd.gov.hk/en/lifts_and_escalators_safety/
  - Contractors' Performance Rating
  - Guidance Notes / Guidelines
  - Code of Practice
  - Circulars
  - Statutory/Advisory Bodies
  - Responsible Persons' Corner

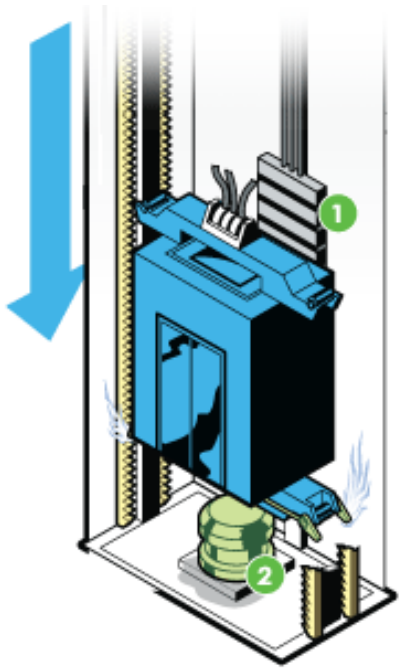
Lift safety systems and components





1. If the cables snap, the elevator's **safeties** would kick in. **Safeties** are braking systems on the elevator.
2. Some safeties clamp the **steel rails** running up and down the elevator shaft, while others drive a wedge into the notches in the **rails**.

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1. The cables that lift the car are also connected to a **counterweight**, which hangs down on the other side of the sheave.
2. The built-in **shock absorber** at the bottom of the shaft - typically a piston in an oil-filled cylinder - helps cushion the imact in the event of snapping cables.

©2004 HowStuffWorks

[Source: http://www.msha.gov/S&HINFO/TECHRPT/HOIST/PAPER4.HTM and http://science.howstuffworks.com/]

Safety Issues



- Lift mechanical & electrical components:
  - Rope brake, machine motor brake
  - Overspeed governor & counterweight
  - Machine & controller (stopping, levelling & braking + speed limiting control)
  - Deflector sheave & interlock
  - Car safety & structural steel car frame
  - Car & counterweight buffers
  - Lower stopping & reversal limits
  - Pit stop switch light switch & ladders

Safety Issues



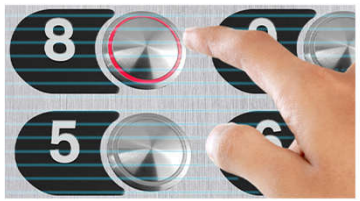
- Lift passenger safety devices:
  - Door operator (open/close car door, e.g. infrared)
  - Door protection (guard against door interference)
  - Emergency light & communication (intercom)
  - Interlock (ensures landing door is closed before car allowed to move)
  - Car position indicator
- Temporary works & platforms for installation, repair & maintenance

Escalator safety devices

- Handrail safety guard
- Emergency stop button
- Skirt guard obstruction device
- Broken drive-chain safety device
- Broken step chain safety device
- Electric circuit protection device
- Electromagnetic brake
- Step upthrust safety device
- Skirt guards
- Fire shutter interlocked device
- Demarcation line
- Reversal protection device
- Governor (overspeed)
- Comb impact switch
- Handrail speed delay sensing device
- Step sag safety device
- Missing step device
- Tandem operation interlock
- Comb plate switch
- Step obstruction device

Hygiene protection (during COVID-19):

- Clean and touchless operation
- Handrail sanitization
- Air cleaner/ionization
- Social distancing visual guidance







Safety Issues



- Safety precautions for lift installation, repair & maintenance works (e.g. prevent person falling)
  - Guidelines on Safety of Lift Shaft Works (Construction Industry Council, Hong Kong)



    - http://www.cic.hk/eng/main/aboutcic/publications/guidelines/
  - Guide on Safety in Lift Repair & Maintenance (Labour Department, Hong Kong)



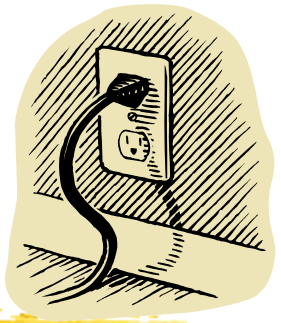
    - https://www.labour.gov.hk/eng/public/os/D/LiftRM.pdf

Safety Issues



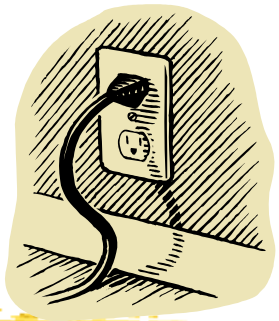
- Builder's works for lifts & escalators
  - Lift entrances (including lift shaft, floor levels)
  - Lift beams/eyes (for lifting equipment)
  - Machine rooms
  - Landing ceiling & walls
  - Landing flooring (finished floor level, FFL)
  - Foundations, pits, structural work for escalators
  - Clearance (e.g. handrails, avoid trapping/falling)
  - Lighting (for safety, servicing & maintenance)

Energy Efficiency

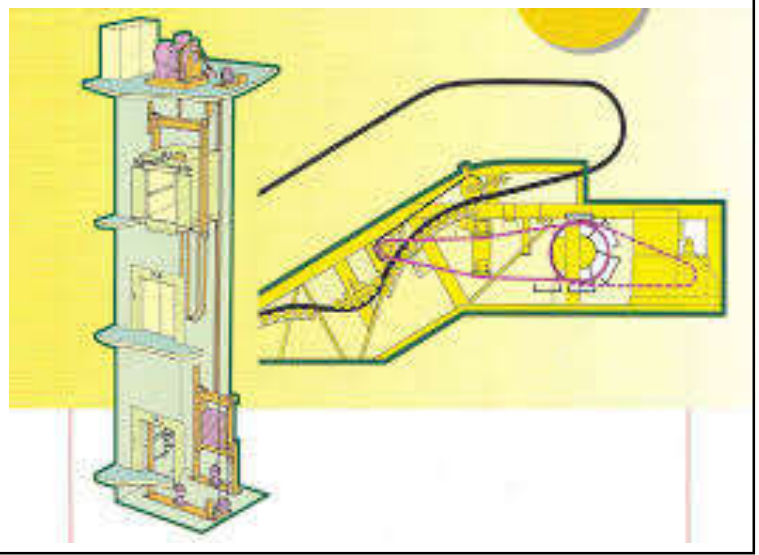


- Lifts & escalators are a major energy consumer in buildings
  - Typically consists 5-15% of electricity in high-rise commercial buildings
  - Also affects peak energy demand & power factor
- EMSD building energy code & guidelines:
  - Code of Practice for Energy Efficiency of Lift and Escalator Installations
  - Guidelines on Energy Efficiency of Lift and Escalator Installations

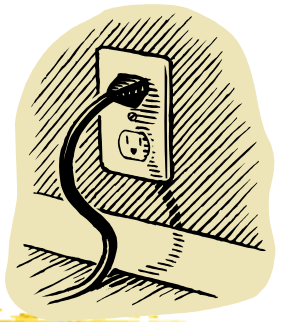
Energy Efficiency



- Requirements on lifts & escalators
  - Maximum allowable electrical power
  - Energy management of lift cars or escalators
  - Total harmonic distortion (motor drive)
  - Total power factor (motor drive)
- Recommendations on lifts
  - Handling capacity
  - Lift traffic design



Energy Efficiency



- General approach for lifts & escalators
  - Minimise friction losses & dynamic losses
  - Possible regeneration into the supply system
- General principles to energy efficiency
  - Specify energy efficiency equipment
  - Do not over design the system
  - Suitable zoning arrangement
  - Suitable control and energy management
  - Use light weight materials for lift car decoration
  - Good house keeping

Classification of energy efficiency of lifts

Energy efficiency class	Energy consumption per day (Wh)
A	$E_d \leq 0.72*Q*n_d*s_{av}/1000 + 50* t_{nr}$
B	$E_d \leq 1.08*Q*n_d*s_{av}/1000 + 100* t_{nr}$
C	$E_d \leq 1.62*Q*n_d*s_{av}/1000 + 200* t_{nr}$
D	$E_d \leq 2.43*Q*n_d*s_{av}/1000 + 400* t_{nr}$
E	$E_d \leq 3.65*Q*n_d*s_{av}/1000 + 800* t_{nr}$
F	$E_d \leq 5.47*Q*n_d*s_{av}/1000 + 1600* t_{nr}$
G	$E_d > 5.47*Q*n_d*s_{av}/1000 + 1600* t_{nr}$

E_d = Total daily energy consumption (Wh)
Q = Rated load (kg)
n_d = Number of trips per day
s_{av} = Average travel distance for target installation (m)
t_{nr} = Non running (idle and standby) time(s) per day (h)

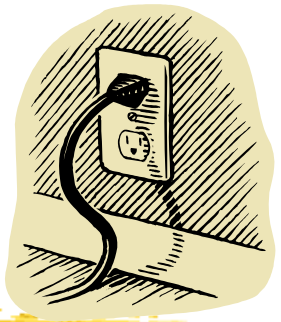
[Source: ISO 25745-2 Energy performance of lifts, escalators and moving walks, Part 2]

Guidelines for reducing energy consumption of escalators

Measure	Description	Remark
Auto start	Stopping the unit in case of absence of passengers	Reduction by switching from $E_{no\ load}$ to $E_{stand\ by}$
Slow speed	Slow down the unit to slow speed in case of absence of passengers	Reduction by switching from $E_{no\ load}$ to $E_{slow\ speed}$
Power OFF	Switch off the main supply, e.g during night	Reduction by switching $E_{standby}$ off
Power OFF ancillary equipment	Switch off the ancillary equipment supply	Reduction by switching $E_{ancillary}$ off
Motor voltage control	Load depending voltage reduction, e.g. star delta switching, frequency converter, voltage control	Improvement of η of motor resulting in reduction of $E_{no\ load}$, $E_{slow\ speed}$ and partial load condition
Gear efficiency improvement	Usage of gear technologies with improved efficiency, e.g. helical gear	Improvement of η of gear resulting in reduction of $E_{no\ load}$, $E_{slow\ speed}$ and any load condition
Motor efficiency improvement	Usage of motor technologies with improved efficiency	Improvement of η of motor resulting in reduction of $E_{no\ load}$, $E_{slow\ speed}$ and any load condition
Handrail system efficiency improvement	Usage of low friction handrail components	Reduction of $E_{no\ load}$, $E_{friction}$, $E_{slow\ speed}$ and any load condition
Step/pallet chain system efficiency improvement	Usage of automatic lubrication system	Reduction of $E_{no\ load}$, $E_{friction}$, $E_{slow\ speed}$ and any load condition

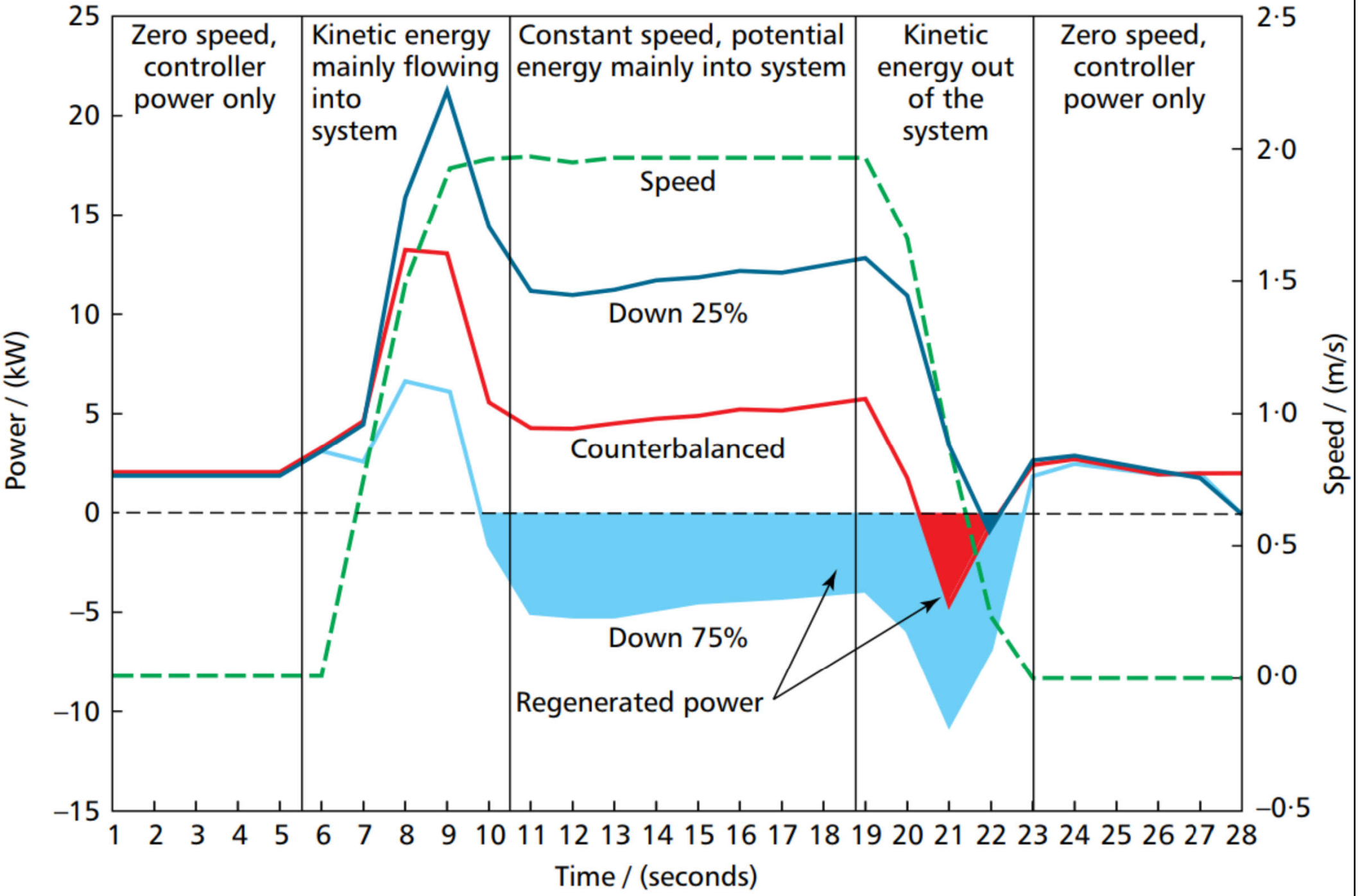
[Source: ISO 25745-3 Energy performance of lifts, escalators and moving walks, Part 3]

Energy Efficiency



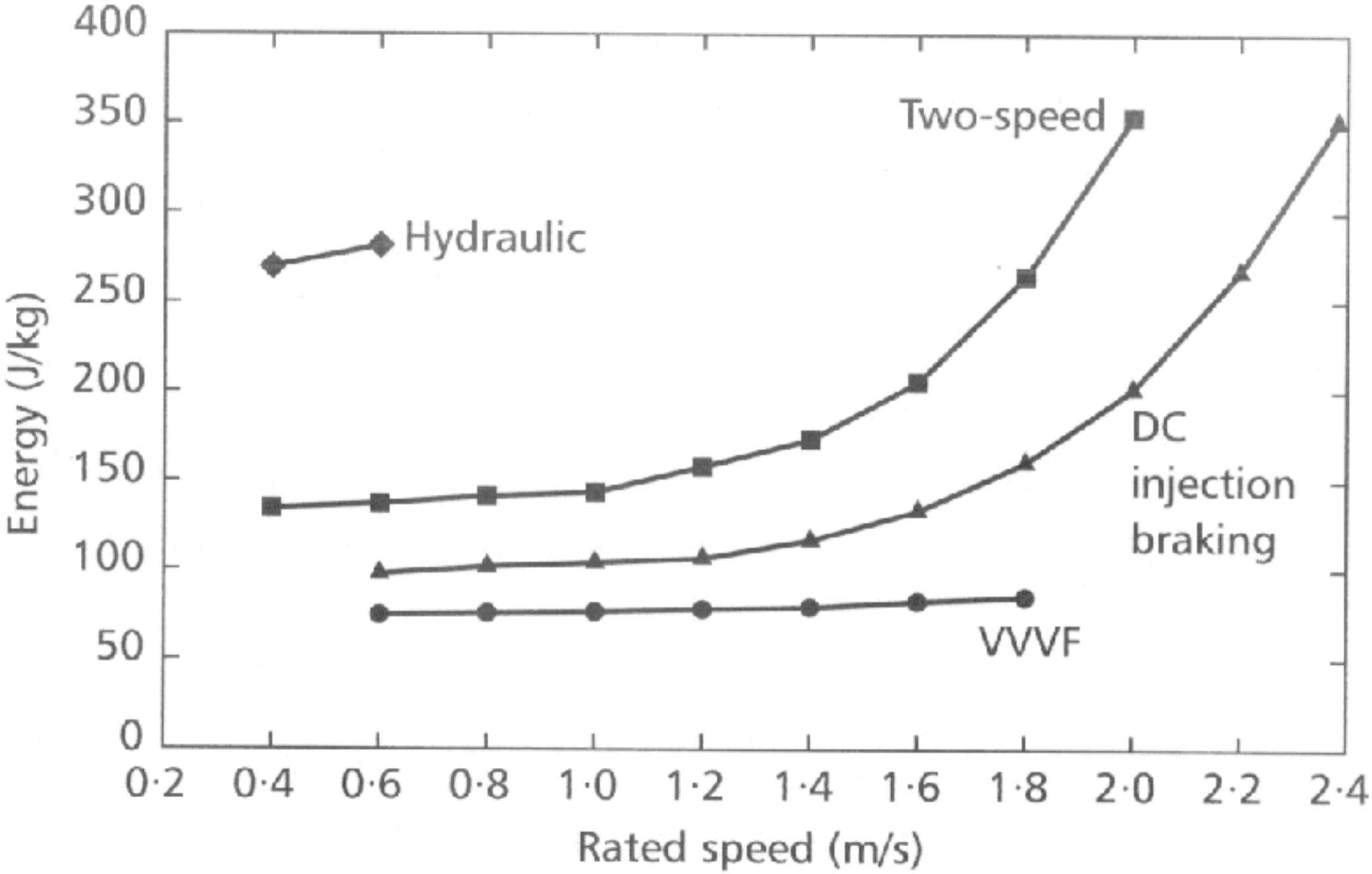
- Factors affecting energy consumption
  - Type of drive (hydraulic, two-speed, etc.)
  - Mechanical design (e.g. gearbox)
  - Efficiency of various components
  - Reduction of inertia (e.g. flywheel)
  - Type of gearing (if applicable)
  - Possibility of electricity regeneration
  - Running power factor
  - Loading (level of usage)

Speed and energy consumption of a lift carrying different loads



[Source: CIBSE Guide D]

Energy consumption of various types of drives



[Source: CIBSE Guide D]

Traction elevator technologies

Component	Basic efficiency	Intermediate efficiency	Advanced efficiency
Hoist drive	Motor-generator or direct-current with silicon-controlled rectifiers	Gearless	Permanent magnet, gearless
Car lift	Wire rope	Wire rope	Polyurethane-coated belts, multiple rope
Controls	Electromechanical relays, group controller	Microprocessor	Software-defined (e.g., destination dispatch)
Lighting, ventilation	Incandescent, halogen	CFLs, efficient fans	LEDs, efficient fans, occupancy sensors
Energy sources	Grid	Grid plus regeneration	Regeneration plus solar
Considerations	Single operating mode, needs machine room	Standby mode, better power factor	Standby mode, variable door motors, power factor near 1, MRL, quick installation

Note: MRL = machine room–less.

Source: American Council for an Energy-Efficient Economy

Characteristics of premium-efficiency elevators

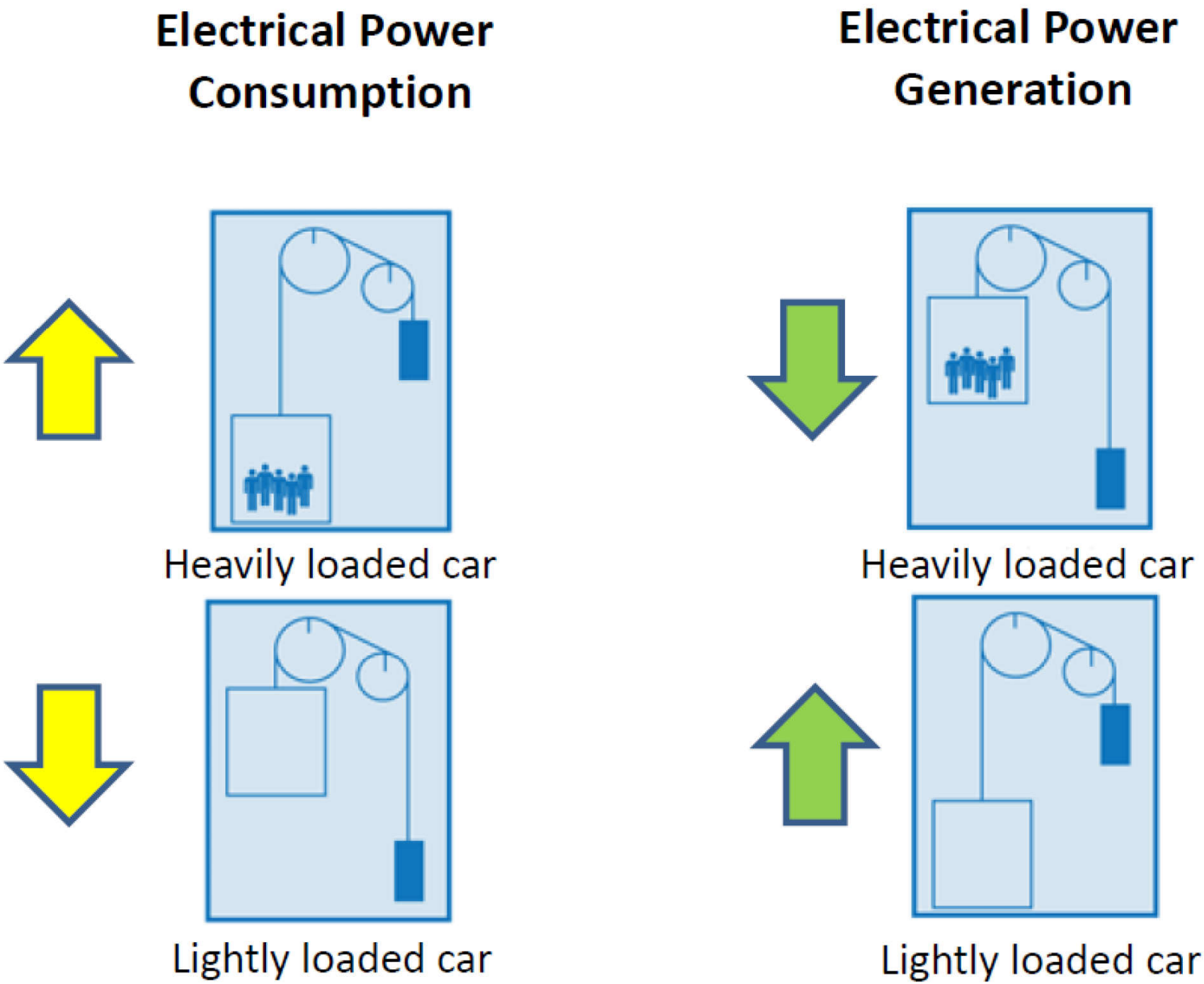
Building type	Conventional elevators	Conventional drive type	Premium-efficiency elevators	Premium-drive type	Energy savings possible (%)
Low-rise (6 or fewer floors)	Hydraulic	Any	Geared regenerative, gearless nonregenerative, gearless regenerative	AC VVVF	21–24
Mid-rise (7–24 floors)	Geared nonregenerative	AC VVVF	Geared regenerative, gearless nonregenerative, gearless regenerative	AC VVVF, DC SCR, DC PWM	31–45
High-rise (25 or more floors)	Geared nonregenerative	AC VVVF	Geared regenerative, gearless nonregenerative, gearless regenerative	AC VVVF, DC SCR, DC PWM	30–43

Notes: AC = alternating current; DC = direct current; PWM = pulse-width modulating; SCR = silicon-controlled rectifier; VVVF = variable voltage, variable frequency.

© E Source

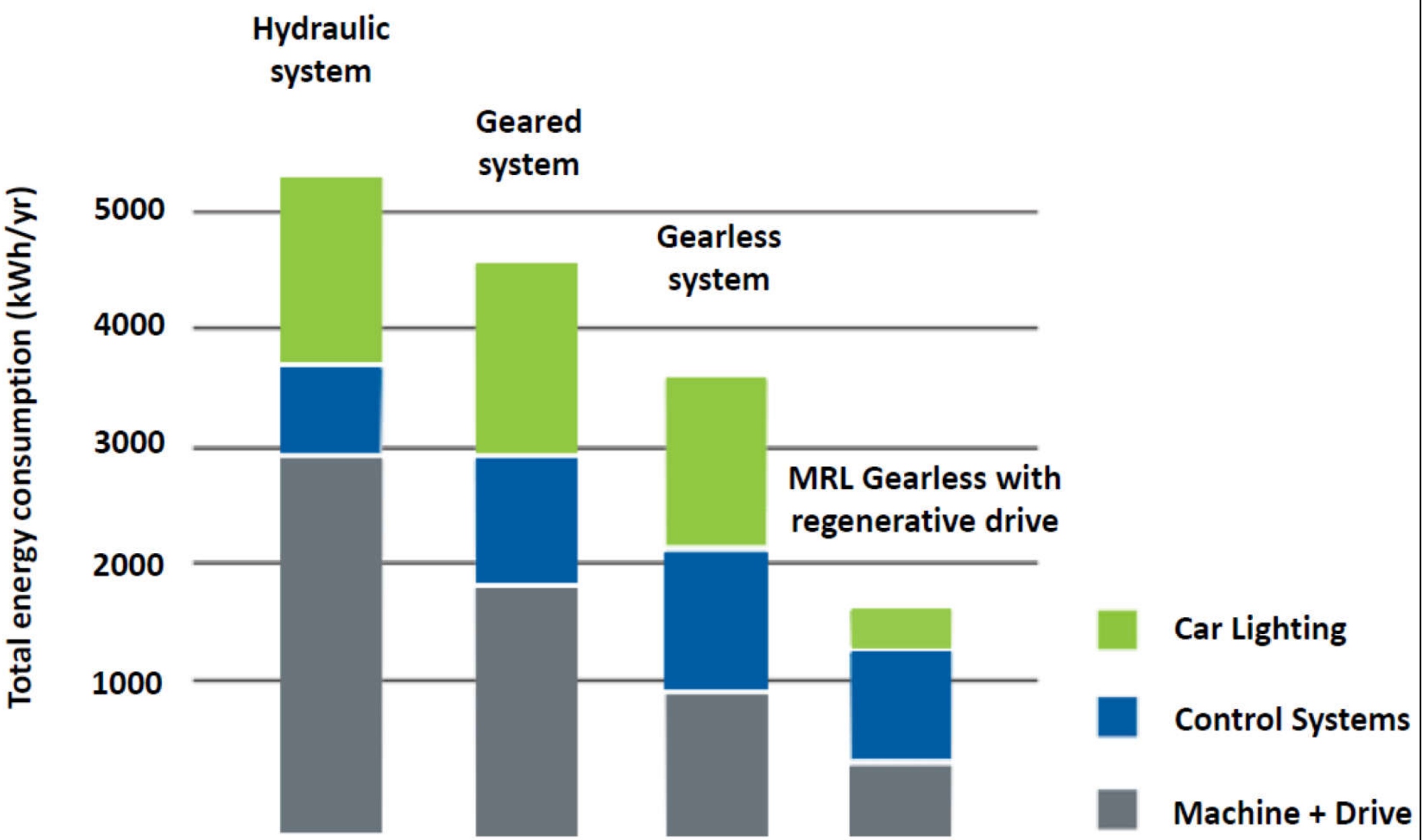
(Source: Elevators (Business Energy Advisor) https://ouc.bizenergyadvisor.com/article/elevators)

Regenerative drive system



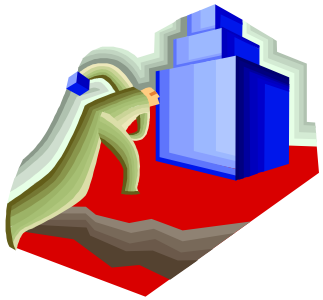
(Source: Al-Kodmany K., 2015. Tall buildings and elevators: a review of recent technological advances, *Buildings*, 5(3) 1070-1104. https://doi.org/10.3390/buildings5031070)

A comparison of energy consumptions among different lift systems



(Source: http://www.otisworldwide.com)

Modernisation

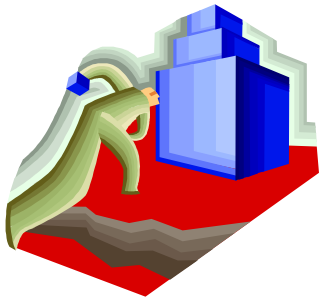


- Lift modernisation*
  - Refurbish, retrofit, renew lift system/components
- Purposes
  - For performance
  - For aesthetic
  - To meet code (e.g. for disabled)
- Consider together with the lift maintenance programme

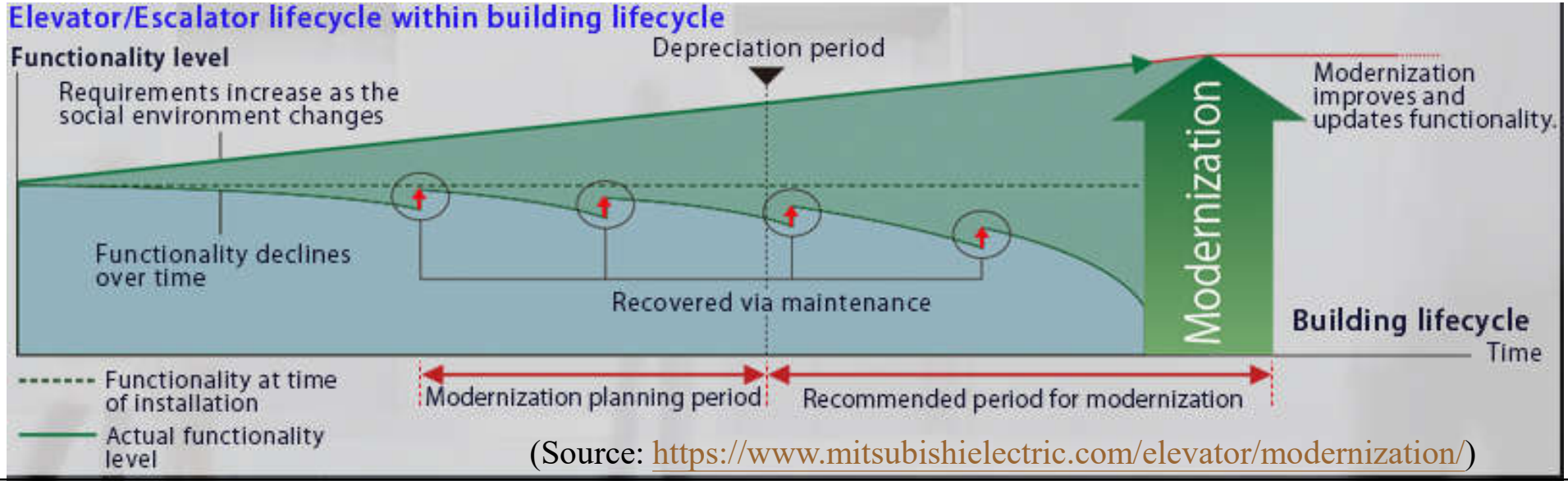
Why modernise the existing lifts?

(* See also EMSD Guidelines for Modernising Existing Lifts http://www.emsd.gov.hk/emsd/e_download/pps/le/Modernising_Lifts.pdf)

Modernisation

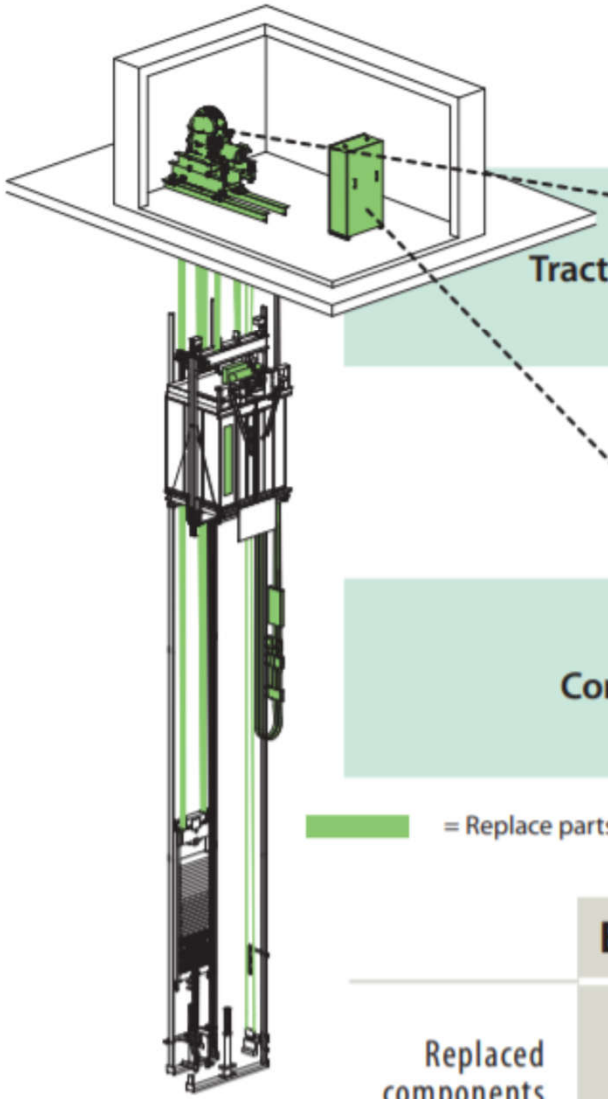


- Modernization options
  - Semi-complete (extensive replacement)
  - Control system modernization
    - Traction machine replaced
    - Traction machine/motor reused



(Source: https://www.mitsubishielectric.com/elevator/modernization/)

Modernization allows a lift to be refurbished by replacing some of its components so that usable components can be retained



Traction machine

Control panel

= Replace parts

Before

After



Old induction motor (AC-2)



New induction motor (VVVF)



Relay circuit



Microcomputer

Benefits

- Energy savings
- Improved traffic efficiency
- Minimal wasted parts
- Safety
- Reliability

	Existing elevators	Modernization: Case A	Modernization: Case B
Replaced components	—	Control panel (VVVF) Door motor Signal fixture	Traction machine & traction motor (Gearless) Control panel (VVVF) Door motor Signal fixture
Energy-saving	100%	62% (38% cut)	54% (46% cut)
Reuse rate	100%	88%	71%

(Source: Mitsubishi Electric https://www.mitsubishielectric.com/)

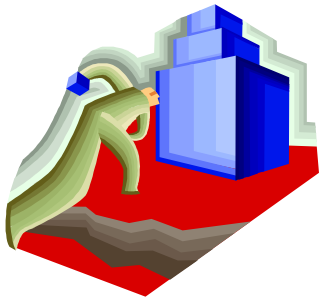
Changes or modifications to existing lift during modernisation

- Rated speed
- Rated load
- Travel
- Mass
- Complete controller including door operations
- Drive control system
- From manual to power-operated doors
- Entrances
- Safety components
- Electric safety devices
- (Electric) drive components (lift machine, brake)
- (Hydraulic) jack & lift machine
- Car enclosure or interior finishes
- Door operator
- From gates to doors
- Guide rails

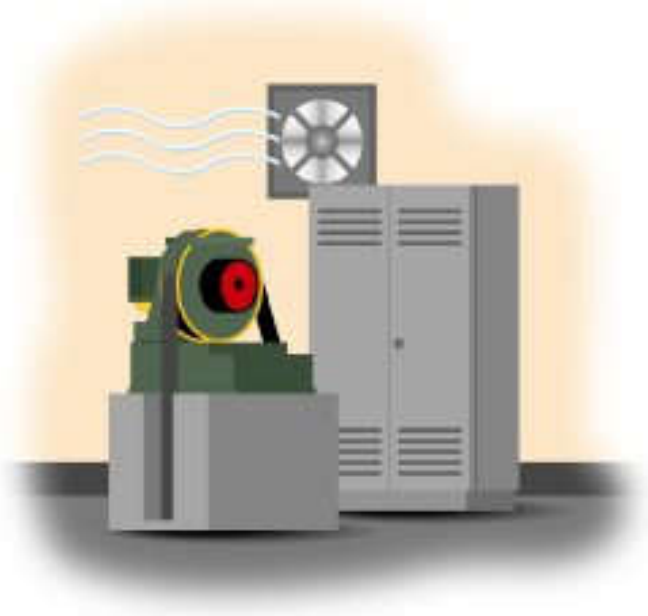


[Source: CIBSE Guide D]

Modernisation



- Influencing factors
  - Type of installation
  - Original manufacturer
  - Budget provision
  - Building life cycle
  - Codes & standards



- Typical elements
  - Lift car, door equipment, control system, drive machinery, guide rails & fixings, pit equipment

Modernisation

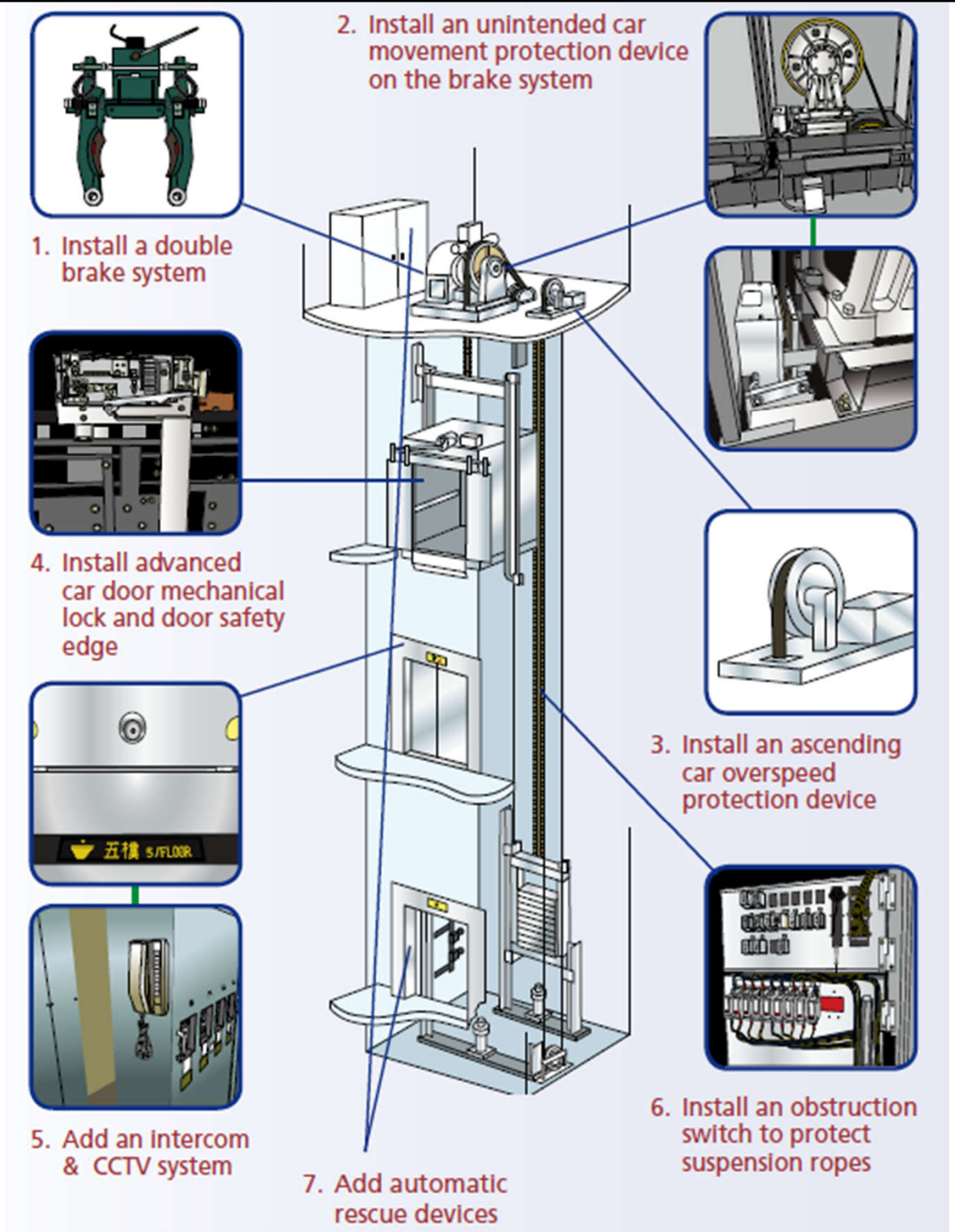
- Recommended work stages
  - 1. Pre-planning
  - 2. Design limitations
  - 3. Planned modernisation
  - 4. System design
  - 5. Specification
  - 6. Tender list
  - 7. Out to tender
  - 8. Post-tender evaluation
  - 9. Award of contract







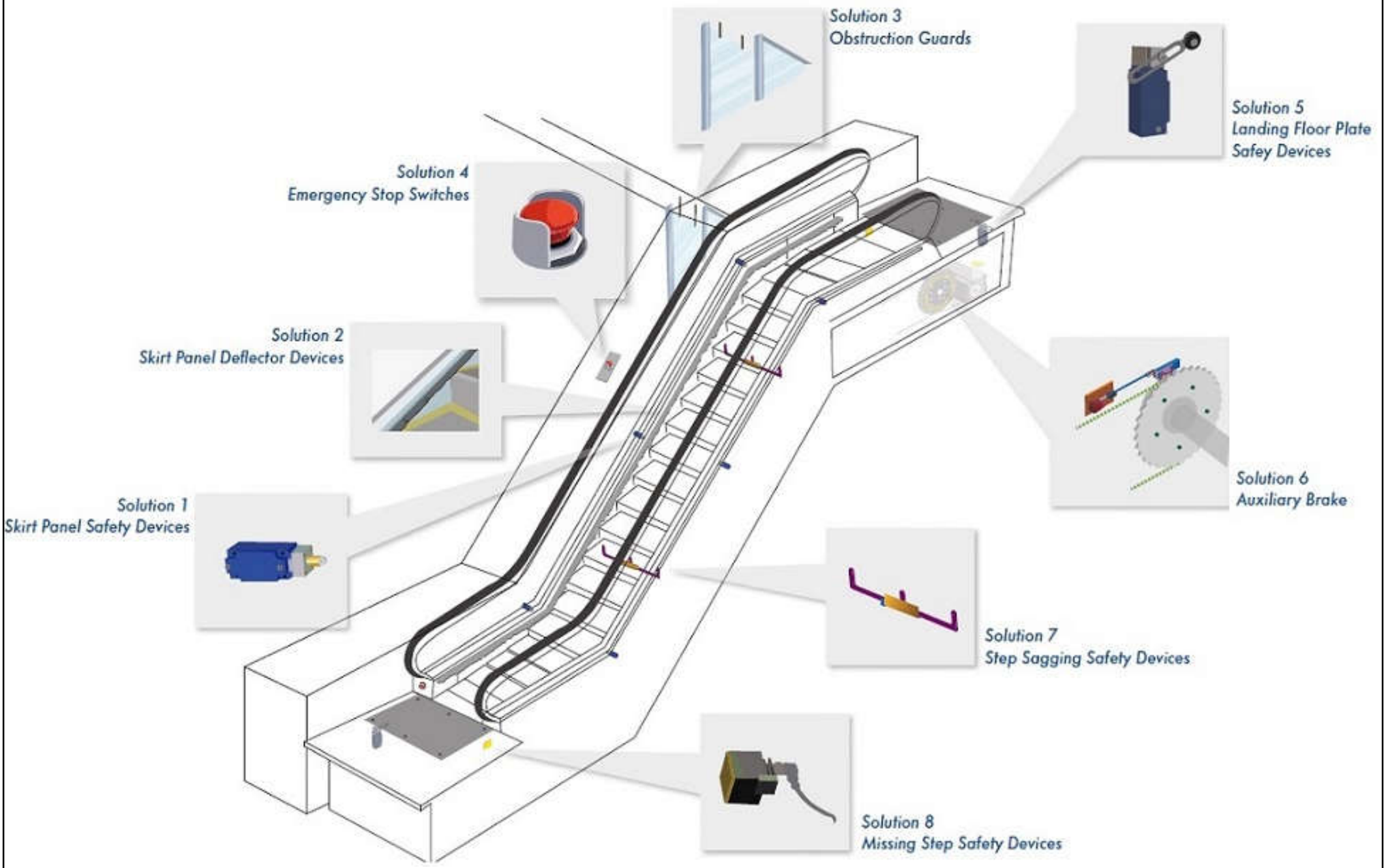




Applicable solutions for enhancing requirements of existing lifts

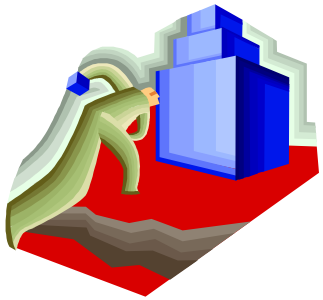
(Source: https://www.brplatform.org.hk/en/defects-and-orders/common-building-defects/defective-lift)

Escalators modernisation



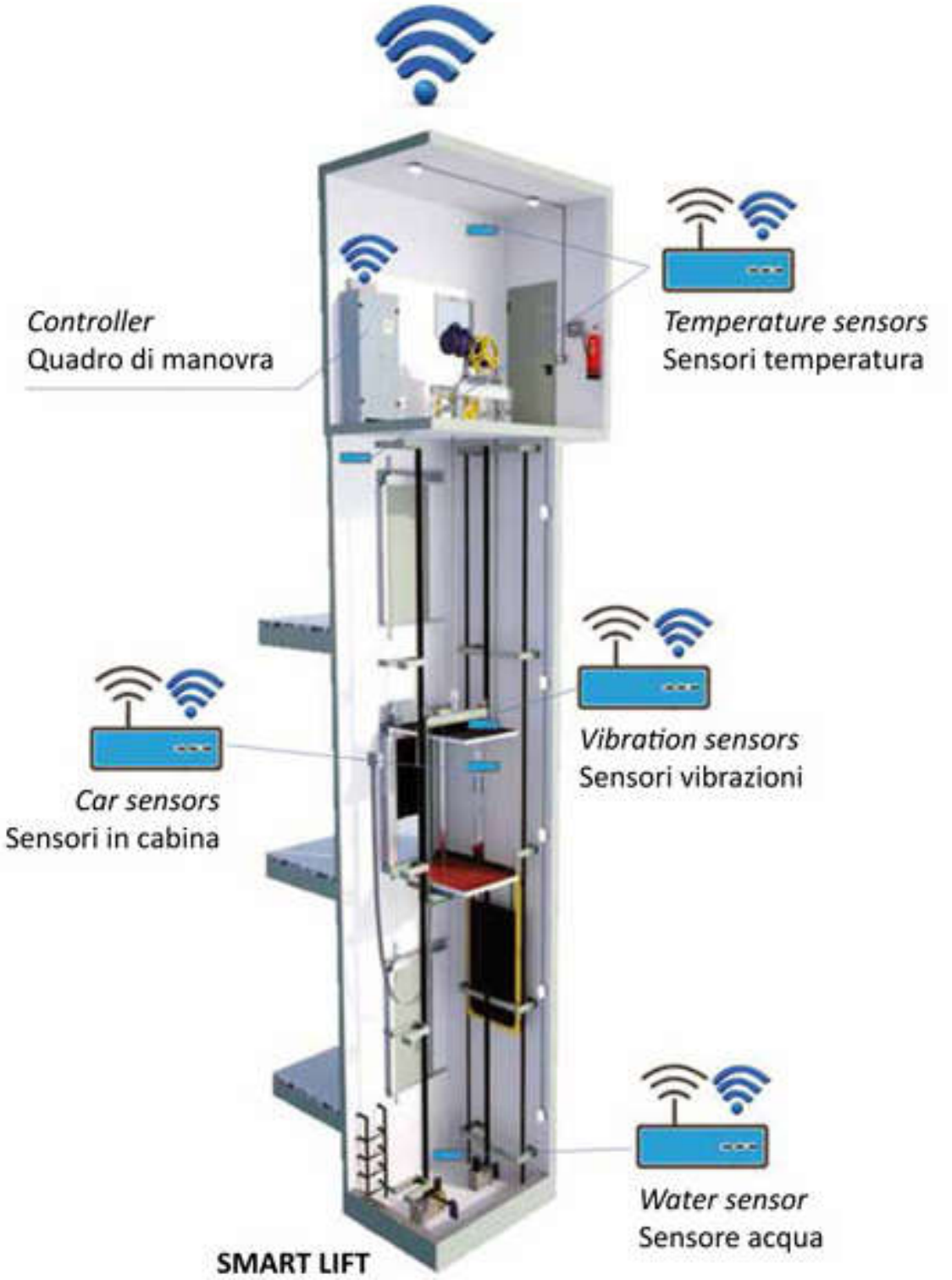
(Source: https://www.emsd.gov.hk/en/lifts_and_escalators_safety/responsible_persons_corner/lift_modernisation_resource_corner/)

Modernisation



- Lift smart technologies for elders
  - Visuality – easily viewable & distinguishable
  - Accessibility – easily accessible for all different people of particular age
  - Simplicity – as simple as possible in order to help users understand what they need to do and how
  - Interactivity – give the sense of interaction being ready to respond to user's requests and possible misunderstandings, increasing his/her feeling of security and safety

(Source: https://www.elevatorimagazine.com/en/lift-smart-technologies-for-elders/)



(Source: https://www.elevatorimagazine.com/en/iot-new-challenge/)

Smart lift and IoT (Internet of Things)

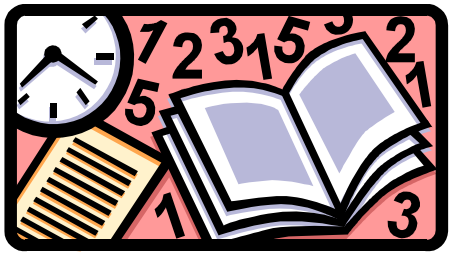
IoT devices are connected to the Wi-Fi network & become an interactive tool that provides and acquires (many times without our knowledge and without our consent) information & data.

Further Reading



- Lift structure & components diagrams 升降機結構圖
  - http://www.ksmak-sir.com/pdf/stru_lift.pdf
  - http://www.hkelev.com/picture/str/HKELEV_A4.pdf
- Course ELEV-1: An Introduction to Transportation Systems in Buildings http://www.electrical-knowhow.com/2012/05/course-elev-1-introduction-to.html
  - Basic Elevator Components - Part One http://www.electrical-knowhow.com/2012/04/basic-elevator-components-part-one.html
  - Basic Elevator Components - Part Two http://www.electrical-knowhow.com/2012/04/basic-elevator-components-part-two.html
  - Elevator Machine and Drive System http://www.electrical-knowhow.com/2012/04/elevator-machine-and-drive-system.html
  - Elevator Safety System http://www.electrical-knowhow.com/2012/04/elevator-safety-system.html
  - Escalators Basic Components - Part One http://www.electrical-knowhow.com/2012/04/escalators-basic-components-part-one.html
  - Escalators Basic Components – Part Two http://www.electrical-knowhow.com/2012/04/escalators-basic-components-part-two.html

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- Hall F. & Greeno R., 2017. *Building Services Handbook*, 9th ed., Chapter 10, Routledge, Oxon & New York.
- ISR-University of Coimbra, 2010. *E4 Energy-Efficient Elevators and Escalators*, brochure prepared for the Intelligent Energy of European Commission, University of Coimbra, Portugal.
  - https://ec.europa.eu/energy/intelligent/projects/sites/iee-projects/files/projects/documents/e4_publishable_report_en.pdf