Principle 1: Segmentation

Aliases: Fragmentation, Division

A. Divide an object into independent parts
B. Make a system easy to put together and take apart
C. Separate according to a condition or parameter
D. Increase the degree of fragmentation or segmentation
E. Transition to microlevel

By dividing a screwdriver into a bit holder component and a selection of drive bits, one and the same tool can be used for different tasks.

Compared to a conventional light bulb with one source of light (filament), this LED bulb has several small illuminating diodes.

In contrast to a fixed yardstick or measuring rod, this carpenter's rule can be folded for easier transport.

The above is a replaceable head toothbrush, on which only the head needs to be replaced when the bristles become worn. Conventional, one-piece toothbrushes produce more waste.

Principle 2: Taking Away

Aliases: Extraction, Removal, Taking Out, Separation, Segregation, Detachment, Isolation

A. Extract (remove or separate) a “disturbing” part or property from an object
B. Extract the only necessary part or property

Pencils need to be sharpened and get shorter over time. This pencil can be reused because the lead is separated.

In order to prevent crop damage by birds, farmers would need to guard their fields non-stop. The principle of separation (# 2, Taking away) plays an important role in the concept of the scarecrow. Scarecrows imitate only those visual and acoustic properties attributable to humans that have the required effect of scaring off the birds.

The blade of this cheese knife has cavities, so the cheese sticks less on it.

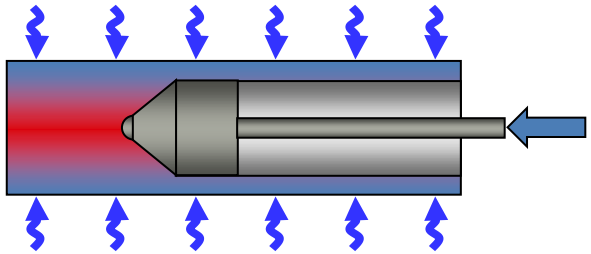
Principle 3: Local Conditions

Aliases: Non-Uniform, Non-uniformity

A. Provide transition from a homogenious structure of an object or outside environment (outside action) to a heterogeneous structure
B. Have different parts of the object carry out different functions
C. Place each part of the object under conditions most favourable for its operations

The end of the shoelace is strengthened and compact in order to lead it through the eyelet of the shoe easier.

On the bottom side these socks have anti-slip knobs and prevent sliding just in the right spot.

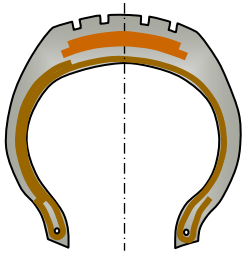


In order to manufacture seamless pipe segments, a forming tool (a so-called pin) is pushed through a heated, cylindrical billet. To prevent the pin from drifting off course, the billet is cooled from the outside. This means that it is cool and hard on the outside, but hot and soft on the inside. In this way, a guide is formed for the pin.

Principle 4: Asymmetry

Aliases: Symmetry Change

A. Replace a symmetrical form with an asymmetrical form of the object
B. If an object is already asymmetrical, increase the degree of asymmetry
C. Change the shape of an object or system to suit external asymmetries (e. g. ergonomic features)



An asymmetrically constructed car tire with an additional layer of fabric on the outside as a sidewall reinforcement provides better protection against shocks. (US Pat. 3,435,875)

The asymmetrical design of card slots and memory cards ensures that only the right cards can be inserted, and only the right way round.

Using this plug is easy, because it can't be plugged the wrong way due to its geometry.

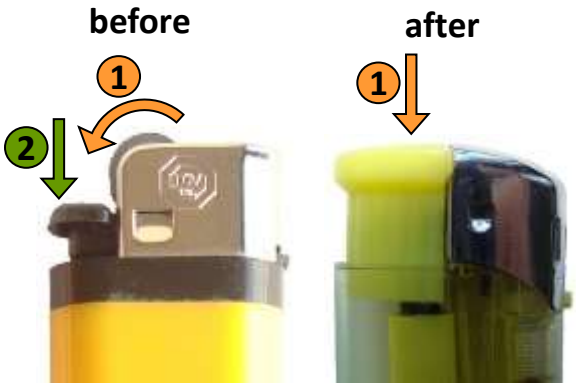
Formerly, stackable boxes had a symmetrical design, which made them bulky even when empty. The tapered, asymmetrical design of the stack-and-nest containers shown in the example allows stacking, but also allows the boxes to fit inside each other, when turned horizontally by 180° (see also principle # 7). This saves space when storing and transporting empty boxes.

Principle 5: Merging

Aliases: Combining, Joining, Consolidation, Composition, Integration, Agglomeration, Combination, Combine Elements with Similar Functions, Harmony

A. Combine in space homogeneous objects or objects designed for contiguous operations
B. Combine in time homogeneous or contiguous operations
C. Agglomerate objects to Bi- and Poly-system

The mechanical coupling of the single chain links keeps the chain flexible but still allows to transmit power.



With a flint lighter, the spark is generated first, then the butane gas valve is opened. With modern piezo ignition lighters, these two separate actions are performed in one.

Photo: © Axel Osterod, 6/2009 / PIXELIO

Multihull watercraft, such as catamarans and trimarans, can reach higher speeds and have a shallower draft than comparable monohulls.
This is accomplished by combining multiple components of the same kind, in this case, hulls.

Principle 6: Multi-functionality

Aliases: Universality, Multi-function

A. Have the object perform multiple functions, thereby eliminating the need for some other objects

The example shows a pen that combines three different writing functions (pencil, ballpoint, and highlighter) with an eraser.

A Swiss Army knife combines the functions of various different tools in one small, portable unit. In addition to the "merging" principle (# 5), the "multi-functionality" principle (# 6) has also been applied here.

The spork combines the functionality of a spoon and a fork and thus reduces the number of cutlery and weight to be carried when backpacking.

Principle 7: Nesting

Aliases: Nested Doll, Matrushka, Recess, Embedding, Guided

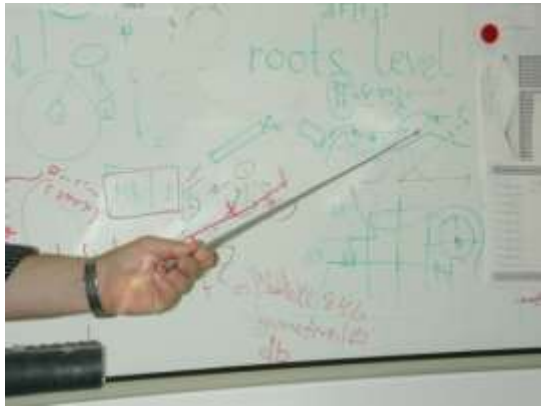
A. Contain an object inside another, which in turn is placed inside a third object, etc.
B. An object passes through a cavity of another object

The foldable trekking cup enables a space-saving transport (e.g. on backpacking trips).

The handle of this travel toothbrush also serves as a protective cap for the brush head when dismantled for traveling.

The egg whip has integrated spheres in order to improve the mechanical frothing.

Telescoping, retractable pointer that easily fits in your pocket. (Earlier fixed-length pointers were not easy to carry around.)



Principle 8: Weight Compensation

Aliases: Counterweight, Anti-weight, Counter Balance, Levitation, Compensate for Inflation, Countering

A. Compensate for the object´s weight by joining with another object that has a lifting force
B. Compensate for the object´s weight by providing aerodynamic or hydrodynamic forces (or general: by its interaction with the environment)

Unlike conventional boats, the hull of a hydrofoil is lifted out of the water when traveling at speed in order to reduce drag.

Divers often wear a lead belt to counteract the uplift of the water.

Airfoils or "wings" on racing cars are designed to create a downforce. This is also termed "aero-dynamic grip", as the idea is to press the car down onto the track rather than risk lift when driving at speed.

Photo: © Jari Villoria, 08/2007 / PIXELIO

This lock uses the magnetic pull of the two masses.

Principle 9: Prior Counteraction

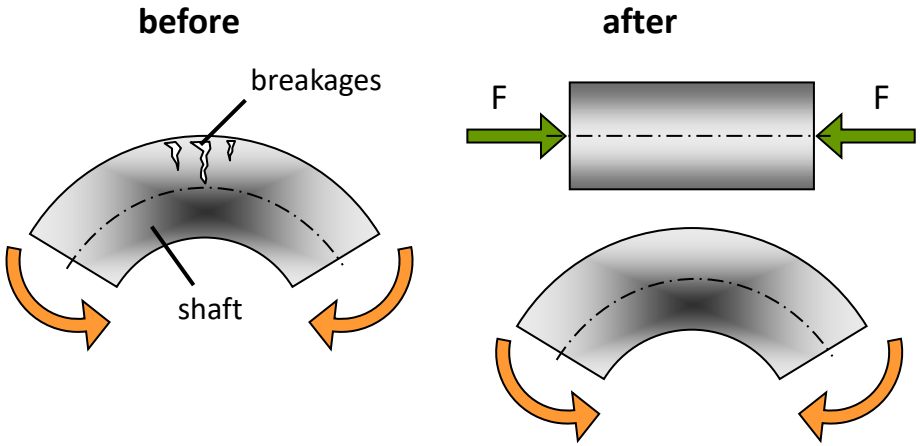
Aliases: Preliminary Counteraction, Preliminary Anti-action

A. If it is necessary to carry out some action, consider a counteraction in advance
B. If an object must be in tension, provide anti-tension in advance

Before the matchbox car drives forward, it has to be pulled backwards to span the spring.

Childproofing: Child-resistant bottle caps need to be simulta-neously pinched or pressed down while turning in order to open them.

Steel rods need to be bent as part of a manufacturing process. The brittleness of the rods means that they can snap easily while being bent. For this reason, the rods are first compressed along their longitudinal axis before bending. This lowers the bending stresses, so that breakages no longer occur.



Principle 10: Prior Action

Aliases: Preliminary Action, Do it in Advance, Preliminary Execution

A. Carry out the required action in advance, in full or in part
B. Arrange objects so that they can go into action, without time loss while waiting for the action (and from the most convenient position)

Instant meals are exactly portioned, flavored and ready-cooked for fast preparation.

The coffee capsule includes powdered coffee for just one cup without any more preparation necessary.

Photo: ©iStock.com/Floortje

Paper towel rolls are perforated so that the single towel can be torn off easier.

Principle 11: Beforehand Compensation

Aliases: Cushion in Advance, Previously Placed Cushion, Beforehand Cushioning, Prior Cushioning, “Expecting the Worst”, Early Cushioning, Cushion

A. Compensate for the relatively low reliability of an object by countermeasures taken in advance

The brush head on this toothbrush is made from soft, padded silicone rubber, to protect sensitive gums. Normal toothbrushes have a hard head.

Photo: © iStock.com/KseniaBuriyanova

Protective cell phone covers prevent damages from downfalls and other impacts.

This electric kettle comes with a fine-mesh wire filter at its spout to keep scale in the kettle when pouring.

The waste gate reliefs pressure if the internal pressure gets too high and prevents bursting of the pipe or tank.

Principle 12: Equipotentiality

Aliases: Bring Things on the Same Level, Remove Tension, Avoid Field Gradients

A. Change operation conditions to eliminate the need to work against a potential field (e. g. eliminate the need to raise or lower objects in a gravity field)

Roller cabinets have casters for greater convenience in the office: they can be moved around and positioned where you need them, unlike fixed, inflexible shelving and other virtually immovable furniture.

The pizza wheel can cut pizza into slices without up and down movement like a knife.

Heavy vehicles can be driven over a service pit for repairs and mainte-nance, such as oil changes.
Work can then be performed from underneath the vehicles without requiring expensive vehicle service lifts.

Photo: ©iStockphoto.com / Don Bayley, 10/2009

The wristband prevents electrostatic charging while working in a dry surrounding e. g. for computer repair.

Principle 13: The Other Way Round

Aliases: Inversion, The Reverse, Do it in Reverse, Do it Inversely, Inverse

A. Instead of an action dictated by the specifications of the problem, implement an opposite action
B. Make object a moving part, or make nonmoving part movable and outside environment immovable
C. Turn the object (or process) „upside down“

Escalators are also known as moving staircases. Unlike a conventional staircase with rigid steps, no effort is required to move in the direction taken.

The seal of the thermos bottle is unlocked by pressing on it and closed in the same way.

Ink pens are handwriting instruments, in other words, they are used for "putting ink on paper". Chemical ink erasers can also be considered handwriting instruments, but do the exact opposite: they remove ink from paper and can therefore be used for making corrections.

Principle 14: Curvature Increase

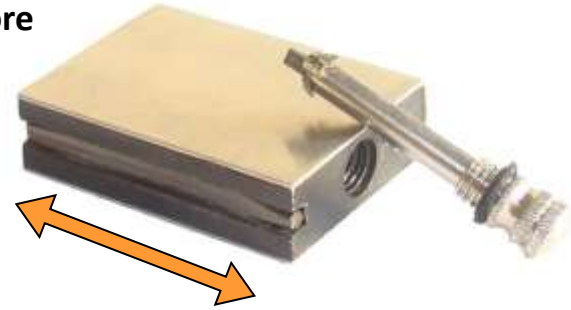
Aliases: Spheroidality, Spheroidality – Curvature, Curvature, Sphericity, Curvilinearity, Use of Curves, Increasing Curvature, Cycles

A. Replace linear parts or flat surfaces with curved ones, and cubical shapes with spherical shapes
B. Use rollers, balls and spirals
C. Replace a linear motion with a rotating motion
D. Utilize a centrifugal force

The spherical mirror reflects light/images from different directions.

Small spheres are used in the ball bearing to realize a rotational movement with little friction.

before



after

The earliest lighters that used ferrocerium (so-called flints) as an igniter were also known as "permanent matches", and worked by scratching the "metal match" along the "flint" strip on the side of the lighter case. Later on, the required sparks were produced by means of friction from a wheel applied to a ferrocerium stick.

Principle 15: Dynamics, Adjustability

Aliases: Dynamicity, Dynamism, Dynamic Parts, Dynamization, Optimization, Make Adjustable

A. Make characteristics of an object or outside environment automatically adjust for optimal performance at each stage of operation
B. Divide an object into elements able to change position relative to each other
C. If an object is immovable, make it movable or interchangeable
D. Increase the amount of free motion

The "flex zone" between the handle and the brush head gives way if too much pressure is applied while brushing, protecting the gums from injury. Normal toothbrushes do not have a flex zone.

The lift pass fastener has a pull-out cord to quickly supply the pass and then withdraw it again.

Modern office chairs are very variable compared with other chairs. They can be adjusted to suit individual requirements.

The paper fan is very small when it is folded but increases in functional size when it is swung open.

Principle 16: Partial, Overdone or Excessive Action

Aliases: Partial or Overdone Action, Partial or Satiated Action, Partial or Excessive Actions, Do a Little Less, Slightly Less/Slightly More, Excess or Shortage, Deficient or Excessive Solution, Perform Excessively

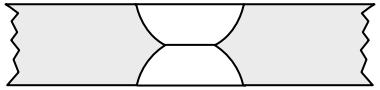
A. If it is difficult to obtain 100 % of a desired effect, achieve somewhat more or less to greatly simplify the problem

The stamp pad transfers more color than needed for one mark, so that it is possible to use the stamp multiple times at once.

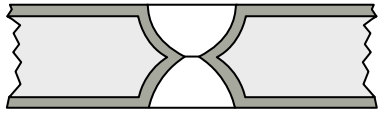
The holder for the soap-bubbles collects more liquid than needed for one bubble. Thus it is possible to create several bubbles at once.

The problem with etching is that apertures of a metal mask cannot be etched smaller than a certain minimum size. However, the size of the apertures can be shrunk afterwards by applying a conformal coating of metal to the metal mask by electrochemical deposition. (US Pat 5268068)

Step 1: Etching



Step 2: Deposition



Principle 17: Transition into New Dimension

Aliases: Moving to a New Dimension, Another Dimension, Dimensionality Change, Change Dimension

A. Remove problems of moving an object in a line by allowing two-dimensional movement (along a plane). Similarly, problems in moving an object in a plane are removed if the object can be changed to allow three-dimensional movement
B. Use a multi-story arrangement of objects instead of a single-story arrangement
C. Incline the object or turn it „on its side“
D. Utilize the opposite side of a given surface
E. Project optical lines on neighboring areas or on to the reverse side of the object

This is an example of a wireless presenter mouse that can be switched to PowerPoint player mode. The conventional mouse functions work as usual, but the underneath of the mouse contains control buttons for navigating through slides as well as a laser pointer button.

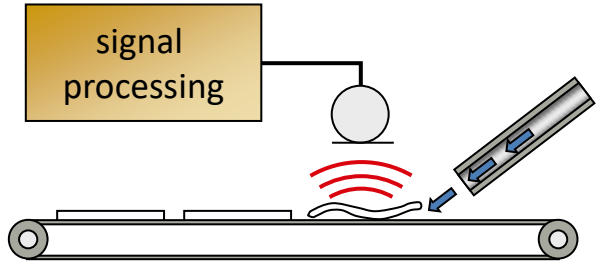
The cheese grater has small bulges to grate foods and has multiple side faces to gain different results.

The telephone cable is spiraled in order to be stretched when needed for a phone call and otherwise retracted.

Principle 18: Vibration

Aliases: Mechanical Vibration, Resonance, Oscillation

A. Cause an object to oscillate or vibrate
B. If oscillation exists, increase its frequency, even as far as ultrasonic
C. Use the frequency of resonance
D. Instead of mechanical vibrators, use piezo-vibrators
E. Use ultrasonic vibrations in conjunction with an electromagnetic field



Mechanical systems for counting items on a conveyor belt are subject to wear over time. In this innovation, an air jet is blown onto the belt. Each item on the belt reacts to the jet and produces a noise, which is picked up by a microphone.
(US Pat. 5 031 156)

The membrane of a loud-speaker vibrates in response to analog electrical signals (in the audio frequency range) to produce sound.

The toothbrush is able to vibrate to improve the dental hygiene by joggling the bristles between the teeth.

Principle 19: Periodic Action

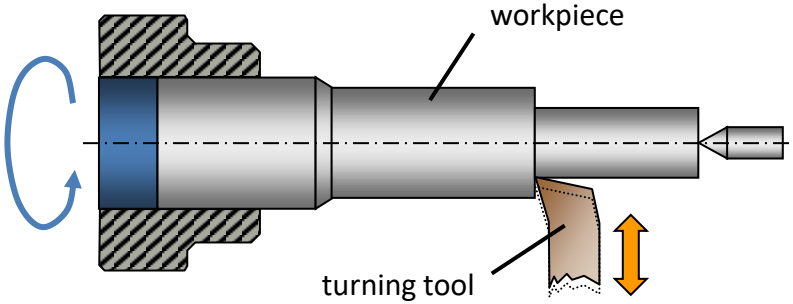
Aliases: -

A. Replace a continuous action with a periodic one (impulse)
B. If an action is already periodic, change its frequency
C. Use pauses between impulses to provide additional action

Photo: ©iStock.com/Tomwang112

The jack-hammer uses periodic movements to gradually take off material.

The scissors slice paper by iterative opening and closing of the cutting face.



In order to reduce vibrations during the machining process, this innovation suggests retracting the turning tool periodically after a set number of revolutions. The number of revolutions depends on the stiffness, the rotation speed, and the natural shock absorption properties of the workpiece and the machining process. (SU A.C. N 241 916)

Principle 20: Continuity of Useful Action

Aliases: Uninterrupted Useful Effect, Steady Useful Action

A. Carry out an action without a brake – all parts of an object should be constantly operating at full capacity
B. Remove an idle and intermediate motion
C. Replace „back-and-forth“ motion with a rotating one

Using a paint roller instead of a brush, a surface can be painted continuously and therefore faster.

Clipless pedals allow for a more continuous power transmission for bicyclists.

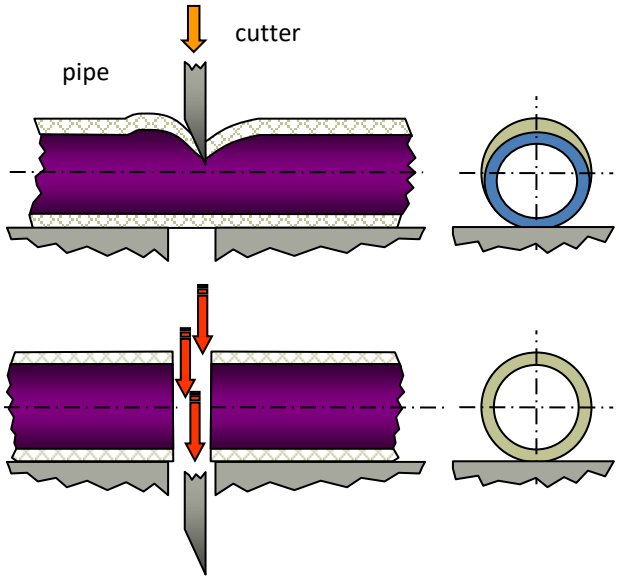
Photo: ©iStock.com/Bet_Noire

The print head of a modern printer prints in both directions, left to right and right to left.

Principle 21: Rushing Through

Aliases: Skipping, Hurrying or Skipping, Hurrying, Do Fast, Haste, High Speed, Skip

A. Perform harmful or hazardous operations at very high speed



One problem when cutting large diameter, thin-walled plastic pipes to length is the tendency of the material to deform under pressure. Moreover, either the continuous extrusion process needs to be stopped while cutting, or the cutter needs to keep pace with it. The solution is to perform the cut with force at an extremely high speed. This also makes use of the inertia of the material, so that it simply does not have enough time to deform. (DE 1 134 821)

The bite-away-device quickly heats the skin around an insect bite. The heat degenerates the poison, but, due to the very short duration, does not burn the skin.

Photo: ©iStock.com/David Herrmann

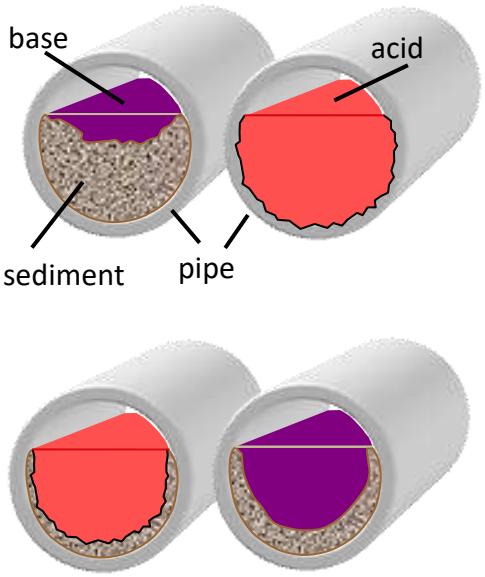
When using a flip book, the printed and gradually changing images are flipped through so rapidly, that it seems like an animation to the human eye.

Photo: ©iStock.com/Jonathan Austin Daniels

Principle 22: Convert Harm into Benefit

Aliases: Turning Harm to Good, Blessing in Disguise, Turn Lemons into Lemonade, Turn Minus into Plus

A. Use harmful factors (particularly, harmful effects of the environment or surroundings) to achieve a positive effect
B. Remove a harmful factor by combining it with another harmful factor
C. Increase the amount of harmful action until it ceases to be harmful



When bases (alkali) are pumped through a pipe, they leave a deposit of sediment over time that eventually clogs up the pipe if it
is left to build up. The adjacent pipe in the example shows acid being transported.
The problem with acids is that they corrode the walls of the pipe. To minimize these problems, the pipes are alternately used for transporting bases and acids and switched over on a regular basis. The sediments left by the alkali can be corroded by the acid.

Photo: ©iStock.com/Nicolas McComber

In healthy condition, laxatives have a negative impact on the human body. In case of a constipation, however, the effects of laxatives can be helpful.

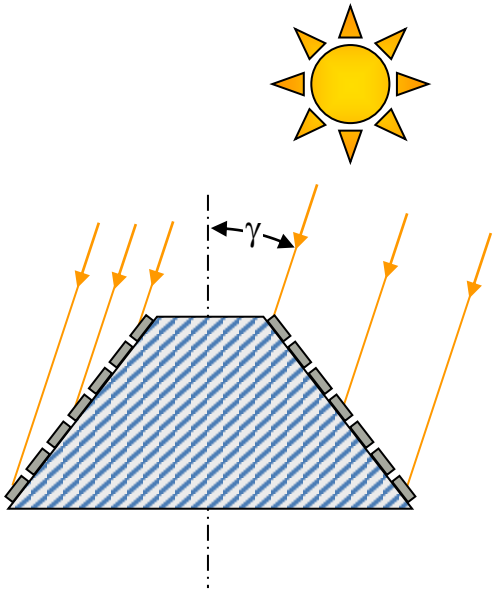
Photo: ©iStock.com/3drenderings

Pepper spray is a dangerous substance, which irritates the eyes and the respi-ratory tract, among other things. How-ever, it may be used for a good purpose, for example in emer-gency situations.

Principle 23: Feedback

Aliases: Add Feedback

A. Introduce feedback
B. If feedback already exists, reverse or change it



Tracking: The example shows a photo-diode array with an inverted V shape. The angle of incidence, relative to the perpendicular, determines the photo-voltaic effect on the photodiodes, and changes as the sun travels across the sky. This changes the current-voltage characteristic of the photodiode array circuit, which can be used to steer a repositioning motor.
(DE 43 06 656 A1)

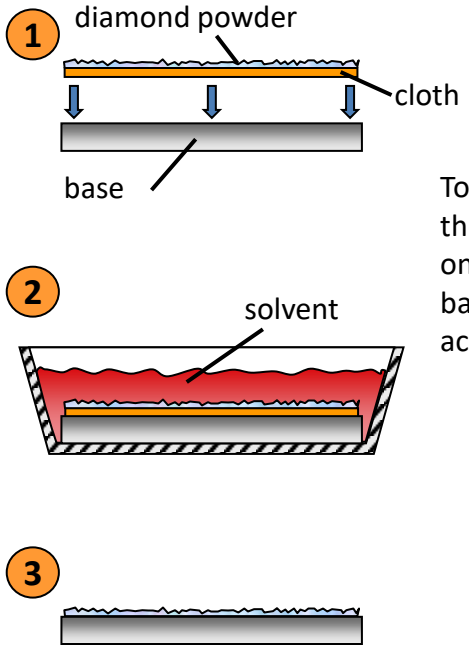
A check valve permits a fluid or gas to flow in only one direction. This effect is achieved by using a feedback loop: A flow in the undesired direction closes the valve, while a flow in the right direction opens the valve.

Advanced thermostats employ a feedback loop by opening or closing the valve of the heater depending on the air temperature.

Principle 24: Mediator

Aliases: Go Between, Intermediary, Insertion, Middleman, Indirect Action, Use of Mediators, Dispose of Carrier

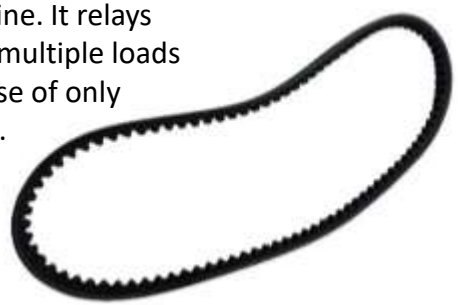
A. Use an intermediary object to transfer or carry out an action
B. Temporarily connect an object to another one that is easy to remove



To produce a single-layer diamond board, the diamond powder is initially applied on a cloth. This is then affixed over a base. Then the cloth is dissolved using acetone.

Protective gloves represent an intermediary. They protect the hands from dangers like heat by isolating the heat or from cuts by spreading the force of sharp edges over a wider area of the skin.

A serpentine belt is used in cars to drive multiple loads with one engine. It relays the power of one engine to multiple loads and therefore enables the use of only one engine for several loads.



Principle 25: Self Service

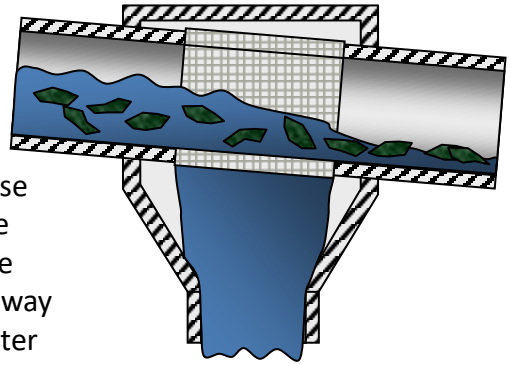
Aliases: Self-organization

A. Make the object service itself and carry out supplementary and repair operations
B. Make use of waste material and energy

Photo: ©iStock.com/Jasmin Awad

In daylight, the solar cell on the top left-hand corner of the calculator can provide the necessary power for operation, preserving the batteries.

A locknut secures itself against loosening when tightened. A plastic ring inside the nut is being elastically deformed when tightening the nut. The resulting counterpressure prevents a rotation and resulting loosening of the nut.



Water collectors for cisterns use self-cleaning filters. Part of the unfiltered water flows over the surface of the filter, washing away any debris. The bulk of the water passes through the filter and is fed into the cistern.

Principle 26: Copying

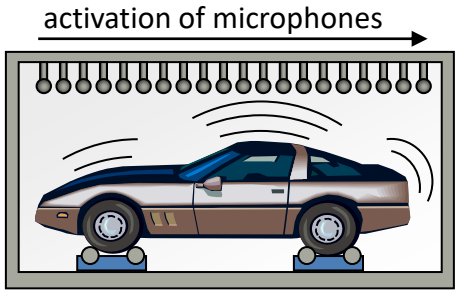
Aliases: Use of Copies, Copy/Facsimile

A. Use a simple or inexpensive copy instead of an object which is complex, expensive, fragile or inconvenient use
B. Replace an object or system of objects by an optical copy or image. A scale can be used to reduce or enlarge the image
C. If visible optical copies are used, replace them with infrared or ultraviolet copies

In a thermal imaging camera, special sensors pick up the invisible heat radiation of an object and convert the information into electrical signals, based on the measured heat intensity. In this way, temperature differences in and around an object can be shown by the thermal image.

Using a duplicate book, a copy of a written document is created simultaneously with the original document like an invoice. This avoids the additional work and time necessary to write the document twice or otherwise having to copy it later.

Plastic replicas represent a cheap copy of diamonds or crystals. They can be used for the same purposes. However, they have the advantage of a significantly lower price and do not require special precautions against theft.



Drive-by noise testing in an acoustic measurement chamber with a "rolling road" simulation: A row of microphones above the car are switched on and off sequentially to simulate the noise experienced as the car drives by.

Principle 27: Cheap Short-living Objects

Aliases: An Inexpensive Short-life Object Instead of an Expensive Durable One, Cheap Short Life Instead of Expensive Longevity, Use Cheap Replacement Objects, Cheap Disposables, Inexpensive Short Life (Dispose), Inexpensive, Short-lived in Place of Expensive, Long-lasting, Cheap Short-life Instead of Costly Long-life, Disposable Objects

A. Replace an expensive object with a multiple of inexpensive objects, comprising certain qualities (such as service life, for instance)

Photo: ©iStock.com/scyther5

Daily lenses can be worn only for a short time, but they are also significantly cheaper than longer-lasting monthly lenses.

Paper handkerchiefs have replaced cloth hand-kerchiefs for personal hygiene purposes, as they are discarded after use.

Photo: ©iStock.com/PhanuwatNandee

A disposable razor is a cheap and short-living object. Instead of developing a robust reusable shaver with interchangeable blades, a disposable razor has a very simple design to minimize development and production costs.

Principle 28: Replace Mechanical System with Fields

Aliases: Replacement of a Mechanical System, Substitution for Mechanical Means, Mechanics Substitution, Mechanical Interaction Substitution, Use of Fields, Mechanics Substitution/Another Sense, Redesigning

A. Replace a mechanical system by an optical, acoustical or odor system
B. Use an electrical, magnetic or electromagnetic field for interaction with the object
C. Replace fields (switching from immovable to movable fields, from fixed to those changing in time, from unstructured to those which possess a definite structure)
D. Use a field in combination with ferromagnetic particles

Nowadays, the mechanical locking and unlocking of a vehicle's doors is per-formed by radio remote control, at the push of a button. With "handsfree" keyless entry systems, there is no need for a conventional tumbler cylinder at all.

A digital clock does not have a traditional mechanical clockwork.

The rangefinder measures the distance to an object using sound waves, thus replacing a tape measure or ruler.

In order to assist in detecting leaks, odorants are added to otherwise odorless natural gases. The smell is enough to alert consumers to the presence of the gas in the air. Complicated gas sensors are no longer required.

Photo: “Kochen mit Gas“ © 2009 Rainer Sturm / pixelio.de

Principle 29: Fluid System

Aliases: Use a Pneumatic or Hydraulic Construction, Pneumatics and Hydraulics, Fluidity, Intangibility, Pneumatic and Hydraulic Structures

A. Replace solid parts of an object with gas or liquid. These parts can use air or water for inflation or use air or hydrostatic cushions

Photo: ©iStock.com/stocksnapper

Bubble wrap contains small air bubbles in plastic film to protect objects from damage.

A bicycle tube is filled with compressed air to ensure a comfortable rolling motion with a bike.

Photo: © Ralf Dietermann, 3/2006 / PIXELIO

The use of airbags in cars provides added protection to passengers far above the level provided by seat belts alone.

Principle 30: Flexible Film or Thin Membranes

Aliases: Flexible Shells and Thin Films, Thin and Flexible, Flexible Membranes, Flexibility, Use Thin Films and Membranes, Flexible Membranes or Thin Films

A. Replace customary construction with flexible membrane and thin film
B. Isolate an object from the outside environment with a thin film or fine membrane
C. Change the degree of flexibility

Unlike conventional batteries, this flexible battery can be used even in a tight or angled installation space.

In a tea bag, the loose tea is contained within a flexible, porous envelope while steeping in the water.

Screen protector film covers: A self-adhesive film cover can be used to protect the screen of a cell phone or laptop from scratches.

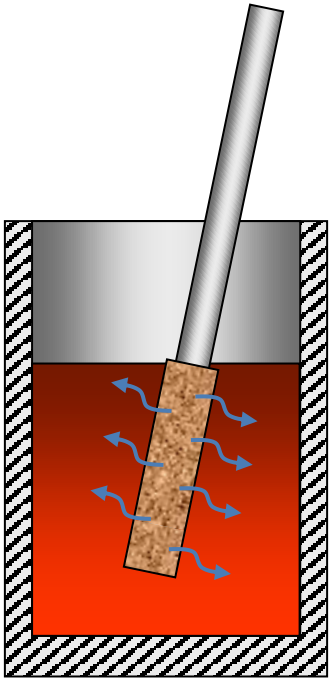
Nowadays, bottles are increasingly made of plastic. Plastic has many advantages over glass, including weight reduction and better fracture resistance.

Principle 31: Porous Materials

Aliases: Use of Porous Material, Holes, Voids and Capillary Structures

A. Make an object porous or use additional porous elements (inserts, covers, etc.)
B. If an object is already porous, fill the pores in advance with some substance

Foam materials are plastics which are porous due to a large number of air containments. They are used for cushion purposes or for mattresses.



Additives are released into a melt by submerging a temperature-resistant porous rod soaked with the required ingredients.

Sandwich-structured composites:
The example shows the principle of a sandwich panel, made from two thin outer layers with a porous foam filling in between, providing excellent mechanical durability at minimum weight.

Principle 32: Optical Property Changes

Aliases: Changing the Color, Color Changes, Allocation, Using Paint/Fakes

A. Change the color of an object or its surroundings
B. Change the transparency of an object or its surroundings
C. Use color additives to observe objects or processes that are difficult to see
D. If such additives are already used, employ luminescent traces or tracer elements
E. Change the emissivity properties of an object subject to radiant heating

Refillable lighters often have a transparent gas tank. This allows users to check the fill level at a glance.

A change in color of a humidity indicator indicates that it had contact with water. Humidity indicators can be used for applications like detecting water damage as the reason for defective smartphones. Or for showing the waterlevel of a potted plant.

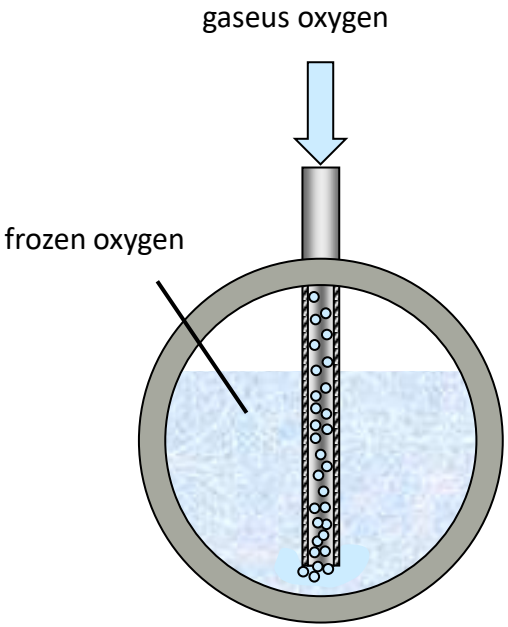
A pH test strip changes its color when coming into contact with a liquid. Depending on the pH-value of the liquid, the test strip changes to a specific color. The pH value can then be read from a color legend.

The blue color of the outer bristles of the brush head fades with use and indicates when the brush needs replacing. Normal bristles do not change color.

Principle 33: Homogeneity

Aliases: -

A. Make objects interact with a primary object of the same material, or a material similar in behaviour



Even in its frozen state, oxygen is highly reactive, so gaseous oxygen is used to melt it.

Peg and wood:
Several parts of one assembly are often made of identical or similar materials to avoid mutual damage or wear of the parts due to different hardnesses or corrosion in case of metals.

Using biodegradable garbage bags, organic waste can be collected inside the bags and does not need to be taken out of the bag for composting.

Principle 34: Rejection and Regeneration

- Aliases: Rejecting and Regenerating Parts, Discarding and Regenerating Parts, Discarding and Recovering

A. After it has completed its function or become useless, reject or modify (e. g., discard dissolve or evaporate) an element of an object
B. Restore directly any used up part of an object

A rechargeable battery is regenerated by recharging and can therefore be used again and again for electricity supply.

Photo: ©iStock.com/deepblue4you

The worn blades of a box cutter are simply broken off to restore the full functionality of the knife.

The case of a spent cartridge is ejected from the breech, in preparation for the next. Before the invention of cartridges, the individual components (powder, bullet, and firing cap) had to be loaded separately.

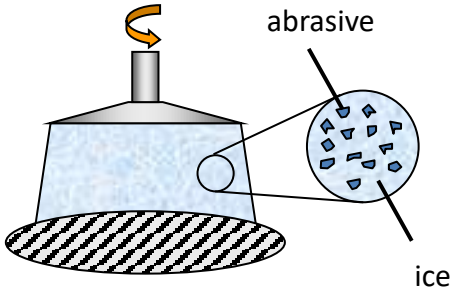
To reduce costs, solid rocket boosters were used for the launch of a space shuttle, which were jettisoned at a set height and recovered for reuse.

Photo: ©iStockphoto.com / Mooneydriver , 1/2009

Principle 35: Changing Properties

Aliases: Transformation of Physical and Chemical States of an Object, Changing the Aggregate State of an Object, Parameter Changes, Transformation of Properties, Change of Physical and Chemical Parameters, Change Bulk Properties

A. Change the aggregate state of an object
B. Change the concentration or consistency
C. Change the degree of flexibility
D. Change the temperature (or volume)
E. Change the pressure
F. Change the atmosphere (environment) to an optimal setting
G. Change other parameters



Using a frozen suspension of abrasive agents in water as a grinding media can help achieve better quality results in the grinding process. Since the grinding media heats up during grinding, it automatically adapts to the shape to be ground and delivers the required water itself.

The glue in a glue stick is initially soft to allow easy application before it hardens to develop its adhesive effect.

Liquid soap can be measured out in small portions and its container leaves less residue on surfaces, compared to wet soap bars.

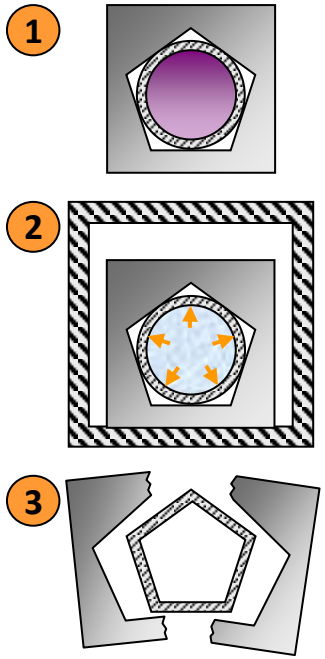
Principle 36: Phase Transition

Aliases: Paradigm Shift, Use of Phase Changes, Liquidity, Transformable States

A. Use phenomena occurring during phase transitions (e. g. volume changes, loss or absorption of heat, etc.)

Heating a shape memory metal initiates a phase transition, which causes the metal to change to its original shape before it was deformed.

One method of shaping metal shells is to solidify water within a mold already containing the material to be shaped. The force of the ice expansion is used to form the material into a shell.

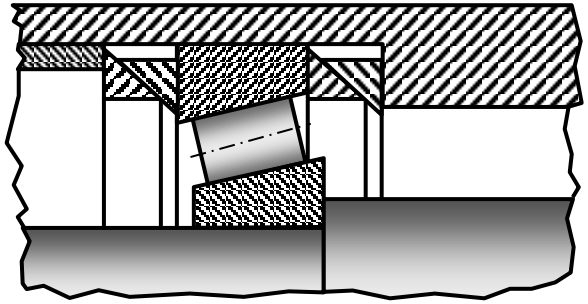


Instead of hot water bottles, which need to be filled before use, gel-based heat packs use the latent heat of fusion. A metal plate triggers the phase transition process (crystallization) when pressed, and this process generates warmth. These types of heat pack can be recharged by immersion in very hot water until the contents are fluid again, and then being allowed to cool.

Principle 37: Thermal Expansion

Aliases: Relative Change, Expansion of Events or Processes

A. Use thermal expansion (or contraction) of materials
B. If thermal expansion is being used, use multiple materials with different coefficients of thermal expansion



The gap that can appear in a bearing due to thermal expansion is compensated by two tapered rings with different thermal expansion coefficients.

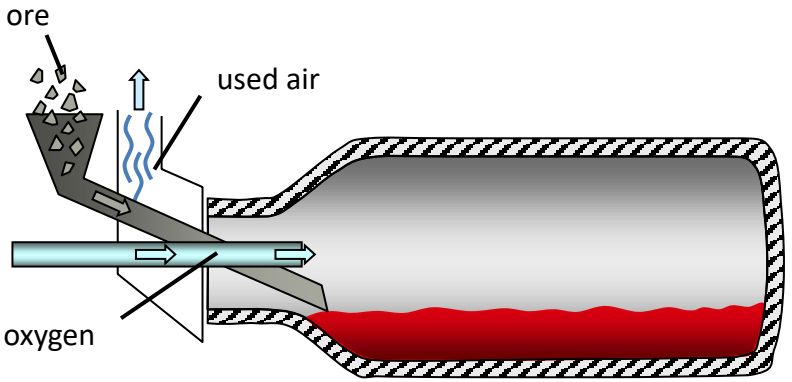
In electrical engineering, heat-shrink tubing is used for electrical insulation and environmental protection for conductors, joints, and terminals. The plastic tubes shrink radially when heated, enclosing the protected components.

Liquid expansion thermometers were the first instruments that could deliver accurate temperature measurements. A thermometer measures temperature changes based on the thermal expansion of a liquid (e. g., mercury).

Principle 38: Use Strong Oxidizers

Aliases: Use Strong Acidifiers, Strong Oxidants, Accelerated Oxidation, 'Boosted Interactions', Enriched Atmosphere, High-risk Environment, Market or Position, Strengthen Oxidation

A. Replace normal air with enriched air
B. Replace enriched air with oxygen
C. In oxygen or air, treat a material with ionizing radiation
D. Use ionized oxygen
E. Replace ozonized (or ionized) oxygen with ozone



The most common type of iron furnace is the oxygen converter, in which pure oxygen is blown through molten pig iron to make low-carbon steel.

Some detergents employ oxidizing agents to remove stains better than usual normal detergent does.

Hydrogen peroxide in blonde hair dye causes a chemical reaction (oxidation), which destroys the color pigments in the hair leading to the resulting blonde color.

Principle 39: Inert Environment

Aliases: Inert Atmosphere, Calm Atmosphere, Low-risk Environment, Market or Position, Inert Substances

A. Replace a normal environment with an inert one
B. Carry out a process in a vacuum
C. Add neutral parts, or inert additives to an object

Shaving foam helps protecting the skin as well as gliding the razor on the skin. Water and soap are replaced by a more “inert” substance.

Photo: ©iStock.com/Gutzemberg

Photo: © Jurec, 12/2008 / PIXELIO

In order to prevent the weld from oxidizing, it is protected by a covering layer of inert gas during welding.

Incandescent light bulbs: The air inside a light bulb is evacuated, to prevent the tungsten filament from burning up. Instead, light bulbs are filled with an inert gas, increasing their useful life and simplifying the manufacturing process.

Photo: ©iStock.com/GrashAlex

Principle 40: Composite Materials

Aliases: Composite Structures, Mixture

A. Replace a homogeneous material with a composite one

A fiber with a high melting point is included in the solder to strengthen it.

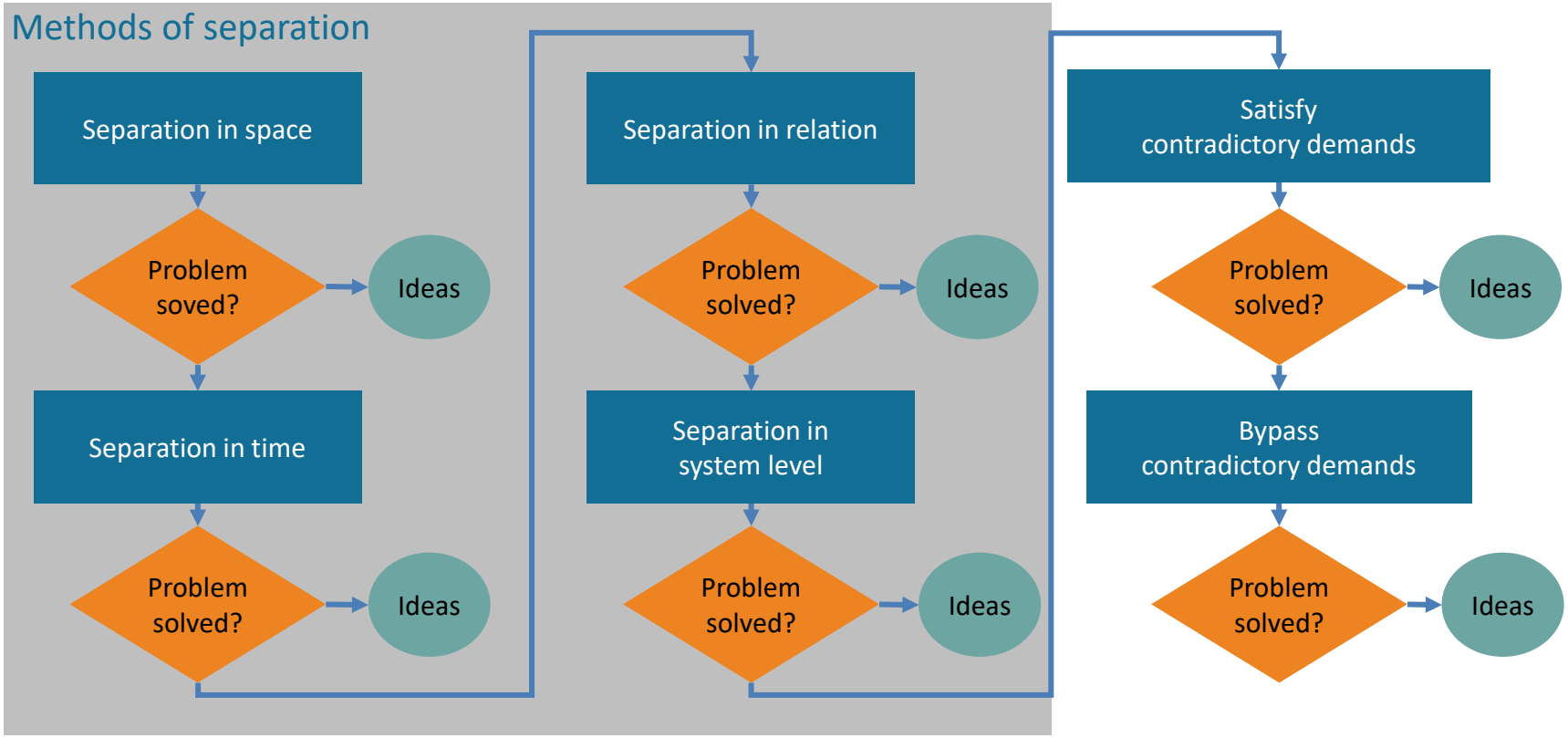
Carbon fiber reinforced plastic (CFRP): CFRP's are used in various applications with high demands regarding strength and light weight. They consist of two main components: Carbon fibers and the surrounding plastic holding together the fibers.

In contrast to most other packaging, a TetraPak consists of several layers: paperboard for stability, plastic (polyethylene) for its sealing properties, and aluminium as a barrier against air and light.

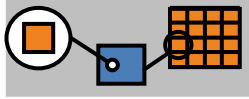
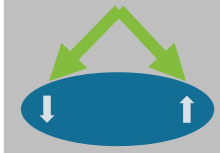
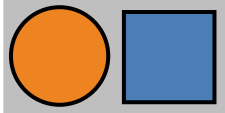
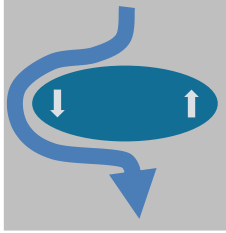
Resolving physical contradictions

Apply the three ways of resolving the contradiction, including the four methods of separation, and write your solution ideas down:

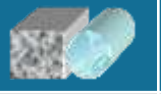
Use the methods of separation and the other ways of resolving the contradiction in this order:



Principles for resolving physical contradictions

Method	Recommended inventive principles	Method	Recommended inventive principles
Separation in space 	# 1 Segmentation # 2 Taking away # 3 Local conditions # 7 Nesting # 4 Asymmetry # 17 Transition into new dimension	**Separation in system level** 	# 1 Segmentation # 5 Merging # 33 Homogeneity # 12 Equipotentiality
Separation in time 	# 15 Dynamics, adjustability # 34 Rejection and regeneration # 10 Prior action # 9 Prior counteraction # 11 Beforehand compensation	**Satisfy** 	# 36 Phase transition # 37 Thermal expansion # 28 Replace mechanical system with fields # 35 Changing properties # 38 Use strong oxidizers # 39 Inert environment
Separation in relation 	# 40 Composite materials # 31 Porous materials # 32 Optical property changes # 3 Local conditions # 19 Periodic action # 17 Transition into new dimension	**Bypass** 	# 25 Self service # 6 Multi-functionality # 13 The other way round Source: S. Litvin, 1993

Groups of S. Fayer: Class 1 and 2

Class 1: Principles for dealing with substances (quantity, quality, structure, form) 	Class 2: Principles for dealing with harmful interactions or factors 
1 Segmentation	9 Prior counteraction
2 Taking away	10 Prior action
3 Local conditions	11 Beforehand compensation
4 Asymmetry	12 Equipotentiality
7 Nesting ('matryoshka doll')	13 The other way round
14 Curvature increase	19 Periodic action
17 Transition into new dimension	21 Rushing through
27 Cheap short-living objects	22 Convert harm into benefit
30 Flexible film or thin membranes	23 Feedback
31 Porous materials	24 Mediator
40 Composite materials	26 Copying
	33 Homogeneity
	39 Inert environment

Groups of S. Fayer: Class 3 and 4

Class 3: Principles for dealing with insufficient interactions (reducing costs, increasing ideality, increasing efficiency)	Class 4: Principles for using scientific effects, fields and special substances
5 Merging	8 Weight compensation
6 Multi-functionality	18 Vibration
15 Dynamics, adjustability	28 Replace mechanical system with fields
16 Partial, overdone or excessive action	29 Fluid system
20 Continuity of useful actions	32 Optical property changes
25 Self service	35 Changing properties
26 Copying	36 Phase transitions
34 Rejection and regeneration	37 Thermal expansion
	38 Use strong oxidizers
	Also, from class 1:
	30 Flexible film or thin membranes
	31 Porous materials
	40 Composite materials

40IP App

All **40 innovation principles** in one app: Accelerate your idea generation process with the 40 innovation principles from the TRIZ teachings. With 40IP, we provide you with the most well-known tool from the TRIZ teachings in a pocket format.

Features:

- 40 innovation principles with over 400 illustrated examples
- Technical contradiction according to Altschuller's matrix
- Technical contradiction according to the matrix 2003
- Physical contradiction
- Grouping of principles according to S. Fayer

Download on the App Store

ANDROID APP ON Google play

Inventive principles and contradiction tables for workshop use

This complete set of slides is available as a handy DIN A5 booklet together with Altschuler's Matrix and the Matrix 2003 for facilitators at a reasonable price from TRIZ Consulting Group GmbH.