

解決技術衝突的40個發明準則與範例

方煒
台大生機系

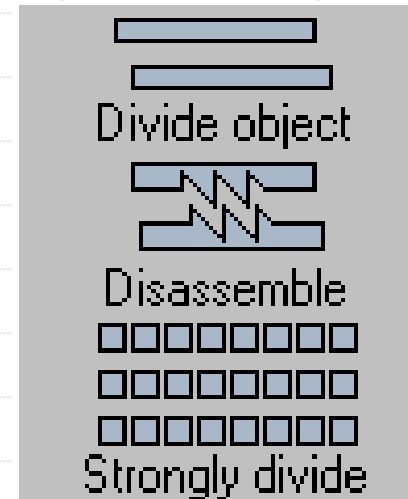
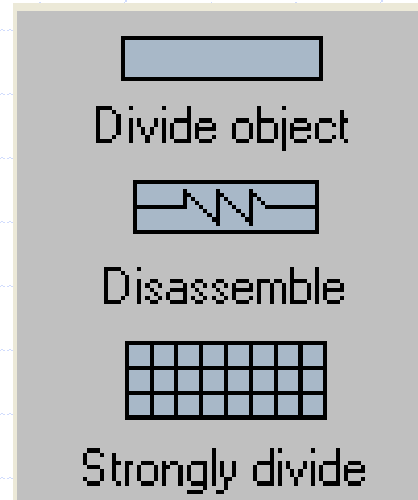


Principle 1. Segmentation

- ◆ Divide an object into independent parts.
 - *Replace mainframe computer by personal computers.*
 - *Replace a large truck by a truck and trailer.*
 - *Use a work breakdown structure for a large project.*
- ◆ *Make an object easy to disassemble.*
 - *Modular furniture*
 - *Quick disconnect joints in plumbing*
- ◆ *Increase the degree of fragmentation or segmentation.*
 - *Replace solid shades with Venetian blinds.*
 - *Use powdered welding metal instead of foil or rod to get better penetration of the joint.*

- ◆ 將物體劃分成獨立的零件
- ◆ 作成組合式的物體
- ◆ 增加物體分割的程度
- ◆ 例：組合式傢俱、模組化電腦組件、木製折尺、可連接成所需長度的花園用水管

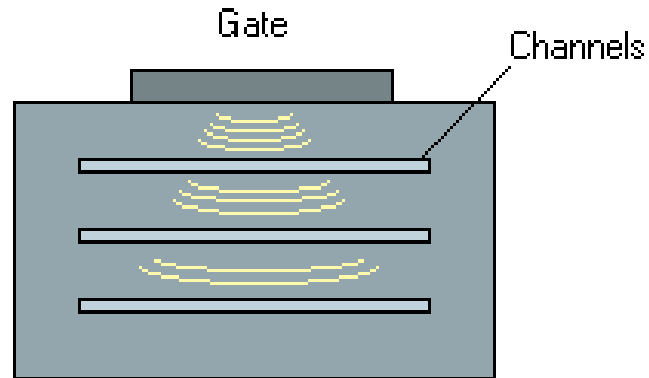
1. Segmentation (分割)



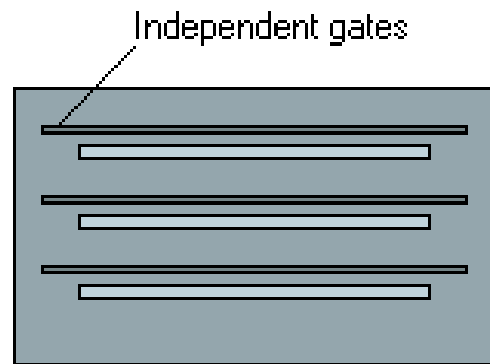
- ? divide an object into independent parts
- ? make an object easy to disassemble
- ? increase the degree of fragmentation (or segmentation) of an object

HETEROSTRUCTURAL FIELD-EFFECT

Prior art



New art



HETEROSTRUCTURAL FIELD-EFFECT

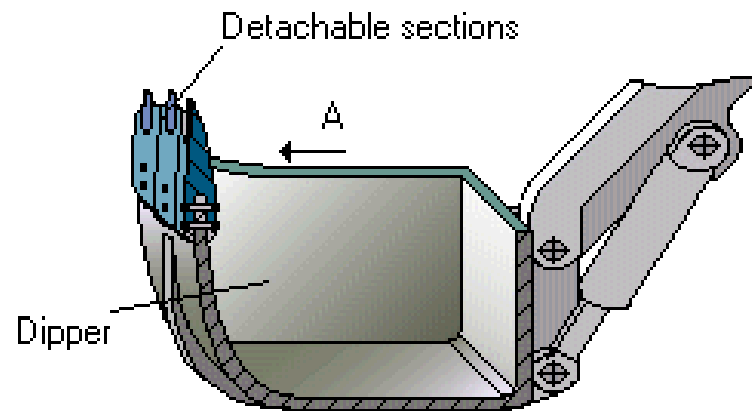
In an FET with multiple vertically stacked channels, the surface gate exerts a stronger effect on the closest channel and a weaker effect on the most distant one.

It is proposed to form an independent semiconductor gate for each vertically stacked channel.

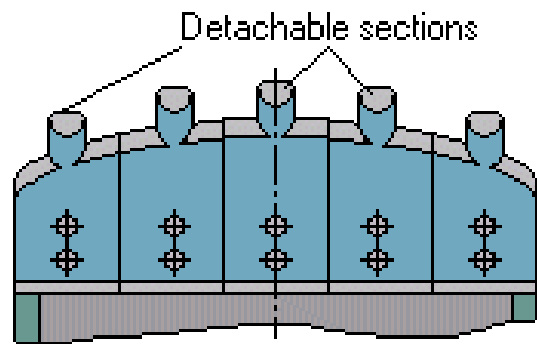
The resulting structure consists of multiple channels where the conductivity can be independently controlled by gate electrodes. It provides improved performance and optimal geometry in a high density device.

United States Patent 5 221 849 Date of Patent: Jun. 22, 1993 Motorola Inc., Schaumburg, Ill., USA

SEGMENTING A DIPPER LIP



View A, enlarged



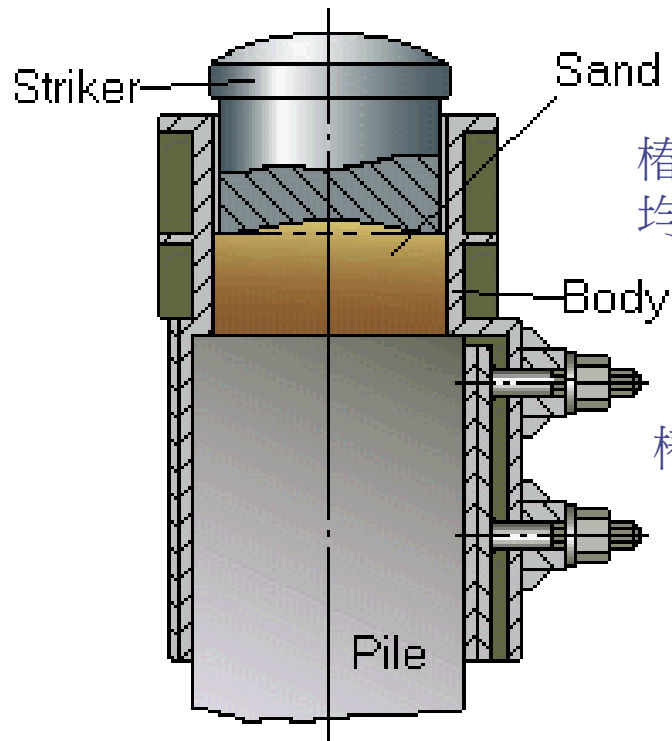
SEGMENTING A DIPPER LIP

An excavator dipper has a lip formed as one piece of hard steel. If only a portion of it has been worn out or damaged, the entire lip must be replaced. This is a labor and time consuming job, causing the excavator to stand idle.

It is proposed to use the segmentation principle to make the dipper lip more serviceable. One can segment the lip by forming it of separate detachable sections. This allows only the damaged or worn sections to be replaced quickly and easily.

SU A.c. N 168 195

樁頭的強化

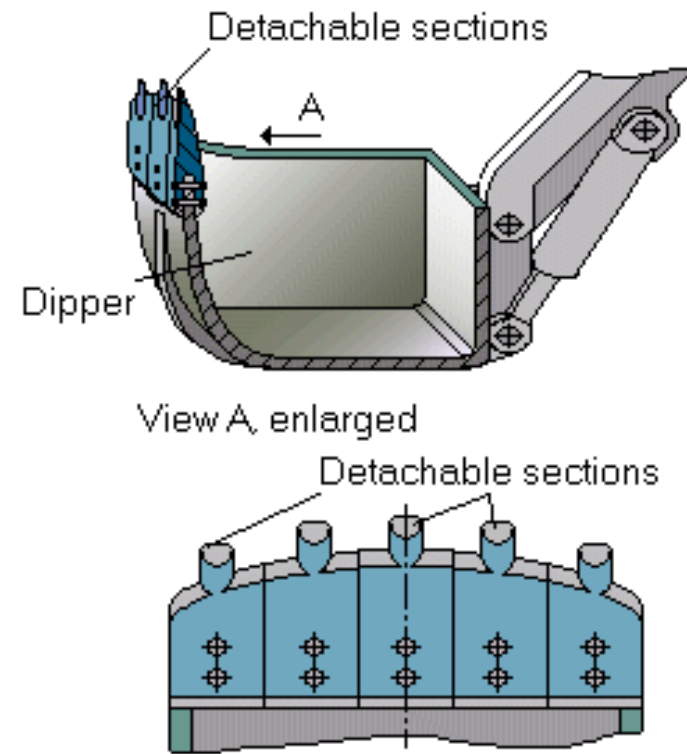


樁頭容易在打擊時因受力不均而破裂。

樁頭分割為砂粒以分散受力。

組合式挖掘爪

挖掘爪的磨損速度不一，更換成本增加。



組合式挖掘爪可以個別更換。

Principle 2. Taking out

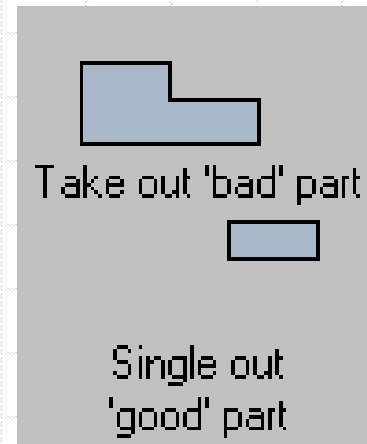
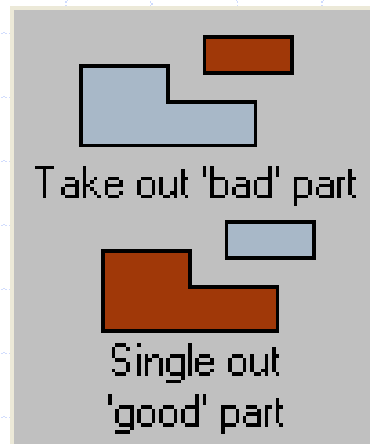
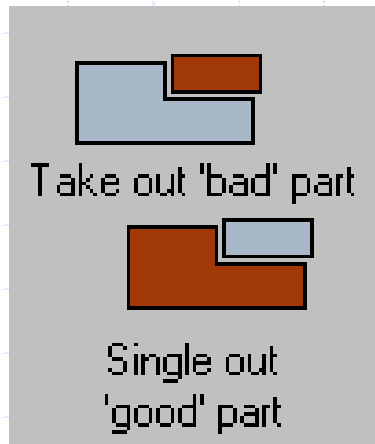
分開



- ◆ Separate an interfering part or property from an object, or single out the only necessary part (or property) of an object.
 - *Locate a noisy compressor outside the building where compressed air is used.*
 - *Use fiber optics or a light pipe to separate the hot light source from the location where light is needed.*
 - *Use the sound of a barking dog, without the dog, as a burglar alarm.*

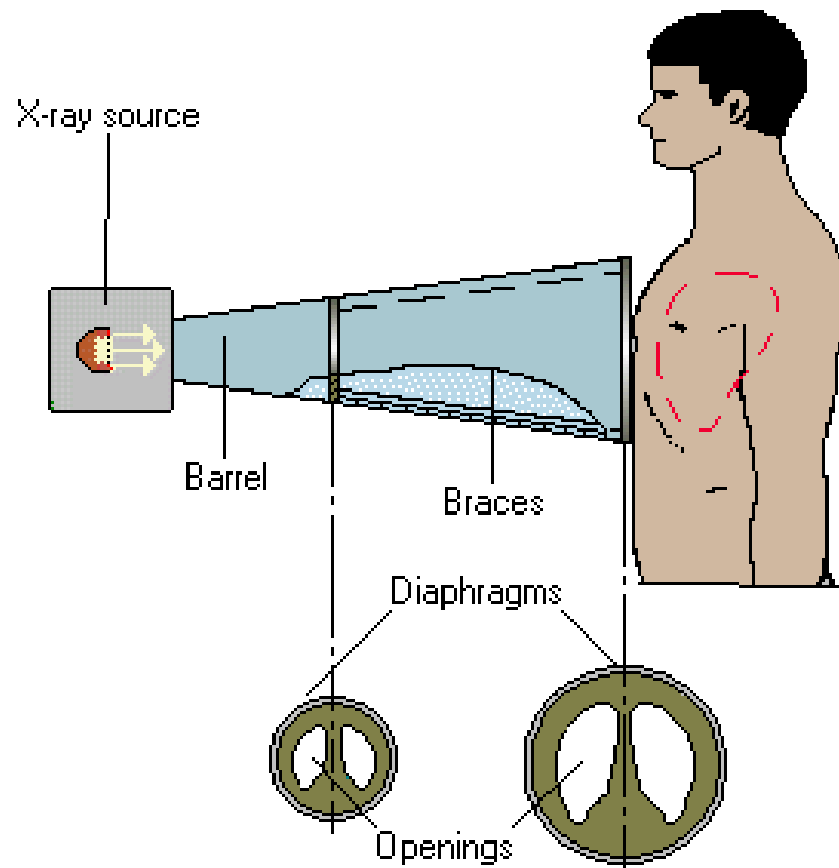
- ◆ 從一個物體中抽出(移除或分離)令人不快的零件或屬性
- ◆ 僅抽出需要的零件或屬性
- ◆ 例:使用錄音機重製可使鳥被嚇離機場的聲音。此聲音是從鳥叫中分離出來的

2. Separation (分開)



? separate an 'interfering' part (or property) from an object, or single out the only necessary part (or property) of an object

DIAPHRAGM TEMPLATES PREVENT IRRADIATION



DIAPHRAGM TEMPLATES PREVENT IRRADIATION

During an X-ray examination of the lungs, the rays normally cover the entire thorax and vertebral column. How can unwanted exposure be reduced?

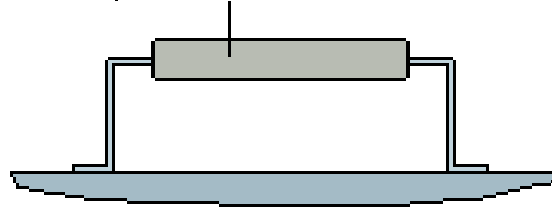
It is proposed to use the taking out and change of color (transparency) principles to reduce exposure. The barrel is equipped with two diaphragm templates that isolate only that portion of the ray flow corresponding to the lung shape. The remainder of each template is opaque to X-rays. As a result, harmful radiation exposure to other parts of the body is reduced.

SU A.c. N 187 933

ENHANCED GAS DETECTOR

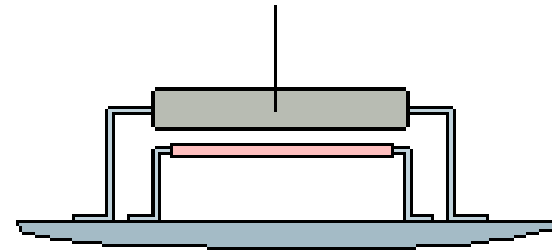
Prior art

Gas+Temperature sensitive element



New art

Gas sensitive element



Heater

ENHANCED GAS DETECTOR

A gas sensor signal depends on both the gas concentration and the measurement temperature. This results in poor measurement precision.

It is proposed to eliminate the temperature dependence of the gas sensor signal.

The gas sensor is held at the temperature corresponding to its maximum sensitivity. The temperature is provided by a heater.

United States Patent 5 019 885 Date of Patent: May 28, 1991 Richon Company, Ltd., Tokyo, Japan

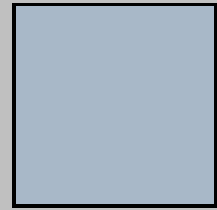


Principle 3. Local quality

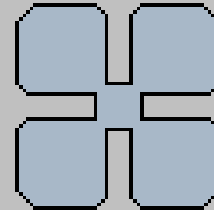
- ◆ Change an object's structure from uniform to non-uniform, change an external environment (or external influence) from uniform to non-uniform.
 - *Use a temperature, density, or pressure gradient instead of constant temperature, density or pressure.*
- ◆ Make each part of an object function in conditions most suitable for its operation.
 - *Lunch box with special compartments for hot and cold solid foods and for liquids*
- ◆ Make each part of an object fulfill a different and useful function.
 - *Pencil with eraser*
 - *Hammer with nail puller*
 - *Multi-function tool that scales fish, acts as a pliers, a wire stripper, a flat-blade screwdriver, a Phillips screwdriver, manicure set, etc.*

- ◆ 一個物件由相同成份組成的結構轉變成由不同成份組成的結構
- ◆ 具有不同零件的物件可實現不同的功能
- ◆ 將物體各零件置於最適合操作的狀況下
- ◆ 例：帶橡皮擦的鉛筆

3. Local Quality (本質)



Make object
non-uniform

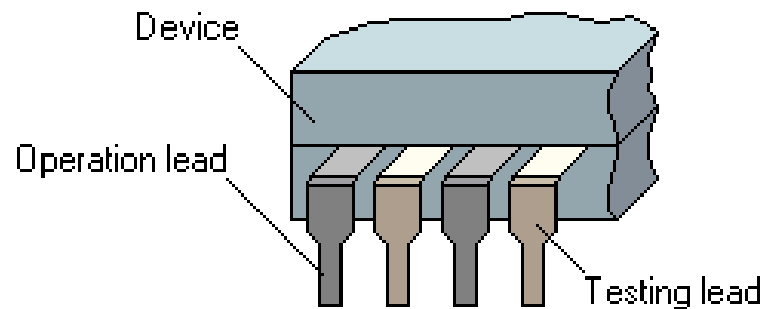


Make object
non-uniform

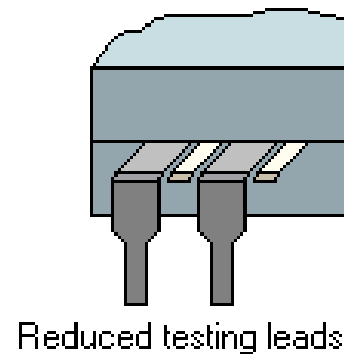
? change an object's structure from uniform to non-uniform,
change an external environment (or external influence) from
uniform to non-uniform,
? make each part of an object function in conditions most
suitable for its operation,
? make each part of an object fulfill a different and useful
function.

REDUCED SIZE SEMICONDUCTOR DEVICE

Prior art



New art



REDUCED SIZE SEMICONDUCTOR DEVICE

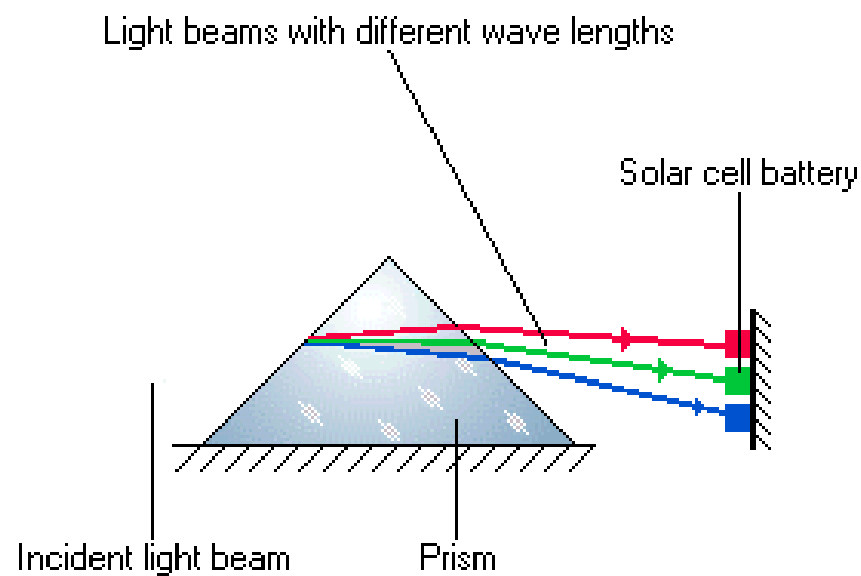
In conventional semiconductor devices, the operation and testing external leads have the same configuration. As a result, the device size is larger than is required.

It is proposed to reconfigure the operation and testing external leads.

Two sets of contacts are configured differently. The size of the testing contact is smaller than that of the operation contact. This results in an overall reduction of the device size.

United States Patent 5 250 841 Date of Patent: Oct. 5, 1993 Motorola Inc., Schaumburg, Ill., USA

HETEROGENEOUS LIGHT-SPLITTING SOLAR



HETEROGENEOUS LIGHT-SPLITTING SOLAR

Solar cells operate effectively at certain light wavelengths, poorly absorbing at other wavelengths.

It is proposed to use the local quality principle to form a 'heterogeneous' solar battery. Several cells are designed for different wavelengths. The incident light is split into different wavelength components. Each cell is positioned to convert the frequencies it was designed for. This results in a more efficient conversion of light into electric current.

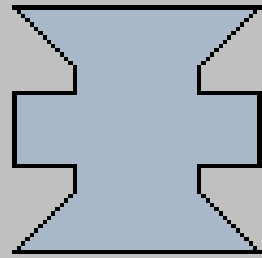
International Application PCT N 87/01 512



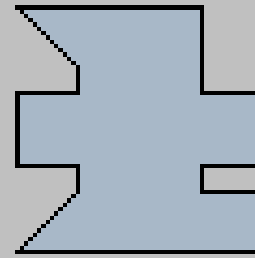
Principle 4. Asymmetry

- ◆ Change the shape of an object from symmetrical to asymmetrical.
 - *Asymmetrical mixing vessels or asymmetrical vanes in symmetrical vessels improve mixing (cement trucks, cake mixers, blenders).*
 - *Put a flat spot on a cylindrical shaft to attach a knob securely.*
- ◆ If an object is asymmetrical, increase its degree of asymmetry.
 - *Change from circular O-rings to oval cross-section to specialized shapes to improve sealing.*
 - *Use astigmatic optics to merge colors.*
- ◆ 以不對稱形狀的物體代替對稱形狀的物體
- ◆ 如果一個物體已經不對稱了，增加其不對稱的程度
- ◆ 例：輪胎的一面因凹凸顆粒比另一面經得起衝磨；用不對稱形狀的漏斗消除架橋

4. Symmetry Change (對稱性改變)



Make object
asymmetric

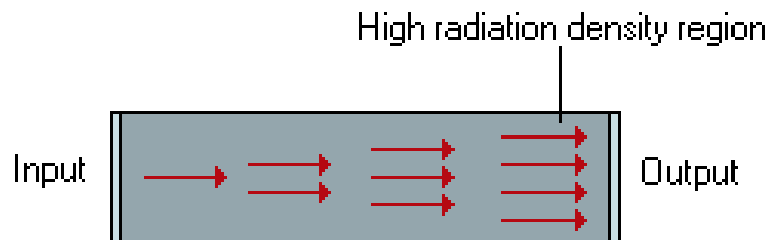


Make object
asymmetric

? change the shape of an object from symmetrical to asymmetrical,
? if an object is asymmetrical, increase its degree of asymmetry.

DYE LASER AMPLIFIER

Prior art

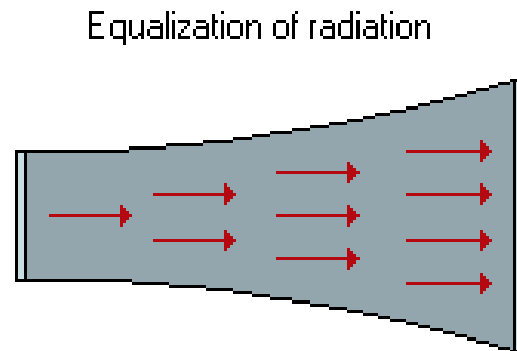


DYE LASER AMPLIFIER

A dye laser amplifier with a uniform cross-section is characterized by an enhanced output radiation density. However, high radiation density results in dye destruction and amplifier gain limitation.

It is proposed to form the dye laser amplifier with an asymmetric profile.

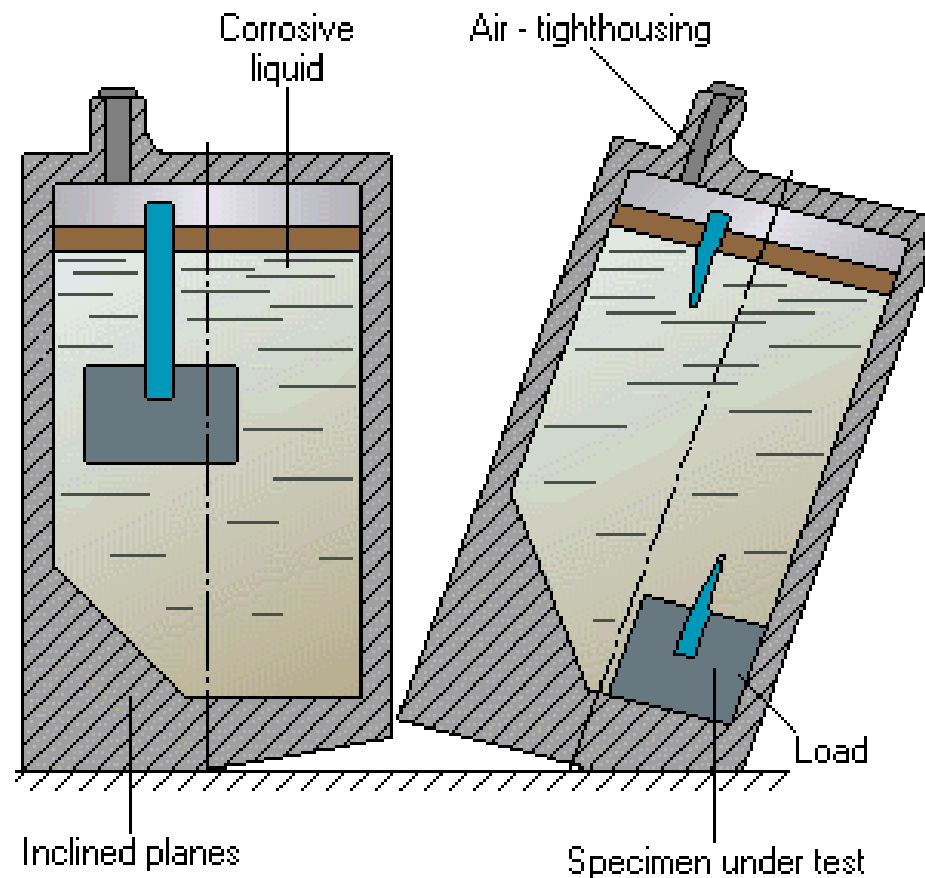
New art



The cross section of the amplifier is made to increase from input to output. This provides equalization of the radiation density from input to output despite increasing the power. As a result, dye destruction is prevented, while amplifier gain can be sufficiently increased.

United States Patent 5 168 392 Date of Patent: Dec. 1, 1992 The United states of America as represented by the Department of Energy, Washington, D.C.

IMPROVED APPARATUS FOR MATERIAL



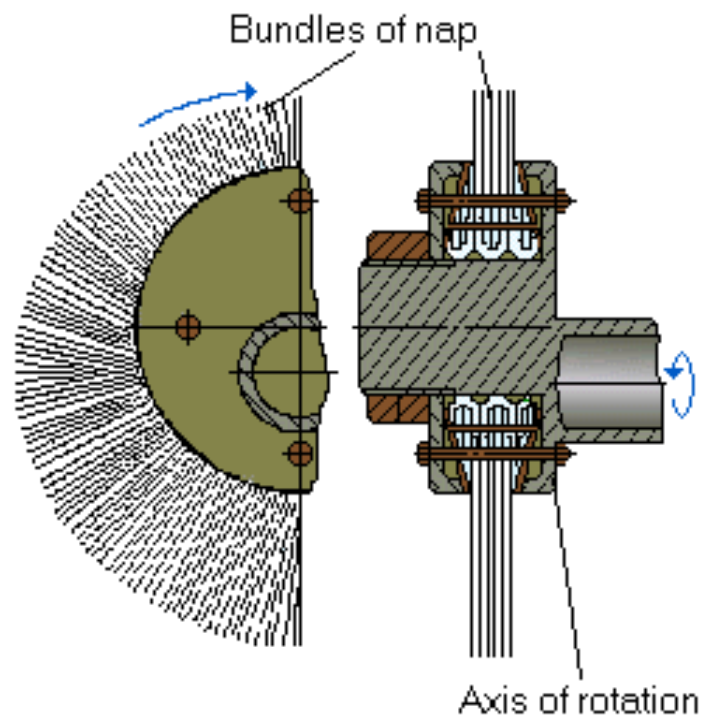
IMPROVED APPARATUS FOR MATERIAL

In testing materials for strength in corrosive media, it is desirable to record accurately the moment of failure of the material. To introduce additional means for this is complicated and expensive.

It is proposed to use the asymmetry principle to make the test chamber itself record the moment of failure of the material without adding more cost! One can make the shape of the chamber asymmetric by introducing two inclined planes. If the specimen fails, the chamber tilts under the weight of the load that fell. This moment is easy to record visually, or by using simple sensors. This design is simple, more accurate and reliable.

SU A.c. N 260 249

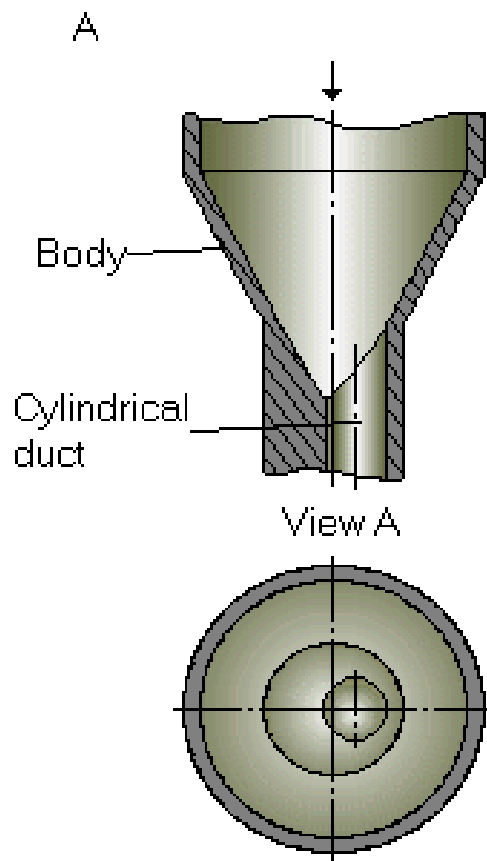
不對稱的刷子



希望刷毛既短而硬，又長而軟。

應用不對稱。

不對稱的漏斗



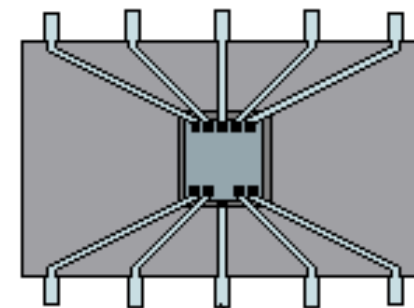
漩渦使水向外拋，減緩漏水速度

不對稱的漏水口降低旋渦速度，而增快漏水速度

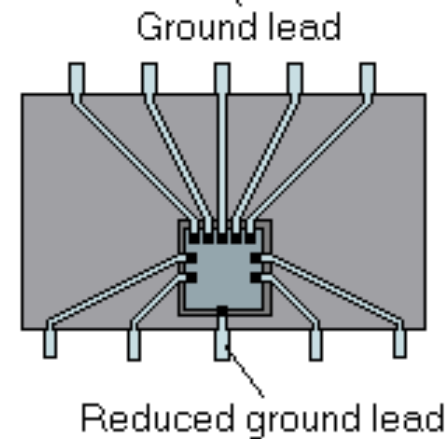
不對稱的接腳

接地的電感延遲電路切換的速度

Prior art



New art



不對稱的接腳縮短接地線長度，增進電路切換速度

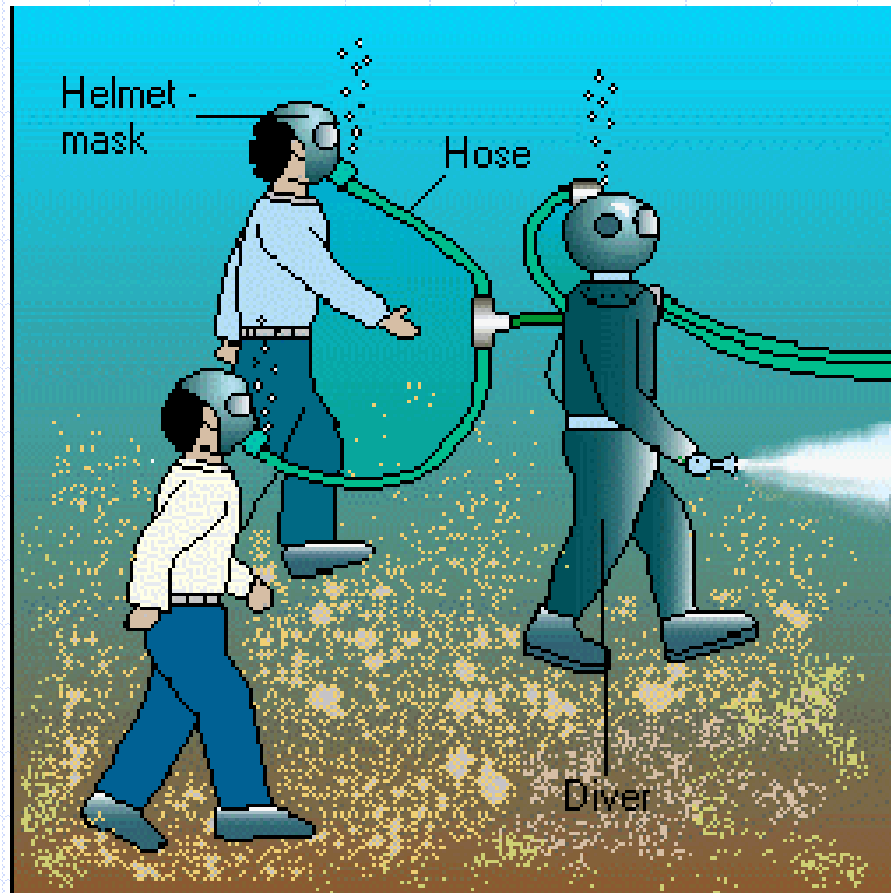
Principle 5. Merging

組合



- ◆ Bring closer together (or merge) identical or similar objects, assemble identical or similar parts to perform parallel operations.
 - *Personal computers in a network*
 - *Thousands of microprocessors in a parallel processor computer*
 - *Vanes in a ventilation system*
 - *Electronic chips mounted on both sides of a circuit board or subassembly*
- ◆ Make operations contiguous or parallel; bring them together in time.
 - *Link slats together in Venetian or vertical blinds.*
 - *Medical diagnostic instruments that analyze multiple blood parameters simultaneously*
 - *Mulching lawnmower*
- ◆ 結合相近(或合併)相同或者相似物體，裝配相同或者相似的部分執行並行操作，使行動接觸或者平行，及時把它們集合在一起。
- ◆ 同質的物體或產生連續作業的物體在空間上加以結合
- ◆ 同質的或連續的作業在時間上加以結合
- ◆ 例:旋轉挖掘機的工作元件具有特別的蒸汽噴嘴以融化並軟化結束的土地

範例：

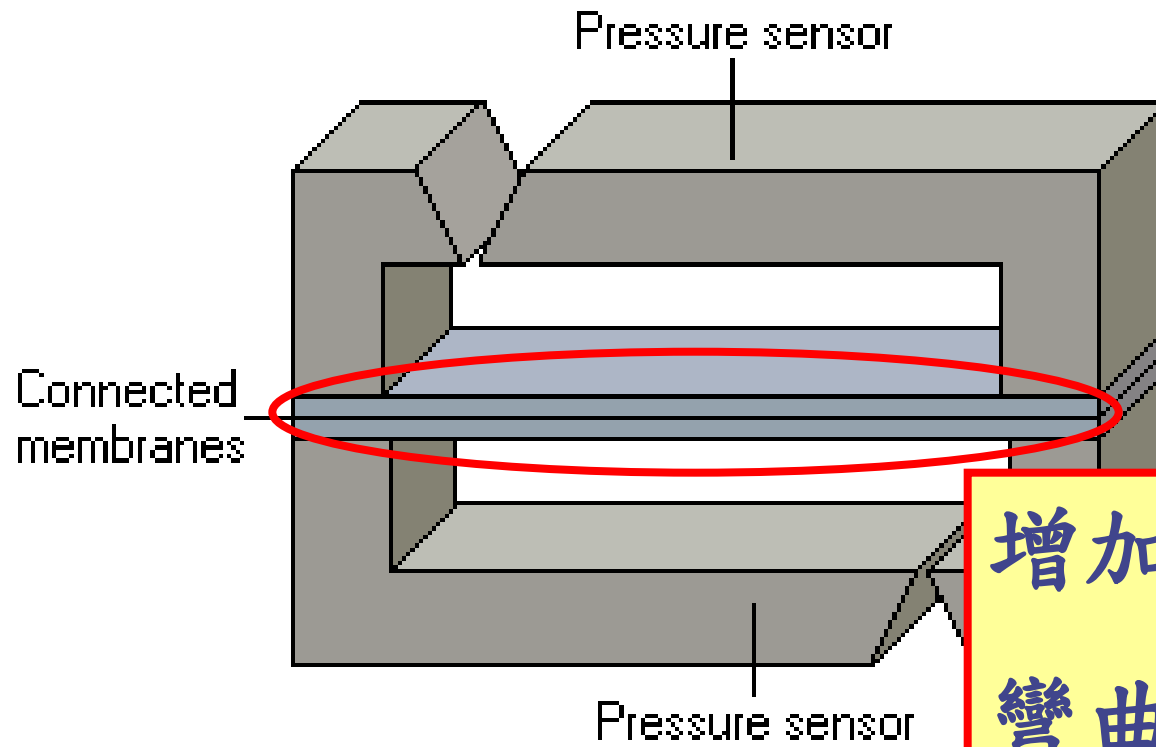


結合潛水員裝配

將多套合併成一套
用鋼盔面罩連結的
經由橡皮軟管結合
到潛水員的空氣提
供系統。

範例：

◆ 壓力保護感測器



增加機械力量

彎曲時防止過壓

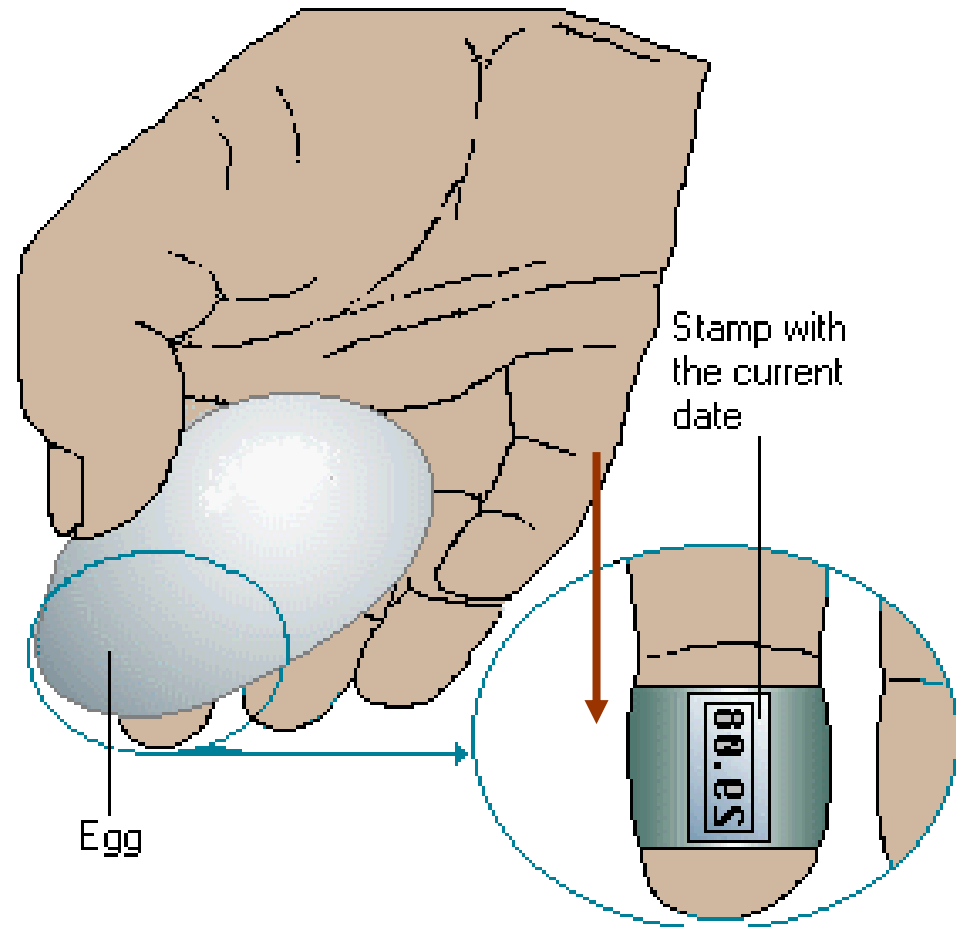
範例：

◆ 蛋的收集和同時標明

蛋的收集、標明和包裝
分開式工作過程

怎麼被縮短呢？

減少人員
增加效率





Principle 6. Universality

Multifunctionality (多功能性)

- ◆ Make a part or object perform multiple functions; eliminate the need for other parts.
 - *Handle of a toothbrush contains toothpaste*
 - *Child's car safety seat converts to a stroller*
 - *Mulching lawnmower (Yes, it demonstrates both Principles 5 and 6, Merging and Universality.)*
 - *Team leader acts as recorder and timekeeper.*
 - *CCD (Charge coupled device) with micro-lenses formed on the surface*

- ◆ 具備多功能的物技，可消除對其他物體的需求
- ◆ 例：在白天為沙發而在晚上可轉換為床的沙發椅、迷你客貨車坐椅可調整成適合乘坐、睡覺或載貨

使一個零件或對象執行多個作用，消除對其它零件的需要。

範例：

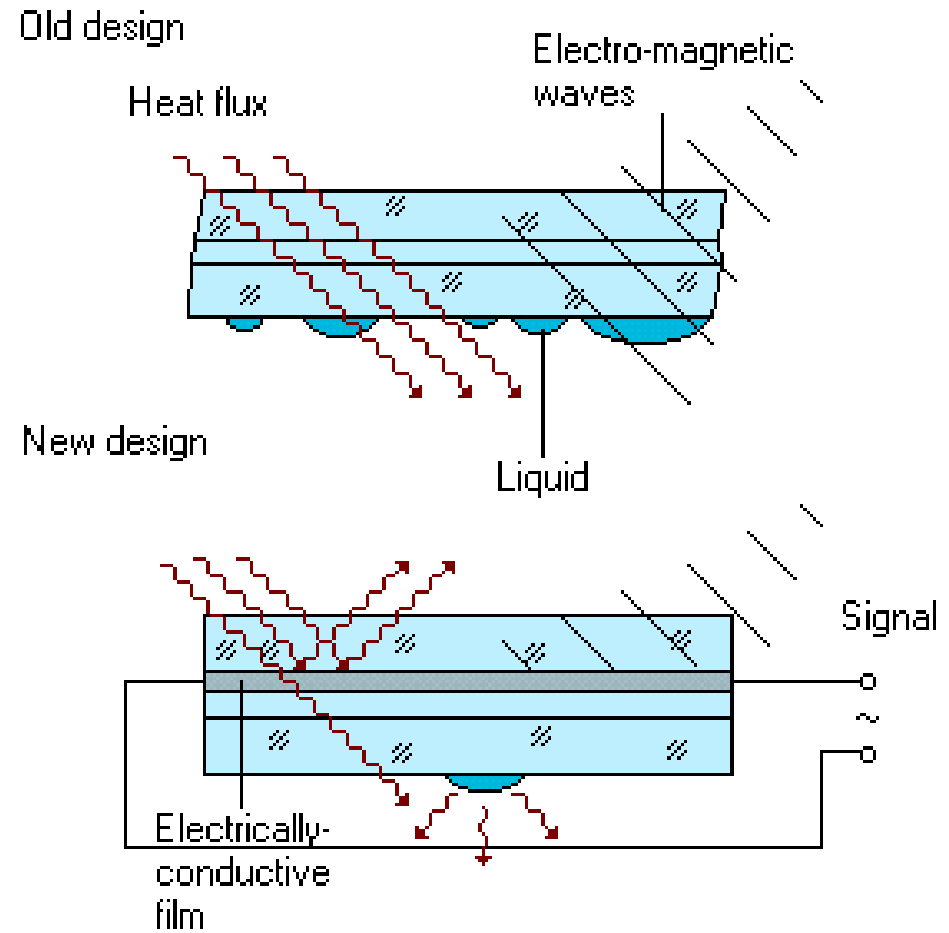
◆ 汽車玻璃

玻璃之間用電力導電

降低熱流入

防止玻璃結露

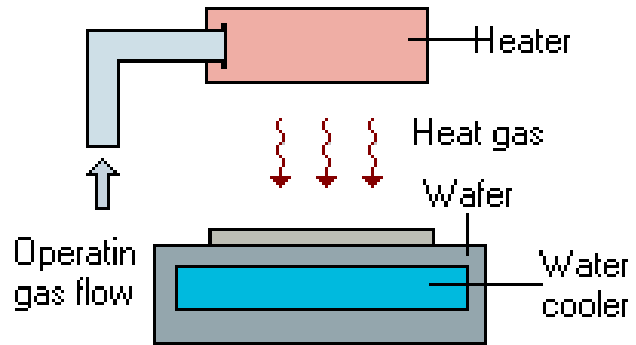
收音機接收天線



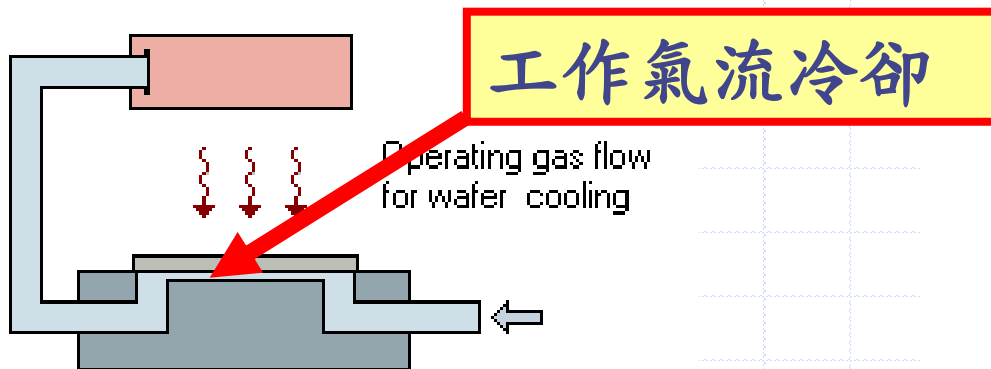
範例：

半導體晶圓的冷卻

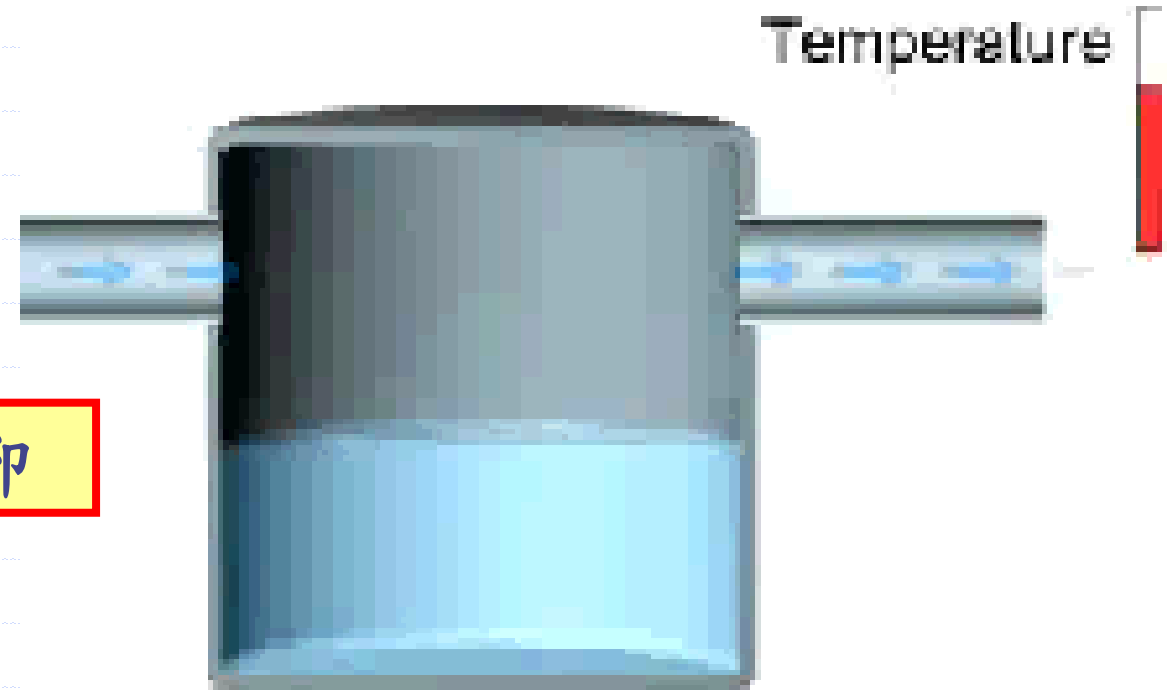
Prior art



New art



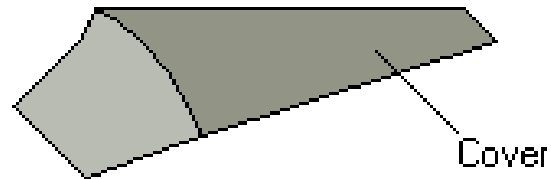
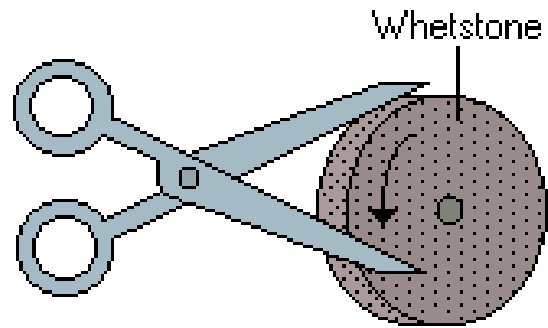
冷卻裝置



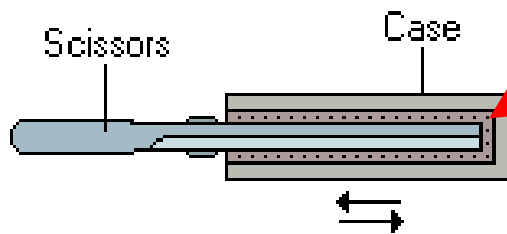
範例：

◆ 使剪刀自行銳利

Old design



New design



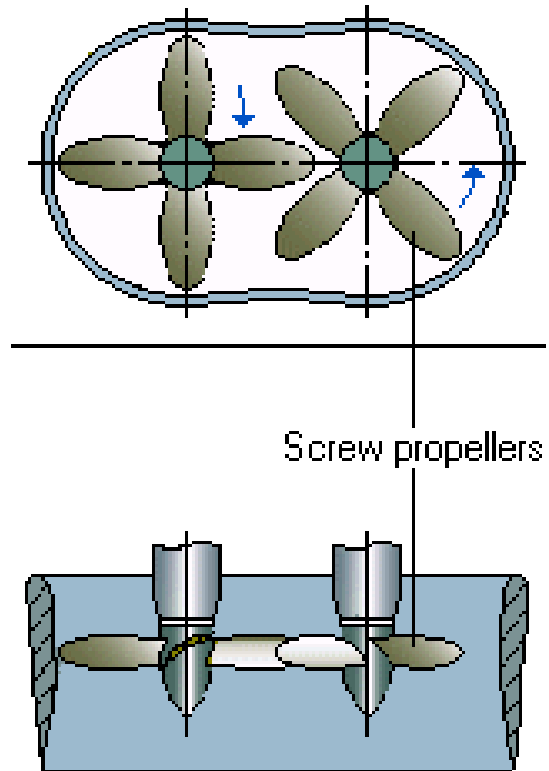
以Pobedit合金做成使銳利設備

Principle 7. "Nested doll"

- ◆ Place one object inside another; place each object, in turn, inside the other.
 - *Measuring cups or spoons*
 - *Russian dolls*
 - *Portable audio system (microphone fits inside transmitter, which fits inside amplifier case)*
- ◆ *Make one part pass through a cavity in the other.*
 - *Extending radio antenna*
 - *Extending pointer*
 - *Zoom lens*
 - *Seat belt retraction mechanism*
 - *Retractable aircraft landing gear stow inside the fuselage (also demonstrates Principle 15, Dynamism).*

範例：

◆螺旋槳的最佳的安排

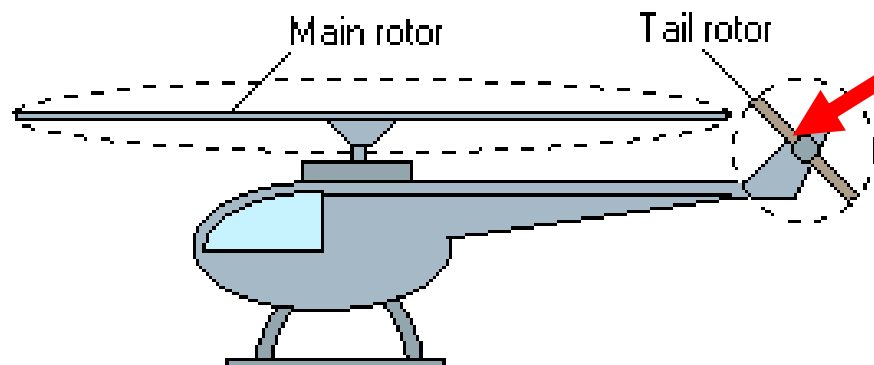


平行軸上安排兩個螺旋槳浪費空間使用重疊放置原理使螺旋槳安排更緊密旋轉時葉片在恰當位置並且協調

範例：

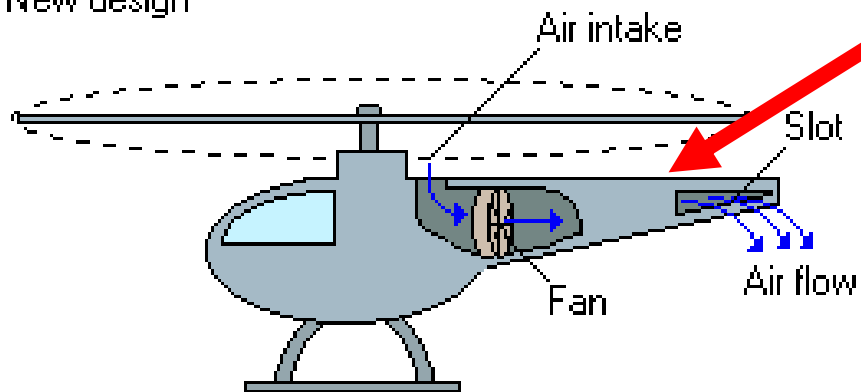
使一架直升飛機穩定

Old design



複雜設計
增加重量

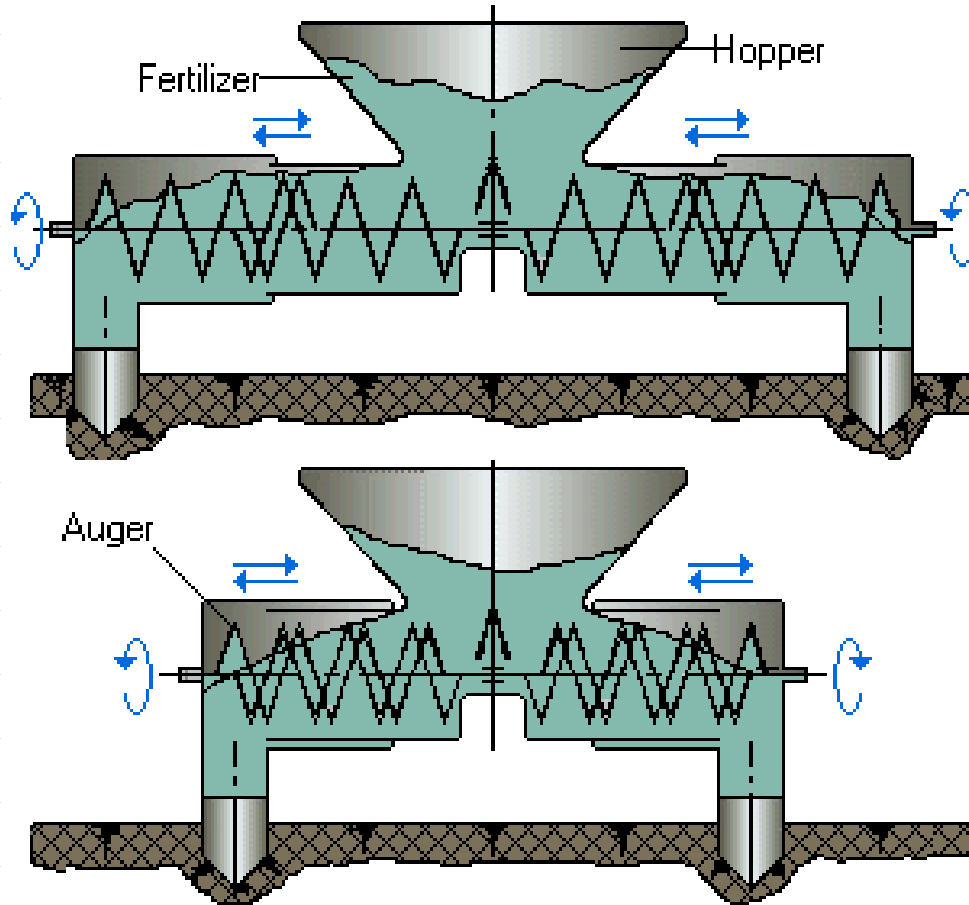
New design



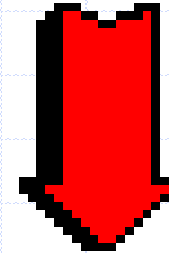
設計簡單
重量降低

範例：

◆可摺疊的動態的木鑽



木鑽是不允許在設備
寬度方面的變化

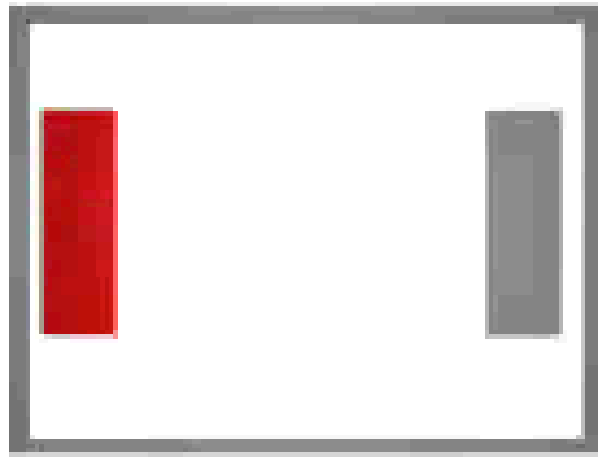


重疊放置
變化性原則

木鑽由兩個部分組成設
計以螺絲擰緊成另一個
按需要調整寬度

範例：

◆ 熱化冷卻熱泵桿



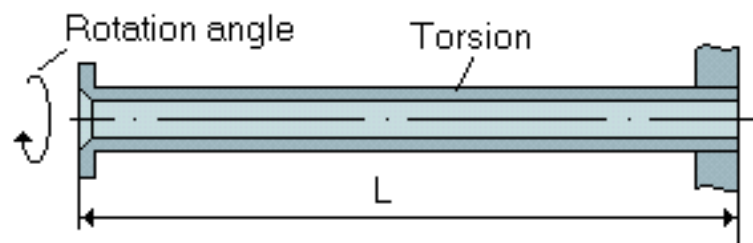
7. 套疊



- ◆ 物體內可依次放入其他物體
- ◆ 一個物體可通過另一個物體的孔洞
- ◆ 例：伸縮天線、堆疊椅、內部可儲存筆心的自動鉛筆

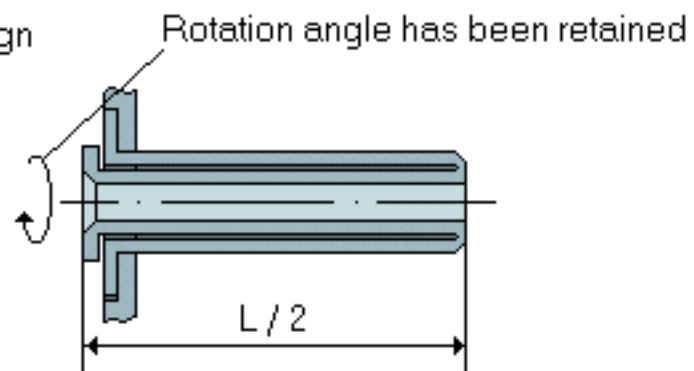
扭力桿

Old design



增加扭轉角度需要增加
扭力桿的長度。

New design



套疊可增加扭轉角度
一倍而不增加長度。

Principle 8. Anti-weight

- ◆ To compensate for the weight of an object, merge it with other objects that provide lift.
 - *Inject foaming agent into a bundle of logs, to make it float better.*
 - *Use helium balloon to support advertising signs.*
- ◆ To compensate for the weight of an object, make it interact with the environment (e.g. use aerodynamic, hydrodynamic, buoyancy and other forces).
 - *Aircraft wing shape reduces air density above the wing, increases density below wing, to create lift. (This also demonstrates Principle 4, Asymmetry.)*
 - *Vortex strips improve lift of aircraft wings.*
 - *Hydrofoils lift ship out of the water to reduce drag.*

8. Weight compensation (重量補償)



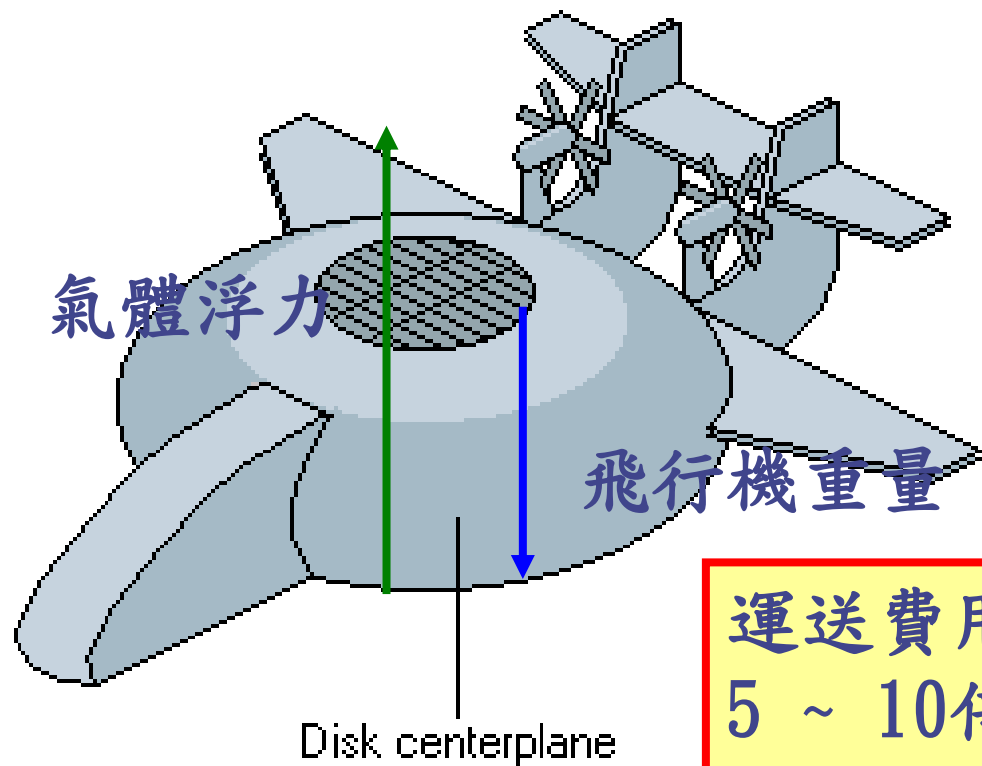
補償對象的重量，與提供推力的其它對象合併它，補償對象的重量使它與環境相互作用（例如使用空氣動力學，流體，浮力和其他力量）。

為了補償物體的重量可連接另一個具有舉升力的物體。
為了補償物體的重量可和環境提供之空氣動力或水力互動。
◦ 例：水翼船、跑車擾流板

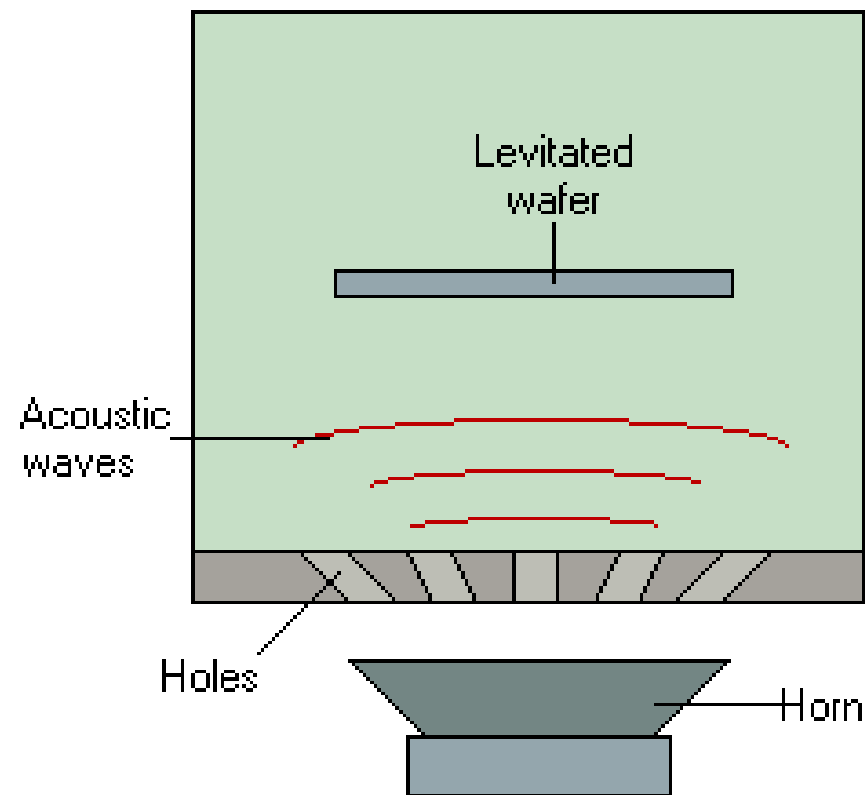
範例：

音波讓晶圓懸浮

飛行機

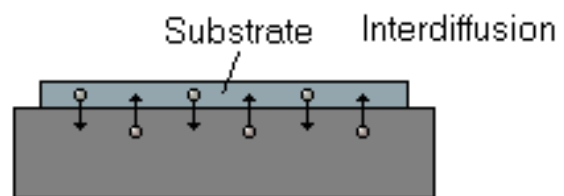


運送費用比直升機低
5 ~ 10倍
比飛機低 2.5 ~ 3倍

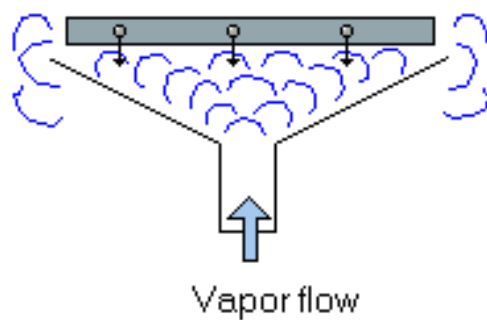


空氣浮力讓晶圓懸浮

Prior art



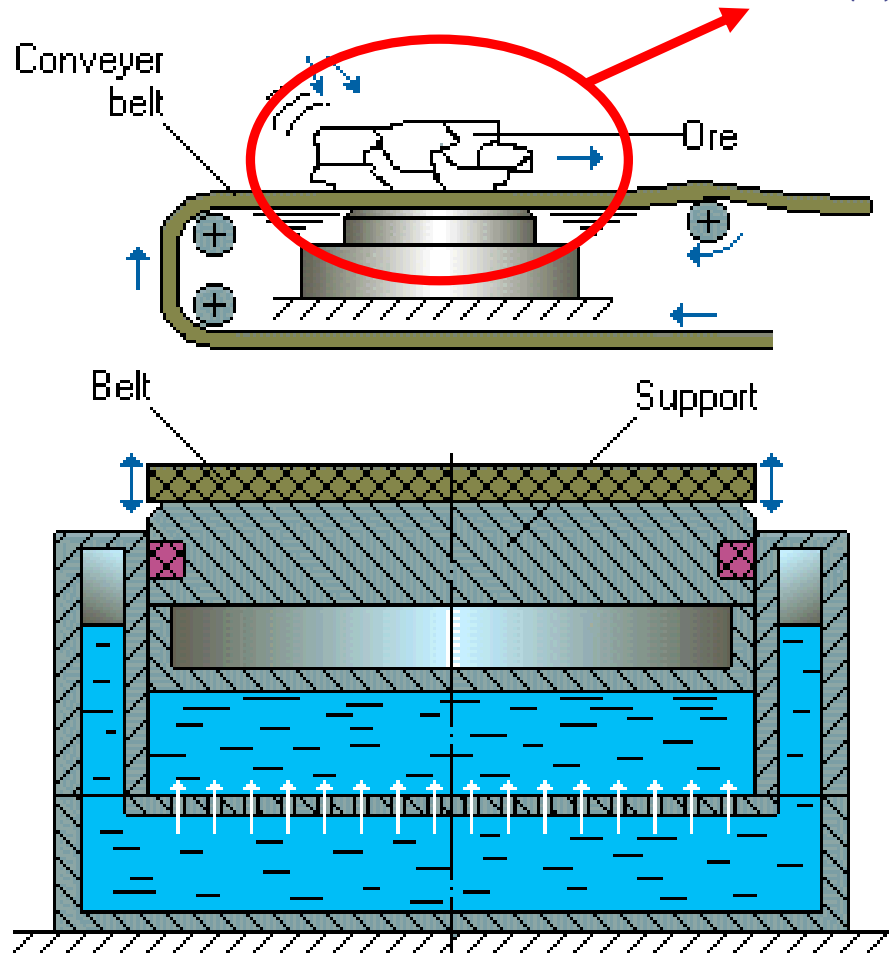
New art



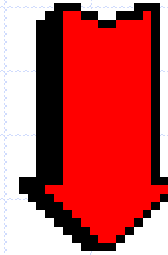
高溫(1500°C)處理晶圓時，
任何接觸都會造成污染。

用空氣浮力使晶圓懸空漂浮

浮力支撐



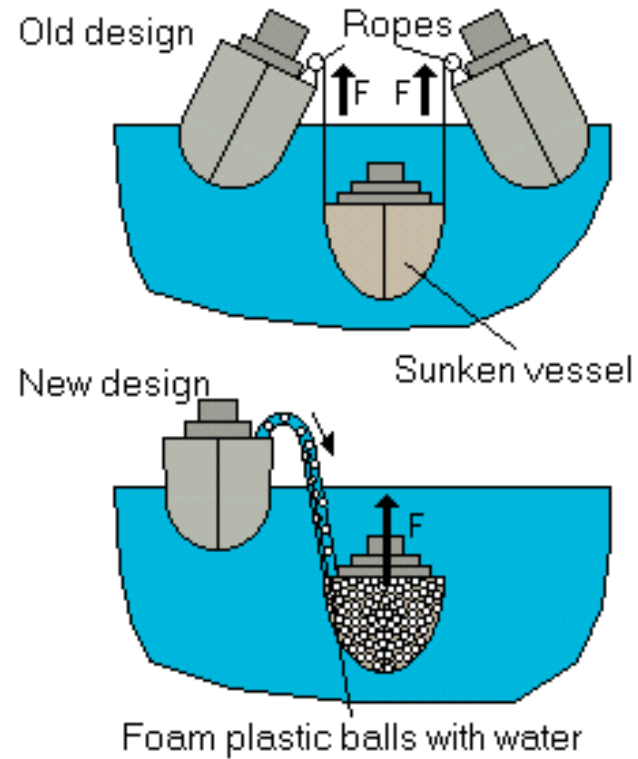
高負荷的輸送帶的支撐容易損壞



氣動力學
水力
反重量原則

利用浮力改進支撐對震動的
吸收能力和耐用性

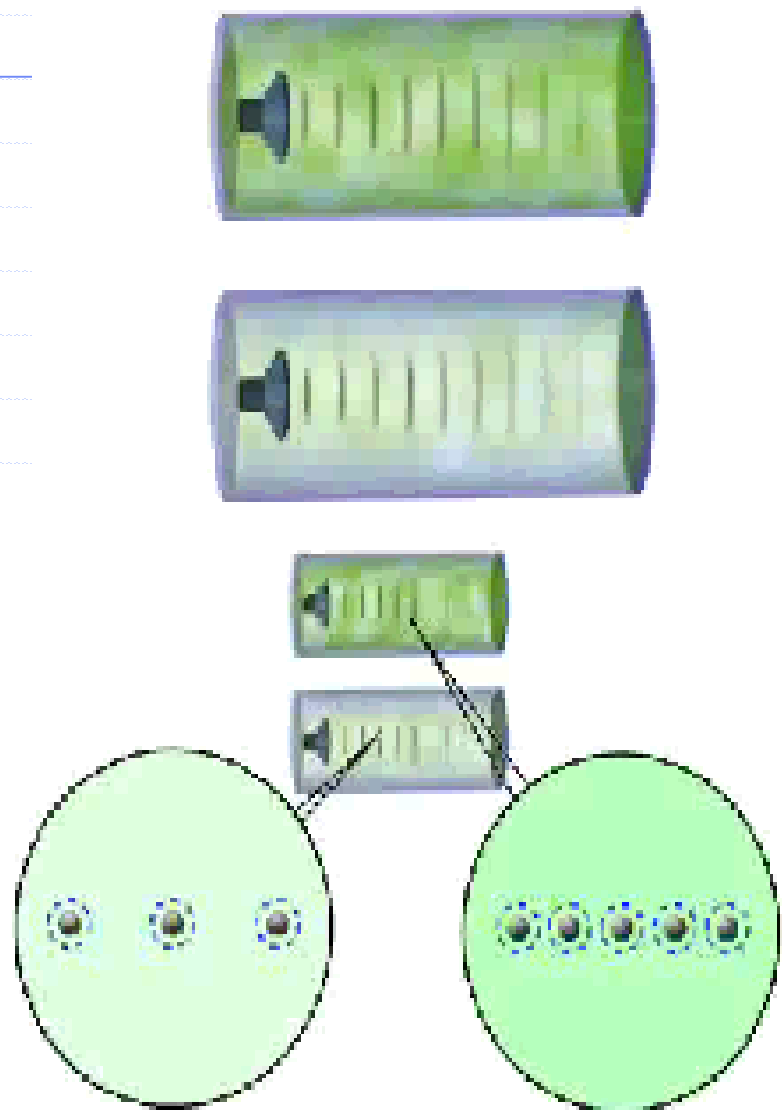
吊起沈船



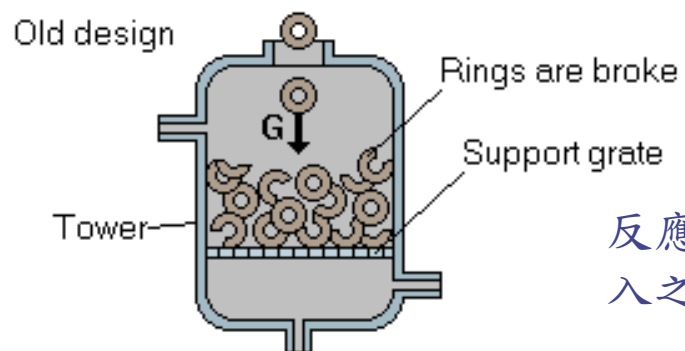
沈船用繩索吊起，不穩定且容易破壞船體。

用保麗龍球灌入船身，使它自行浮起，既安全又有效。

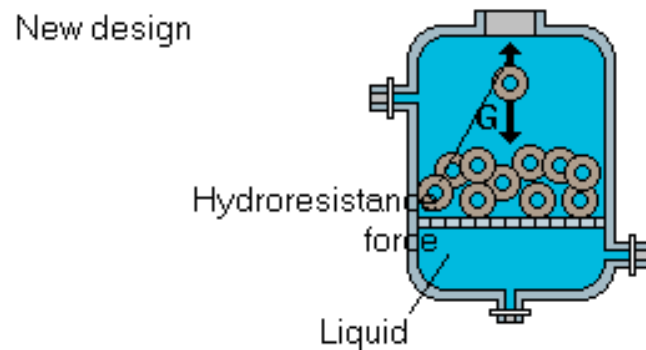
壓力影響氣體裡音速



液體減緩撞擊力



反應器充填陶瓷圈時，因為投入之撞擊力大，容易打破。



充滿液體時可以減緩下沈速度

Principle 9. Preliminary anti-action

- ◆ If it will be necessary to do an action with both harmful and useful effects, this action should be replaced with anti-actions to control harmful effects.
 - *Buffer a solution to prevent harm from extremes of pH.*
- ◆ Create beforehand stresses in an object that will oppose known undesirable working stresses later on.
 - *Pre-stress rebar before pouring concrete.*
 - *Masking anything before harmful exposure: Use a lead apron on parts of the body not being exposed to X-rays. Use masking tape to protect the part of an object not being painted*

9. 先前的反作用力



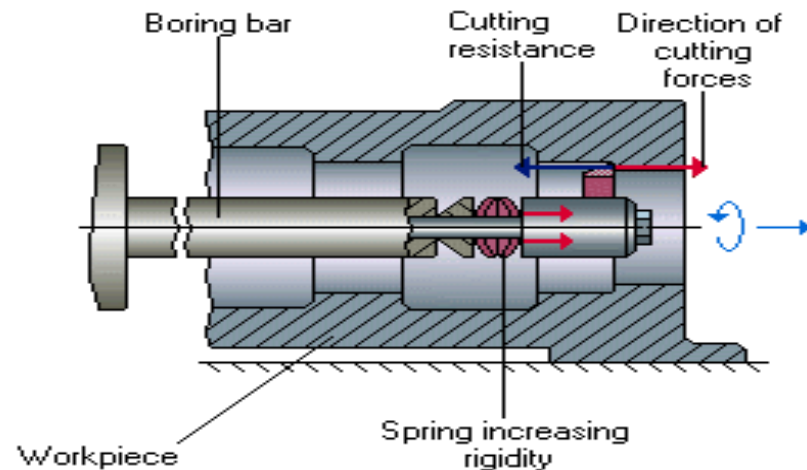
- ◆ 如果需要的話應事先考慮反作用力
- ◆ 如果一個物體必須有張力，事先給予反張力
- ◆ 例：預力混凝土柱或地板；預力軸

9. Preliminary counteraction

Make anti-action
in advance

PRE-STRESSING AGAINST VIBRATION

- ◆ In machining holes, boring bars are used frequently. However, boring bars (if not rigid enough) tend to vibrate.
- ◆ It is proposed to use the principle of preliminary anti-action to reduce the vibration problem. One can add a pre-stress (a compressed spring) to increase rigidity in the direction of the cutting force. The properly sized compressed spring will reduce vibration, improving machining precision.



SU A.c. N 663 493

Principle 10. Preliminary action

- ◆ Perform, before it is needed, the required change of an object (either fully or partially).
 - *Pre-pasted wall paper*
 - *Sterilize all instruments needed for a surgical procedure on a sealed tray.*
- ◆ Pre-arrange objects such that they can come into action from the most convenient place and without losing time for their delivery.
 - *Kanban arrangements in a Just-In-Time factory*
 - *Flexible manufacturing cell*

10. 事先動作



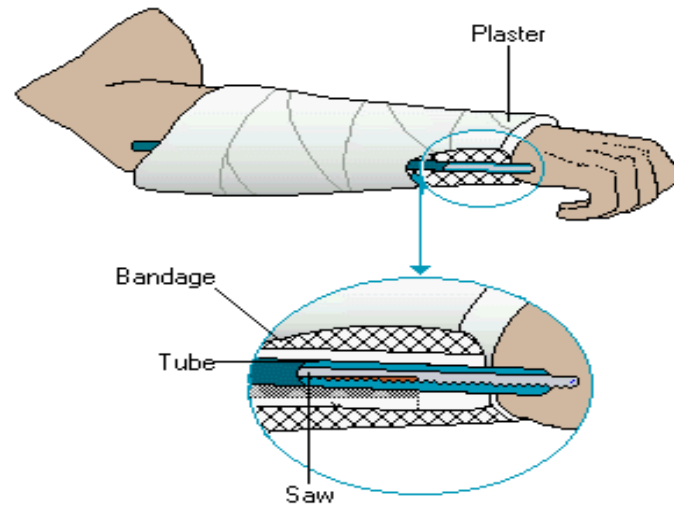
- ◆ 事先完成全部的動作或至少完成部份動作
- ◆ 安置物體使他們能行動起來而不會浪費時間在等待行動
- ◆ 例: 美工刀片上製作溝槽, 使刀片鈍的部份易斷裂, 恢復鋒利

10. Preliminary action

Prepare
in advance

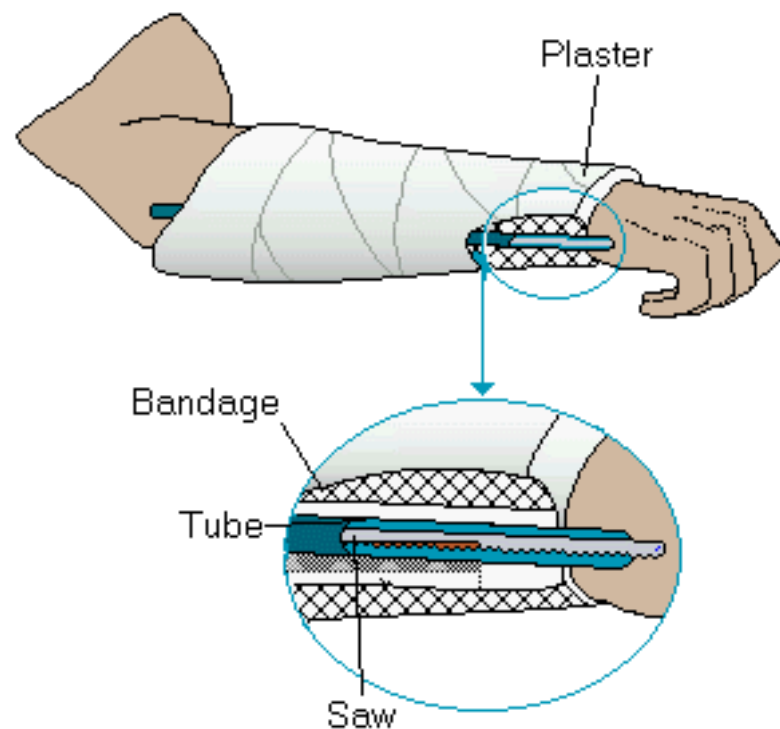
PALSTER BANDAGE WITH A SAW INSIDE

- ◆ It is difficult to remove a plaster bandage from a broken limb, since the patient may be injured when the bandage is cut with a saw.
- ◆ It is proposed to use the preliminary action principle to improve safety. A saw blade (in a plastic tube) is set inside the bandage by applying the bandage over the tube. Using this technique, the plaster can be removed from the patient by sawing away from the limb. This eliminates the risk of injury to the patient.



SU A.c. N 162 919

容易拆的石膏模



鋸開石膏模時，容易使病患受傷。

預先安置鋸子在石膏模中。

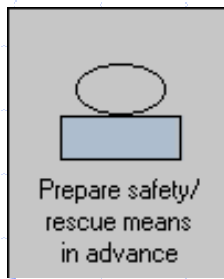
Principle 11. Beforehand cushioning

- ◆ Prepare emergency means beforehand to compensate for the relatively low reliability of an object.
 - *Magnetic strip on photographic film that directs the developer to compensate for poor exposure*
 - *Back-up parachute*
 - *Alternate air system for aircraft instruments*

11. 事先緩和



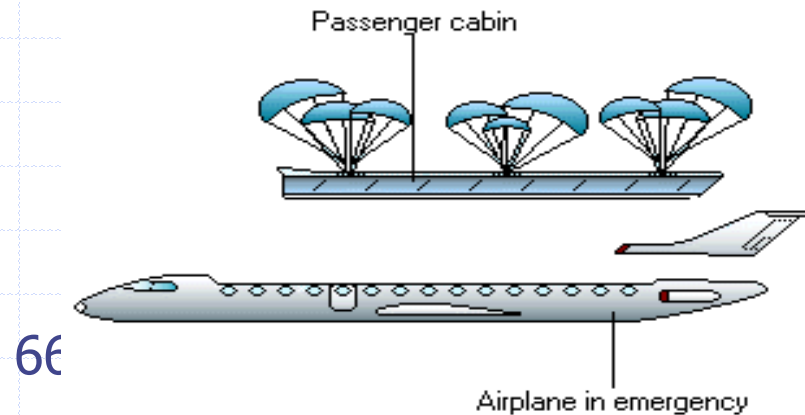
- ◆ 為了補償低可靠性的物體，可事先採取對策
- ◆ 例：為了預防竊賊，商店主人在物品上裝上磁性板標籤，為了使客戶能攜出此商品，此磁性板須在收銀台消磁



TRIZ - 11 Beforehand Compensation

PASSENGER CABIN WITH PARACHUTCH

- ◆ How can air passengers be rescued in a flight accident or emergency?
- ◆ It is proposed to use the principles of early cushioning, segmentation and universality to improve air safety. The passenger cabin section is provided with parachutes. This requires a detachable air-tight cabin equipped with a bail-out device. In many emergency situations this can ensure a smooth descent of the cabin with the passengers.



US Patent N 4

Principle 12. Equipotentiality

等位能

- ◆ *In a potential field, limit position changes (e.g. change operating conditions to eliminate the need to raise or lower objects in a gravity field).*
 - *Spring loaded parts delivery system in a factory*
 - *Locks in a channel between 2 bodies of water (Panama Canal)*
 - *"Skillets" in an automobile plant that bring all tools to the right position (also demonstrates Principle 10, Preliminary Action)*

12. 等位性



- ◆ 改變工作的狀況那麼物體就不需被舉起降低
- ◆ 例：工人在地溝更換汽車引擎機油（昂貴的升降設備就不需要了）

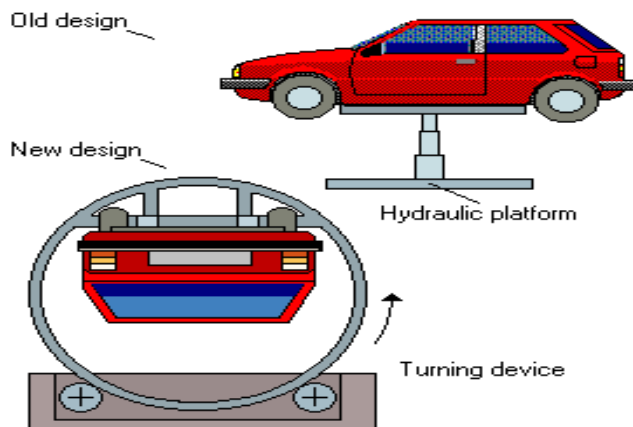


Eliminate the need
to raise object

12. Equipotentiality

TURNING BENCH FOR A CAR

- ◆ To gain access underneath a car, the car is either placed over an open tunnel, driven onto a trestle, or secured on a hydraulic platform. While repairing a car, a mechanic holds the tools over his head which is inconvenient and unsafe.
- ◆ A possible solution proposes to use the equipotentiality principle.
- ◆ A car fixed on a ring-shaped turning device is easily turned on its side or upside-down. Thus, the car repair conditions are improved.



p.6

US Automotive Industry. No. 1-2, 1992,

Principle 13. 'The other way round'

- ◆ Invert the action(s) used to solve the problem (e.g. instead of cooling an object, heat it).
 - *To loosen stuck parts, cool the inner part instead of heating the outer part.*
 - *Bring the mountain to Mohammed, instead of bringing Mohammed to the mountain.*
- ◆ Make movable parts (or the external environment) fixed, and fixed parts movable).
 - *Rotate the part instead of the tool.*
 - *Moving sidewalk with standing people*
 - *Treadmill (for walking or running in place)*
- ◆ Turn the object (or process) 'upside down'.
 - *Turn an assembly upside down to insert fasteners (especially screws).*
 - *Empty grain from containers (ship or railroad) by inverting them.*

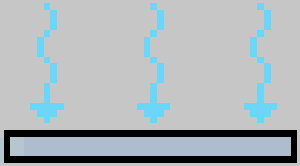
13. 倒轉



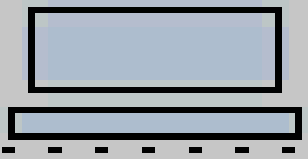
- ◆ 執行相反的行動，而不要被制式的行動所主導
- ◆ 使物體的可動零件或外在環境固定與不動零件可移動將物體上下顛倒
- ◆ 例：以振動零件的方式來清潔零件取代原先的研磨料

13. The other way around

Cooling

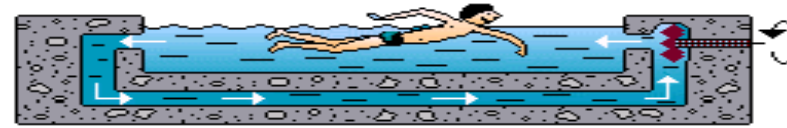


Replace action
with converse one



Invert movement,
position

The diagram shows a grey rectangular box containing text and two diagrams. At the top, three blue wavy arrows point downwards towards a horizontal line, with the word 'Cooling' to their right. Below this is the text 'Replace action with converse one'. Underneath is a diagram consisting of a blue rectangle above a grey rectangle, with a dashed line below the grey rectangle. At the bottom is the text 'Invert movement, position'.



● **LONG-DISTANCE
SWIMMING WITHOUT
MOVING?**

Principle 14. Spheroidality - Curvature

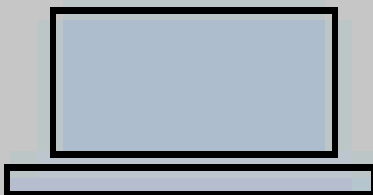
- ◆ Instead of using rectilinear parts, surfaces, or forms, use curvilinear ones; move from flat surfaces to spherical ones; from parts shaped as a cube (parallelepiped) to ball-shaped structures.
 - *Use arches and domes for strength in architecture.*
- ◆ Use rollers, balls, spirals, domes.
 - *Spiral gear (Nautilus) produces continuous resistance for weight lifting.*
 - *Ball point and roller point pens for smooth ink distribution*
- ◆ Go from linear to rotary motion, use centrifugal forces.
 - *Produce linear motion of the cursor on the computer screen using a mouse or a trackball.*
 - *Replace wringing clothes to remove water with spinning clothes in a washing machine.*
 - *Use spherical casters instead of cylindrical wheels to move furniture.*

14. 增加曲率




- ◆ 以曲線取代線性零件或平面，以球體取代立方體
- ◆ 使用滾筒、球、螺旋
- ◆ 以旋轉運動取代線性運動，利用離心力
- ◆ 例：電腦滑鼠利用球狀結構將兩軸的線性動作轉換成向量

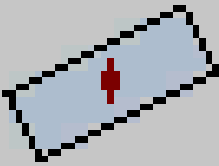
14. Curvature increase



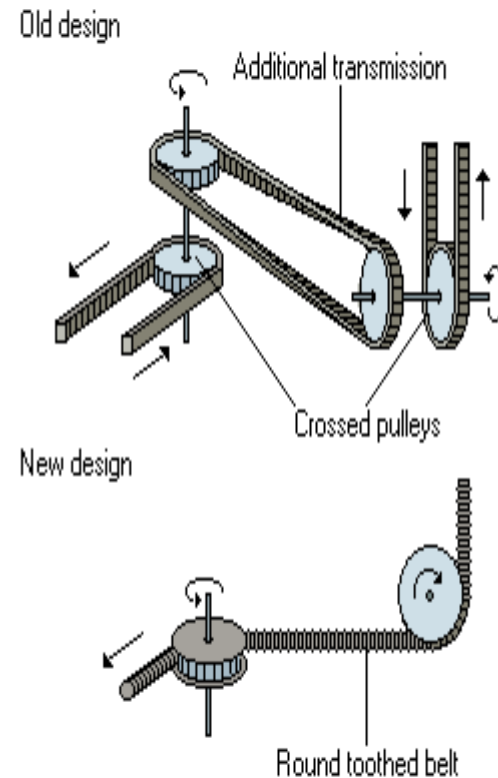
Use non-flat shapes



Rollers



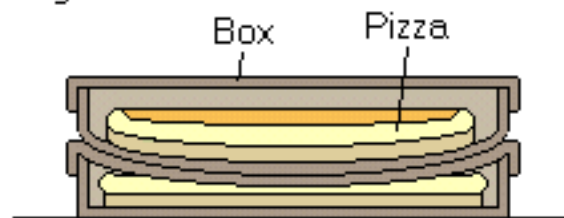
Rotation



◆ **Round-toothed belt**

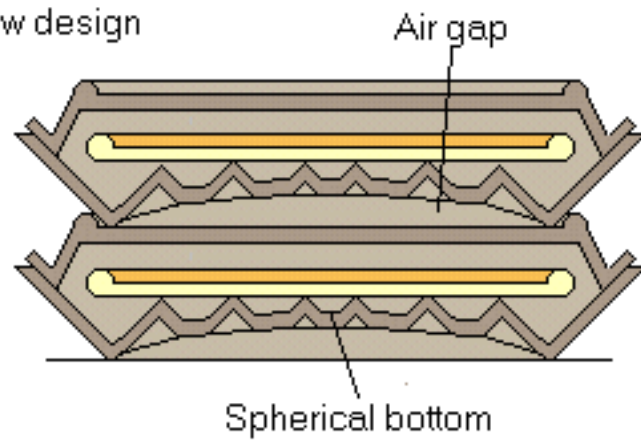
比薩盒

Old design



平底易因重量而凹陷。

New design



拱形底增加強度和隔熱。

Principle 15. Dynamics

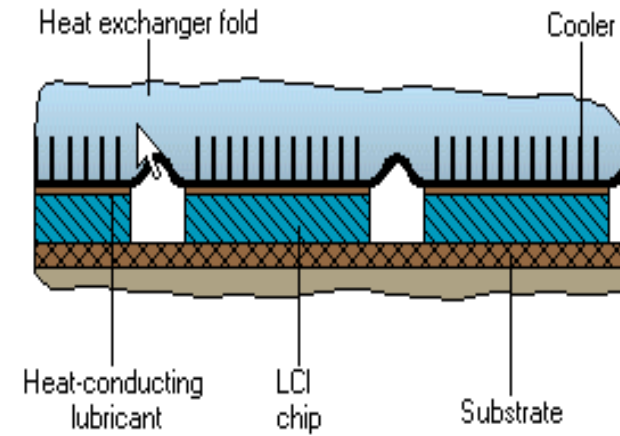
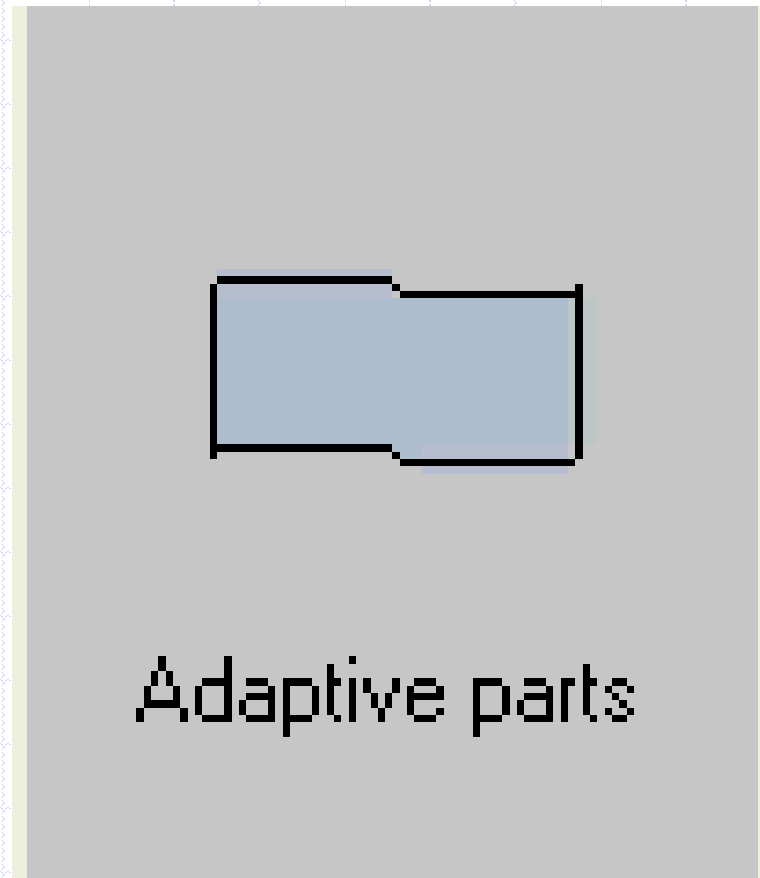
- ◆ Allow (or design) the characteristics of an object, external environment, or process to change to be optimal or to find an optimal operating condition.
 - *Adjustable steering wheel (or seat, or back support, or mirror position...)*
- ◆ Divide an object into parts capable of movement relative to each other.
 - *The "butterfly" computer keyboard, (also demonstrates Principle 7, "Nested doll".)*
- ◆ If an object (or process) is rigid or inflexible, make it movable or adaptive.
 - *The flexible boroscope for examining engines*
 - *The flexible sigmoidoscope, for medical examination*

15. 動態



- ◆使物體的特性或外界環境能在作業的各階段為了達到最佳性能而自動地調整。
- ◆將物體分成元素，使各元素間的位置能被改變。
- ◆使無法移動的物體可移動。
- ◆例：可撓性的鵝頸管手電筒。

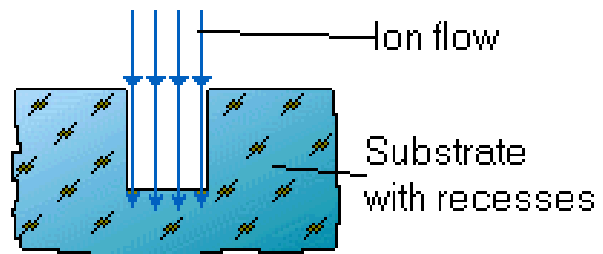
15. Dynamic parts



◆ **Flexible heat sink alignments**

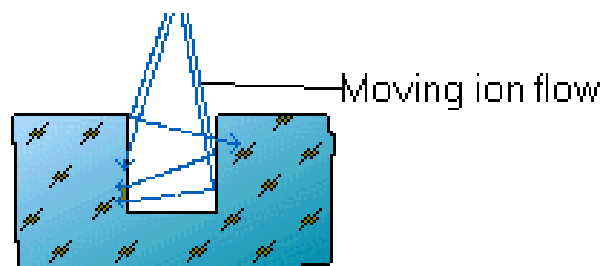
動態Doping

Fig.1



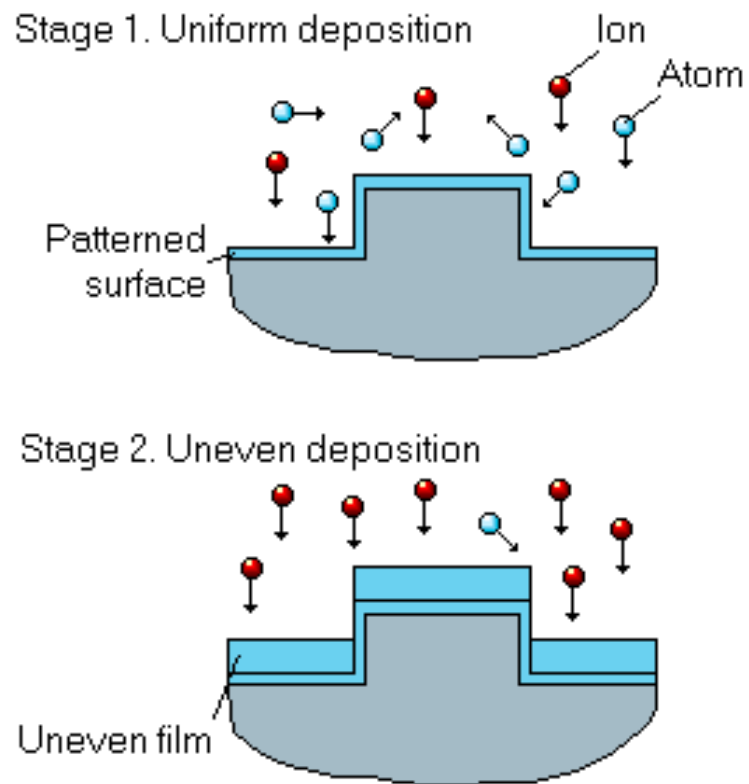
用離子束在孔內加藥，側壁和底部加藥不均勻。

Fig.2



在過程中移動離子束和晶圓的相對位置，可使加藥效果更均勻。

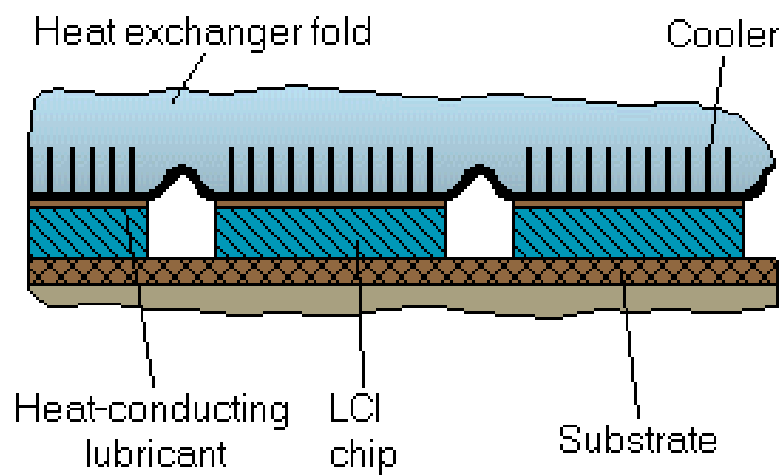
動態Doping



要做水平面和垂直面的加藥厚度不同。

用兩步驟加藥，每次的壓力和加藥成份不同。原子呈隨機運動，加藥厚度在各方向一致。離子向著晶圓移動，在水平面加藥多。

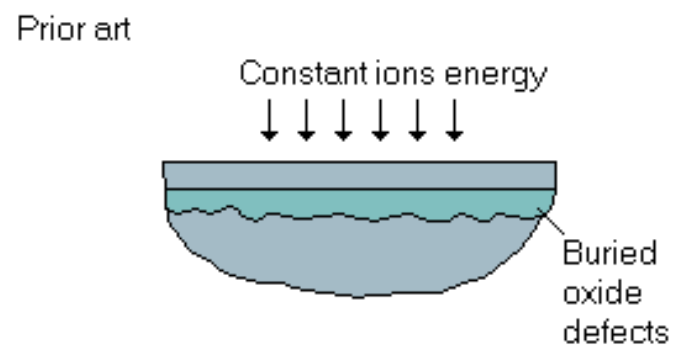
彈性散熱片



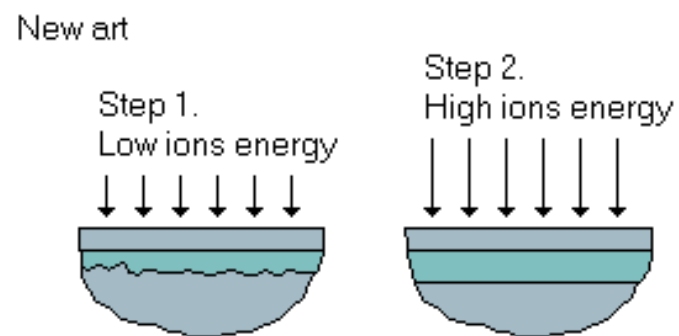
多個晶片常共用一個散熱片。要保證散熱的效果，散熱片必須與每個晶片良好接觸。

散熱片可以分割為適當大小，再用彈性體連接。如此可以使個別散熱片能與晶片接觸良好。

氧化能量的變化



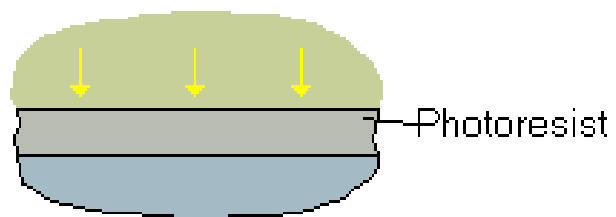
固定的離子能量造成不均勻的
介面和瑕疵。



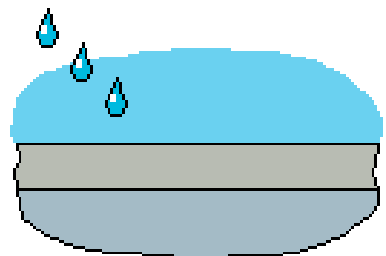
分兩次氧化產生均勻的氧化層。

光罩的成形

Low humidity during exposure



High humidity during storage



光罩成形過程中，溶劑逐漸揮發。
會影響光罩的品質。

在低濕度產生光罩，在高濕度環境
儲存光罩。

Principle 16. Partial or excessive actions


- ◆ *If 100 percent of an object is hard to achieve using a given solution method then, by using 'slightly less' or 'slightly more' of the same method, the problem may be considerably easier to solve.*
 - ◆ *Over spray when painting, then remove excess. (Or, use a stencil--this is an application of Principle 3, Local Quality and Principle 9, Preliminary anti-action).*
 - ◆ *Fill, then "top off" when filling the gas tank of your car.*

16. 局部或過度的動作

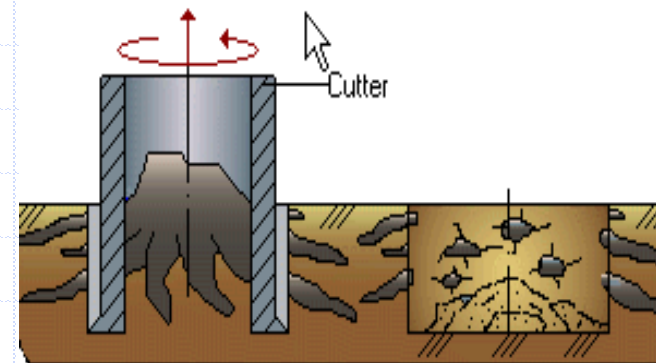
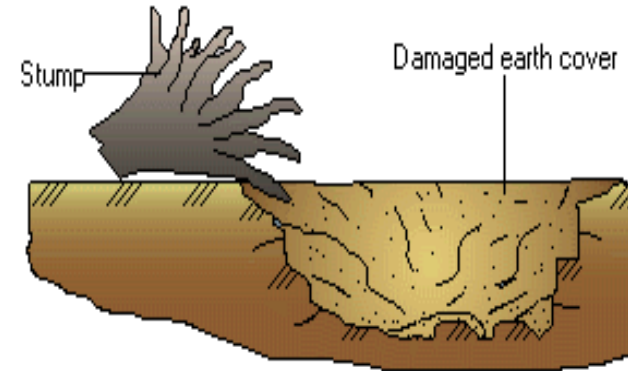


- ◆ 如果不易獲得100期望效果，作得多一點或少一點可大大地簡化問題
- ◆ 例：以浸塗方式對汽缸進行塗裝，可是上了太多漆。多餘的漆可以快速旋轉圓柱體將它除去；為了從儲藏櫃均勻卸下金屬粉末，貯藏器有一特殊的內藏漏斗，它可持續保持滿溢狀態以提供幾乎固定的壓力

16. Partial or excessive actions



Use more or less
of an action



◆ On pulling stumps

Principle 17. Another dimension

- ◆ To move an object in two- or three-dimensional space.
 - *Infrared computer mouse moves in space, instead of on a surface, for presentations.*
 - *Five-axis cutting tool can be positioned where needed.*
- ◆ Use a multi-story arrangement of objects instead of a single-story arrangement.
 - *Cassette with 6 CD's to increase music time and variety*
 - *Electronic chips on both sides of a printed circuit board*
 - *Employees "disappear" from the customers in a theme park, descend into a tunnel, and walk to their next assignment, where they return to the surface and magically reappear.*
- ◆ Tilt or re-orient the object, lay it on its side.
 - *Dump truck*
- ◆ Use 'another side' of a given area.
 - *Stack microelectronic hybrid circuits to improve density.*

17. dimensionality change

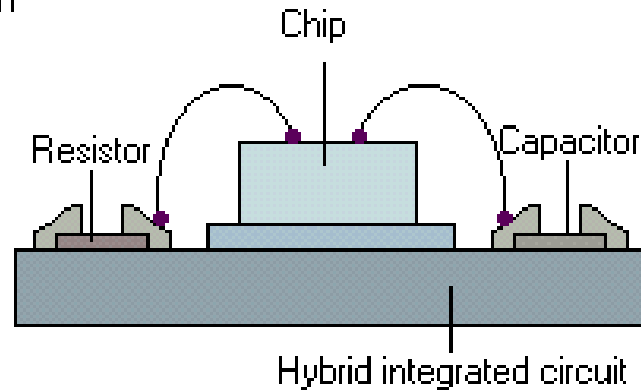
17. 移到新的次元



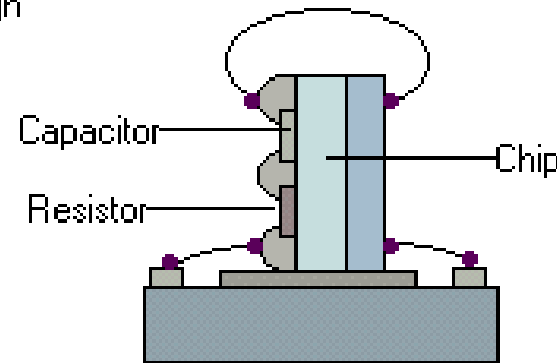
- ◆ 點-線-空間
- ◆ 以多層組合代替單層
- ◆ 傾斜物體
- ◆ 投射影像到鄰近區域或該物體的另一側
- ◆ 例: 在溫室的北側安置凹面反射器白天時可反射日光以改善該處的照明

Hybrid microcircuit

Old design



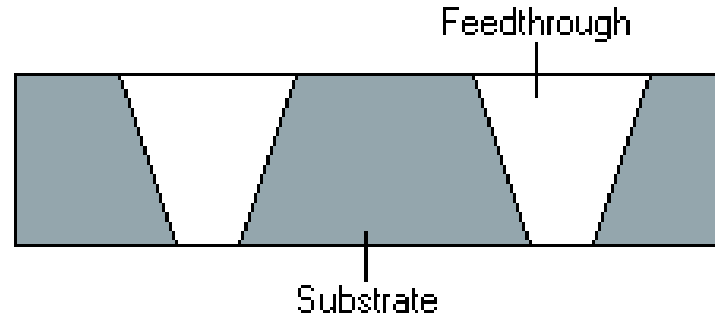
New design



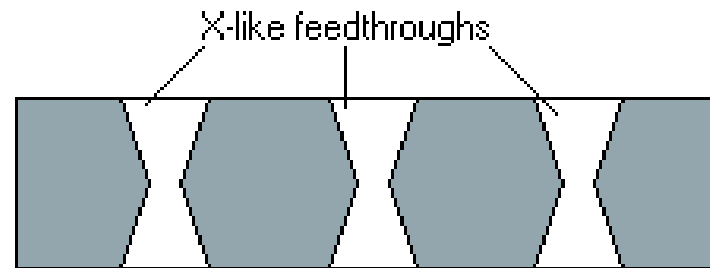
- ◆ Application of Japan (NEC) 1 283 896 H05R1/16 H01L 27/04 Review Magazine "Radiotechnika", 1991

Silicon wafers with feedthroughs

Prior art



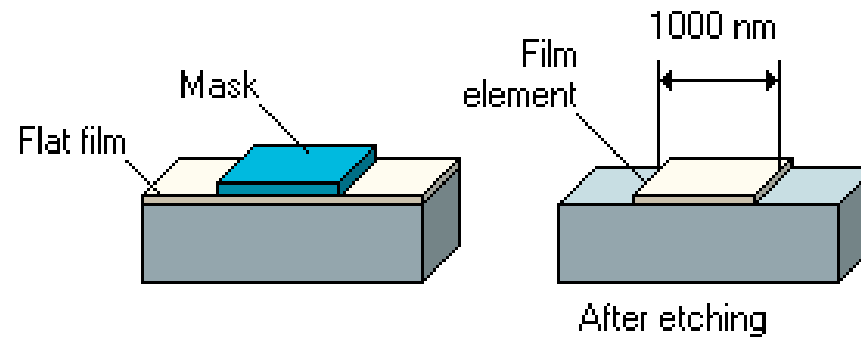
New art



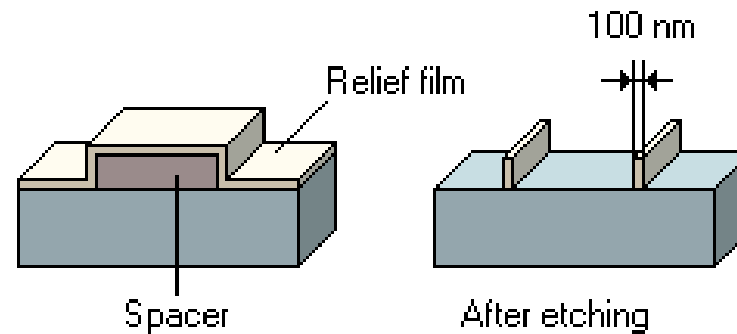
- ◆ United States Patent 5 166 097 Date of Patent: Nov. 24, 1992 The Boeing Company, Seattle, Wash., USA

Submicron film elements

Prior art



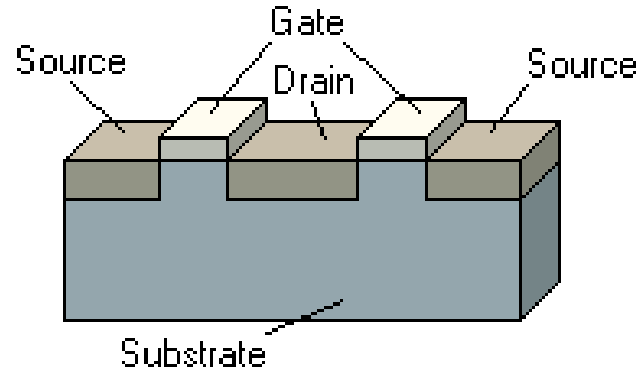
New art



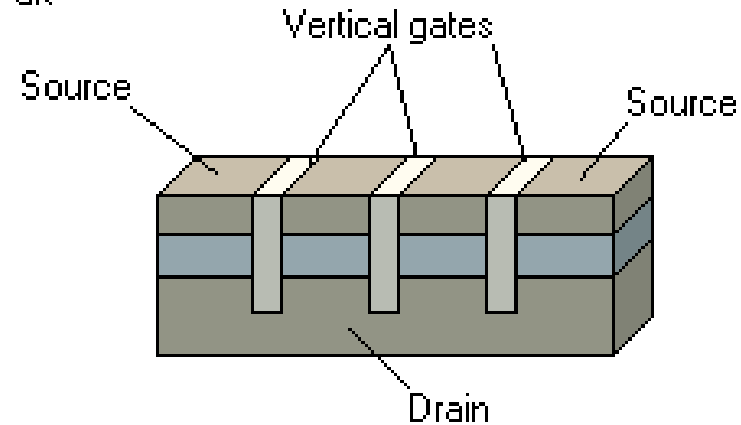
- ◆ United States Patent 5 202 272 Date of Patent: Apr. 13, 1993
International Business Machines Corporation, Armonk, N.Y.

Vertical field-effect transistor

Prior art



New art

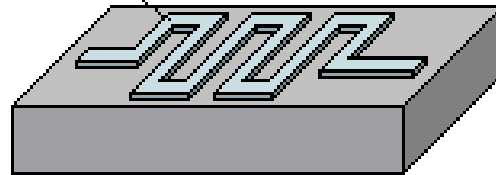


- ◆ United States Patent 5 164 325 Date of Patent: Nov. 17, 1992
Siliconix Incorporated, Santa Clara, Calif.

Vertical trench inductor

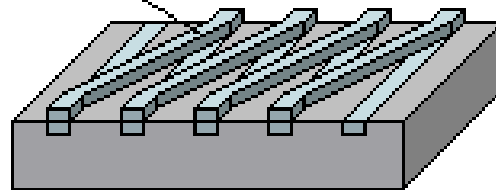
Prior art

Surface inductor



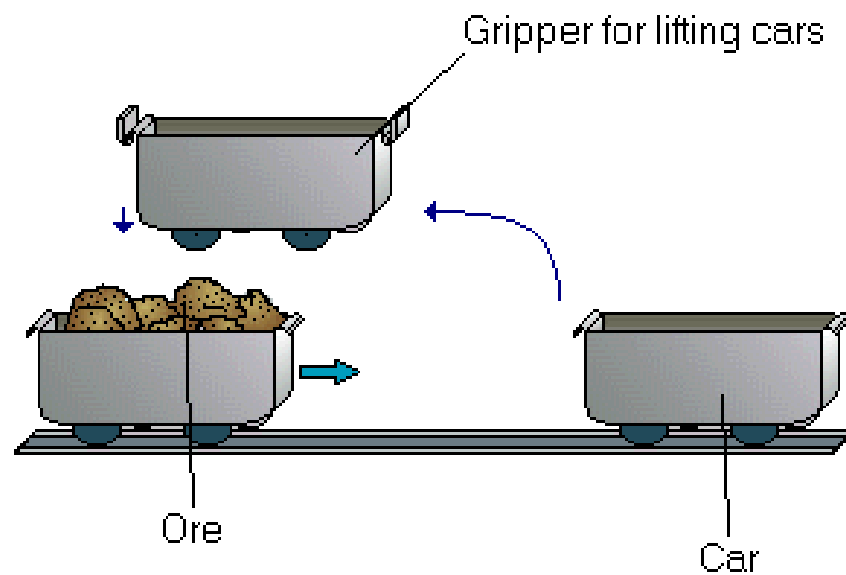
New art

Vertical trench inductor



- ◆ United States Patent 5 372 967 Date of Patent: Dec. 13, 1994
Motorola Inc, Schaumburg, Ill., USA

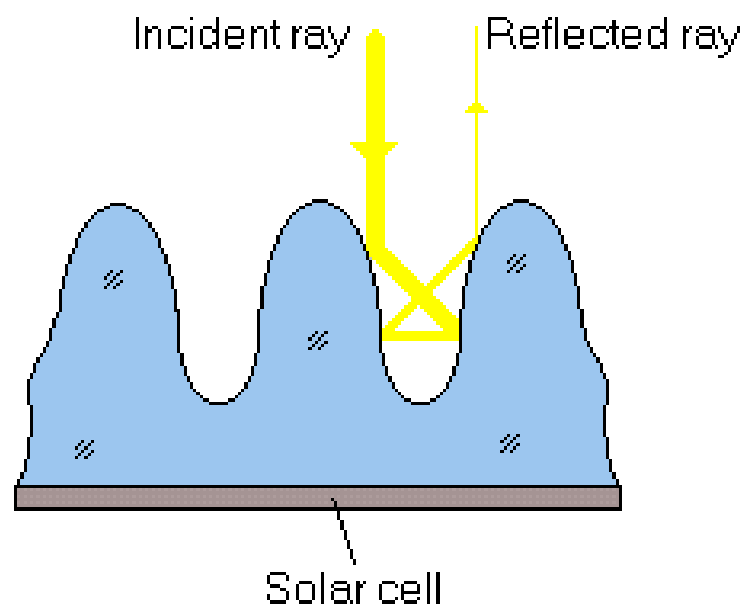
礦坑中錯車



礦坑中錯車需要較大空間，
崩坑危險增加。

利用吊車由上方錯車。

提高光電池效率

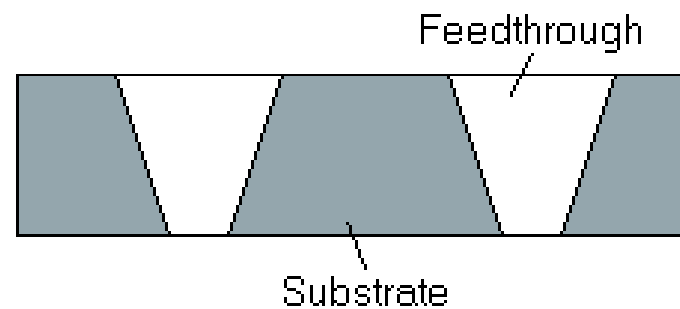


平面光電池因反射作用
浪費許多光能。

立體化增加光能吸收
效率。

晶圓蝕孔

Prior art



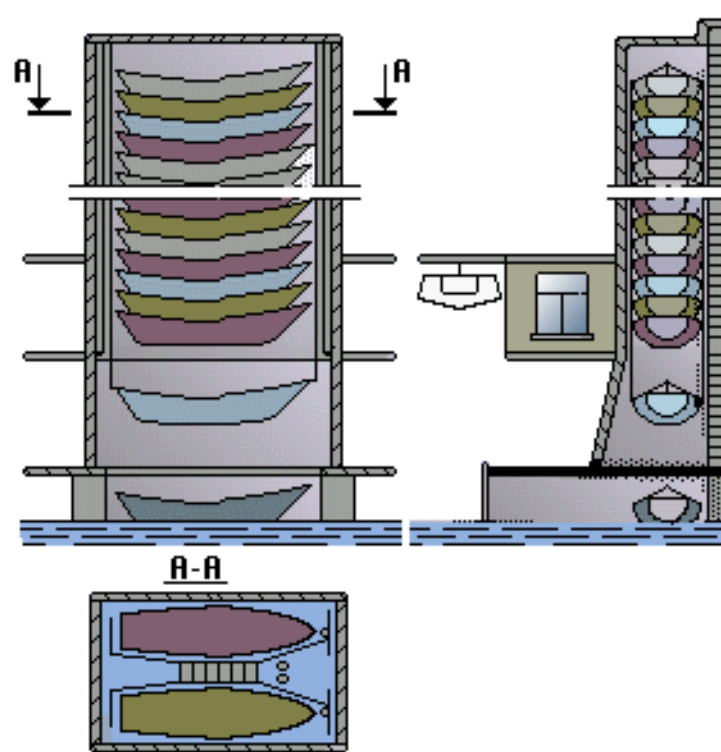
傳統晶圓蝕孔因孔形為倒錐形，密度較低。

New art



由兩面同時蝕孔，可以增加密度。

立體停船



平面停船太占空間。

立體化可以解決這個問題。

Principle 18. Mechanical vibration

- ◆ *Cause an object to oscillate or vibrate.*
 - *Electric carving knife with vibrating blades*
- ◆ *Increase its frequency (even up to the ultrasonic).*
 - *Distribute powder with vibration.*
- ◆ *Use an object's resonant frequency.*
 - *Destroy gall stones or kidney stones using ultrasonic resonance.*
- ◆ *Use piezoelectric vibrators instead of mechanical ones.*
 - *Quartz crystal oscillations drive high accuracy clocks.*
- ◆ *Use combined ultrasonic and electromagnetic field oscillations.*
 - *Mixing alloys in an induction furnace*

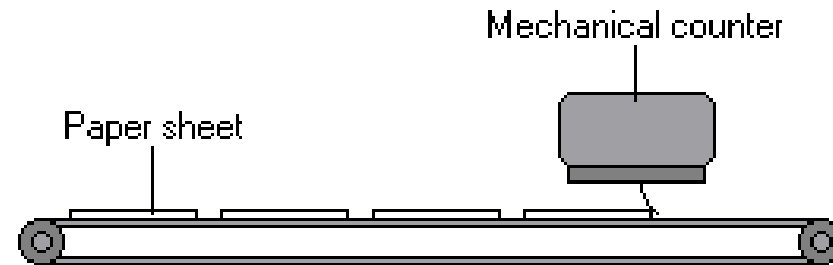
18. 機械振動



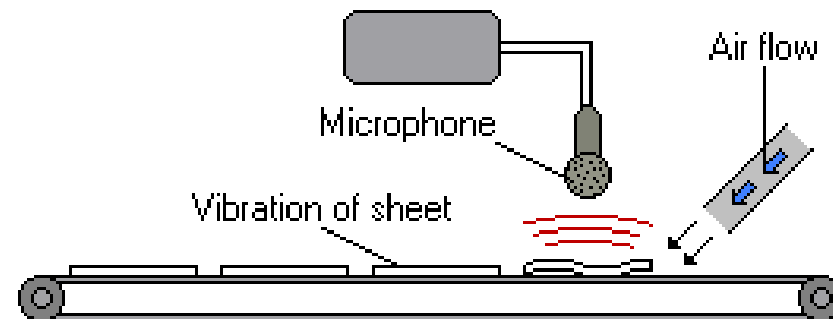
- ◆使物體振動。如果已振動，增加它的頻率，甚至可達到超音速
- ◆利用共振頻率
- ◆使用壓力振動取代機械振動；運用電磁場與超音波振動連結
- ◆例：以振動手術刀取代傳統手鋸；振動鑄造模以改善流動特性

Apparatus for counting articles

Prior art



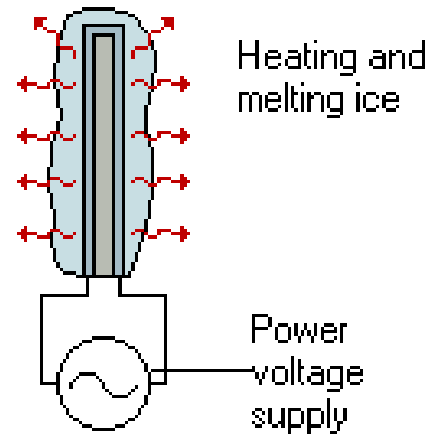
New art



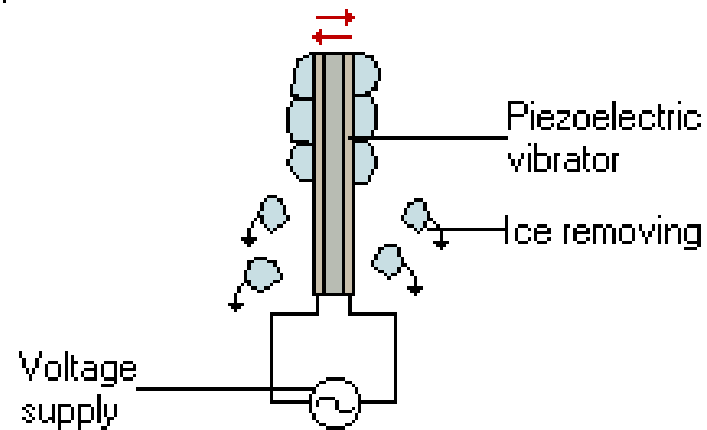
- ◆ United States Patent 5 031 156 Date of Patent: Jul. 9, 1991
EDS Technologies, Inc., Hialeah, Fla., USA

Ice removal from radioelectronic

Prior art



New art

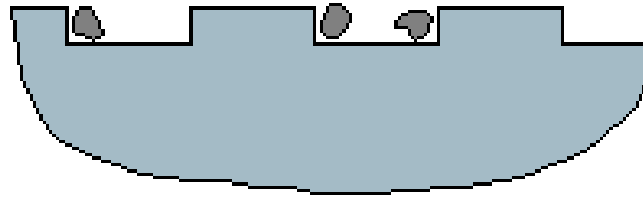


- ◆ United States Patent 5 172 024 Date of Patent: Dec. 15, 1992
Thomson-CSF, Puteaux, France

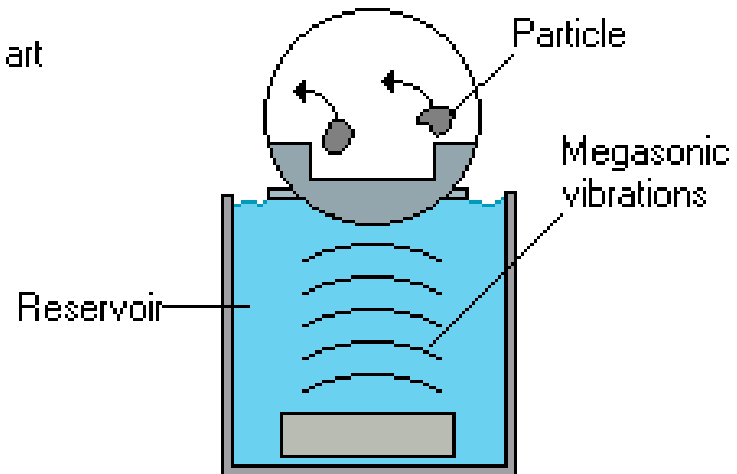
Megasonic cleaning

Prior art

Usual liquid cleaning



New art



- ◆ United States Patent 5 339 842 Date of Patent: Aug. 23, 1994
Specialty Coating Systems, Inc., Indianapolis, Ind.

Principle 19. Periodic action

- ◆ Instead of continuous action, use periodic or pulsating actions.
 - *Hitting something repeatedly with a hammer*
 - *Replace a continuous siren with a pulsed sound.*
- ◆ If an action is already periodic, change the periodic magnitude or frequency.
 - *Use Frequency Modulation to convey information, instead of Morse code.*
 - *Replace a continuous siren with sound that changes amplitude and frequency.*
- ◆ Use pauses between impulses to perform a different action.
 - *In cardio-pulmonary respiration (CPR) breathe after every 5 chest compressions.*

19. 周期性動作



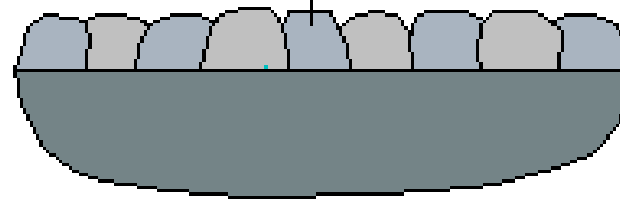
- ◆ 以週期性的動作或脈衝取代連續動作
- ◆ 如果已經走週期性的動作，改變它的頻率
- ◆ 在脈衝間暫停以提供額外的動作
- ◆ 例：用扳手以衝擊方式將已腐蝕的螺帽鬆開比連續施力要好；警告燈以閃光方式比連續開亮著更引人注意

Doped poly-si film deposition

Prior art

Deposition and doping

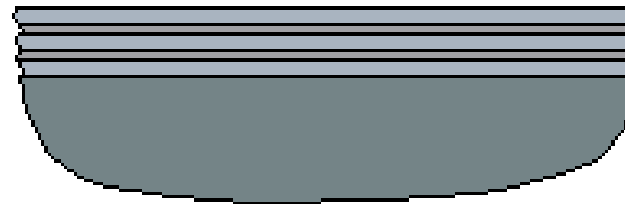
Nonuniform doped poly-Si



silane, arsine

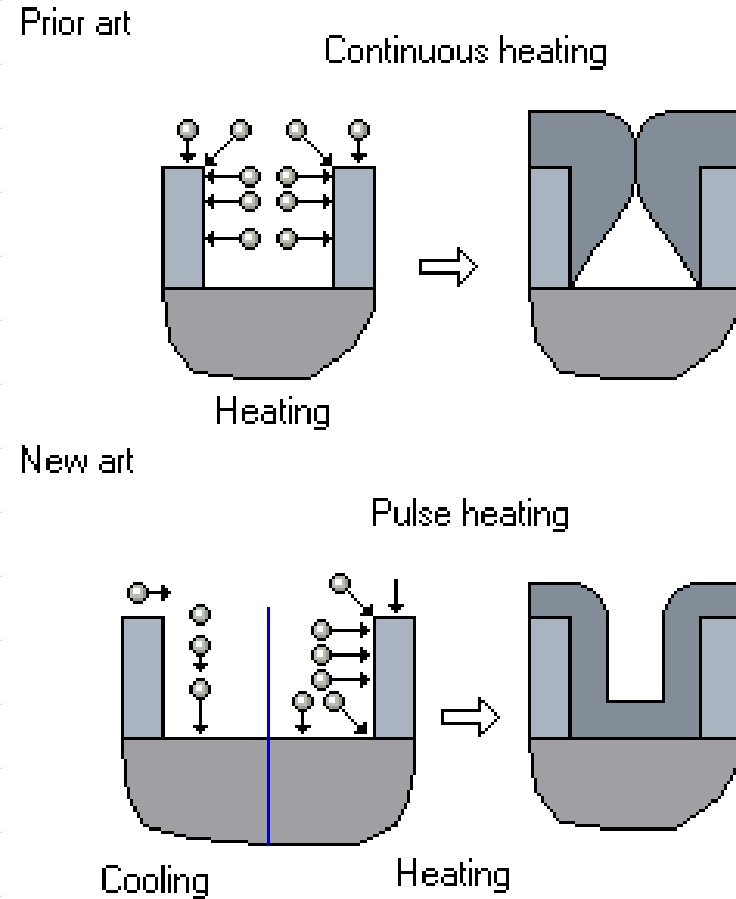
New art

Uniform doped poly-Si



- ◆ United States Patent 5 332 689 Date of Patent: Jul. 26, 1994
Micron Technology, Inc., Boise, USA

Pulsed chemical vapor deposition



- ◆ United States Patent 5 227 331 Date of Patent: Jul. 13, 1993
Micron Technology, Inc., Boise. Id.

Principle 20. Continuity of useful action

- ◆ Carry on work continuously; make all parts of an object work at full load, all the time.
 - *Flywheel (or hydraulic system) stores energy when a vehicle stops, so the motor can keep running at optimum power.*
 - *Run the bottleneck operations in a factory continuously, to reach the optimum pace. (From theory of constraints, or takt time operations)*
- ◆ Eliminate all idle or intermittent actions or work.
 - *Print during the return of a printer carriage--dot matrix printer, daisy wheel printers, inkjet printers.*

20.有效動作的連續性



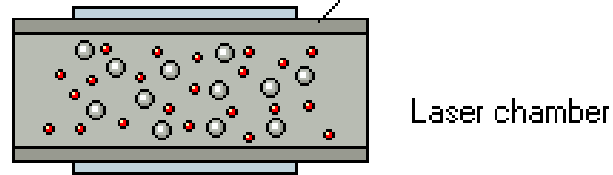
- ◆ 不間斷的完成一個動作——一個物體的所有零件應該全力的作業
- ◆ 移除開無益及中間的動作
- ◆ 例：具有銳利刀口的鑽頭允許切削過程中正轉及反轉

Layer cross-flow gas system

Prior art

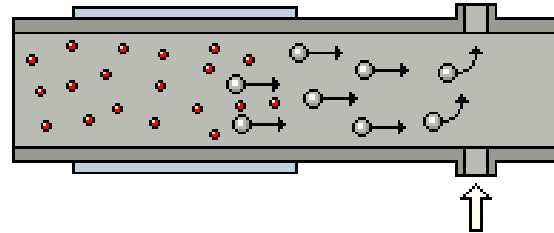
Contamination

Active metal vapor



New art

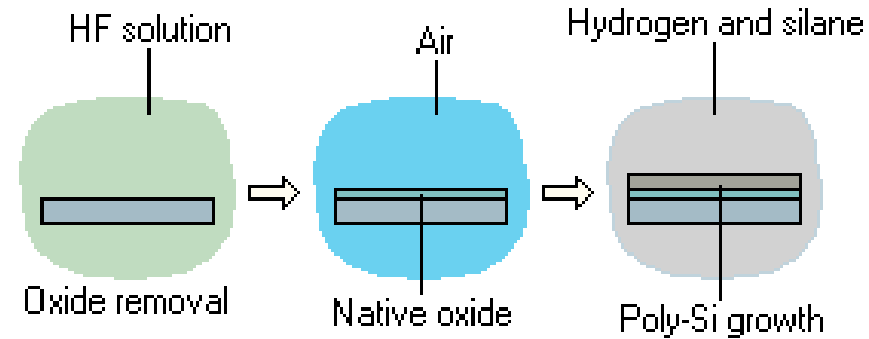
Gas flow



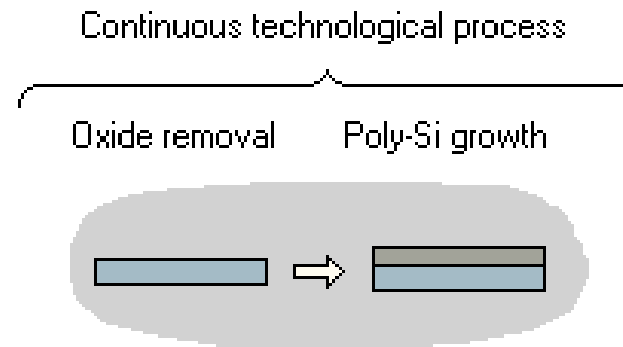
- ◆ United States Patent 5 166 947 Date of Patent: Nov. 24, 1992 The United States of America as represented by the United States Department of Energy, Washington, D.C.

Low defect polysilicon layer

Prior art

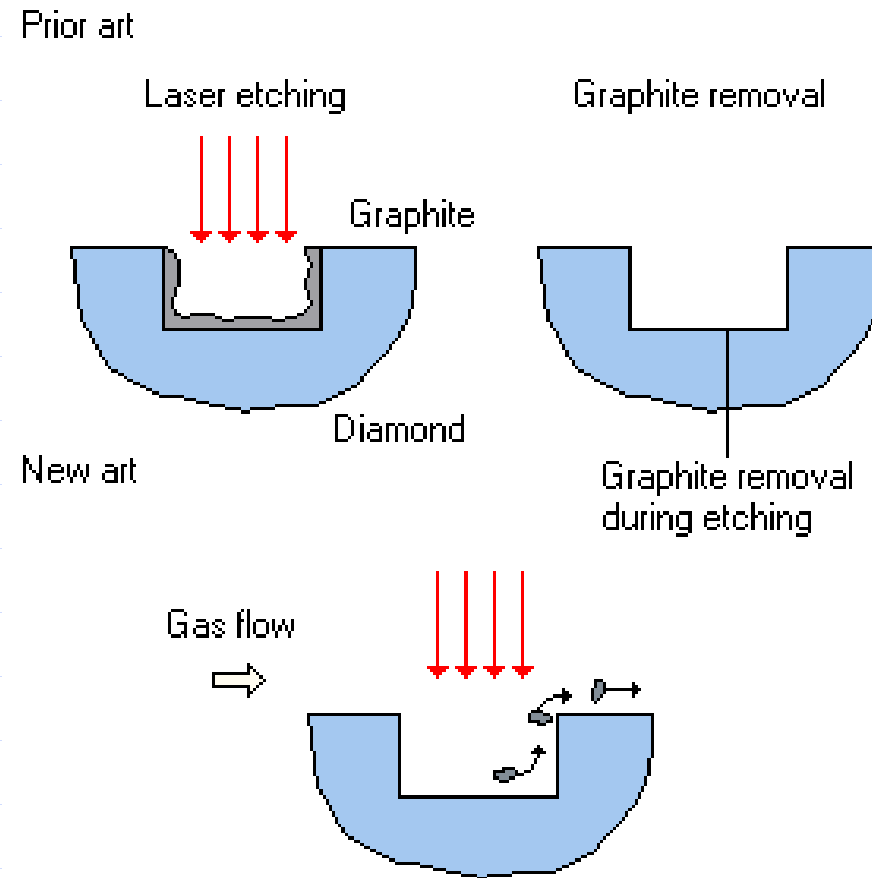


New art



- ◆ United States Patent 4 981 811 Date of Patent: Jan. 1, 1991 AT&T Bell Laboratories, Murray Hill, N. J.

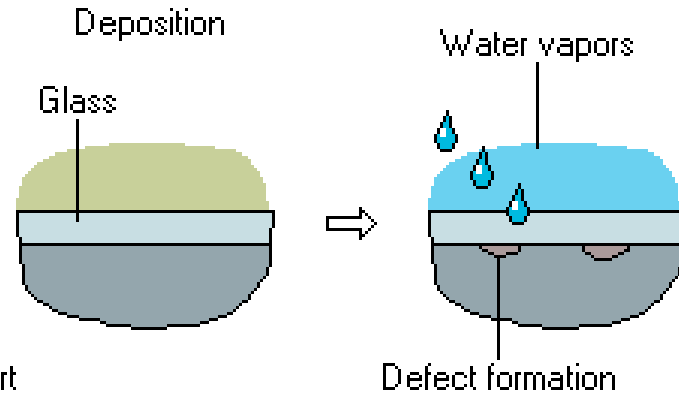
Suppression of graphite formation



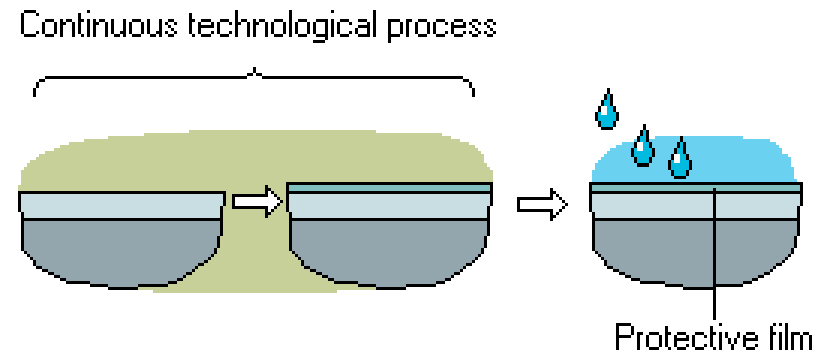
- ◆ United States Patent 5 334 280 Date of Patent: Aug. 2, 1994 General Electric Company, Schenectady, N.Y. US

Suppression of water vapor absorption

Prior art



New art



- ◆ United States Patent 5 094 984 Date of Patent: Mar. 10, 1992
Hewlett-Packard Company, Palo Alto, Calif.

Principle 21. Skipping

- ◆ Conduct a process , or certain stages (e.g. destructible, harmful or hazardous operations) at high speed.
 - *Use a high speed dentist's drill to avoid heating tissue.*
 - *Cut plastic faster than heat can propagate in the material, to avoid deforming the shape.*

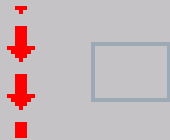
21. 急速通過



- ◆ 在高速下完成有害或危險的操作
- ◆ 例：薄壁塑膠管的切割器為了避免塑膠管變形，在切割時以高速進行（在管子有機會變形前切斷）

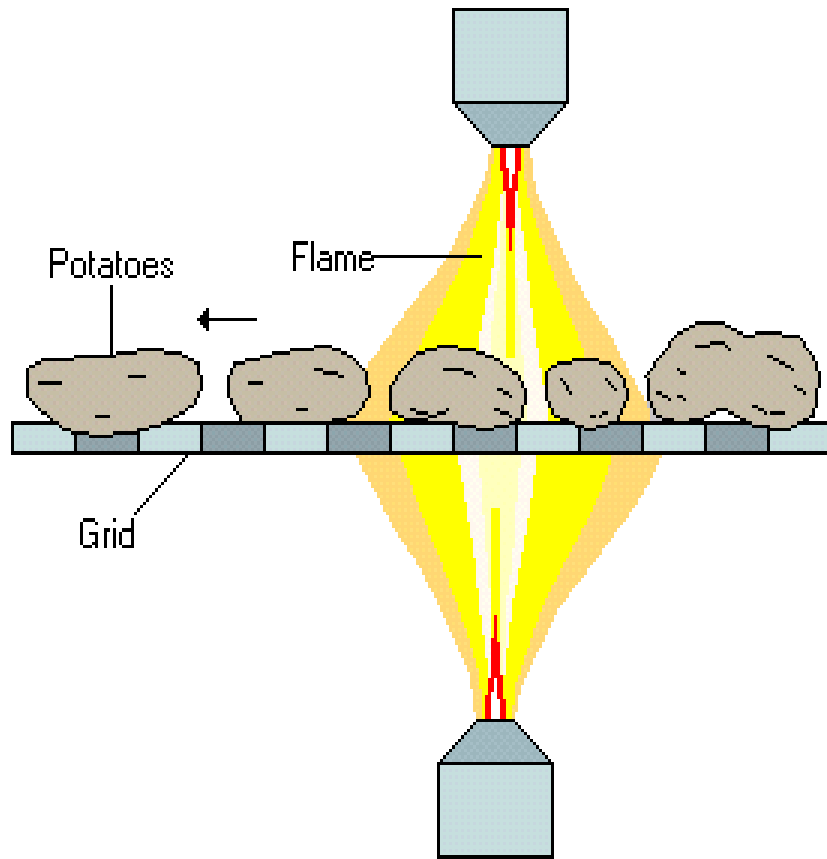
21. HURRYING

- ◆ 在高速中執行一個程序或是某個有破壞性、有害、危險的作業階段



Skip 'bad' action

? conduct a process, or certain stages (e.g. destructive, harmful or hazardous operations) at high speed.



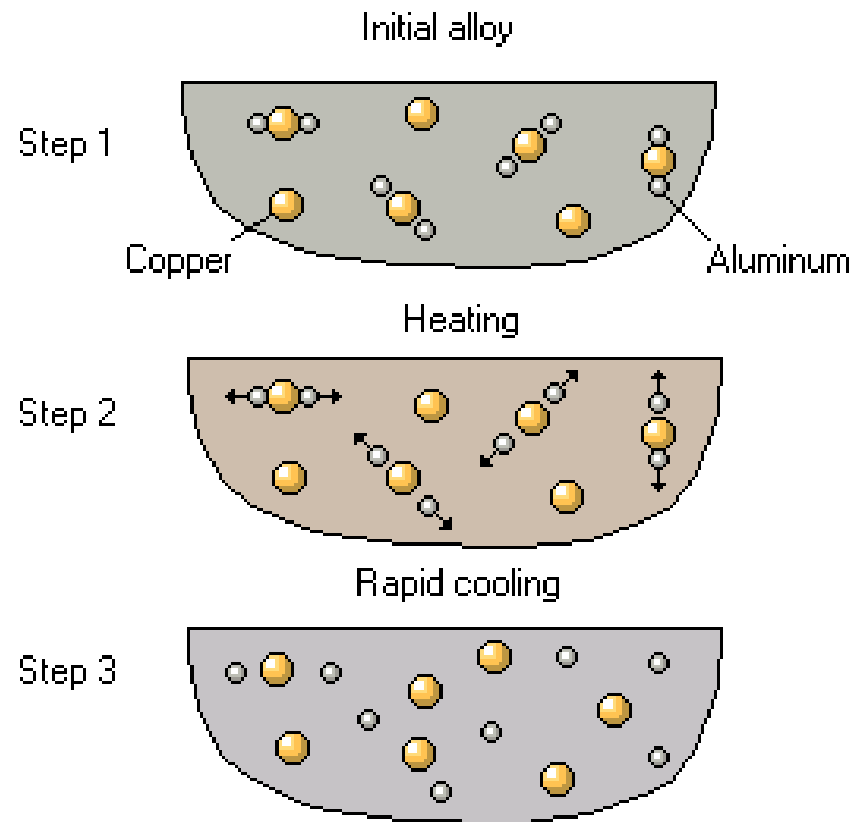
DISINFECTING POTATOES

How might one increase the storage time of a potato, if traditional methods were not adequate?

It is proposed to expose potatoes to a flame (900 deg.C) for no more than 8 seconds.

The result is a completely disinfected potato surface and a longer shelf life.

A.C. No. 1 114 365



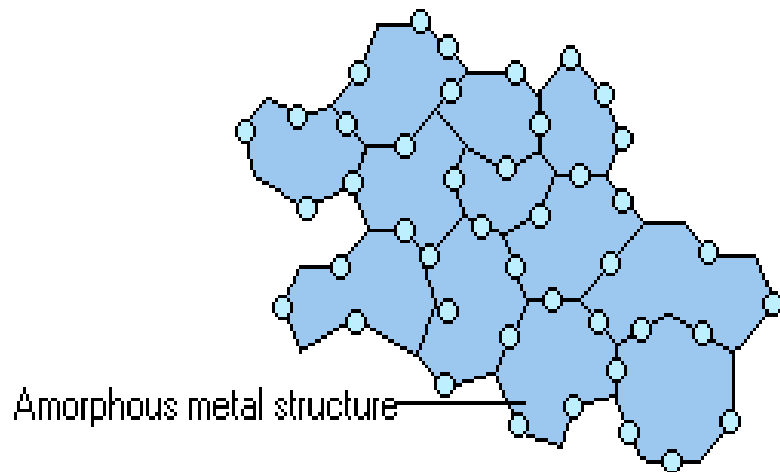
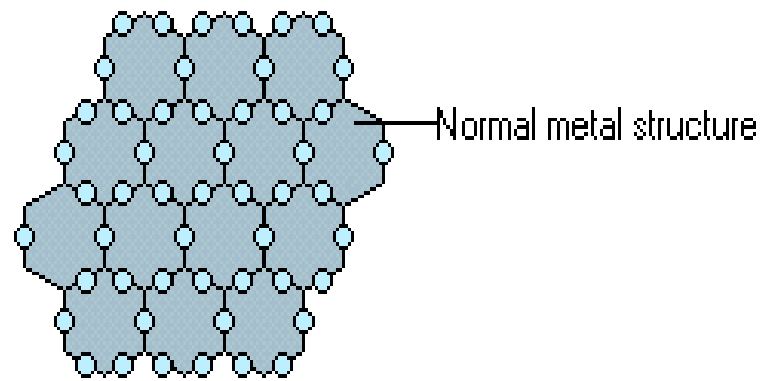
ELIMINATION OF METAL VOID FORMATION

The undesirable Al_3Cu compound in the aluminum/copper alloy causes a spontaneous electrochemical reaction. This results in the Al etching and the formation of voids.

It is proposed to heat the alloy to the compound disintegration temperature, and then to quickly cool it thereby avoiding secondary chemical interactions between alloy components.

Heating the alloy results in Al_3Cu disintegration. During quenching down to room temperature, the undesirable chemical compound has no time to be formed. This process prevents the future formation of voids.

United States Patent 5 248 384 Date of Patent:
Sep. 29, 1993 Taiwan Semiconductor
Manufacturing Company, Hsin-Chu, Taiwan

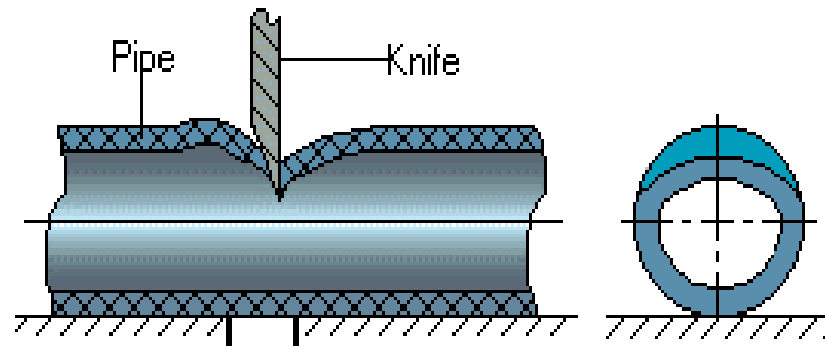


GLASS-LIKE METAL

Ordinary metals at room temperature have a crystalline structure. If a metal melt is cooled at a high rate (about 10^4 K/s), there is no time for crystals to form and the resulting metal is an amorphous substance like glass.

Metallic glass made in this way features high strength combined with plasticity and resistance to corrosion stability.

Physical Encyclopedic Dictionary. Moscow, Sovetskaya Entsiklopedia Publishers, 1983

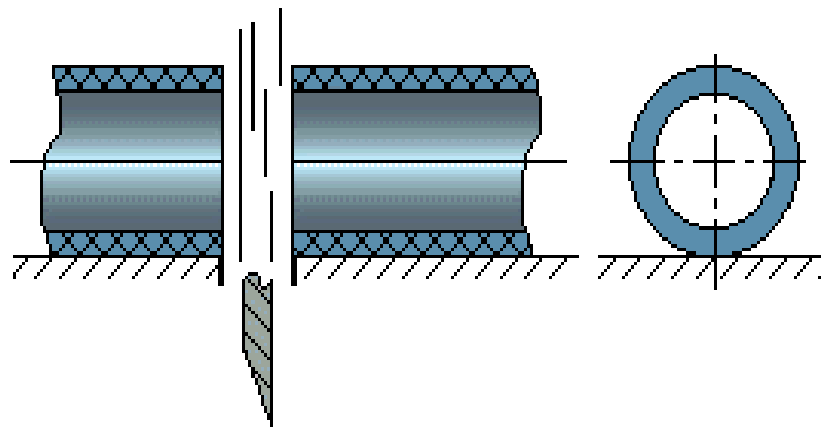


HIGH-SPEED DISSECTION OF PIPES

Conventional tools used to cut thin-walled, large-diameter plastic pipes have a significant disadvantage in that the pipe is deformed and over stressed.

A similar device [is proposed](#) using the skip principle. The knife is designed to slice so quickly that the pipe (having a certain mass inertia) has no time to deform.

DE Patent N 1 134 821



Principle 22. “Blessing in disguise” or “turn Lemons into Lemonade”

- ◆ Use harmful factors (particularly, harmful effects of the environment or surroundings) to achieve a positive effect.
 - *Use waste heat to generate electric power.*
 - *Recycle waste (scrap) material from one process as raw materials for another.*
- ◆ Eliminate the primary harmful action by adding it to another harmful action to resolve the problem.
 - *Add a buffering material to a corrosive solution.*
 - *Use a helium-oxygen mix for diving, to eliminate both nitrogen narcosis and oxygen poisoning from air and other nitrox mixes.*
- ◆ Amplify a harmful factor to such a degree that it is no longer harmful.
 - *Use a backfire to eliminate the fuel from a forest fire.*

22. 將害處轉換成益處

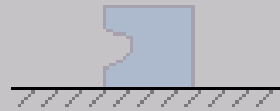


- ◆ 利用環境上的有害因素或效應以獲得一個正面的效應
- ◆ 以再加上另一有害因素，移除原有的有害因素
- ◆ 增加有害動作的量直到它停止造成傷害
- ◆ 例：當砂或碎石在冷天運輸時會凝固變硬，同液態氮使它過度凝固使它變脆而可傾倒灌注

22. Blessing in disguise (善意的偽裝)

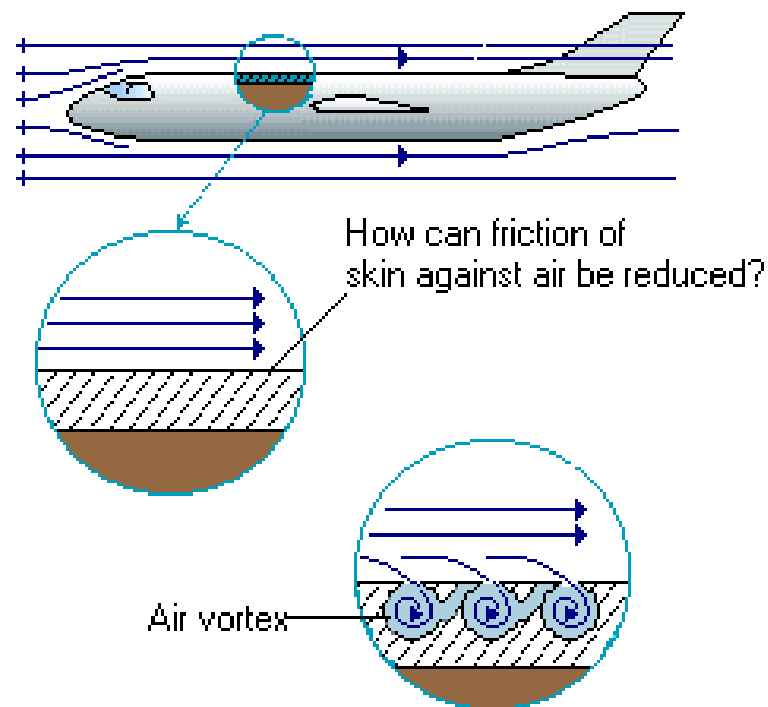
Convert Harm into Benefit 轉變害處為利處

- ◆ 使用一個有害的元素(特別是對周圍環境有害的效果),一個不同的方法去達到正向的效果
- ◆ 消滅原本有害的行為,靠加入它至其他有害的行為中去解決這個問題
- ◆ 擴大一個有害的元素一定的程度,使它不能持續產生有害的影響



Arrange 'bad' action
to get good

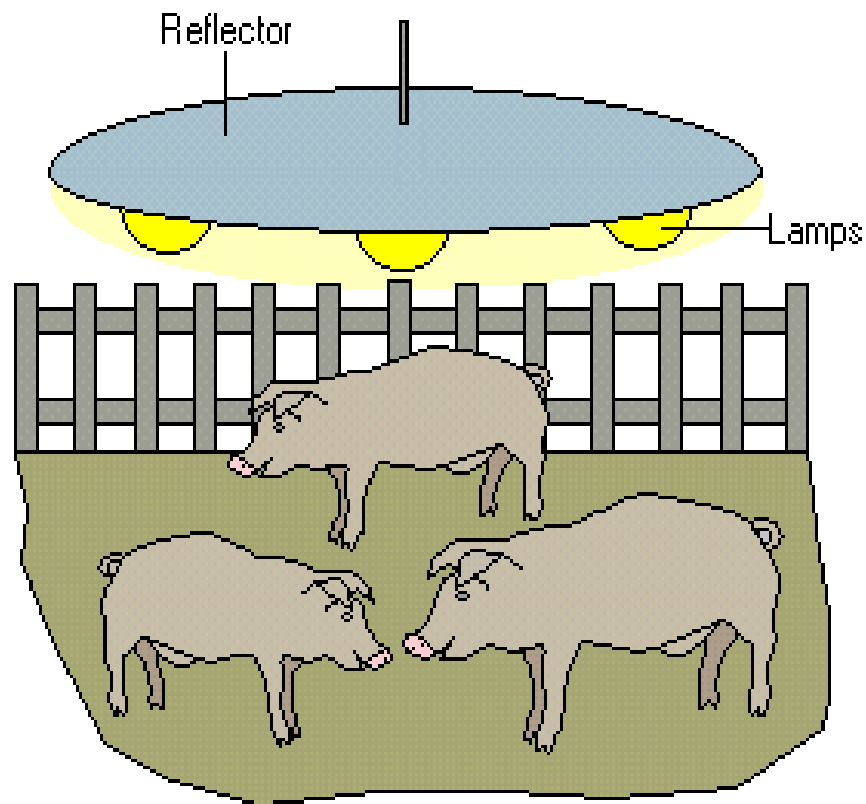
? use harmful factors (particularly, effects harmful to the environment or surroundings) a different way to achieve a positive effect,
? eliminate the primary harmful action by adding it to another harmful action to resolve the problem,
? amplify a harmful factor to such a degree that it is no longer harmful.



AIR LUBRICANT PARADOX

In aerodynamics, the phenomena known as skin friction drag is caused by air flow 'touching' the skin of the aircraft. How can one reduce the friction of an airplane skin against air?

It is proposed to use the blessing in disguise principle to reduce skin friction. One can intensify the 'touching' to the extent that the air flow enters the skin (a condition that would seem to increase the friction). For this to occur, the straight-line motion of the air along the skin must be changed into a rotary motion in the skin. Lateral cylindrical slots are formed in the skin that communicate with the atmosphere via narrow slits. Upon entering these, air is forced to rotate at a high speed forming vortex rings. These rings force approaching airflow away from the skin thereby serving as a kind of air lubricant, the blessing in disguise. The fabrication of this skin design,



LAMPS-HEATERS

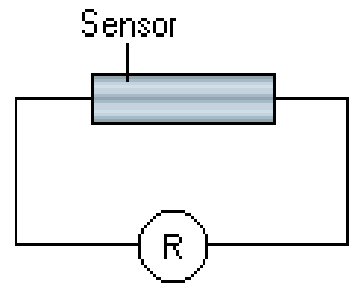
Modern incandescent lamps transform 5 to 6 percent of electric energy into visible light, while the remaining energy is lost in the form of heat radiation.

It is proposed to use incandescent lamps for heating and illuminating cages of young stock.

The parameter of the lamps can be selected so that the highest intensity of the light radiation is produced. Such lamps not only illuminate but also generate a lot of heat.

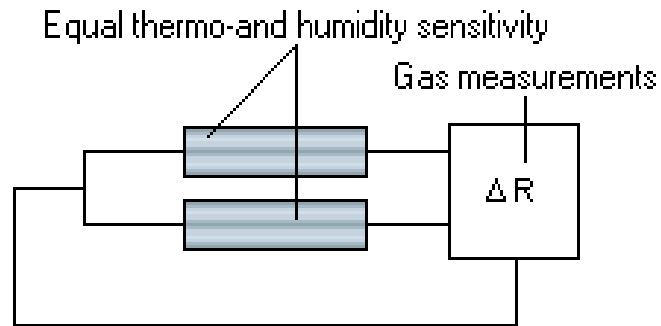
Agricultural Encyclopedia. Moscow, 1991

Prior art



Gas+temperature+humidity measurements

New art



COMBINED SEMICONDUCTOR GAS SENSOR

Gas sensors based on one gas-sensitive material have poor thermal and humidity stability.

It is proposed to form a gas sensor element from two materials with different gas sensitivities but the same thermal and humidity sensitivity.

Gas concentrations in this sensor are measured by the difference in resistance of two materials. Therefore, equal increments in the absolute value of resistance that are caused by temperature and humidity are mutually destroyed.

United States Patent 5 298 783 Date of Patent: Mar. 29, 1994 Yunnan University, China

Principle 23. Feedback

- ◆ Introduce feedback (referring back, cross-checking) to improve a process or action.
 - *Automatic volume control in audio circuits*
 - *Signal from gyrocompass is used to control simple aircraft autopilots.*
 - *Statistical Process Control (SPC) -- Measurements are used to decide when to modify a process. (Not all feedback systems are automated!)*
 - *Budgets --Measurements are used to decide when to modify a process.*
- ◆ If feedback is already used, change its magnitude or influence.
 - *Change sensitivity of an autopilot when within 5 miles of an airport.*
 - *Change sensitivity of a thermostat when cooling vs. heating, since it uses energy less efficiently when cooling.*
 - *Change a management measure from budget variance to customer satisfaction.*

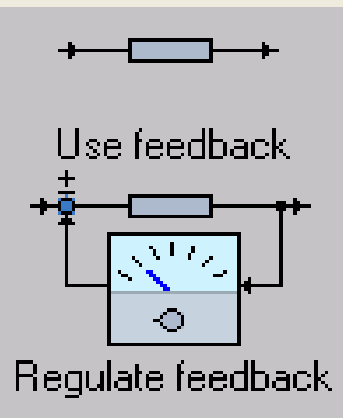
23. 回饋



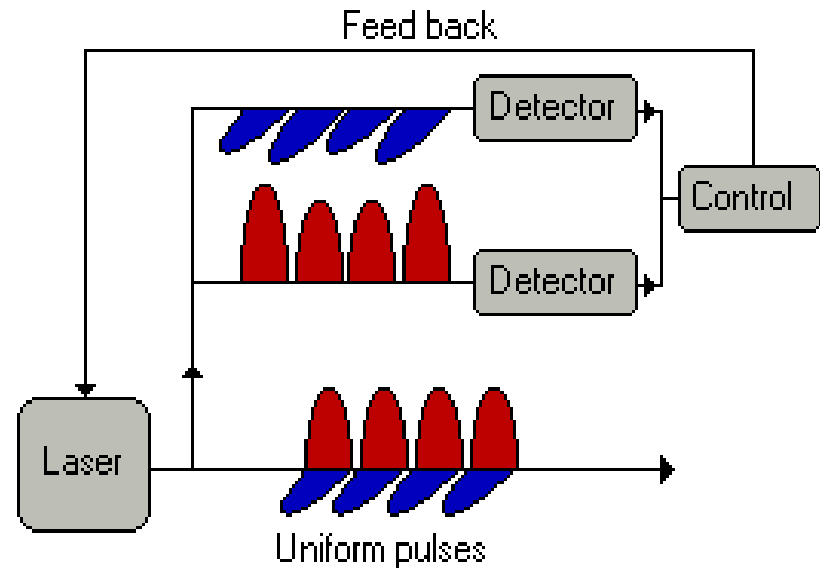
- ◆ 採用回饋
- ◆ 如果回饋已存在，將它反轉
- ◆ 例：檢測輸出壓力以維護水井的水壓，如果壓力太低就打開泵；噪音消除設備抽樣噪音訊號，改變它們的相位並回回去以消除噪音源的效應

23.Feedback(回授)

- ◆ 傳入一個回授(referring back,cross-checking),去改善它的過程或行為
- ◆ 假如已經使用了一個回授系統,則去改變它的大小和影響



? introduce feedback (referring back , cross-checking) to improve a process or action,
? if feedback is already used , change its magnitude or influence.



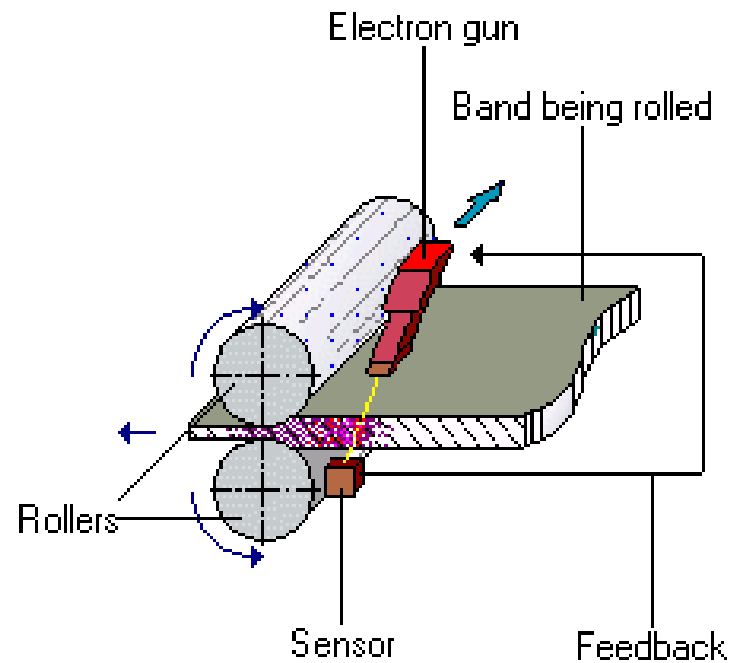
LASER OUTPUT STABILIZATION

Laser light polarization changes randomly from pulse to pulse. It results in undesirable variations in laser beam energy.

It is proposed to use feedback to control the output energy of the laser radiation.

Polarized laser radiation is divided into two orthogonal components. The energy of each component is measured, and their sum is compared to a certain value. The energy of the output beam is then controlled based on the result of the comparison.

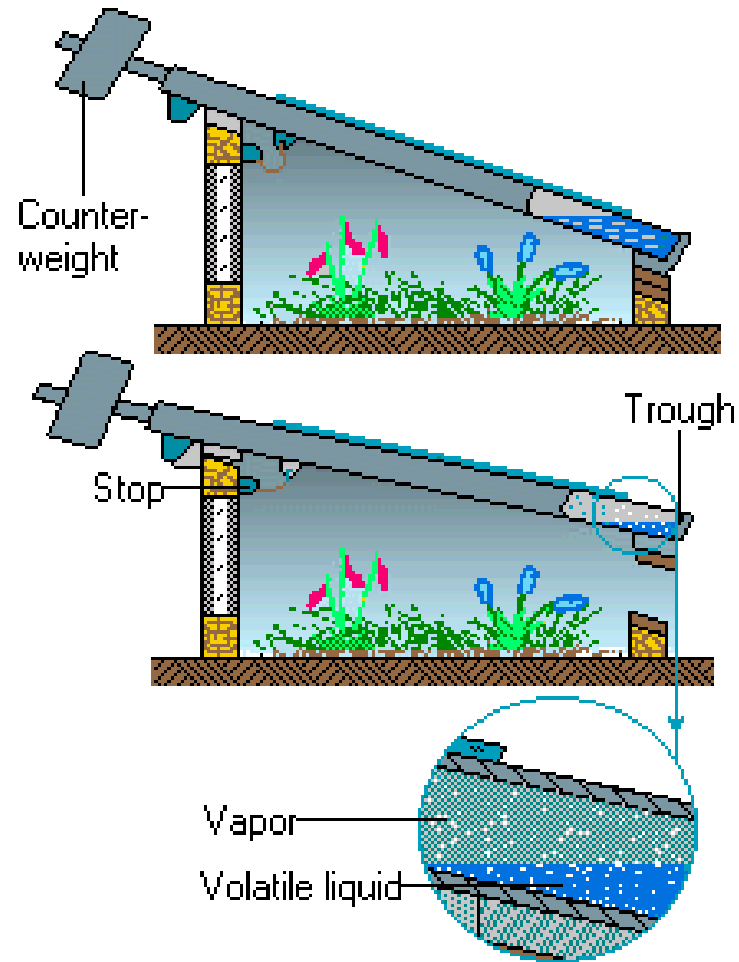
United States Patent 4 949 345 Date of Patent: Aug. 14, 1990 Microelectronics and Computer Technology Corporation, Austin, Tex., USA



ROLLING MILL THICKNESS CONTROLLER

To control the thickness of a rolled metal band, it is important to control its temperature. The final thickness obtained is a function of both the temperature and the thickness of sheet approaching the roller.

It is proposed to use the feedback principle to control output thickness. One can couple the thickness of sheet approaching the rollers to the feed velocity under the heater (electron gun) and thereby, the input band temperature. Electrons passing through the band are monitored by sensors. The thicker the band, the lower the intensity of radiation received. This signals a slower feed velocity under the electron beam, causing more intense heating of the band. This feedback control improves the dimensional precision of the thickness of rolled sheet at the output.



ADAPTIVE GREENHOUSE FRAMES

Can one design a greenhouse that adapts to abrupt changes of temperature? This requires an automatic opening and closing roof section.

It is proposed to use the principles of phase transitions, feedback, self-service and change of parameters to design the adaptive greenhouse. The roof section frames are made from hollow pipes with an evaporating liquid inside. The section center of gravity changes with temperature, causing the frame to rotate up or down automatically. Water collection pans act as weights at the lip to make sure the frame closes during rain or hail storms. The greenhouse thereby responds automatically to changes of weather.

SU A.c. N 463 423

Principle 24. 'Intermediary'

- *Use an intermediary carrier article or intermediary process.*
 - ◆ *Carpenter's nailset, used between the hammer and the nail*
- *Merge one object temporarily with another (which can be easily removed).*
 - ◆ *Pot holder to carry hot dishes to the table*

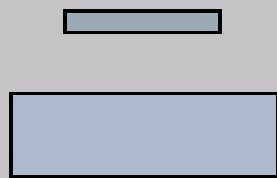
24. 中介物



- ◆ 利用一個中間物體去轉換或完成一個動作
- ◆ 暫時地將一個物體和另一個連接在一起以方便將它移除
- ◆ 例：當通電流於液態金屬時為減少能源損失，使用冷的電極和具較低融溶溫度的中間液態金屬

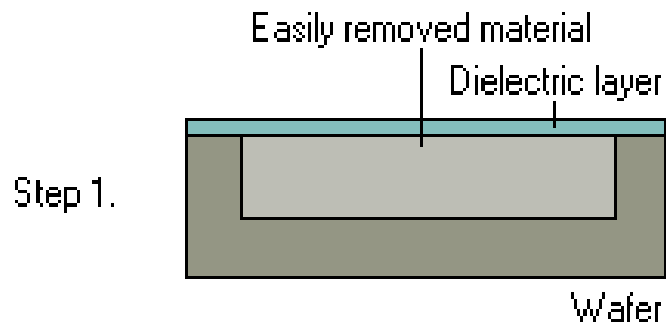
24. Intermediary (Mediator) 媒介

- ◆ 使用中間型的運送物或是中間體的一個過程
- ◆ 合併一個暫存的物體和其他的物體(可以很輕易移動者)



Control action
by intermediary

? use an intermediate carrier article or intermediary process,
? merge one object temporarily with another (which can be easily removed).



CAVITY FORMATION IN A WAFER

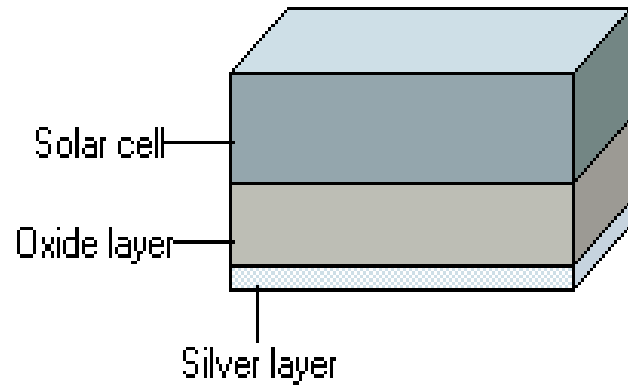
A thin film overlying a cavity cannot be formed by film deposition on a wafer surface with a hollow.

It is proposed to fill the hollow with easily removed material before thin film deposition, and then to remove this material through an opening in the backside of the wafer.

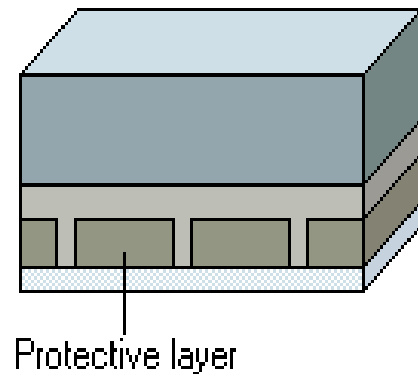
Hollow filling provides a planar wafer surface and the possibility for thin film deposition. Using an easily removed material (which differs from the wafer material) allows selective removal without any damage to the wafer.

United States Patent 5 344 523 Date of Patent: Sep. 6, 1994 The Foxboro Company, Foxboro, Mass., USA

Prior art



New art



IMPROVED SOLAR CELL

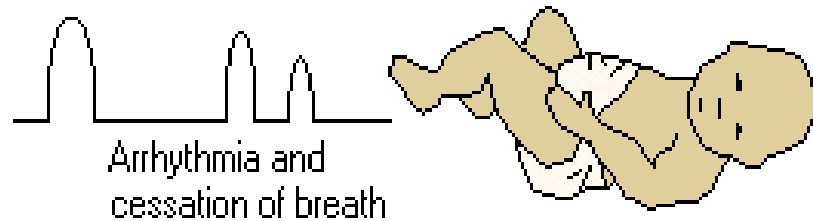
The interaction of oxide and silver inside a light reflector results in solar cell degradation.

It is proposed to insert a protective layer between the silver and oxide parts.

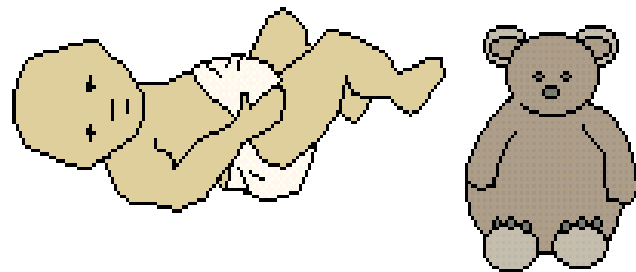
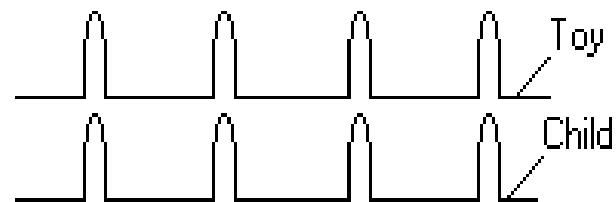
The continuous or discontinuous protective layer prevents undesirable interactions, and allows an unimpeded electrical flow inside the solar cell.

United States Patent 5 221 854 Date of Patent: Jun. 22, 1993 United Solar Systems Corporation, Troy, Mich., USA

Old design



New design



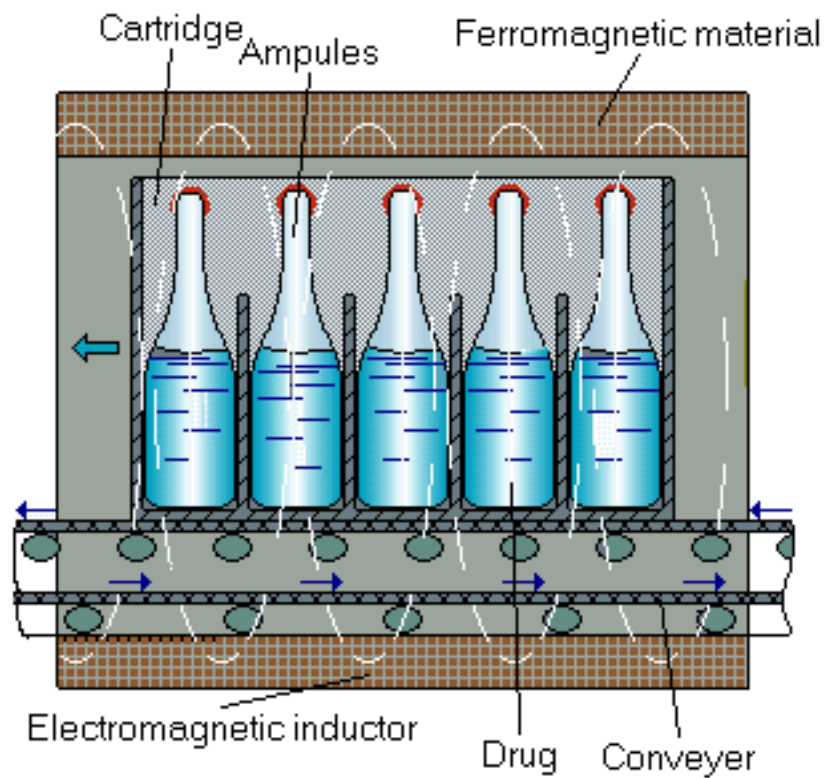
"BREATHING" TOY

New-born children may sometimes start breathing improperly which may cause disability or even death.

A proposed solution to improve breathing requires the use of a toy-bear that "breathes" with a preset rhythm. The properly "breathing" toy tunes the child to the correct rhythm.

US. California University. Institute of Medical Technology. Nauka I Technika No.8, 1983

藥瓶封口



加熱封口會影響藥質。

用磁性物質加在玻璃瓶口，
用電磁感應加熱。加熱超過居量點後磁性消失，即不再加熱。

Principle 25. Self-service

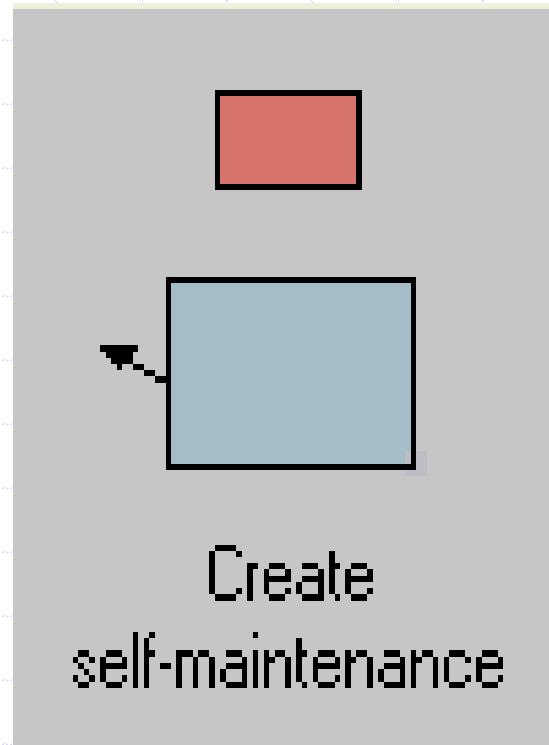
- ◆ Make an object serve itself by performing auxiliary helpful functions
 - *A soda fountain pump that runs on the pressure of the carbon dioxide that is used to "fizz" the drinks. This assures that drinks will not be flat, and eliminates the need for sensors.*
 - *Halogen lamps regenerate the filament during use--evaporated material is redeposited.*
 - *To weld steel to aluminum, create an interface from alternating thin strips of the 2 materials. Cold weld the surface into a single unit with steel on one face and copper on the other, then use normal welding techniques to attach the steel object to the interface, and the interface to the aluminum. (This concept also has elements of Principle 24, Intermediary, and Principle 4, Asymmetry.)*
- ◆ Use waste resources, energy, or substances.
 - *Use heat from a process to generate electricity: "Co-generation".*
 - *Use animal waste as fertilizer.*
 - *Use food and lawn waste to create compost.*

25. 自助



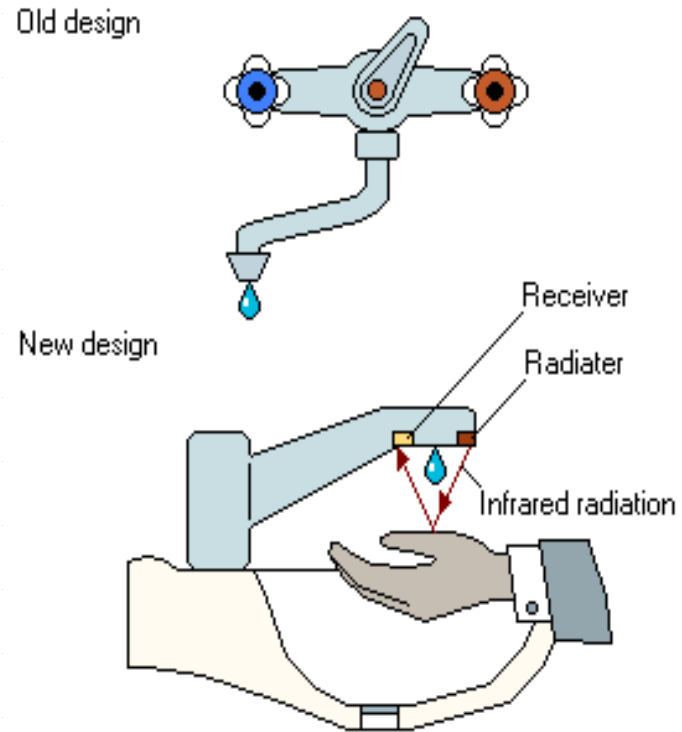
- ◆ 使物體能自己完成補充及修護作業
- ◆ 使材料和能源沒有浪費
- ◆ 例：平坦地將研磨料分布到粉碎滾筒上，為防止供給裝置磨損在其表面也放置相同的研磨材料；電焊槍的焊棒被特殊設備向前推進，為簡化此系統，改成焊棒接電流控制的螺線管推進

25. Self-service



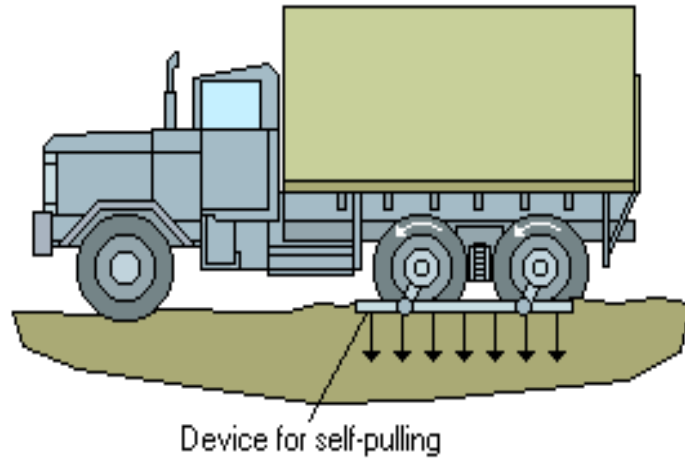
- ◆ make an object serve itself by performing auxiliary helpful functions.

Conserving tap water



The tap design comprises an infrared radiator. Radiation is reflected off a hand on to a receiving device .

Cross country vehicle self-pulling out



When the wheels are rotated synchronously, the device lifts the vehicle and pushes it forward.

Principle 26. Copying

- ◆ Instead of an unavailable, expensive, fragile object, use simpler and inexpensive copies.
 - *Virtual reality via computer instead of an expensive vacation*
 - *Listen to an audio tape instead of attending a seminar.*
- ◆ Replace an object, or process with optical copies.
 - *Do surveying from space photographs instead of on the ground.*
 - *Measure an object by measuring the photograph.*
 - *Make sonograms to evaluate the health of a fetus, instead of risking damage by direct testing.*
- ◆ If visible optical copies are already used, move to infrared or ultraviolet copies.
 - *Make images in infrared to detect heat sources, such as diseases in crops, or intruders in a security system.*

26. 複製



- ◆ 用簡單、便宜的複製品取代複雜、昂貴、易脆、不方便的物體來操作
- ◆ 以光學複製品，光學影像代替一個物體或系統，一個尺度能被用來縮小或放大影像
- ◆ 以紅外線或紫外線複製取代可見光複製
- ◆ 例：物體的高度可由測量它們的陰影面決定

26. Copy



Use object's copy

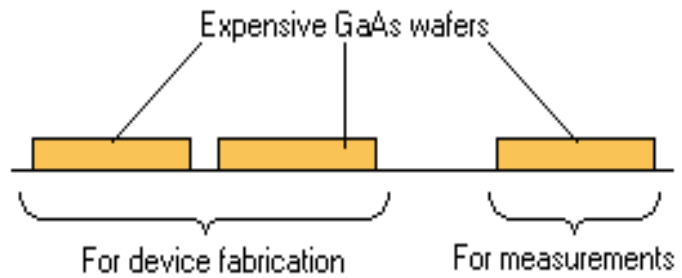


Optical copies

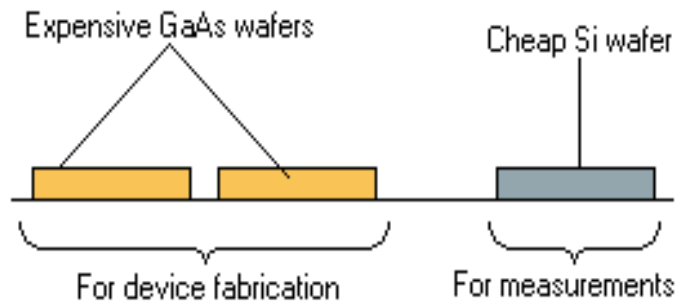
- instead of an unavailable, expensive, fragile object; use simpler and inexpensive copies.

Implanted Ion Measurement

Prior art

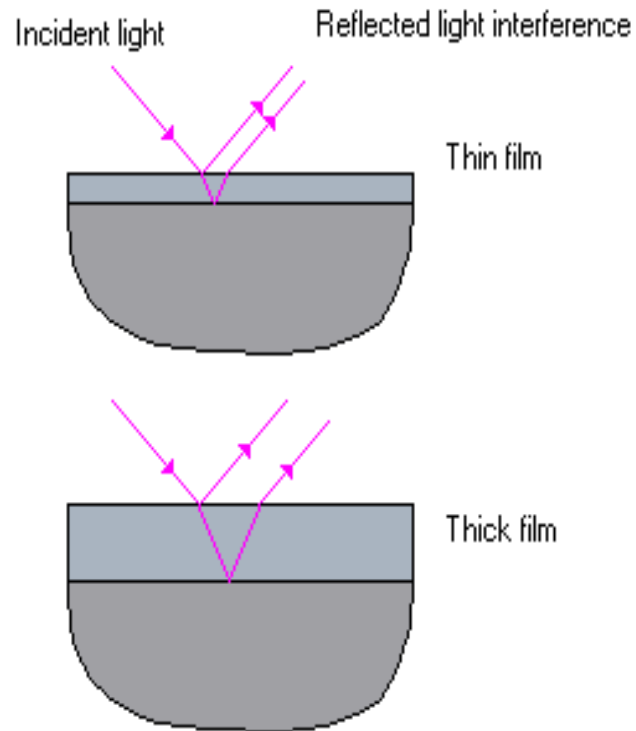


New art



It is proposed to use less expensive silicon wafers for measuring the number of implanted ions.

Plasma process control



The reflected light intensity distribution depends on the film thickness, and is due to interference.

Principle 27. Cheap short-living objects

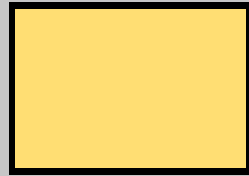
- ◆ Replace an inexpensive object with a multiple of inexpensive objects, comprising certain qualities (such as service life, for instance).
 - *Use disposable paper objects to avoid the cost of cleaning and storing durable objects. Plastic cups in motels, disposable diapers, many kinds of medical supplies.*

27. 便宜壽命短的物體取代



- ◆ 以累積便宜的物體取代昂貴的物體，會危及其它的特性
(如:壽命)
- ◆ 例: · 丟棄式尿布、單次使用的捕鼠器

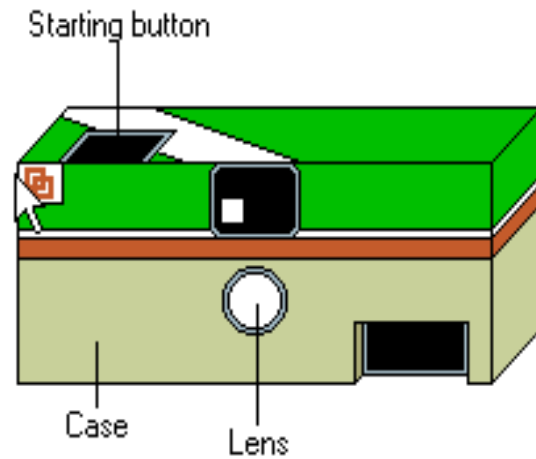
27. Cheap disposables



Use cheap
disposable
objects

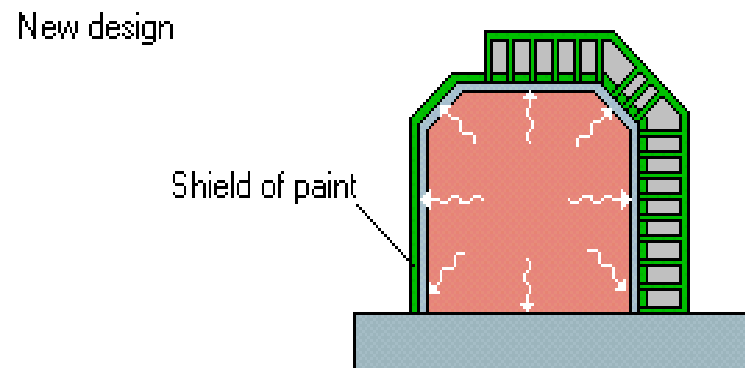
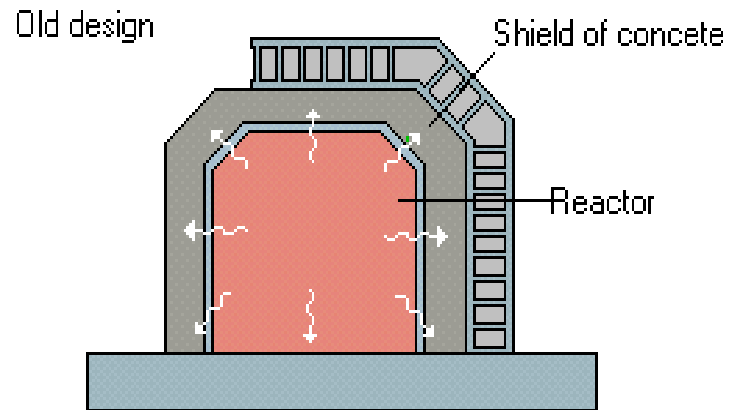
- ◆ replace an expensive object with a multitude of inexpensive objects.

Disposable Camera



The most important parts of the camera is made of plastic while the case is made of cardboard.

Protection with Paint



The paint is made of gadolinium(鈰) and applied to the neutron (中子) radiation source. It forms a shield with a large neutron capture section.

Principle 28 Mechanics substitution

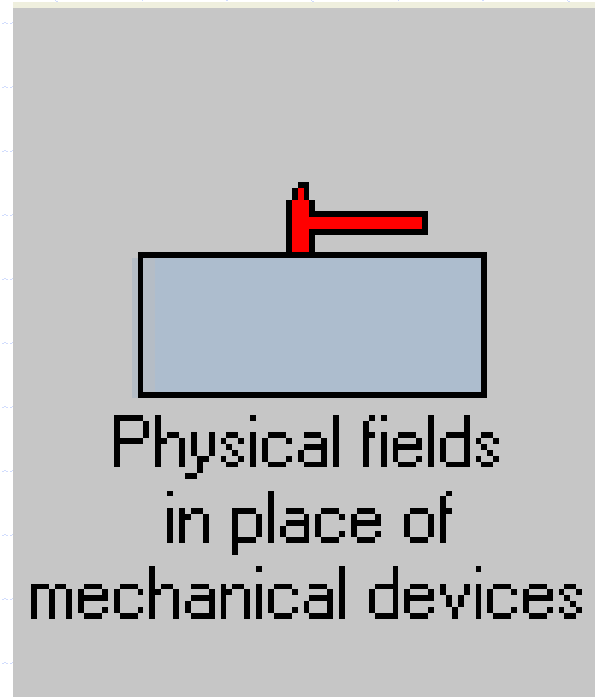
- ◆ Replace a mechanical means with a sensory (optical, acoustic, taste or smell) means.
- ◆ *Replace a physical fence to confine a dog or cat with an acoustic "fence" (signal audible to the animal).*
 - *Use a bad smelling compound in natural gas to alert users to leakage, instead of a mechanical or electrical sensor.*
 - *Use electric, magnetic and electromagnetic fields to interact with the object.*
 - *To mix 2 powders, electrostatically charge one positive and the other negative. Either use fields to direct them, or mix them mechanically and let their acquired fields cause the grains of powder to pair up.*
- ◆ *Change from static to movable fields, from unstructured fields to those having structure.*
 - *Early communications used omnidirectional broadcasting. We now use antennas with very detailed structure of the pattern of radiation.*
- ◆ *Use fields in conjunction with field-activated (e.g. ferromagnetic) particles.*
 - *Heat a substance containing ferromagnetic material by using varying magnetic field. When the temperature exceeds the Curie point, the material becomes paramagnetic, and no longer absorbs heat.*

28. 更換機械系統



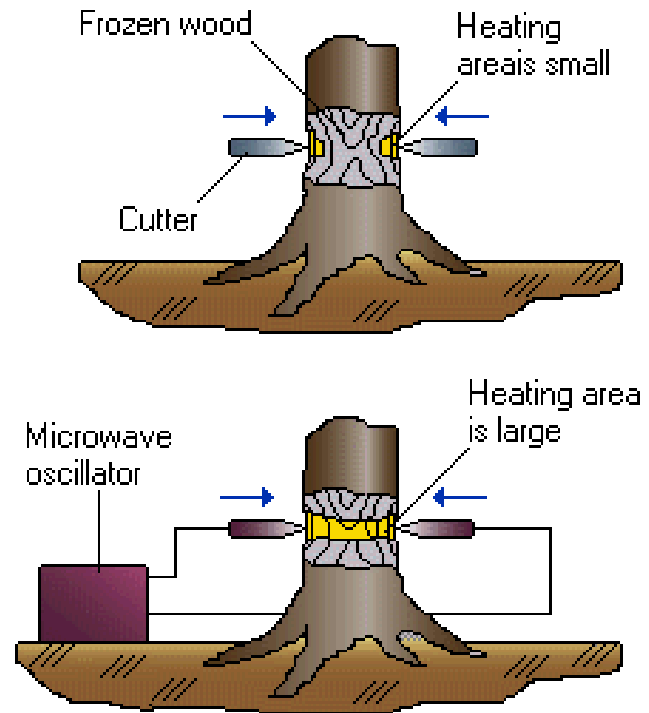
- ◆ 以視覺、聽覺、嗅覺系統取代機械系統
- ◆ 以電場、磁場、電磁場使物體互相影響
- ◆ 更換範疇：不動場和移動場、固定趨向及時改變、從隨意的到結構化的、運用結合了強磁性粒子的場合
- ◆ 例：為了增加金屬和其塗裝的熱塑型材料的結合力，其方式是在金屬施予一個電磁場

28. Mechanical Interaction Substitution

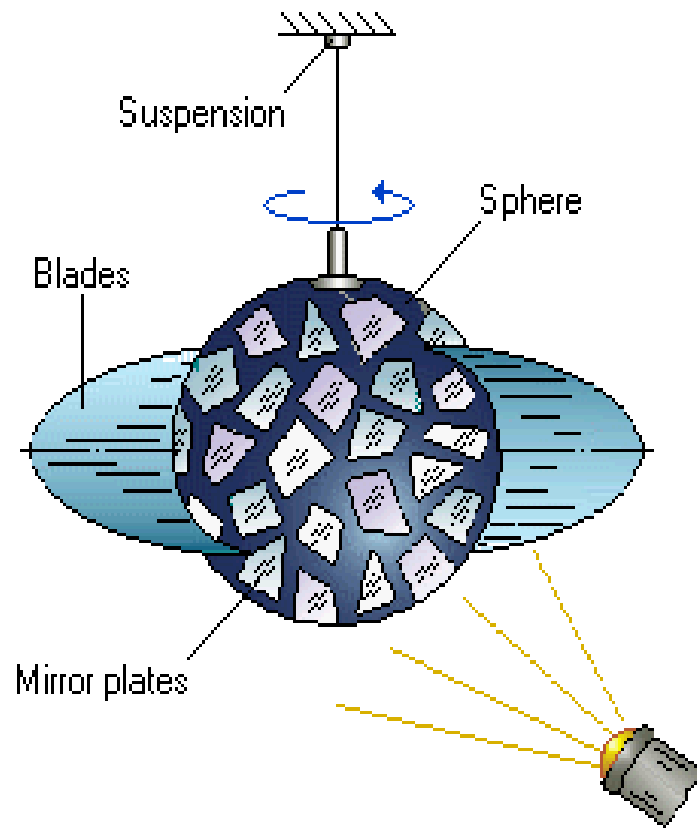


- ◆ use electric, magnetic, and electromagnetic fields to interact with the object.

Cutting with microwave heating



This defrosts the wood and reduces the hardness of the cutting zone by microwave oscillator.



Bright rays are reflected, flashing and changing direction repeatedly, thereby scaring away the birds.

Principle 29. Pneumatics and hydraulics

- ◆ Use gas and liquid parts of an object instead of solid parts (e.g. inflatable, filled with liquids, air cushion, hydrostatic, hydro-reactive).
 - *Comfortable shoe sole inserts filled with gel*
 - *Store energy from decelerating a vehicle in a hydraulic system, then use the stored energy to accelerate later.*

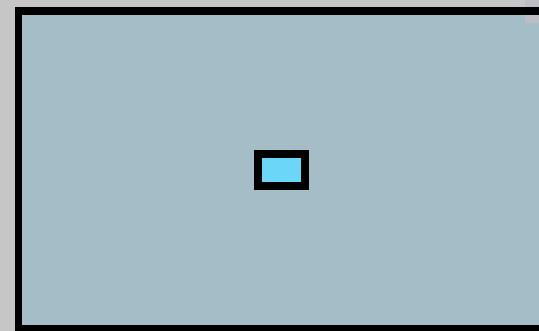
29. 運用氣壓或水力



- ◆ 以氣體或液體取代一個物體的固體零件—這些零件能用空氣或水面膨脹或用空氣或流體靜力的緩衝墊。
- ◆ 例：使用氣泡封套或類似泡沫的材料運送易碎產品。

29. 氣體力學和流體力學

在一物體內，使用氣體和液體部分取代固體的部分



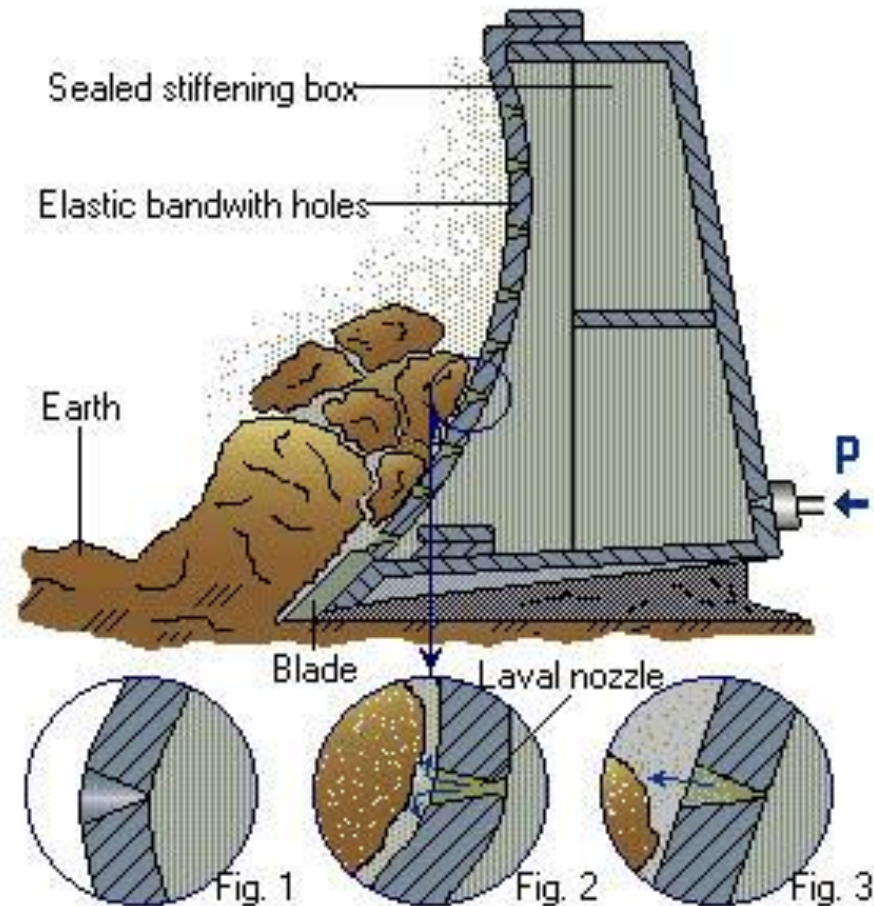
Make object's
parts gaseous
or liquid

適應性推土機刀身

如何能降低刀片和地面之間的磨擦損耗？

推土刀上累積的土塊和摩擦力耗費能源。

彈性膜片上的孔在受壓時打開，使土塊與膜片隔離，減少摩擦力。

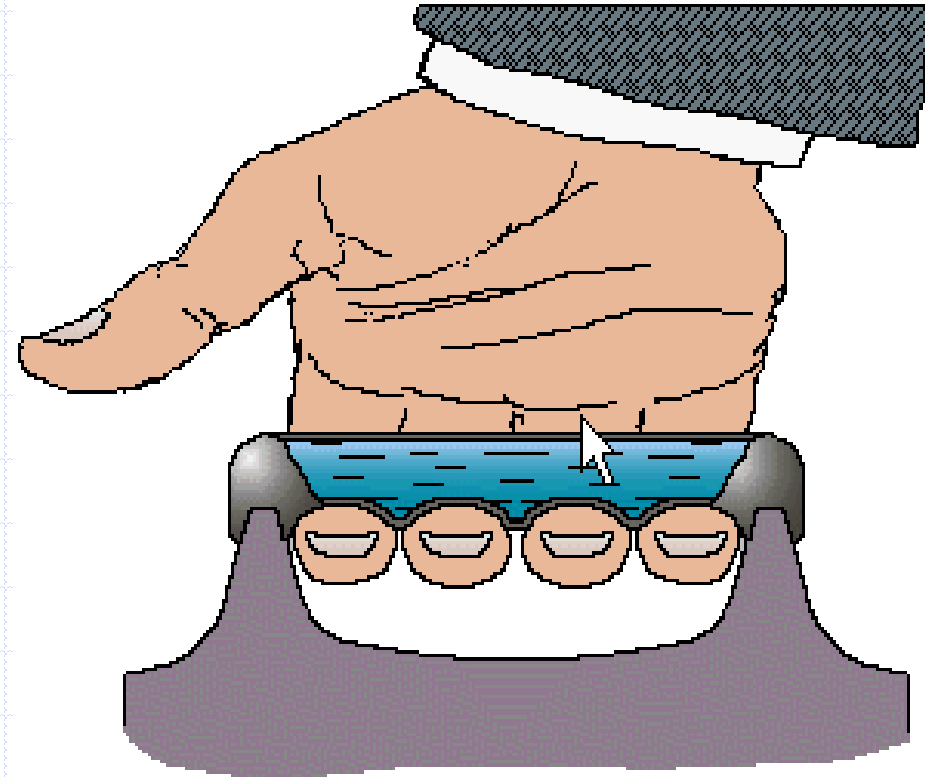


流體充滿提把的應用

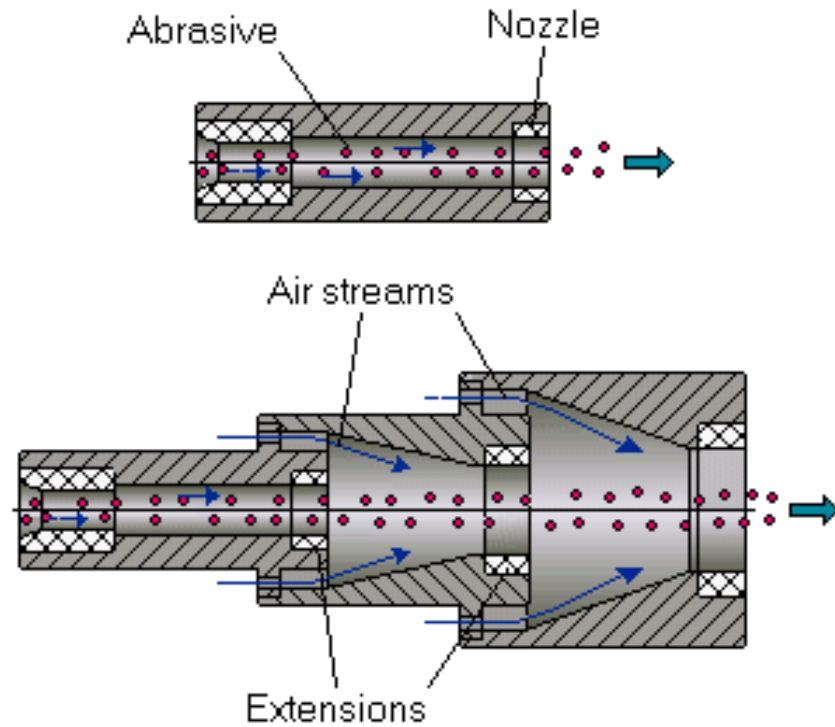
一個購物袋提帶時負荷很難均勻分配給手指造成提拿的不舒適。

硬的提把不夠舒適。

用水充填的提把可以配合手形自動調整。



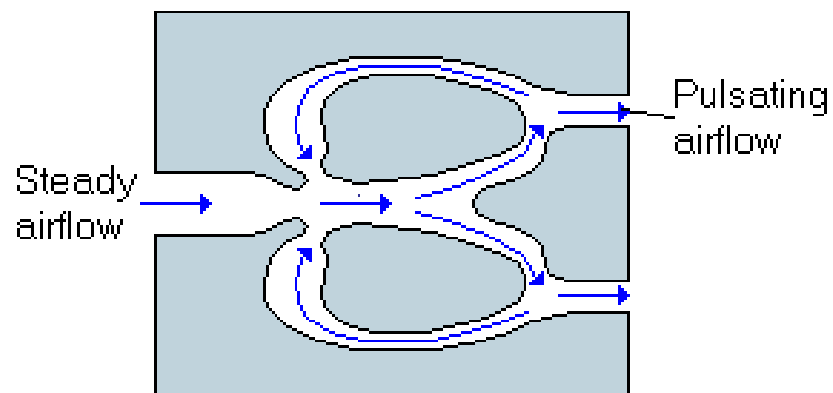
防止噴嘴磨損



用於打磨的顆粒的高速噴嘴
很容易磨損。

使用環狀噴射氣流來加速粒
子，可以保護噴嘴。

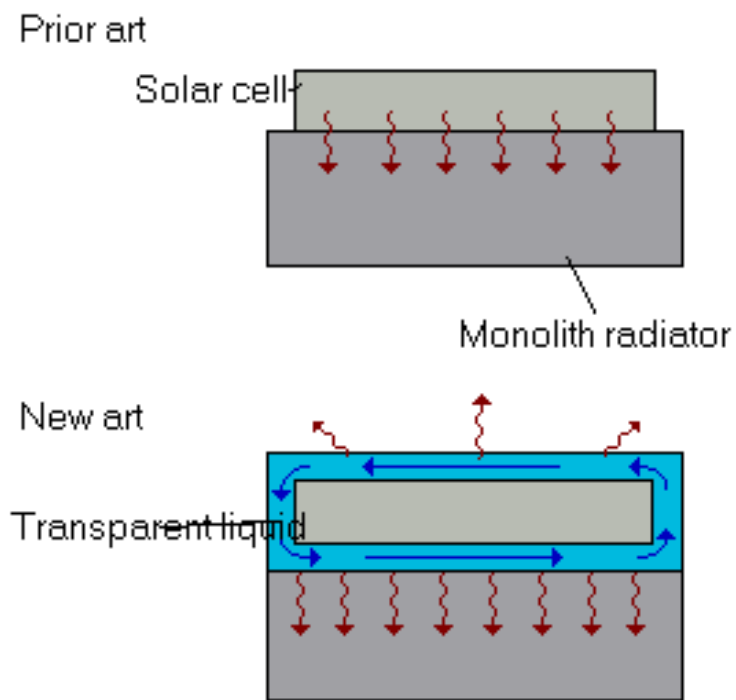
產生脈動氣流



脈動空氣的冷卻效果較穩定氣流更好。

利用對稱流道的振動效果產生脈動氣流。

太陽能電池降溫



僅靠反面的散熱片，降溫效果不足。

浸泡在流動的透明液體中，降溫效果最好。

Principle 30. Flexible shells and thin films

- *Use flexible shells and thin films instead of three dimensional structures*
 - ◆ *Use inflatable (thin film) structures as winter covers on tennis courts.*
- *Isolate the object from the external environment using flexible shells and thin films.*
 - ◆ *Float a film of bipolar material (one end hydrophilic, one end hydrophobic) on a reservoir to limit evaporation.*

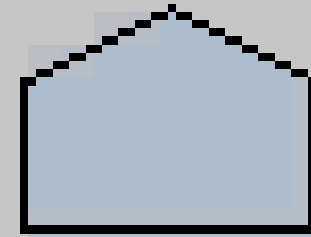
30. 彈性膜或薄膜



- ◆ 以彈性膜及薄膜更換原來的構造
- ◆ 以純淨的薄膜將物體和外界環境隔離
- ◆ 例：將聚乙烯噴在植物的葉子上以阻止因蒸發而失水。
經過一會兒，聚乙烯變硬，植物生長改善很多，因為聚乙烯膜比水汽更透氧。

30-易彎曲的殼和薄膜

使用易彎曲的殼和薄膜把對象物和外部環境隔離



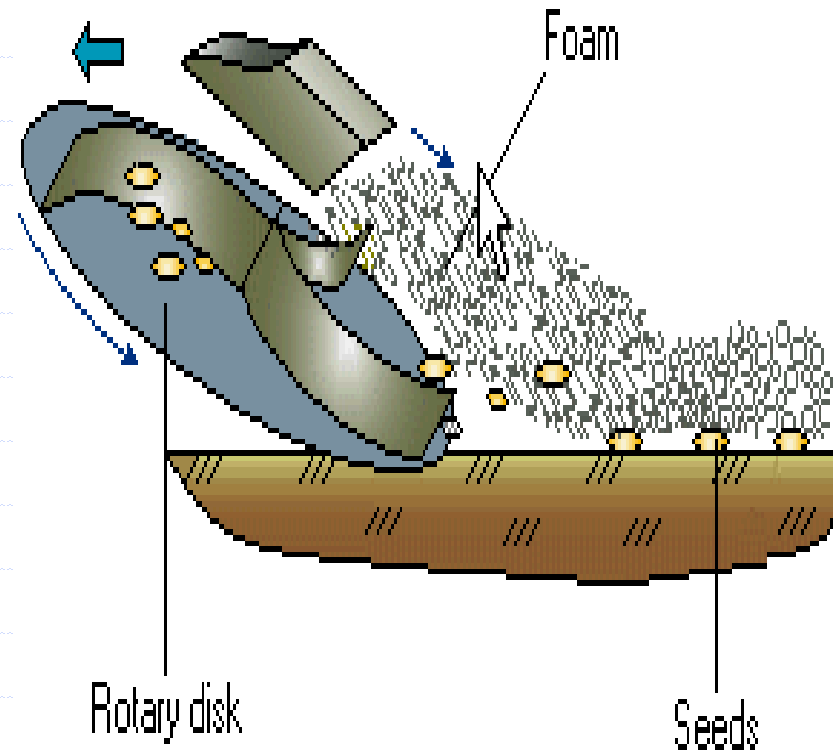
Make object
of shells



Isolate by shells

泡沫與種子結合應用

如何以低的成本完成播種作業？

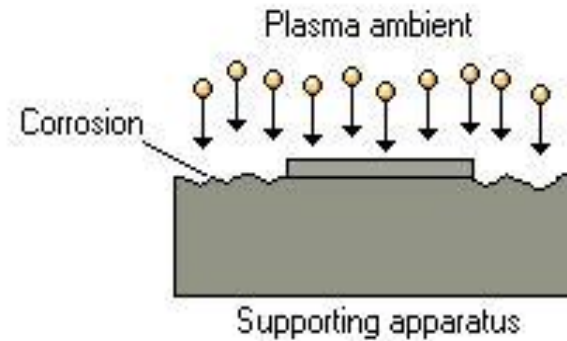


平台沉積一薄的保護層

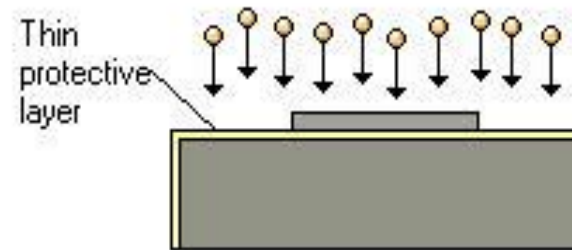
在蝕刻製程裡

如何避免操作平台受到電漿離子侵蝕呢？

Prior art



New art



United States Patent 5 364 496 Date of Patent:
Nov. 15, 1994 Hughes Aircraft Company, Los
Angeles, Calif., USA

Principle 31. Porous materials

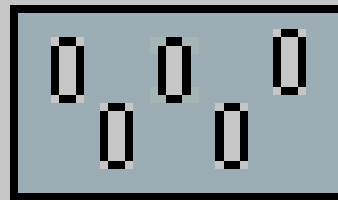
- ◆ *Make an object porous or add porous elements (inserts, coatings, etc.).*
 - ◆ *Drill holes in a structure to reduce the weight.*
- ◆ *If an object is already porous, use the pores to introduce a useful substance or function.*
 - ◆ *Use a porous metal mesh to wick excess solder away from a joint.*
 - ◆ *Store hydrogen in the pores of a palladium sponge. (Fuel "tank" for the hydrogen car--much safer than storing hydrogen gas)*

31 多孔的材料

製作一多孔物體或加入
多孔的要素(嵌入, 塗
覆...等等)



Make object
porous



Fill pores

31. 使用多孔材料

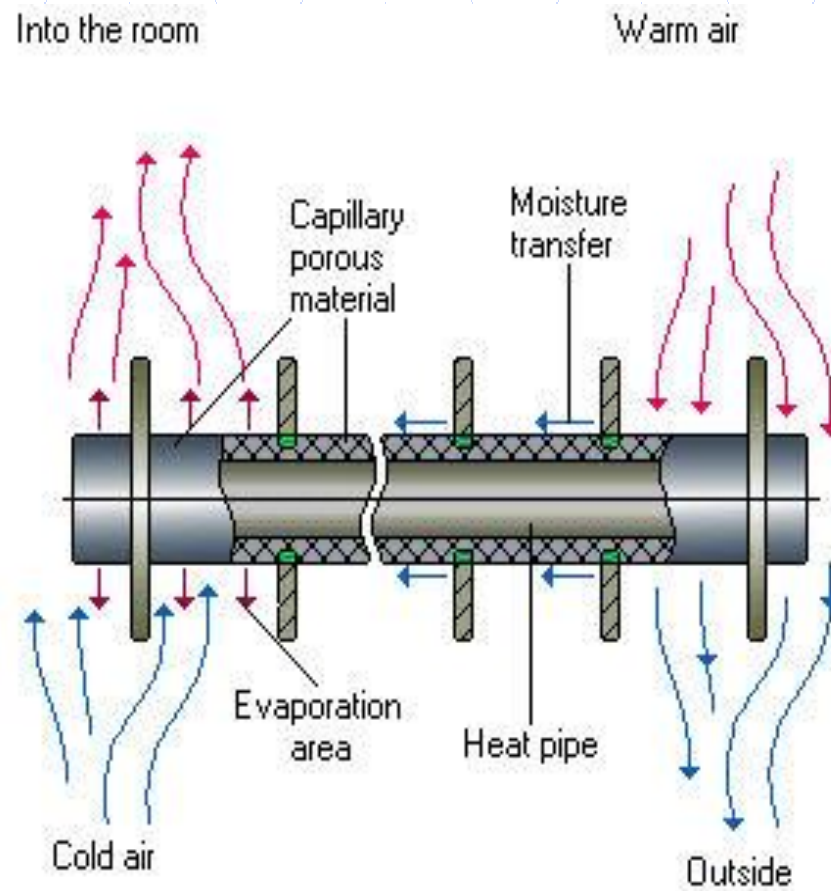


- ◆使物體多孔化或使用附加多孔元件的物體(嵌入件，蓋等)
- ◆假如物體有許多孔，則預先填充物質
- ◆例:為了避免對機器的冷卻，有些機器的零件被填塞多孔的物質(多孔的粉鋼)浸在冷卻液體，當機器運作時會汽化，提供暫時冷卻。

雙目的之多重導熱管

廢熱回收系統裡的熱管

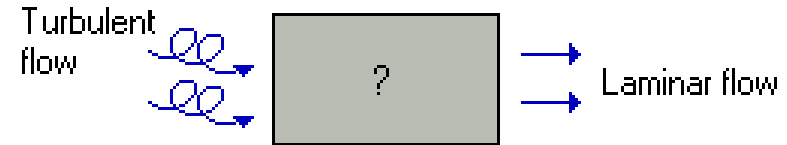
如何能夠由室內獲得熱而且同時能使溼氣再利用呢？



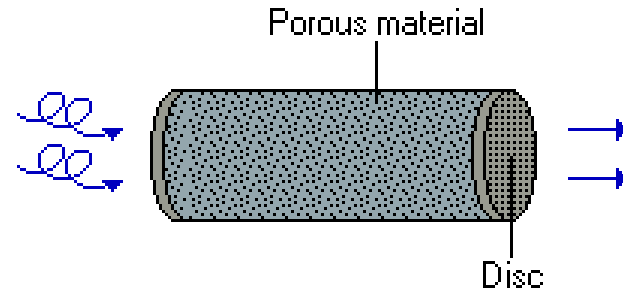
孔材料元件改善線性氣流

典型的線性氣流，要素複雜非可調整且易受到微粒污染。

Prior art



New art



United States Patent 5 332 005 Date of Patent: Jul. 26, 1994 Aalborg Instruments & Controls, Inc., Monsey, N.Y.

Principle 32. Color changes

- ◆ Change the color of an object or its external environment.
 - *Use safe lights in a photographic darkroom.*
- ◆ Change the transparency of an object or its external environment.
 - *Use photolithography to change transparent material to a solid mask for semiconductor processing. Similarly, change mask material from transparent to opaque for silk screen processing.*

32. 改變顏色



- ◆ 改變一個物體或它周圍事物的顏色
- ◆ 改變一個物體或它周圍事物的透明程度
- ◆ 使用顏色添加劑去觀察不易看到的物體或過程
- ◆ 如果此種添加劑已被使用，可再運用發光追蹤元素
- ◆ 例：使用透明繃帶，不須將包紮除去就能檢查傷口

32-視覺的性質變化

改變一個物體外觀顏色，即可改善明亮度



Change object's
color



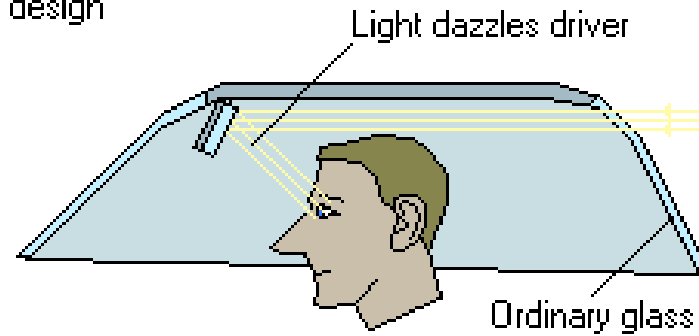
Make object
transparent

後照鏡塗覆物的應用

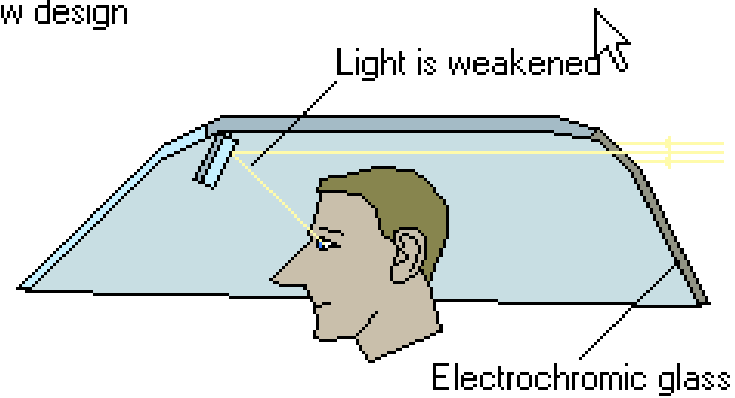
在後視鏡裡另一輛汽車的前燈會讓司機因刺眼看不清楚。

如何改善？

Old design



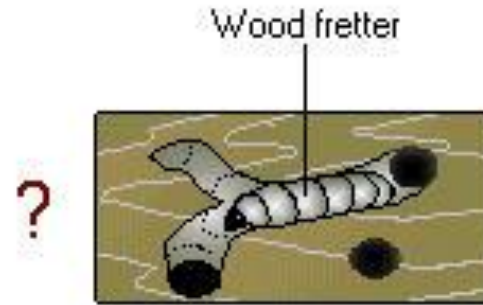
New design



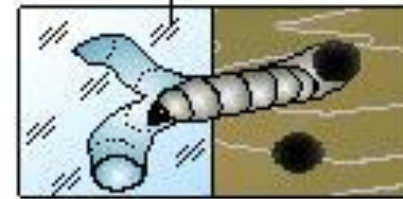
透明木頭

如何抑制蛀蟲生長？

蛀蟲觀察



Pressed cellulosic coating



Principle 33. Homogeneity

- ◆ Make objects interacting with a given object of the same material (or material with identical properties).
 - *Make the container out of the same material as the contents, to reduce chemical reactions.*
 - *Make a diamond cutting tool out of diamonds.*

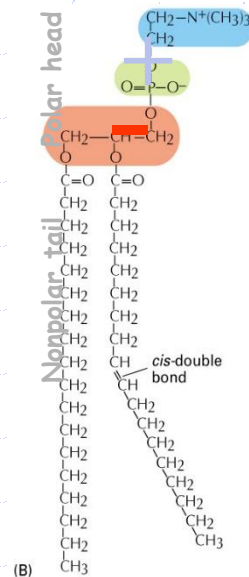
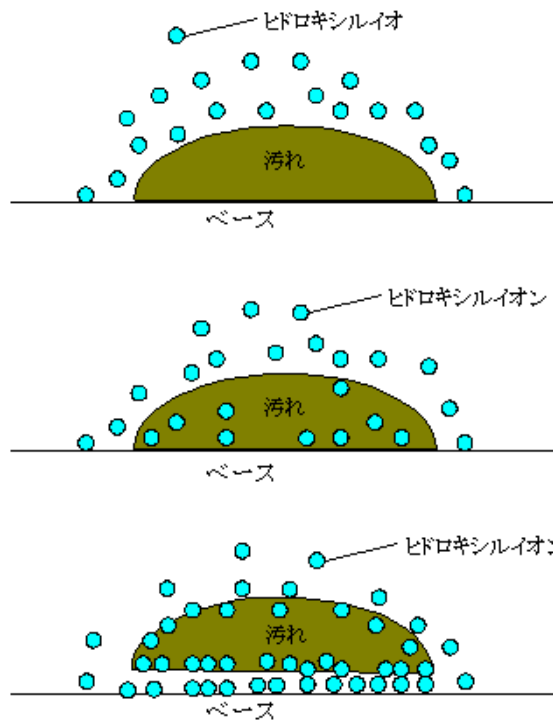
33. 同質性



- ◆使物體的相互作用得自於相同材料或接近其行為的材料
- ◆例：研磨粒供給裝置約表面是由通過供給裝置的相同材料所製成一允許此表面能持續復原而不會磨耗

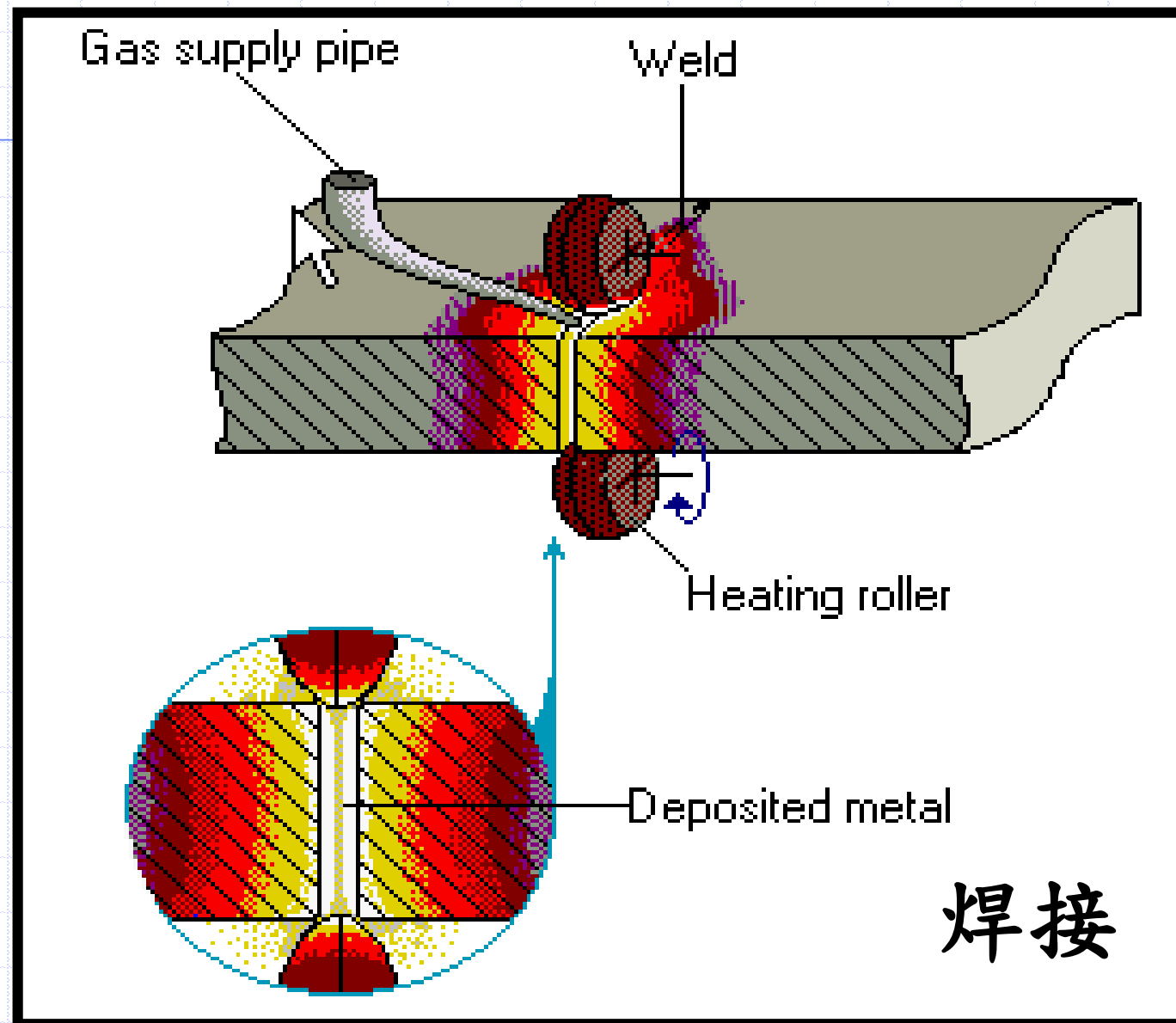
33. Homogeneity

◆ Make objects that **interact** with a given out of the **same materials**.

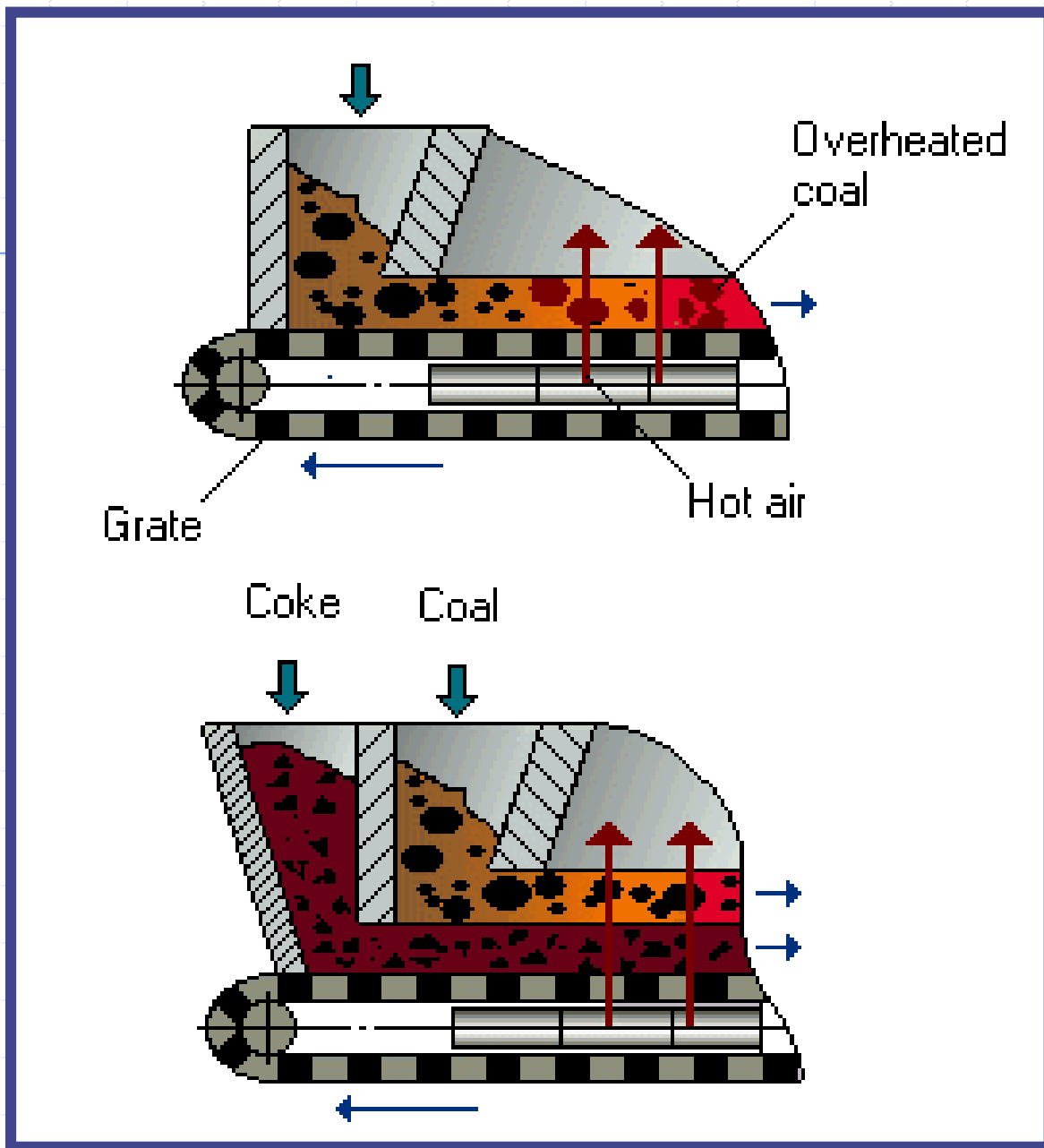


介面活性劑





焊接

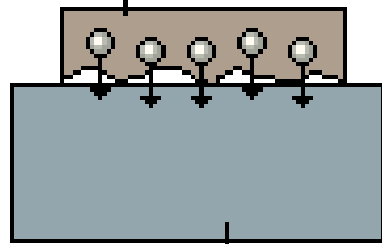


焦炭保護爐柵

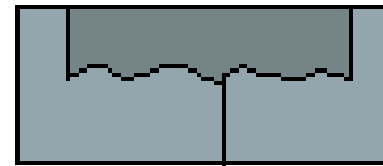
Prior art

Thermal diffusion from poly-Si

Poly-Si layer



Mono-Si substrate

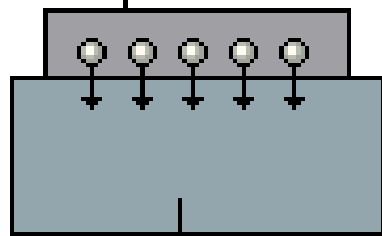


Uneven diffusion front

New art

Thermal diffusion from mono-Si

Mono-Si layer



Mono-Si substrate



Uniform diffusion front

勻相添加劑

Principle 34. Discarding and recovering

- ◆ Make portions of an object that have fulfilled their functions go away (discard by dissolving, evaporating, etc.) or modify these directly during operation.
 - *Use a dissolving capsule for medicine.*
 - *Sprinkle water on cornstarch-based packaging and watch it reduce its volume by more than 1000X!*
 - *Ice structures: use water ice or carbon dioxide (dry ice) to make a template for a rammed earth structure, such as a temporary dam. Fill with earth, then, let the ice melt or sublime to leave the final structure.*
- ◆ Conversely, restore consumable parts of an object directly in operation.
 - *Self-sharpening lawn mower blades*
 - *Automobile engines that give themselves a "tune up" while running (the ones that say "100,000 miles between tune ups")*

34. 拋棄及再生零件



- ◆ 當物體的功能達成後或無用時把它拋棄或修正(如:拋棄、分解、消散)
- ◆ 直接復原已耗盡的零件或物體
- ◆ 例:槍發射後彈殼被彈出；完成功用後火箭推進器被分離

34. *Discarding and recovering*

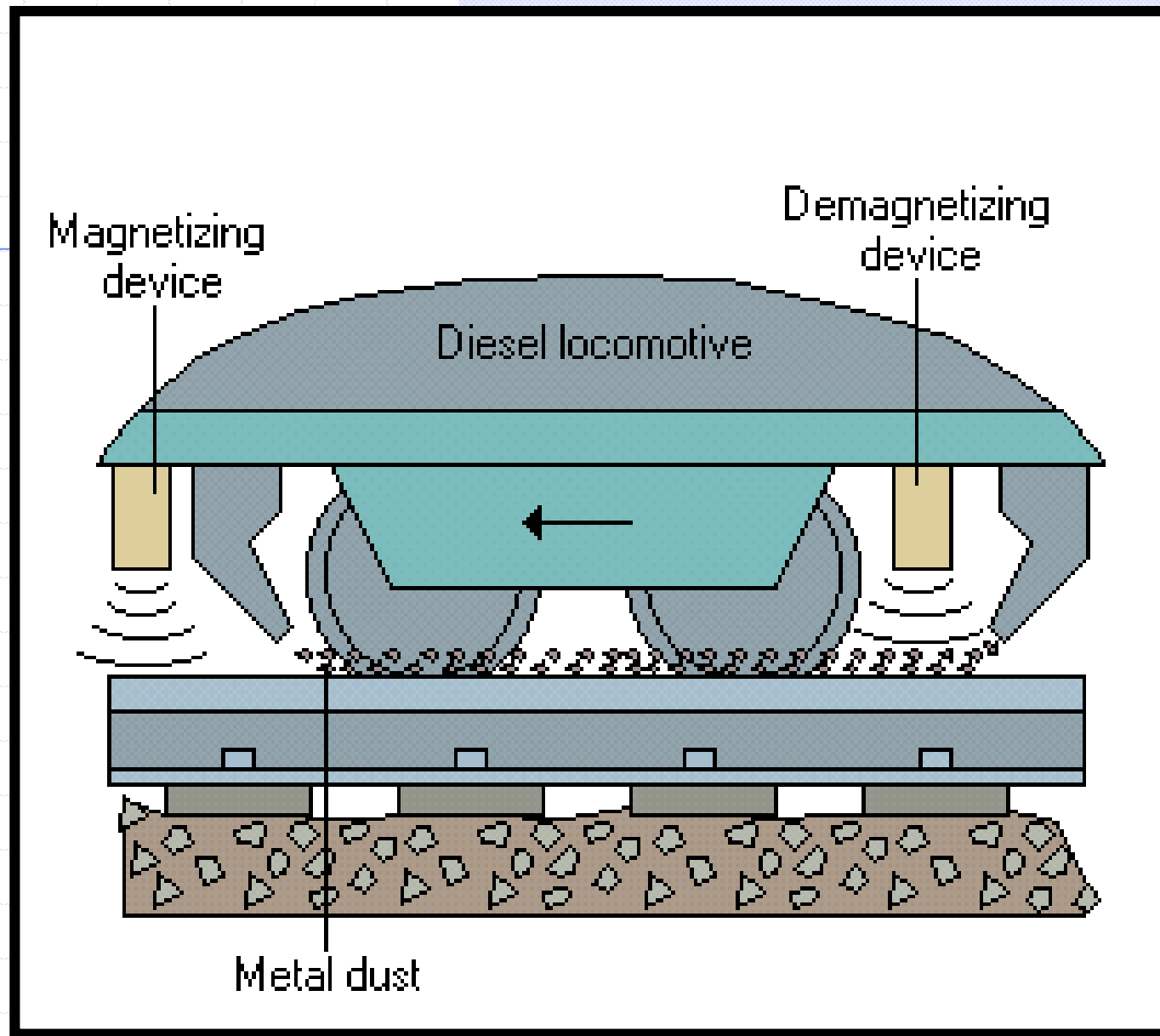
- ◆ Make portion of object that have fulfilled their function **go away** or modify these directly during operation.
- ◆ Conversely, **restore** consumable parts of an object directly during operation.



Eject used parts



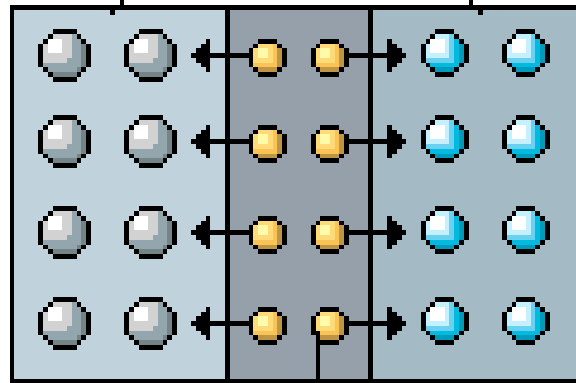
Renovate object
during action



金屬殘渣取代砂石

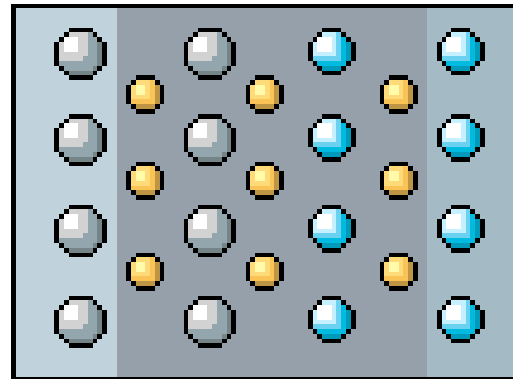
Low temperature heating

Refractory metals

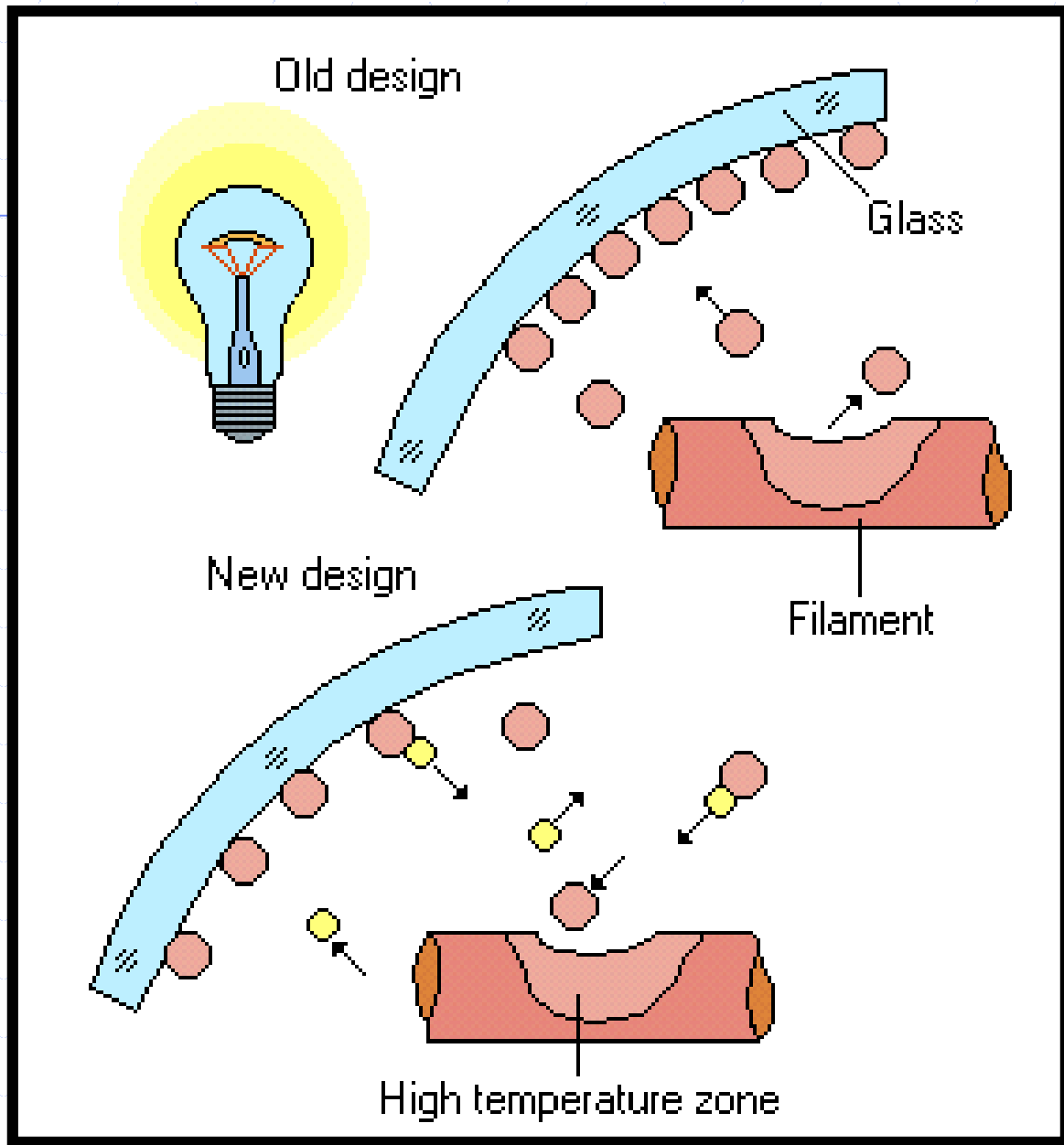


Light-melting metal

After heating



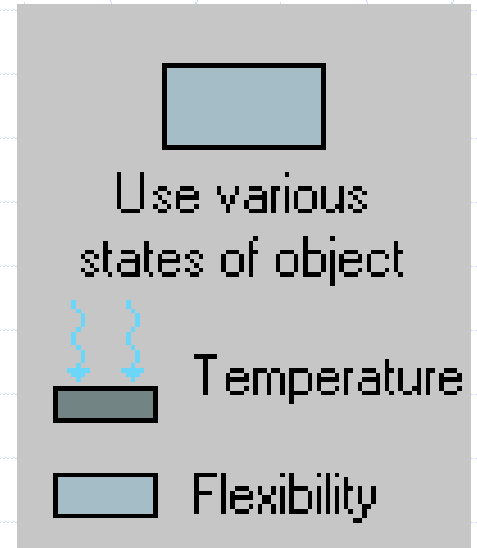
金屬黏接



鎢絲燈

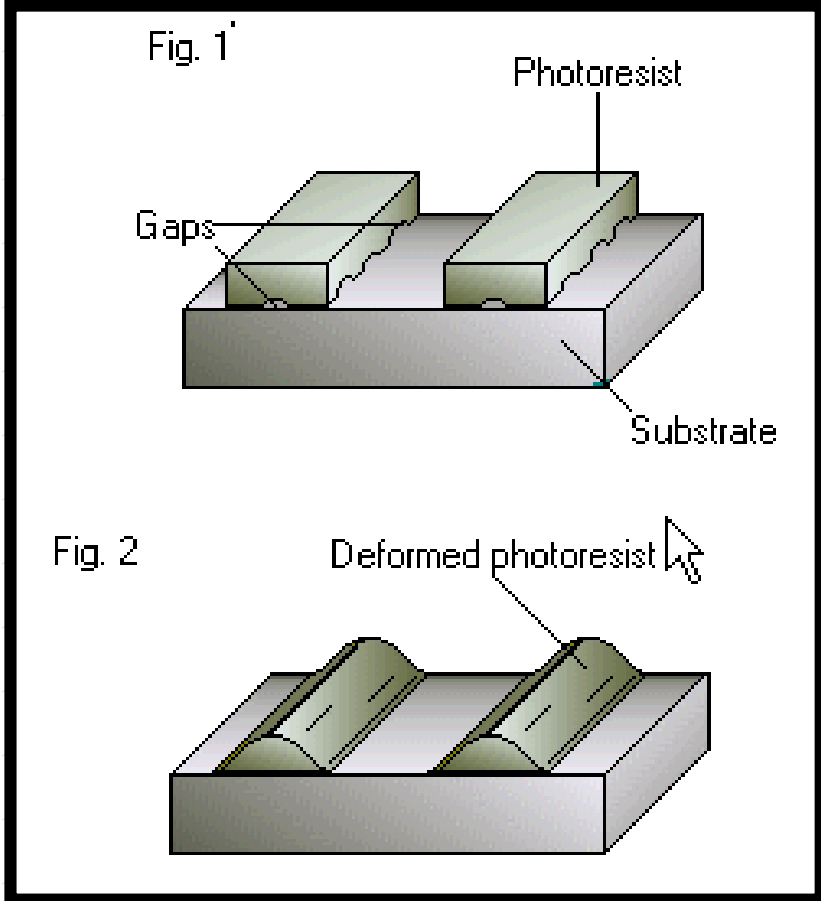
Principle 35. Parameter changes

- ◆ Change an object's physical state (e.g. to a gas, liquid, or solid).
 - *Freeze the liquid centers of filled candies, then dip in melted chocolate, instead of handling the messy, gooey, hot liquid.*
 - *Transport oxygen or nitrogen or petroleum gas as a liquid, instead of a gas, to reduce volume.*
- ◆ Change the concentration or consistency.
 - *Liquid hand soap is concentrated and more viscous than bar soap at the point of use, making it easier to dispense in the correct amount and more sanitary when shared by several people.*
- ◆ Change the degree of flexibility.
 - *Use adjustable dampers to reduce the noise of parts falling into a container by restricting the motion of the walls of the container.*
 - *Vulcanize rubber to change its flexibility and durability.*
- ◆ Change the temperature.
 - *Raise the temperature above the Curie point to change a ferromagnetic substance to a paramagnetic substance.*
 - *Raise the temperature of food to cook it. (Changes taste, aroma, texture, chemical properties, etc.)*
 - *Lower the temperature of medical specimens to preserve them for later analysis.*

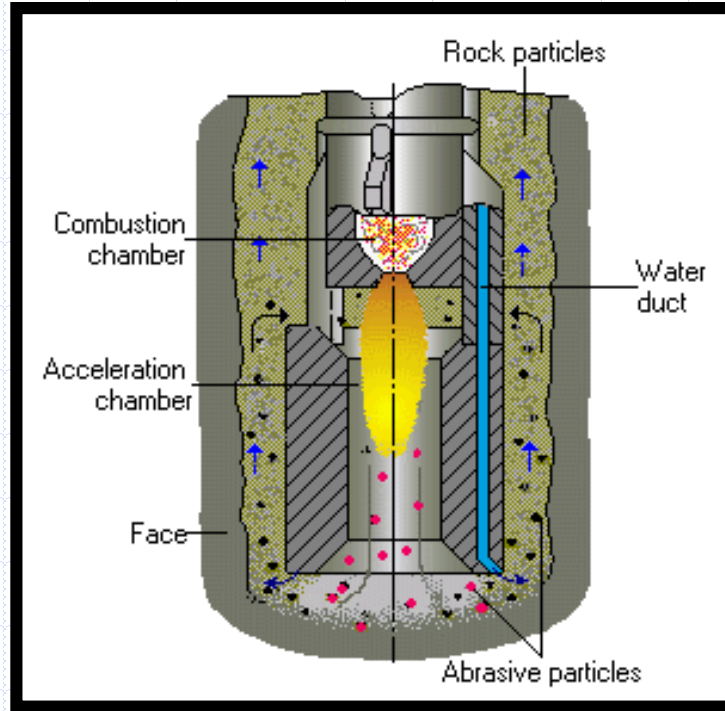


- ◆ 改變物體各種狀態、密度、濃度、彈性、溫度
- ◆ 例：在一個易碎的物質，其螺旋狀的表面由兩個螺旋彈簧作成有彈性的物體，以控制螺旋嵌入的過程

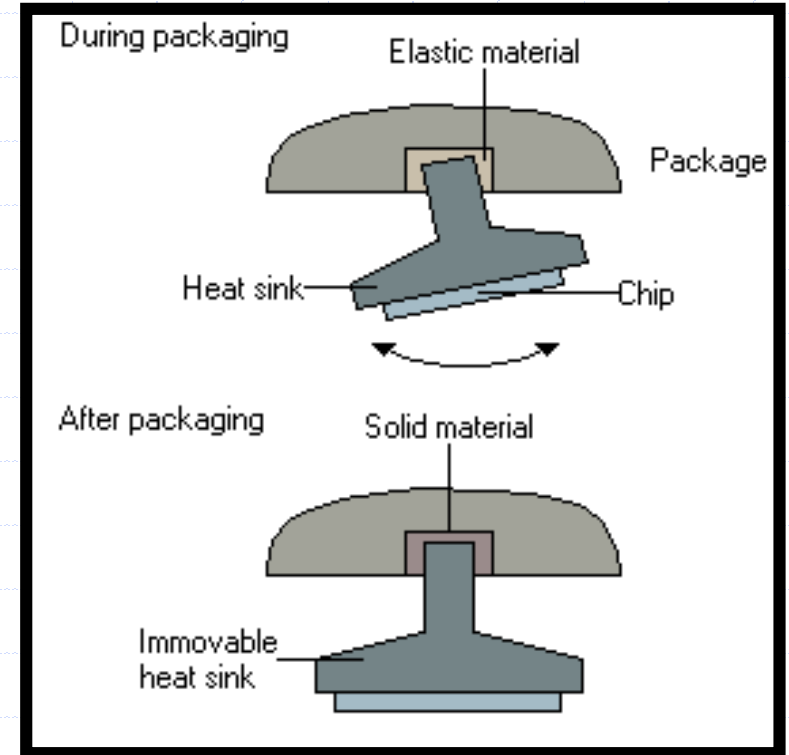
光阻



挖掘器



包裝印刷



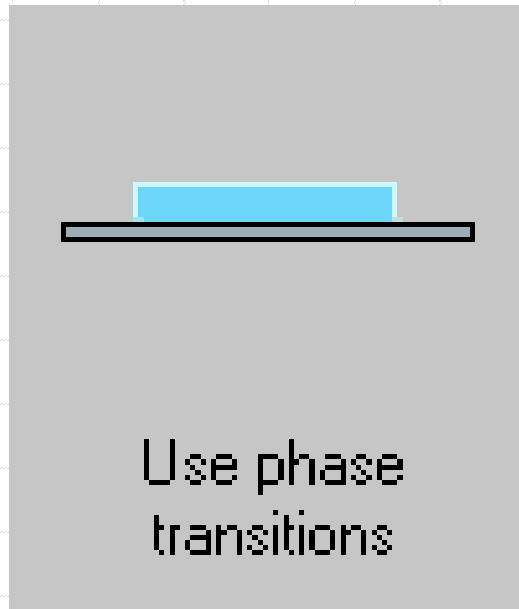
Principle 36. Phase transitions

- ◆ Use phenomena occurring during phase transitions (e.g. volume changes, loss or absorption of heat, etc.).
 - *Water expands when frozen, unlike most other liquids. Hannibal is reputed to have used this when marching on Rome a few thousand years ago. Large rocks blocked passages in the Alps. He poured water on them at night. The overnight cold froze the water, and the expansion split the rocks into small pieces which could be pushed aside.*
 - *Heat pumps use the heat of vaporization and heat of condensation of a closed thermodynamic cycle to do useful work.*

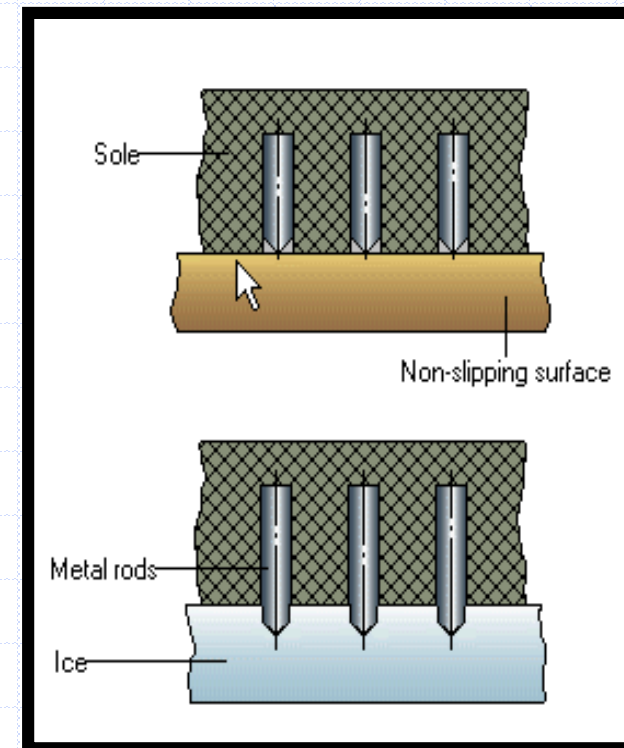
- ◆ 在物質的相的轉變過程中實現一個有效的成長。例如，在體積改過程中可釋放熱量或吸收熱量
- ◆ 例：為了控制強化導管的膨脹，將其充滿水並冷列冰點

36. Phase transitions ☆☆

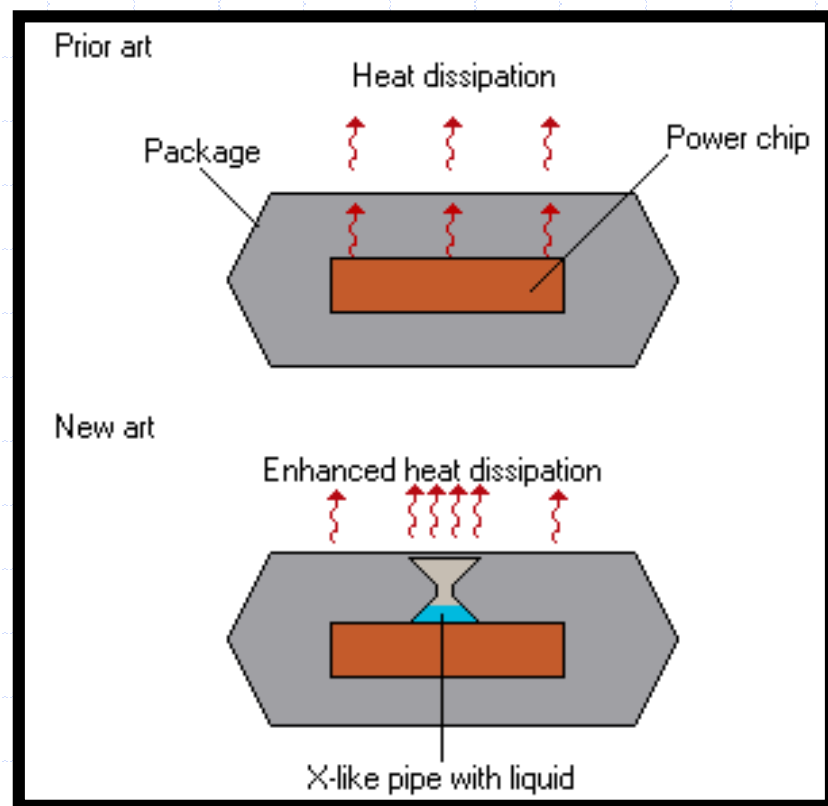
◆ Use phenomena occurring during **phase transitions**.



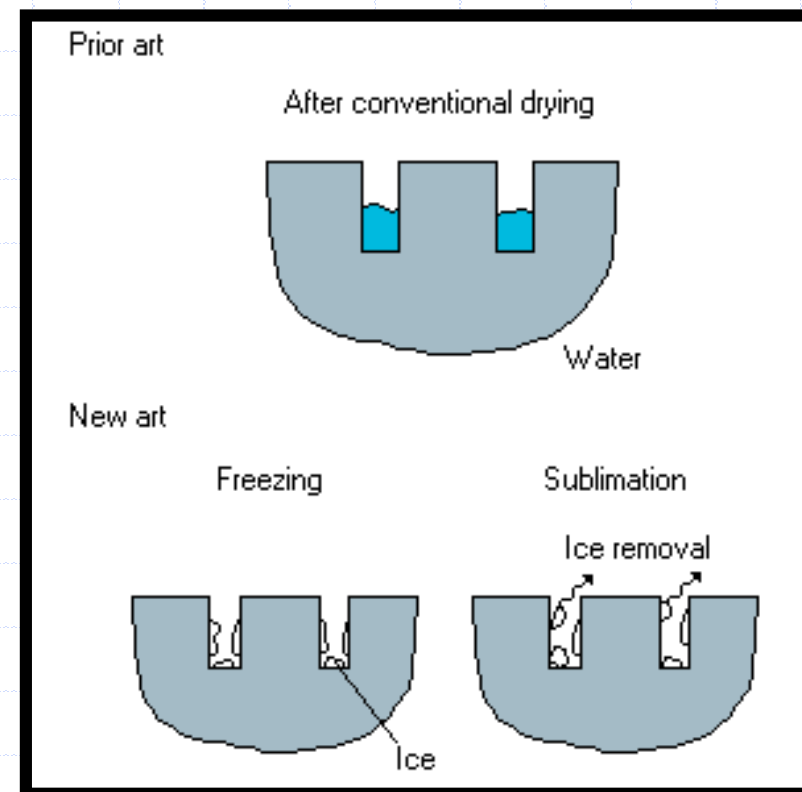
多功能鞋



電子零件包裝



移除隙縫水分



Principle 37. Thermal expansion


熱膨脹

- *Use thermal expansion (or contraction) of materials.*
 - ◆ *Fit a tight joint together by cooling the inner part to contract, heating the outer part to expand, putting the joint together, and returning to equilibrium.*
 - *If thermal expansion is being used, use multiple materials with different coefficients of thermal expansion.*
 - ◆ *The basic leaf spring thermostat: (2 metals with different coefficients of expansion are linked so that it bends one way when warmer than nominal and the opposite way when cooler.)*
- ◆ 運用熱使材料膨脹或收縮
 - ◆ 使用具有不同熱膨脹係數的材料
 - ◆ 例：將雙金屬板和溫室屋頂窗戶連接以控制其開閉。當溫度改變，雙金屬板就彎曲使窗口打開或關閉

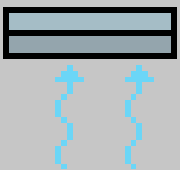
37. Thermal expansion



◆ What is thermal expansion?



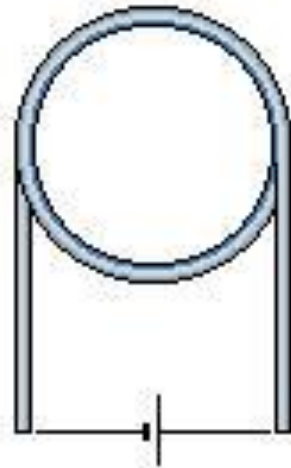
Use temperature
to change sizes



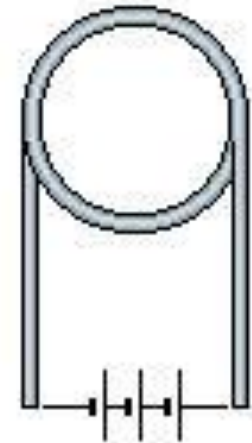
Use poly-
expansion

◆ What is its applications?

Current-adjusted diaphragm.

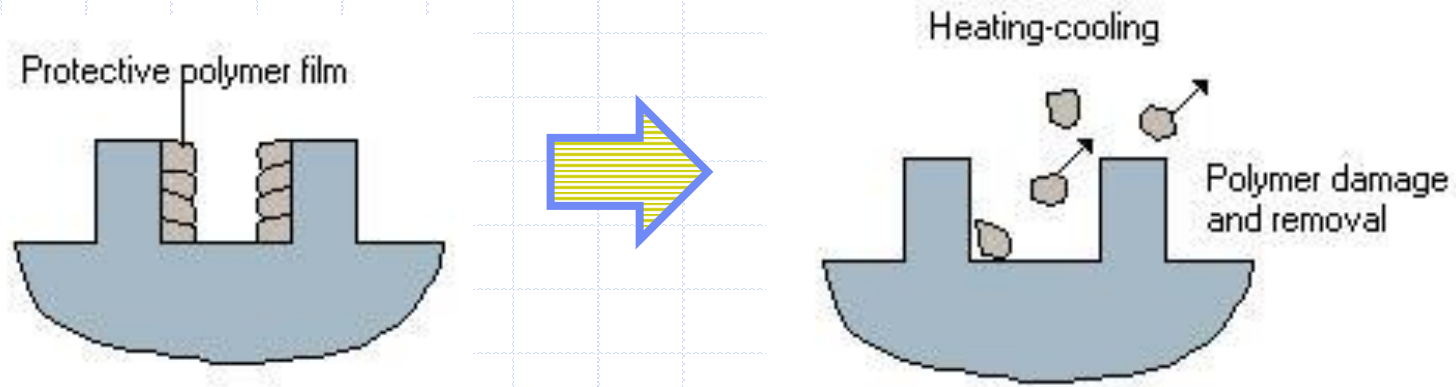


Low current - big diameter

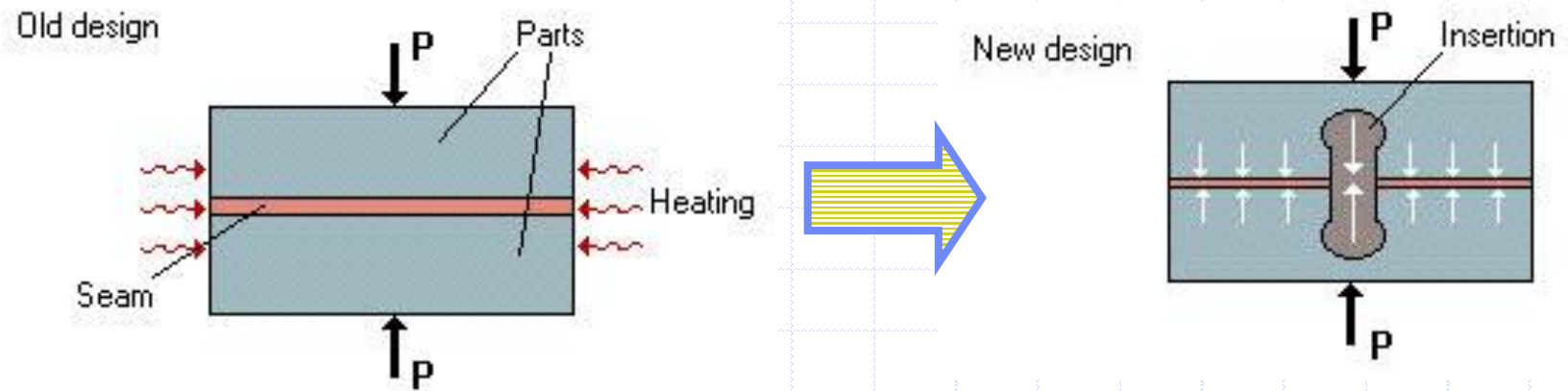


High current - small diameter

Protective polymer removal



Welded structure



Principle 38. Strong oxidants

- ◆ Replace common air with oxygen-enriched air.
 - *Scuba diving with Nitrox or other non-air mixtures for extended endurance*
- ◆ Replace enriched air with pure oxygen.
 - *Cut at a higher temperature using an oxy-acetylene torch.*
 - *Treat wounds in a high pressure oxygen environment to kill anaerobic bacteria and aid healing.*
- ◆ *Expose air or oxygen to ionizing radiation.*
- ◆ Use ionized oxygen.
 - *Ionize air to trap pollutants in an air cleaner.*
- ◆ Replace ozonized (or ionized) oxygen with ozone.
 - *Speed up chemical reactions by ionizing the gas before use.*

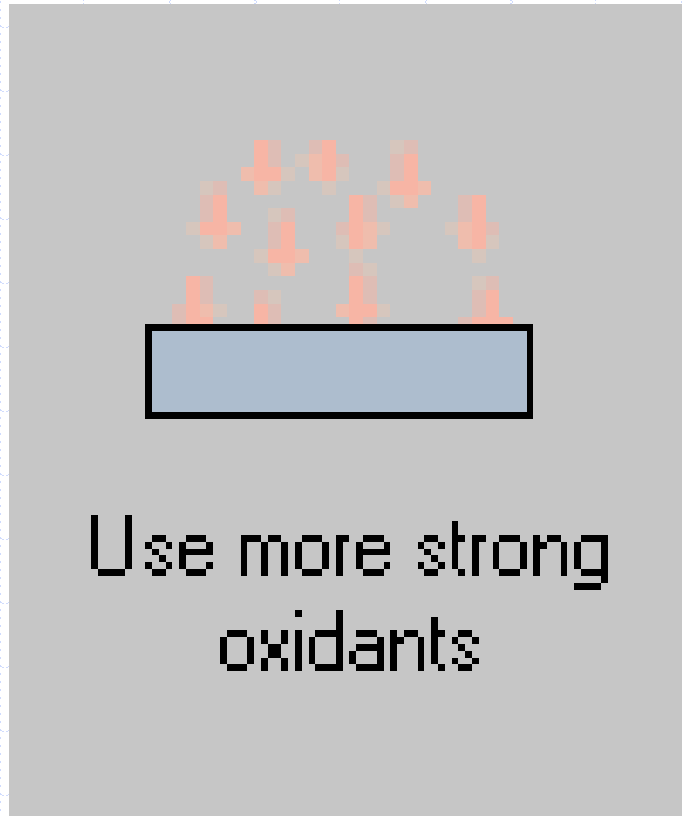
38. 使用強氧化劑



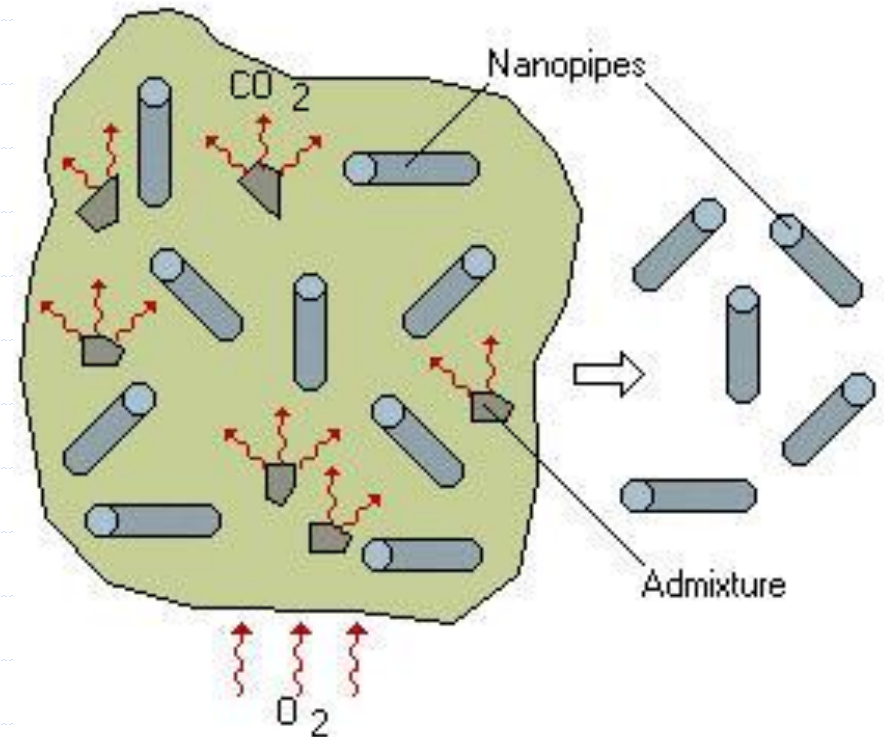
- ◆ 以加濃空氣取代正常空氣
- ◆ 以氧氣取代加濃空氣
- ◆ 在空氣或氧氣中進行離子化
- ◆ 使用氧離子
- ◆ 例: 為了從火炬中得到更多的熱量，以氧氣取代大氣中的空氣

38. Strong Oxidants

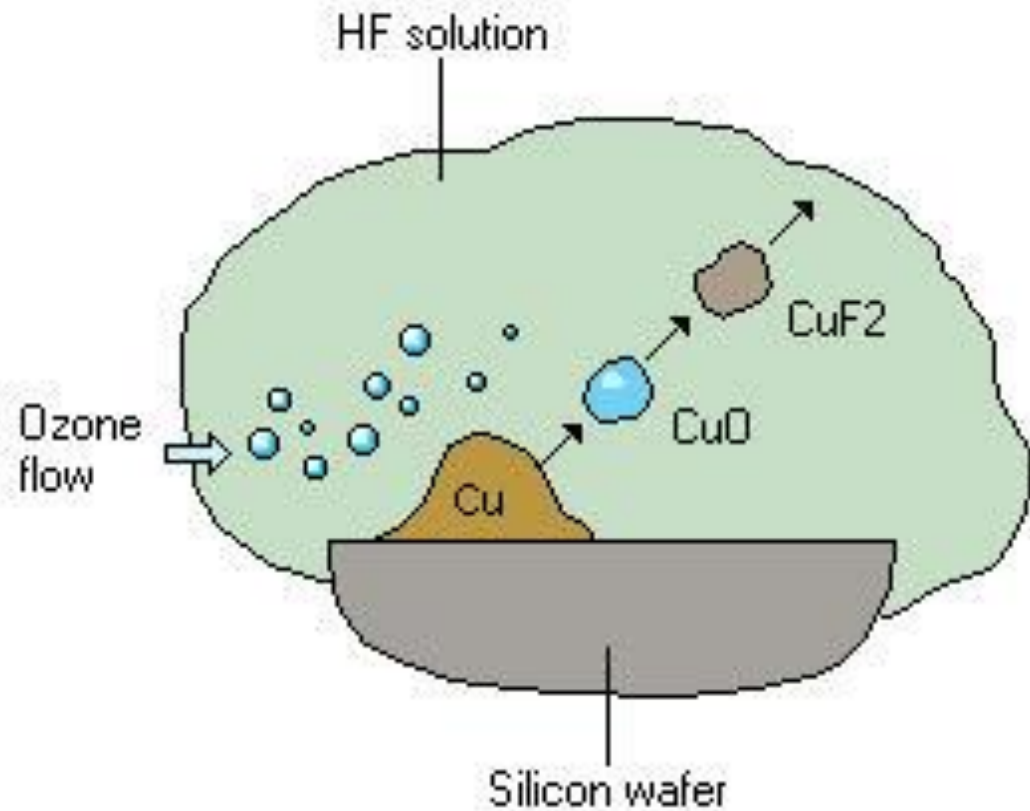
◆ What is Strong Oxidants?



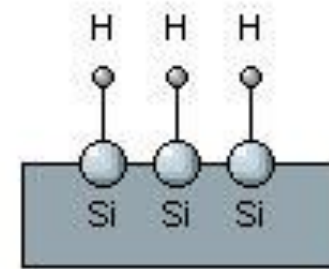
◆ What is its applications?
■ Obtaining nano tubes



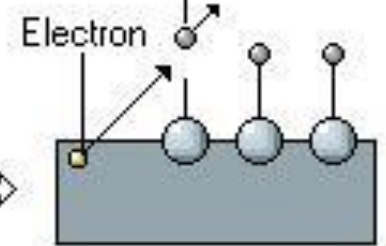
- Ozone-aerated cleaning solution ■ Reduced of hot electron-induced



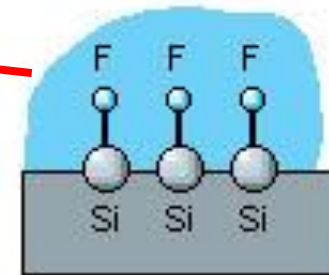
Prior art



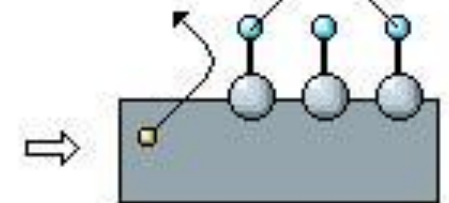
Hydrogen removal



New art



Strong molecular bonds



N₂+HF acid



Principle 39. Inert atmosphere

- ◆ Replace a normal environment with an inert one.
 - *Prevent degradation of a hot metal filament by using an argon atmosphere.*
- ◆ Add neutral parts, or inert additives to an object.
 - *Increase the volume of powdered detergent by adding inert ingredients. This makes it easier to measure with conventional tools.*

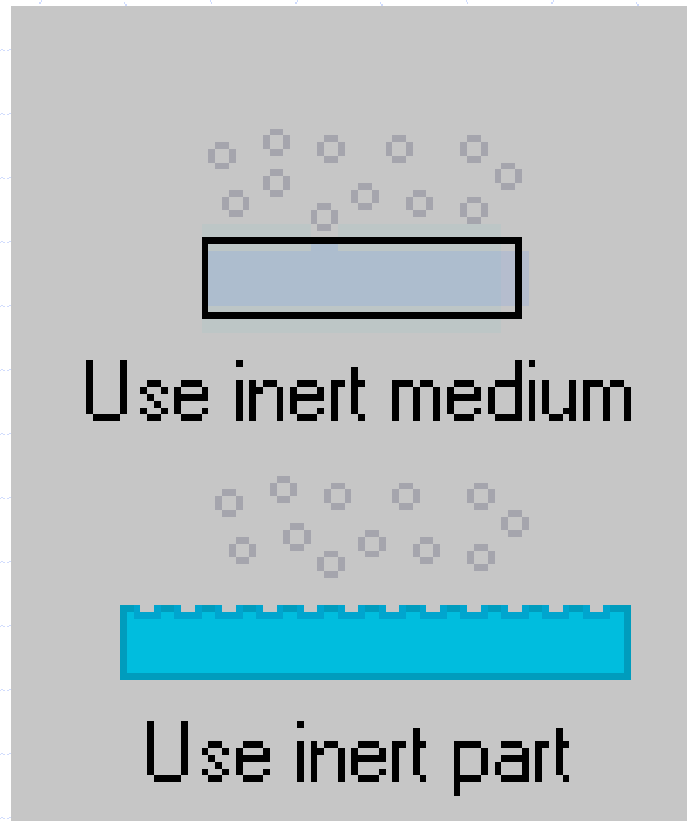
◆ 以非活性環境取代正常環境

◆ 在其空中完成過程

◆ 為預防棉花儲存時著火，在運輸過程中以鈍氣處理

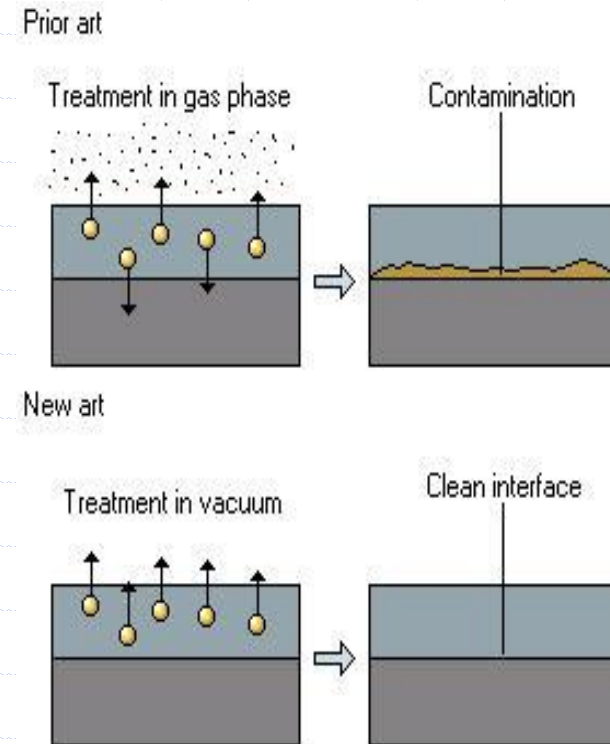
39. Inert atmosphere

◆ What is inert atmosphere?



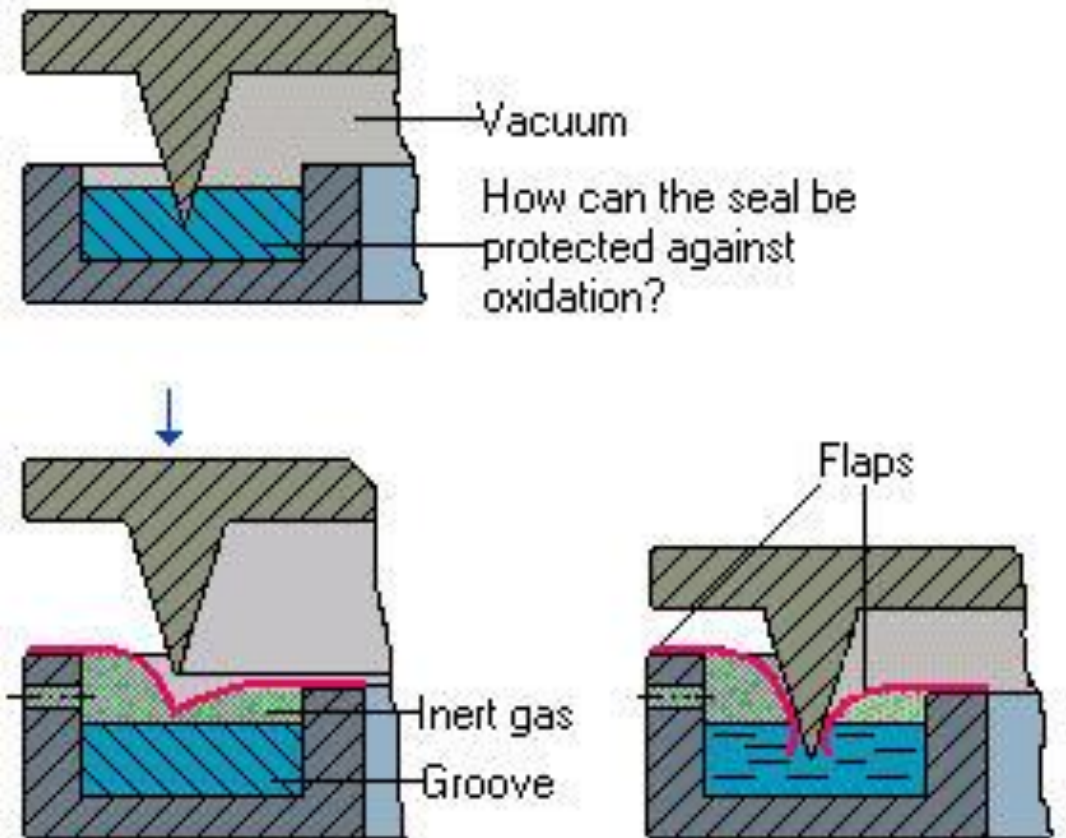
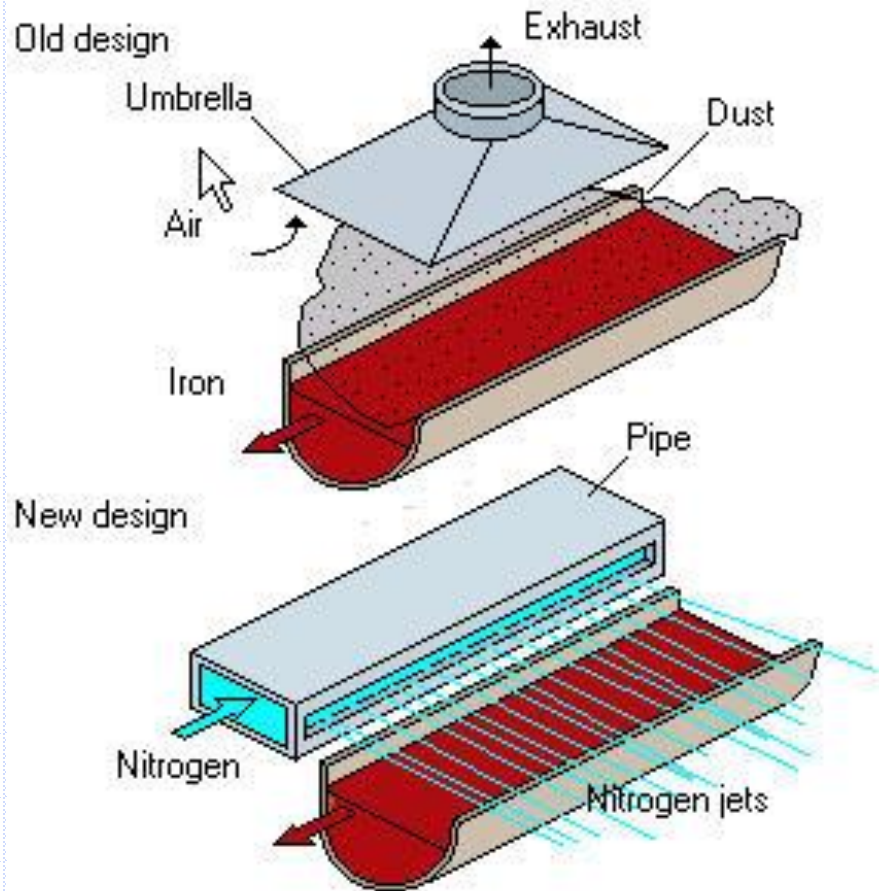
◆ What is its applications?

High vacuum curing of a spin glass

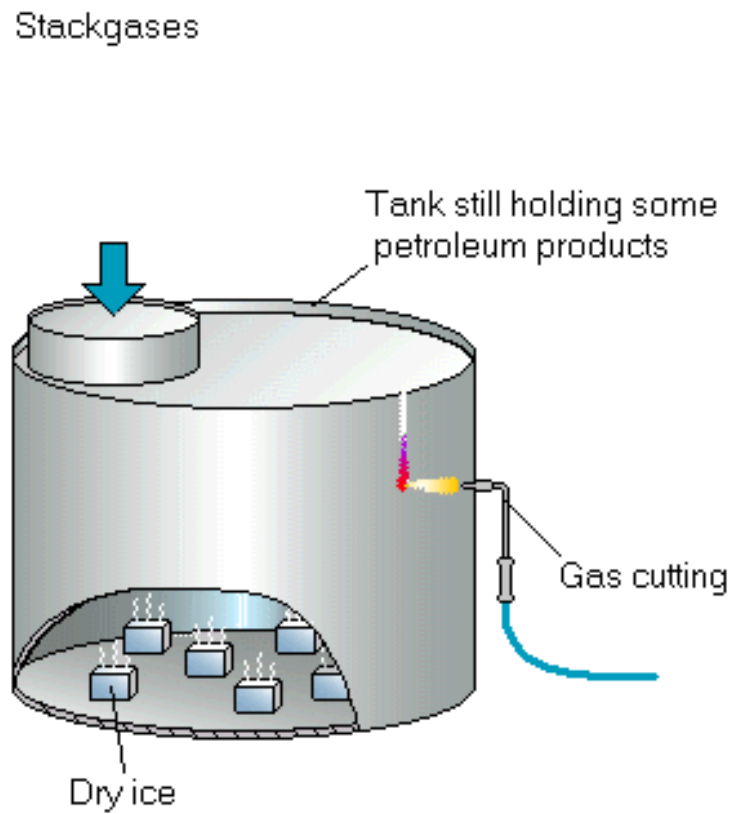


Protecting pig iron from oxidation

Protecting with inert gas



切割油槽時 避免餘氣引起爆炸



加入乾冰。

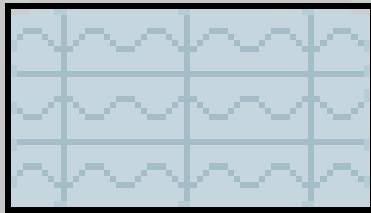
Principle 40. Composite materials



- ◆ Change from uniform to composite (multiple) materials.
 - *Composite epoxy resin/carbon fiber golf club shafts are lighter, stronger, and more flexible than metal. Same for airplane parts.*
 - *Fiberglass surfboards are lighter and more controllable and easier to form into a variety of shapes than wooden ones.*

40. Composite (multiple) materials

What is Composite (multiple) materials?

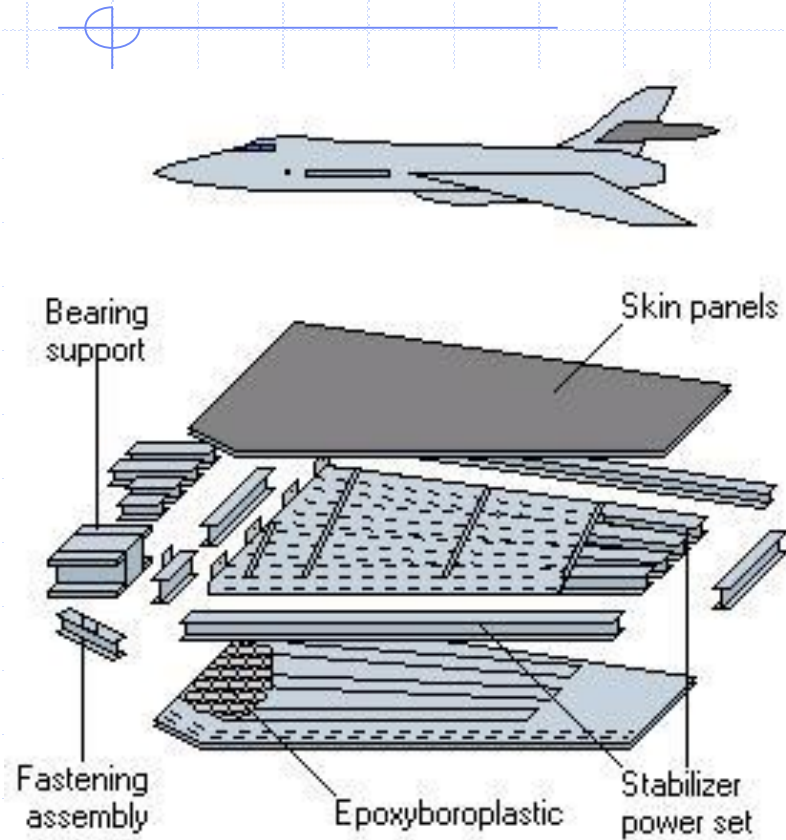


Use a protective layer

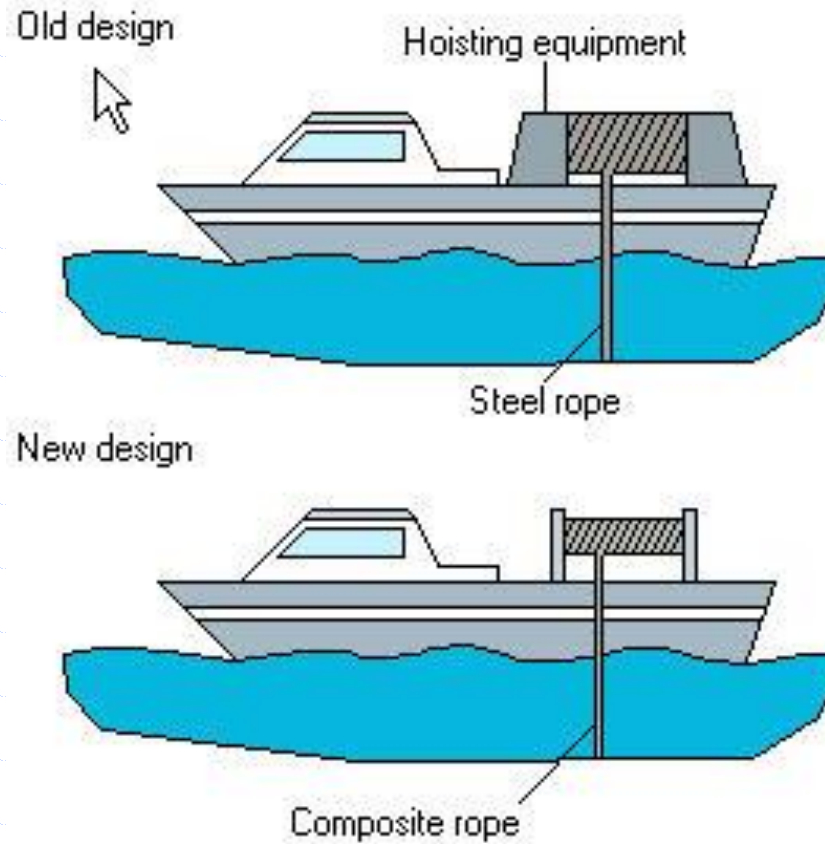
- ◆ 以合成材料取代同質材料
- ◆ 例：軍機機翼為了高強度和低重重以塑膠與碳纖維的合成材料製造

◆ What is its applications?

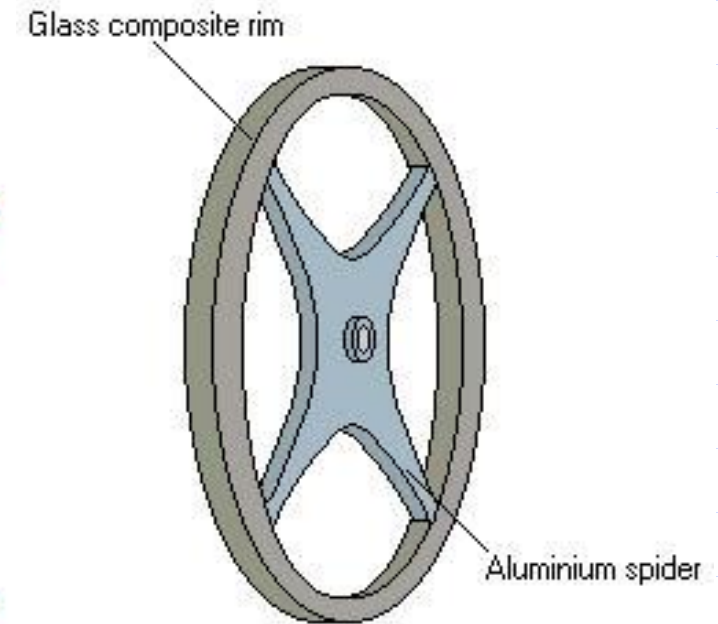
Aircraft stabilizer



Composite rope



Superfly-wheel



網路文獻

- Contradiction Matrix and the 40 Principles for Innovative Problem Solving
- 40 Inventive Principles With Examples