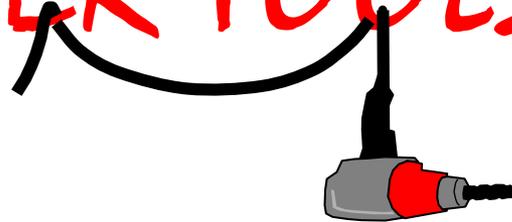


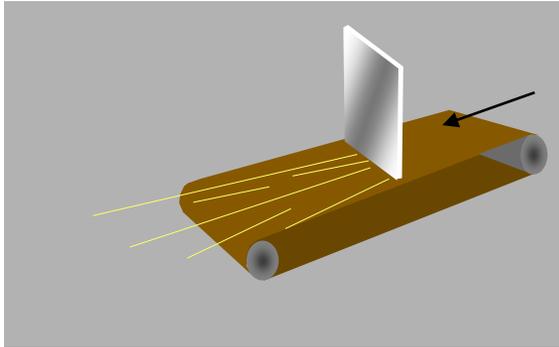
# TRIZ POWER TOOLS



## Contradiction Exercises

*All exercises are designed to be solved with  
Separation Principles Found in "TRIZ Power  
Tools—Job #5 Resolving Problems"*

# A Slight Polishing



Your company polishes the edges of glass plates. Thousands of plates are polished each day. The edges of the glass plates are polished on a fast moving belt covered with abrasive materials. One day an order comes in for polishing glass plates which are only .010 inches thick. The first attempts to polish the edges are catastrophic. The edges are chipped so badly that the plates are unusable. Due to the high volume of plates which are normally processed, it is not practical to change the machinery. The problem would go away if the plates were thicker, but they only come thin.

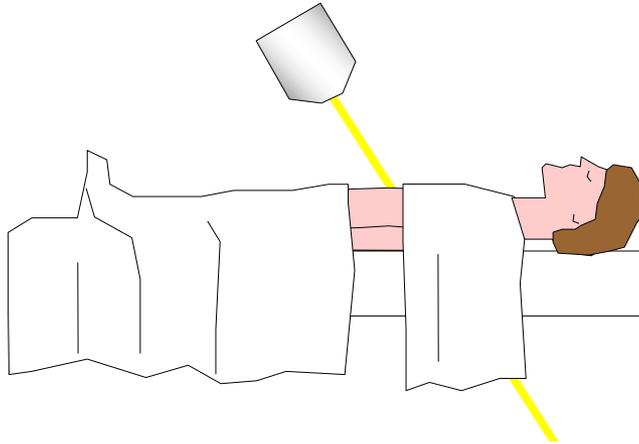
**The Plate Thickness  
Needs to be  
Thin & Thick**

Plate Thickness is Thick	Plate Thickness is Thin
--------------------------	-------------------------

Plate only comes in one thickness

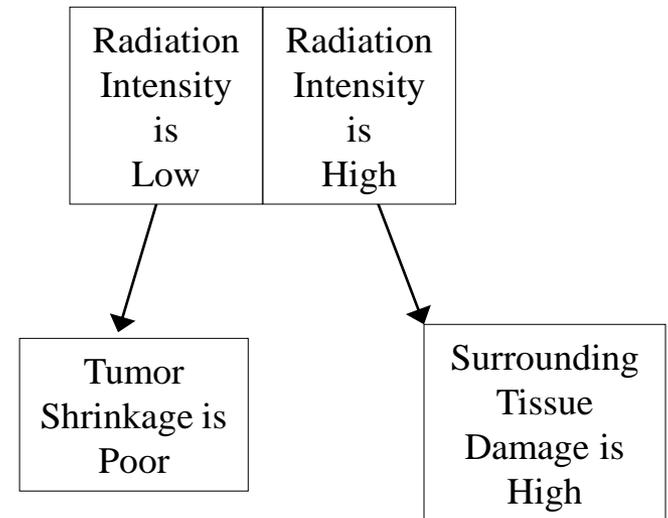
Edge Breakage is High

# Radiation Treatment

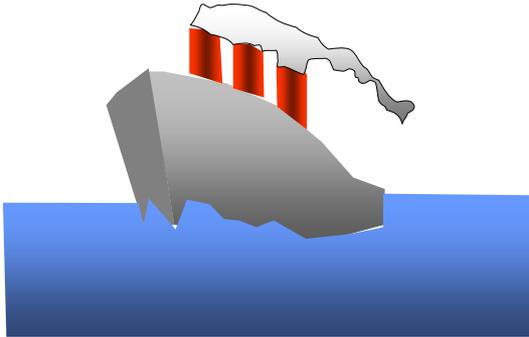


High levels of radiation can damage the structure of cells and cause them to cease functioning. This is useful in the treatment of tumors. A beam of high energy radiation is focused on the tumor. After the procedure, the tumor shrinks. Unfortunately, the tissue surrounding the tumor is also damaged by the high energy radiation.

The Radiation Intensity needs to be  
**High & Low**

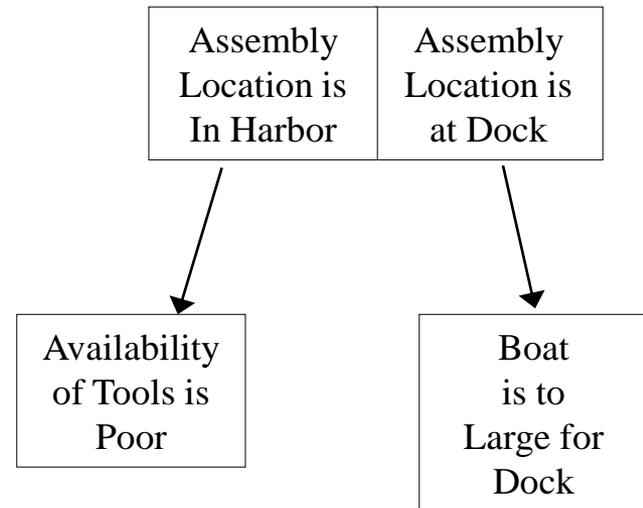


# Super Yacht

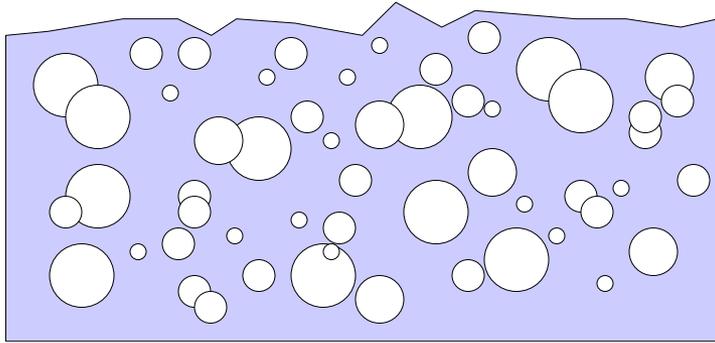


A small ship building company considers a contract to build a super yacht. The yacht is so big that only a third will fit into their dock. “We will need to build this in the open harbor.” A frustrated engineer says. “ We can’t do that, we need the availability of lifts and tools.”

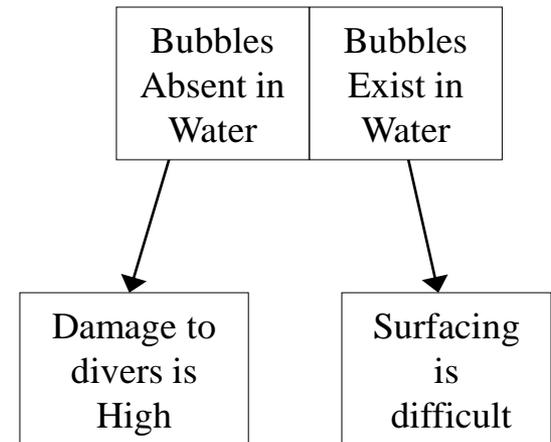
**The Building Location  
should be  
In the Harbor & At the Dock**



# Soft Water



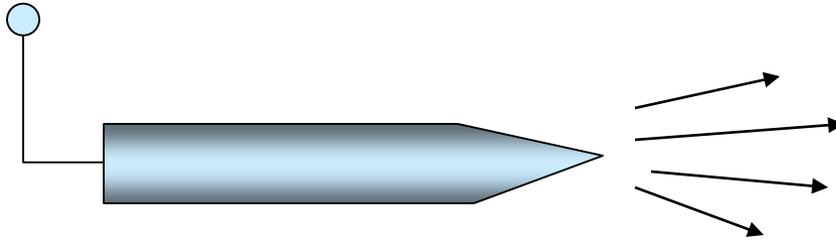
The addition of bubbles to diving pools is a good way to keep diving injuries to a minimum. This is especially true when diving from great heights. Unfortunately, the diver is no longer buoyant in the water and finds it difficult to surface after a dive.



The Bubbles need to be  
**Existent & Absent**

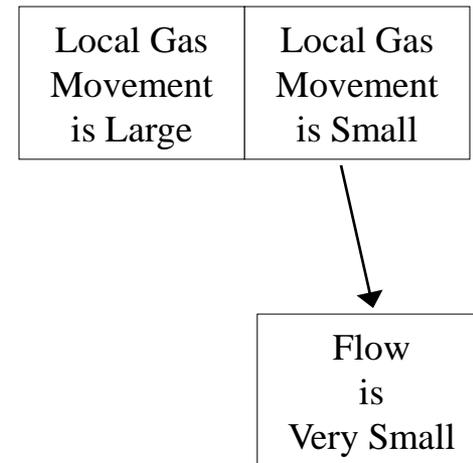
# Molecular Wind Pump

30,000 volts

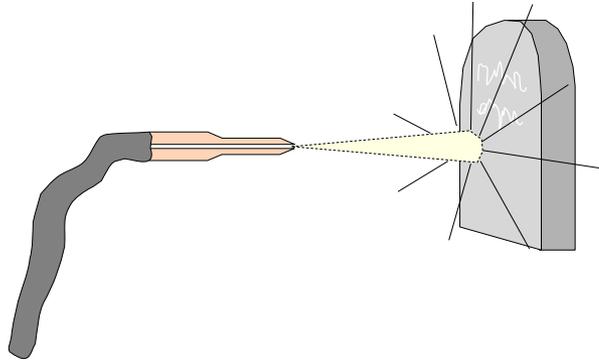


A molecular wind is created by applying a very high voltage source to a very sharp object. The electrostatic field gradient at the tip is very high. Any stray electrons in the gas (knocked off by a stray gamma ray for example) are accelerated by the field and collide with other molecules causing an avalanche of charges seen as a “corona discharge”. The resulting ionized molecules are repelled from the charged object, causing a molecular wind. The wind is localized to the point and could be used to pump rarified gas, except that the movement of the gas is so small.

The Local Gas Movement  
should be  
**Small & Large**

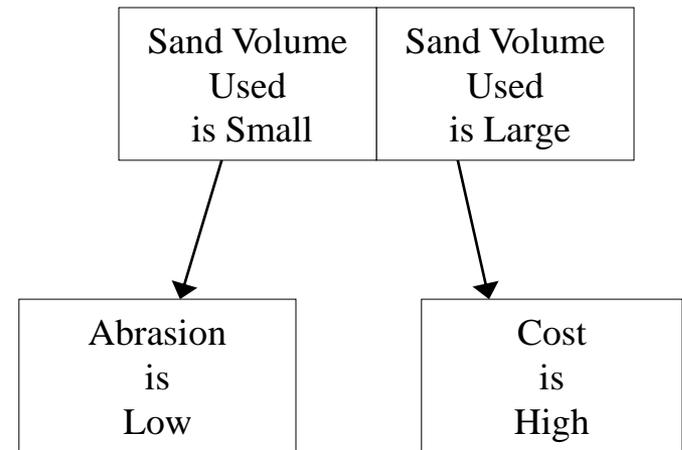


# Eternal Sand

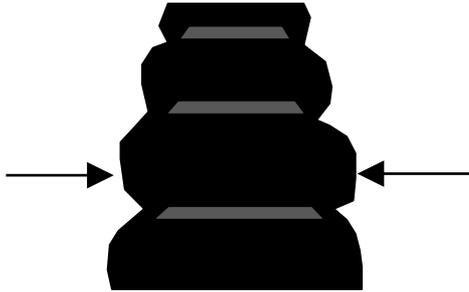


Inscriptions on grave stones are made by sandblasting the polished stone through a rubber mask. The mask is attached to the stone by adhesive and later peeled off. The sand is ejected through a nozzle at high velocity in a pneumatic stream. The sand can be reused for a time, but must eventually be replenished because it breaks down and becomes too fine for use. A large operation must replenish the sand often and dispose of the used sand.

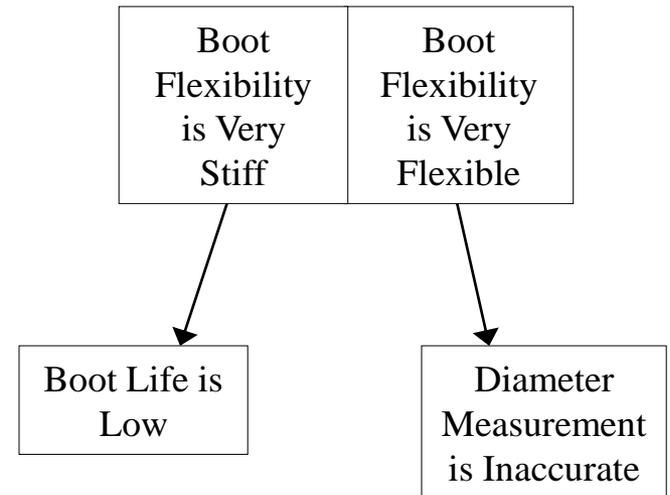
The Volume of Sand Used  
must be  
**Large & Small**



# Too Flexible

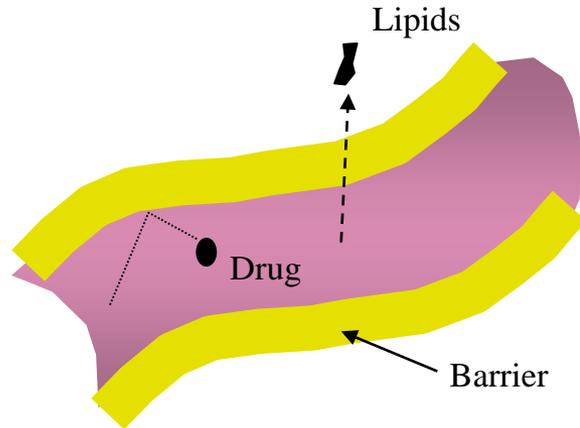


Various diameters of a thin rubber boot (which covers part of a car shift mechanism) must be measured with great accuracy at several points. Unfortunately, the micrometer which is used deforms the boot during the measurement. This makes the measurement inaccurate. How can the boot be measured more accurately?

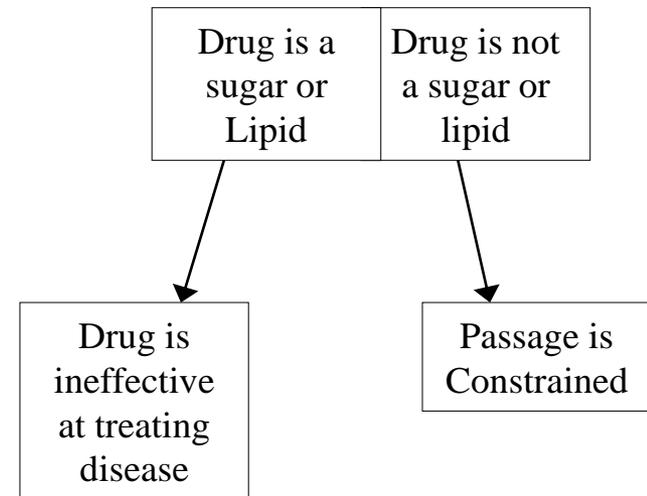


The Boot Flexibility  
Needs to be  
**Flexible & Stiff**

# Blood Brain Barrier

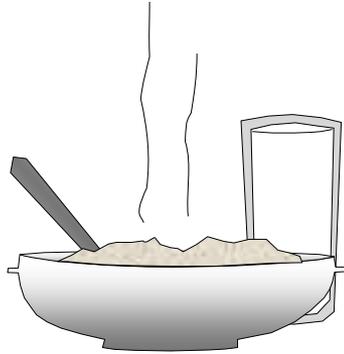


Some medicines need to be delivered to the brain, but cannot cross the blood-brain barrier. Molecules that pass easily are lipids and sugars. How can these medicines be delivered across the blood-brain barrier?

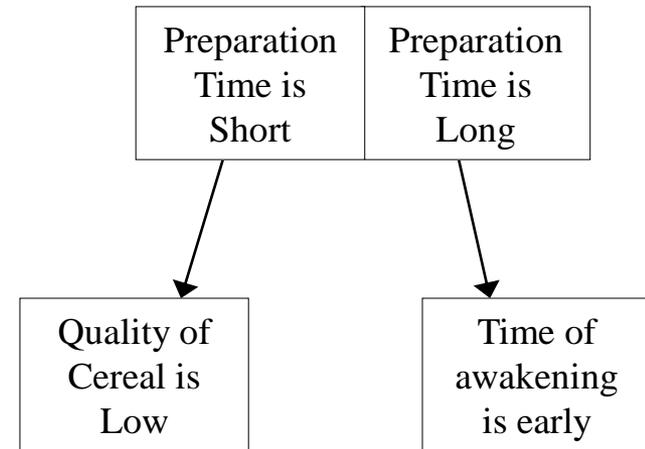


The composition should be  
**Lipid & non-Lipid**

# The Farmer's Mush

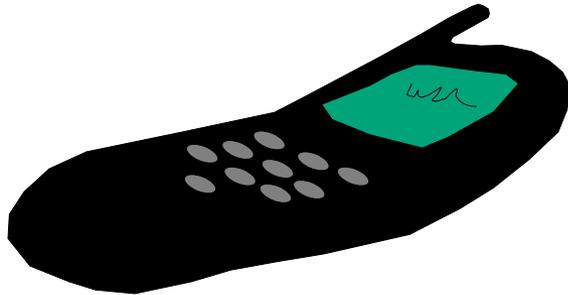


“I can’t stand cold cereal any more!” the farmer says. “Yes, but it takes a long time to make hot cereal the way that you like it! I’m not getting up any earlier to make it!” the farmer’s wife complains.

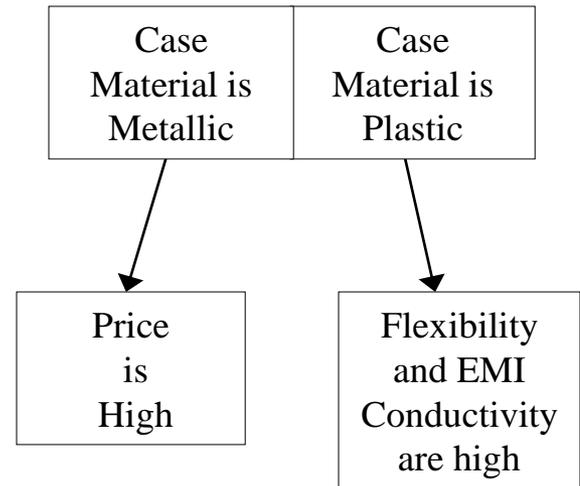


The Preparation Time  
should be  
**Long & Short**

# A Limit to Cell Phones

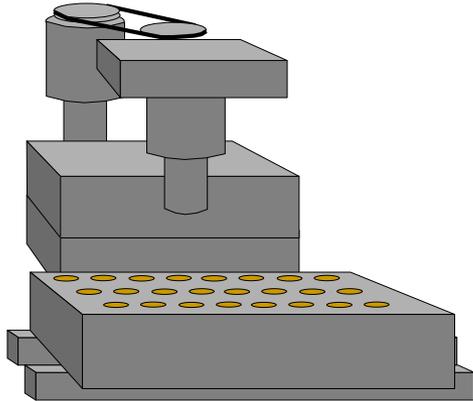


Consumers want cell phones that are thinner, lighter and cheaper. Plastic is lighter than metal and generally results in a lower product cost. However, a plastic phone will have too much electromagnetic interference and it is too flexible to hold the phone together.



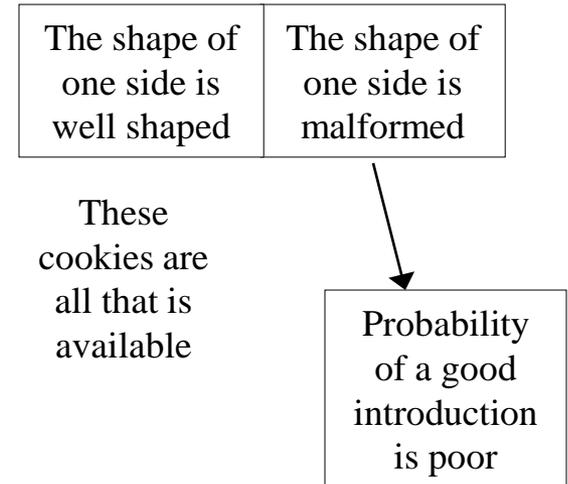
The Cases  
should be  
**Metallic & Plastic**

# Ugly Cookies

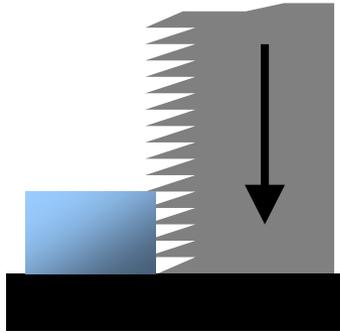


A production line for gourmet cookies has just been brought on line and has been in production for several days. The plant manager's wife inspects the cookies and discovers that they do not look like her home-made recipe. They are well shaped on one side but malformed on the other. "The equipment will have to be retooled to make them bake right" the wife says. "It's too late!" The plant manager says. "We have produced ten tons and the cookie introduction is next week at the Convention."

The Cookie Shape  
Should be  
**Malformed & Well Shaped**

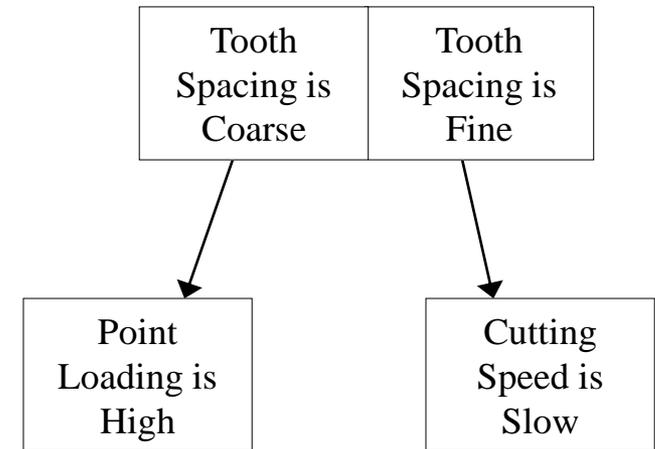


# Take Smaller Bites

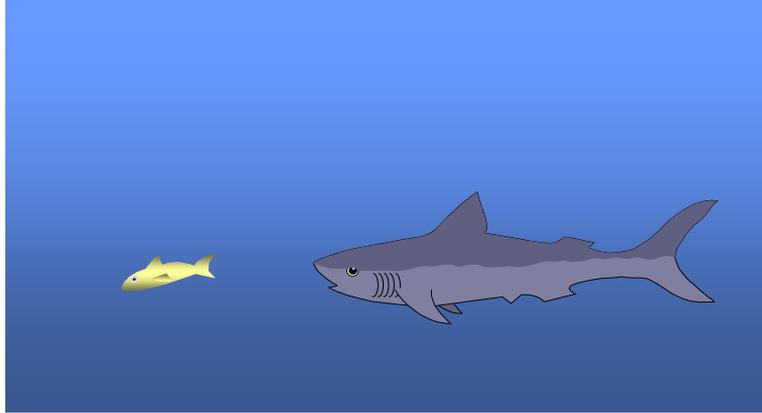


Industrial saws push the material into the blade with a set load. A rule of thumb for cutting a piece of metal in a band saw is to have at least three teeth on the piece of metal. This is because the point loading becomes too high. This causes bad things to happen such as breaking teeth, blades or rough cutting. On the other hand, if the teeth are too fine, the point loading on each tooth is too small. In a large production shop where many pieces of metal are cut, it is necessary to cut both thick and thin pieces. How can we speed up production?

The Tooth Spacing Needs  
to be  
**Fine & Coarse**

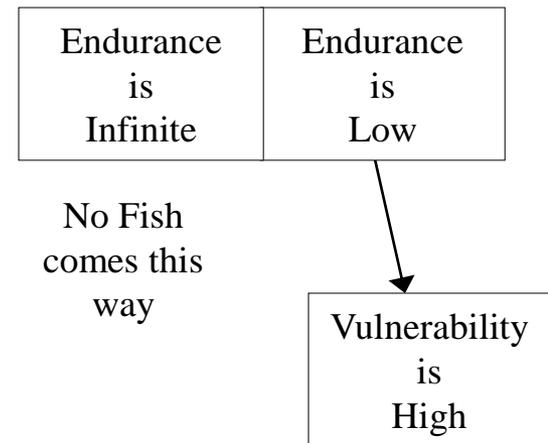


# Fish to the Rescue

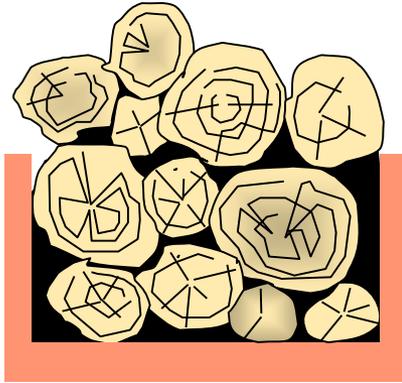


Like most large predators, a shark will follow its prey in close pursuit until the smaller prey exhausts its energy. Although the prey may be more nimble, it cannot outrun its larger foe forever. If the smaller fish could dodge and dart forever, it could easily outmaneuver the larger shark.

The Fish  
should have  
**Infinite Endurance & Be Normal**

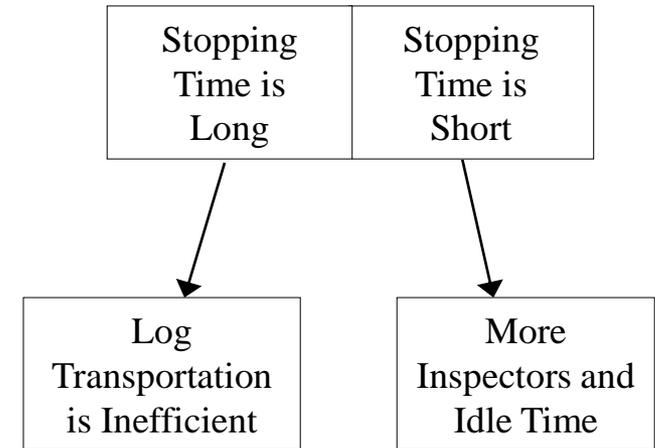


# Log Jam

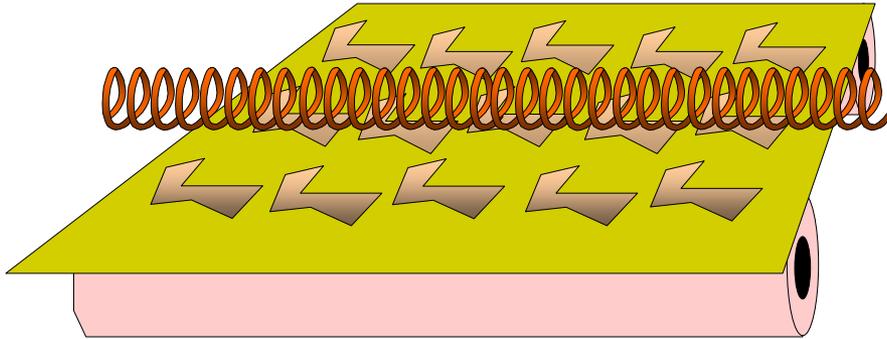


Every few hours, a train enters the depot with several cars full of logs. It is the job of the inspector to measure each log diameter. Unfortunately the train does not stay long. So far, the problem has been solved by hiring many inspectors. The inspectors have nothing to do between trains and sit for hours. The productivity of the inspectors is low. If the logs would just stay at the station for a long time, one inspector could do the job and would be fully occupied.

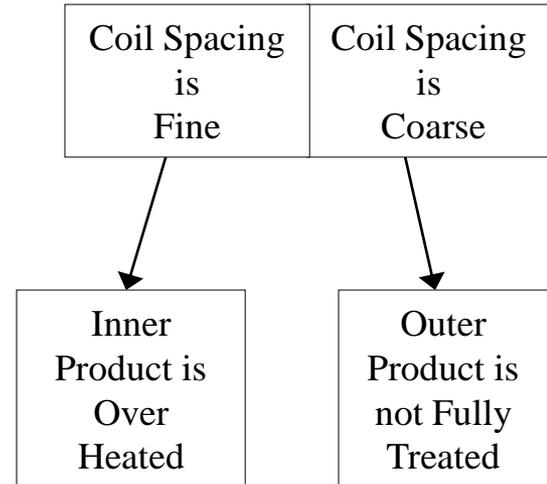
The Stopping Time Needs to  
be  
**Long & Short**



# Blistering Coils

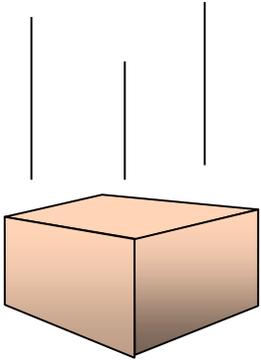


Product on an assembly line must pass under a heating coil in order to be fully treated. The product that passes under the center part of the coil is fully treated, but the product that passes under the coil at the edge of the conveyor belt is not fully treated. If the coil spacing was more fine, the outer product could be fully treated. However, the product at the center of the belt is over-heated.



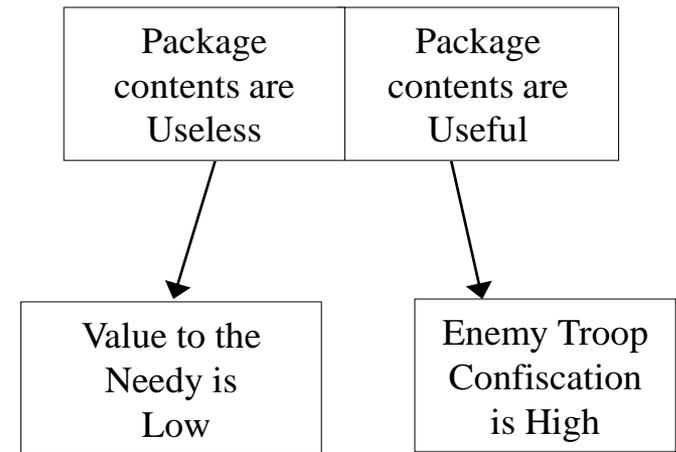
The Coil Spacing  
should be  
**Coarse & Fine**

# Special Delivery

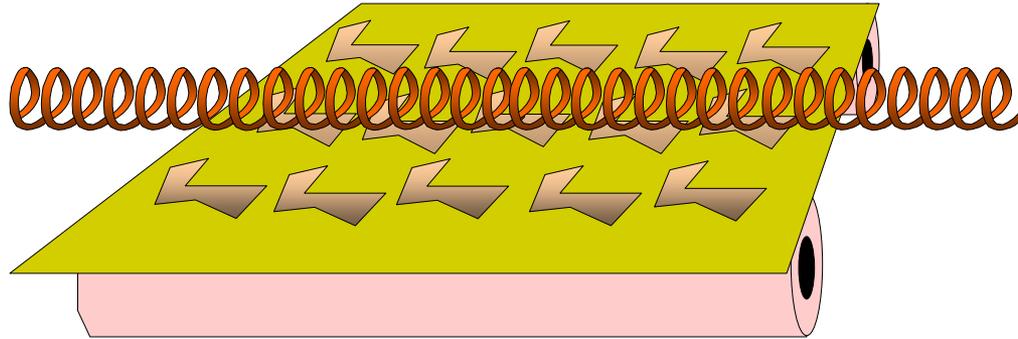


During war in a third world country, an effective means of gaining support from the local people is to give them much needed supplies such as medicine, food and clothing. In order to avoid anti-aircraft and small arms fire, the drop plane must fly high. If the package is dense and compact, it falls with pinpoint accuracy. A chute opens near the end to keep the contents from being damaged. Unfortunately, enemy troops on the ground then confiscate the package and horde the supplies to themselves. They quickly discover that the contents are useful and look for them.

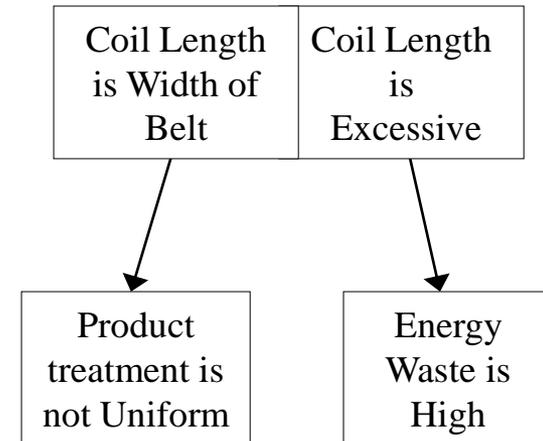
**The Package Contents must be  
Useful & Useless**



# Blistering Coils

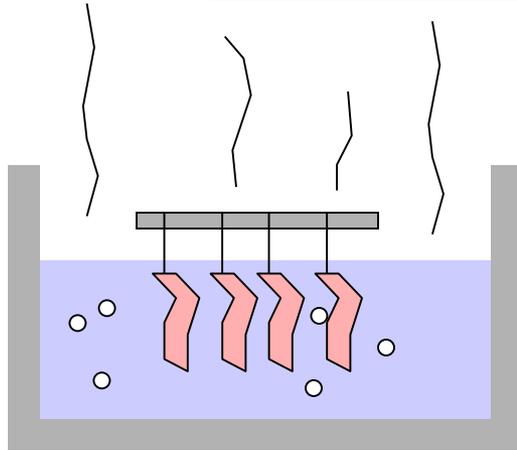


Product on an assembly line must pass under a heating coil in order to be fully treated. The product that passes under the center part of the coil is fully treated, but the product that passes under the coil at the edge of the conveyor belt is not fully treated. If the coil length is much longer, the product will be uniformly heated as it passes under the coil. Unfortunately, a lot of energy is wasted.

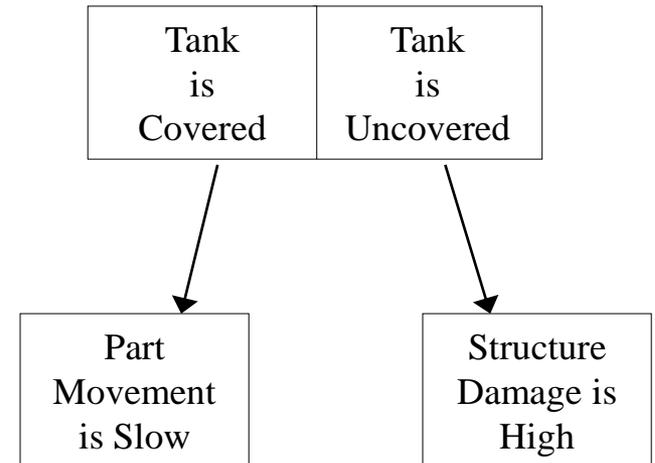


The Coil Length  
should be  
**Excessive & The Width of the Belt**

# The Cover that Wasn't

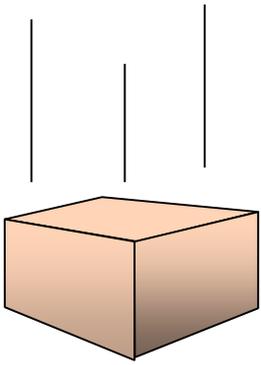


In large plating operations, the plating tanks give off large amounts of corrosive gasses. Over the course of time, these gasses damage the plating facility and everything in it. Covering the tanks with non-corrosive covers would greatly reduce the evolution of gasses, but a cover slows down production.

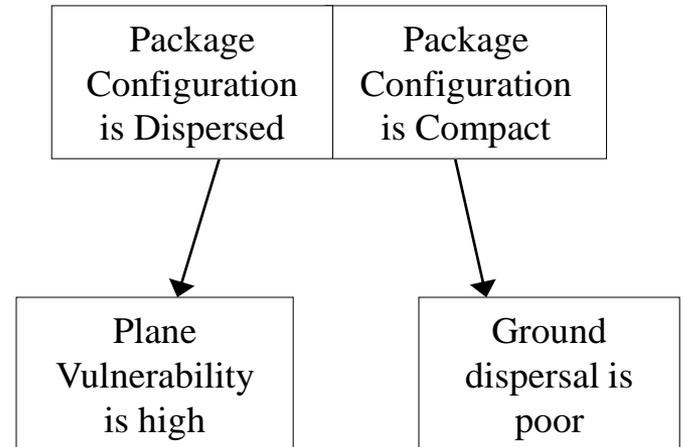


**The Plating Tank Needs to be Covered & Uncovered**

# Special Delivery

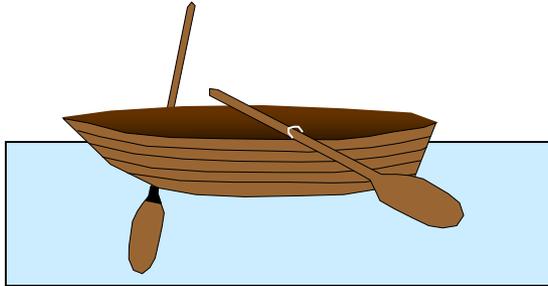


During war in a third world country, an effective means of gaining support from the local people is to give them much needed supplies such as medicine, food and clothing. In order to avoid anti-aircraft and small arms fire, the drop plane must fly high. If the package is dense and compact, it falls with pinpoint accuracy. A chute opens near the end to keep the contents from being damaged. Unfortunately, enemy troops on the ground then confiscate the package and horde the supplies to themselves. Dropping many packages gets more packages into the hands that need them, but high winds may disperse the drop if they are dropped separately.

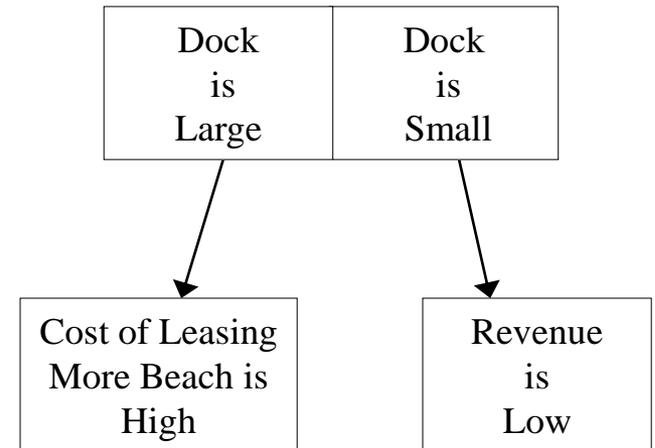


The Package Configuration  
must be  
**Compact & Dispersed**

# What's Up Dock

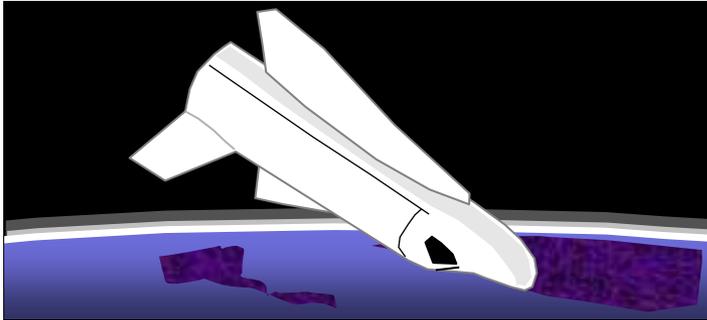


“We’ll make a fortune” the small investor said. “When they build the houses around this lake, everyone will want a place to dock their boats and we got the last parcel on the lake”. “Yes, but it is too small to store many boats” his wife complained, “And we are not allowed to build the dock out more than 20 yards”. “I know” she continued “We can fill every available square foot with dock and boats!” “ We still will not be able to store enough boats to make money” the investor said after making a few calculations.



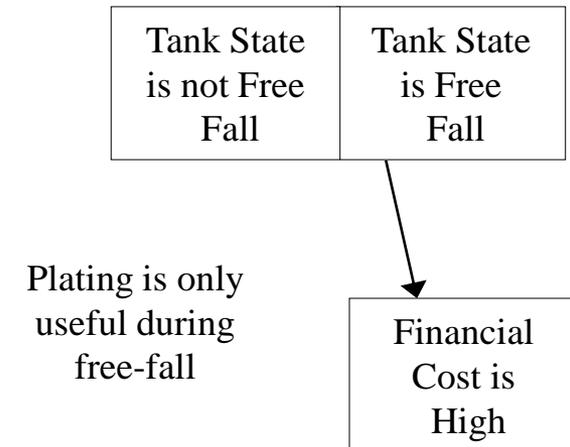
The Dock should be  
**Small & Large**

# Free-Fall Plating

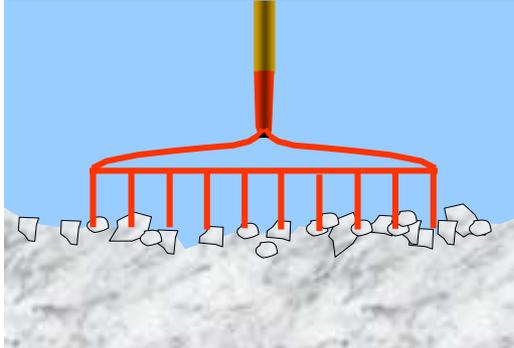


Crystals grown in a micro-gravity environment have unusual properties. Such an environment is created by objects in free-fall. A space craft in orbit about the earth achieves this same effect by being in a constant free fall state. Plating in such a free-fall state might also have unusual properties. We are a small company which cannot afford a shuttle experiment. How can we perform such experiments.

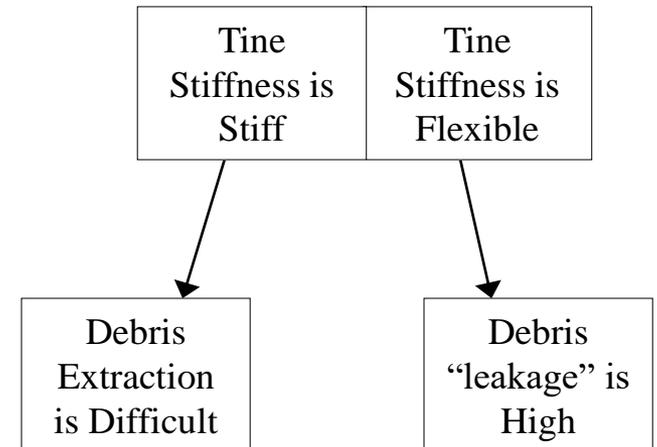
A Plating Tank State  
should be  
**Free Fall & Not Free Fall**



# Two Tining Rake

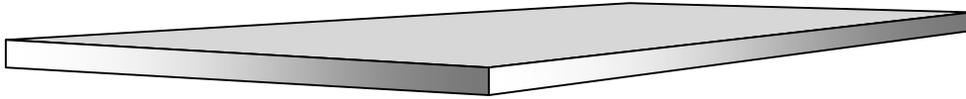


A common garden rake is somewhat inefficient when raking small debris. While riding over uneven surfaces, unwanted debris settles into the uneven surface and the tines ride over the top without collecting the debris. If the tines were more flexible, they could ride over the uneven surfaces like a leaf rake and collect the materials. On the other hand, if the tines are flexible, then the rake is not useful for extracting embedded debris or for moving earth about.



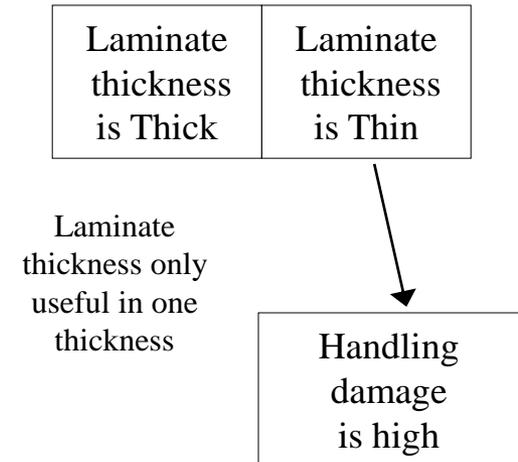
The Tine Flexibility should  
be  
**Flexible & Stiff**

# Metallic Film

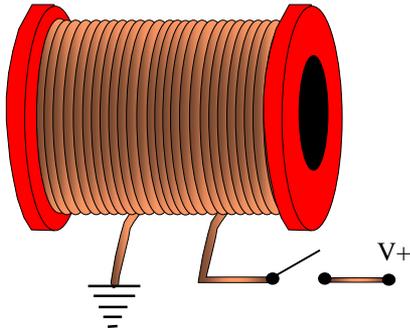


In the production of metallic laminates, Thick metallic films are produced by successively rolling the metal between rollers until it reaches the desired thickness. The resulting film is rolled up into large rolls which are easily manipulated. When making ultra thin films for laminates, new problems arise. Because the film is so thin, both the production and manipulation becomes difficult. The tolerance between rollers becomes unreasonable and handling damage becomes very high.

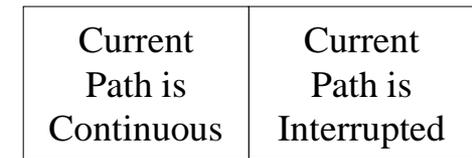
The laminate  
must be  
**Thick & Ultra-Thin**



# I Just Can't Stop



Electromagnetic coils are used for many applications which require the generation of force. Magnetic fields generated by the coil and the spool upon which the wire is wound interact with plungers also made of magnetic materials. Usually, the flow of current to the coil is initiated by throwing a switch which allows electrons to begin flowing. Such coils are natural inductors, meaning that the flow of electrons begins slowly, like trying to push a heavy object. When it comes time to turn off the coil, the opposite effect occurs. The electrons do not want to stop moving, but “bunch up” causing high voltages. In many applications this causes difficulties such as sparking (deteriorating brushes and switches or causing electromagnetic pulses) or high voltages across other elements.

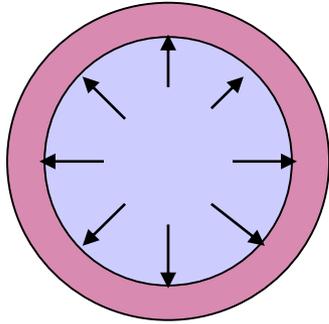


Coil Operation not Adjustable

Voltage Spikes are High

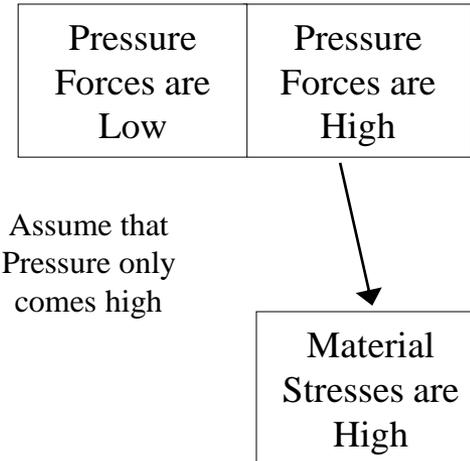
**The Current Path Needs to be Continuous & Interrupted**

# Storing Almost Protons

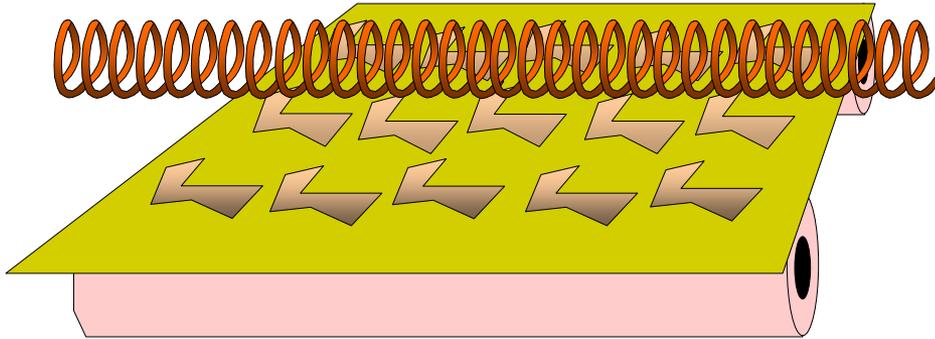


Hydrogen is very difficult to store as a gas. This is primarily because of the high gas constant. A small mass of gas can exert very high pressures when constrained to a small volume. In order to reduce the stresses in the vessel walls, the walls are made very thick. The resulting vessel weight is high (95%) compared to the weight of the hydrogen (5%). If only the pressure forces were not so high, the vessel walls could be made much thinner.

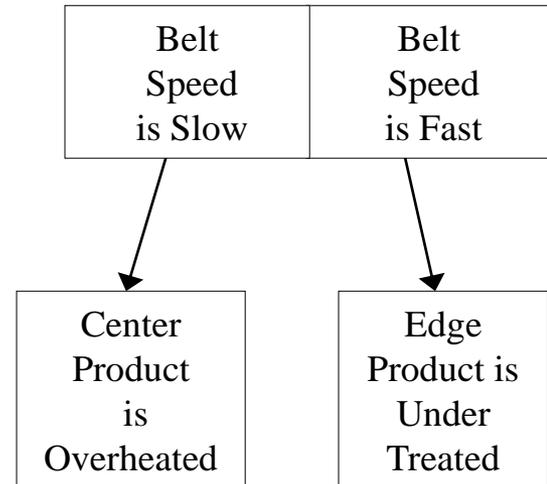
The Pressure Forces  
should be  
**Low & High**



# Blistering Coils

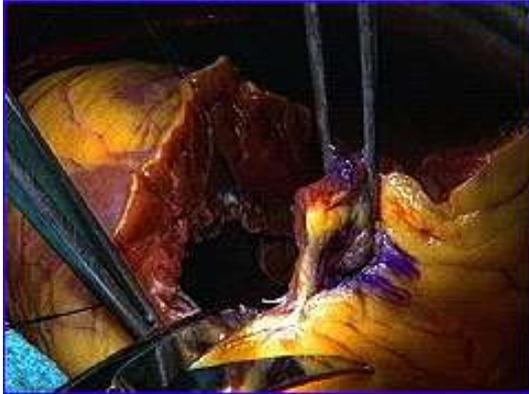


Product on an assembly line must pass under a heating coil in order to be fully treated. The product that passes under the center part of the coil is fully treated, but the product that passes under the coil at the edge of the conveyor belt is not fully treated. If the belt speed were slower at the edges, the product will be uniformly heated as it passes under the coil. If the belt is slowed down, the center pieces will be over heated



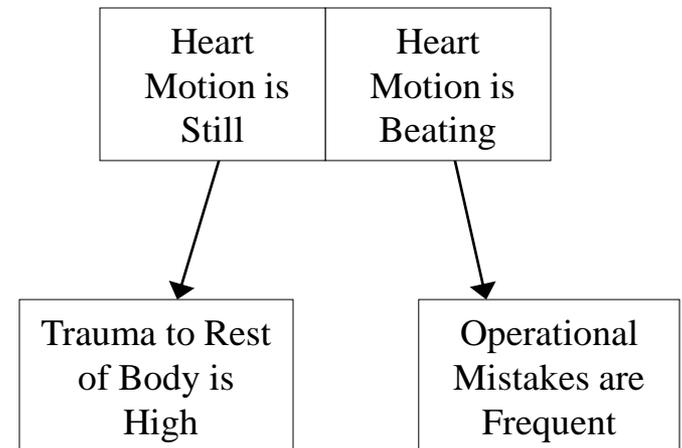
The Belt Speed  
should be  
**Slow & Fast**

# The Beat Goes On

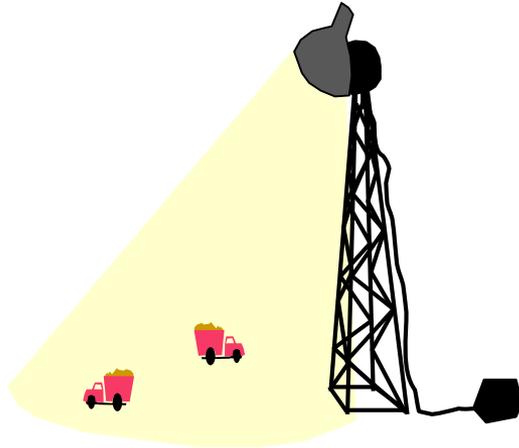


Heart surgery is sometimes required for battlefield wounds to the heart. Small pieces of shrapnel become lodged in the heart muscle. Usually, the heart is stopped, temporarily, to repair it since it is very difficult to operate on a beating heart. This stoppage of blood flow is very traumatic for the rest of the body which may be badly damaged. If it were possible to operate on the beating heart, there would likely be more survivors.

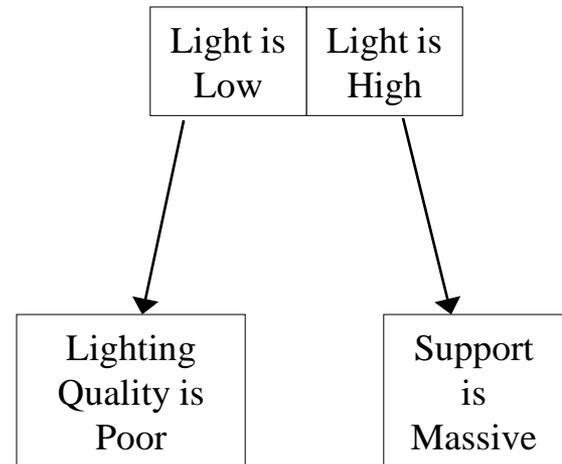
The Heart Movement  
must be  
**Beating & Still**



# Construction Lights

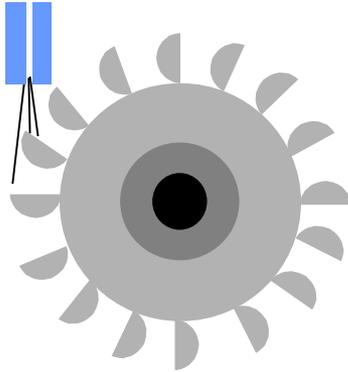


During large construction projects, it is desirable to light a work area the size of many football fields. It would be desirable to have one very large and high light. But, doing this is prohibitive because of the large structure that would be required to support the light.

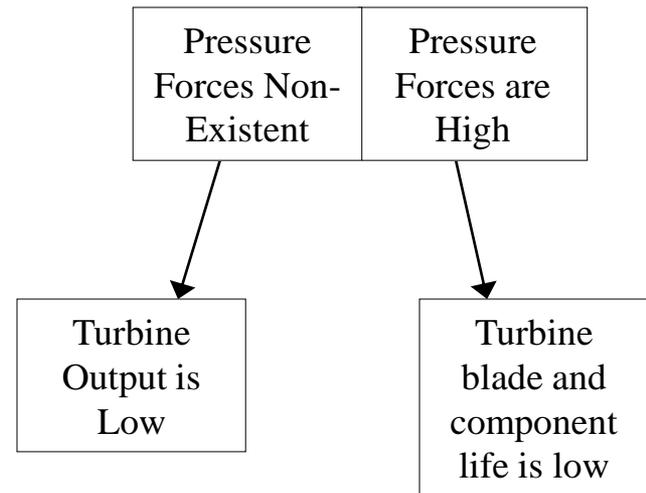


The construction light needs to  
be  
**High & Low**

# Water Wheel

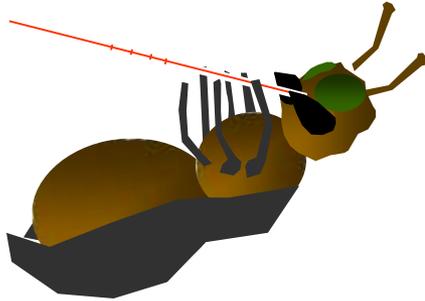


Consider an aluminum water wheel. Inlet flow strikes the blades after accelerating in the nozzle, transferring energy and momentum to the blade and wheel. During energy transfer the blade is bent slightly and released causing it to vibrate. The resulting alternating stresses decreases the life of the turbine blades. If the pressure forces were eliminated, so would the vibration. (Assume a constant speed).



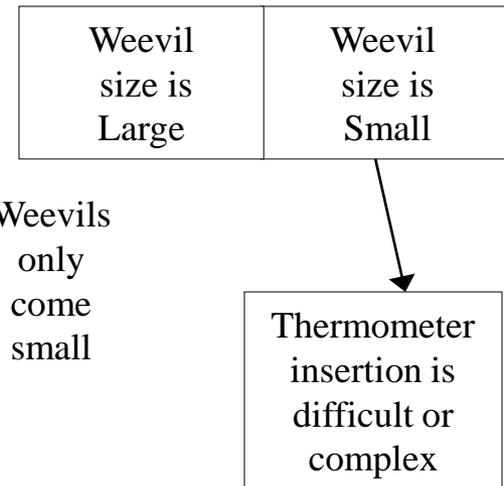
The Pressure Forces should  
be  
**High & Non-existent**

# The Lesser Weevil

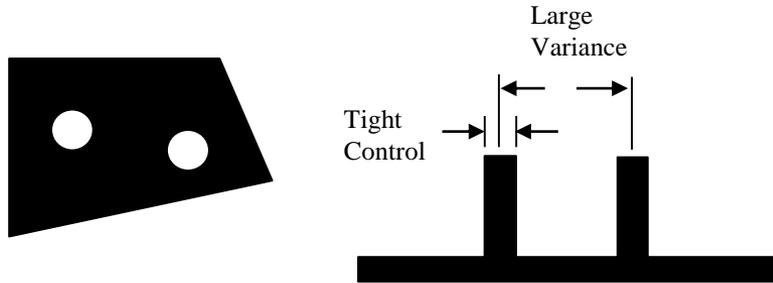


In the war on hunger, Russian scientists were studying the metabolism of the weevil. This required the scientists to be able to measure the body temperature over a period of time. Tiny temperature probes were proposed, which through the aid of a microscope could be inserted into the weevil. The cost of these probes and placement apparatus were prohibitive. If the Weevil were only larger, we could put a normal thermometer into its mouth opening?

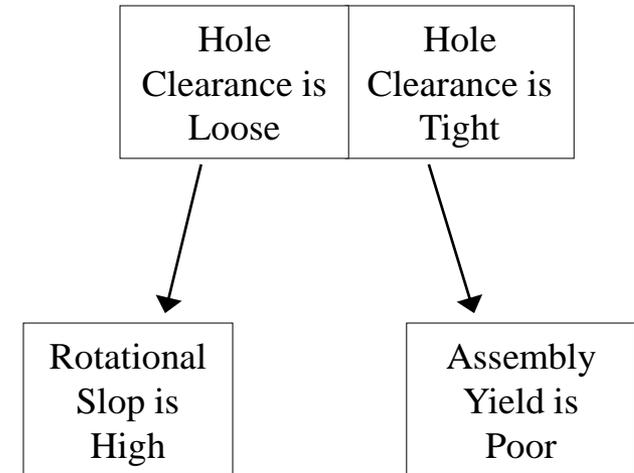
The Weevil Needs to be  
**Large & Small**



# A Post and an Outpost

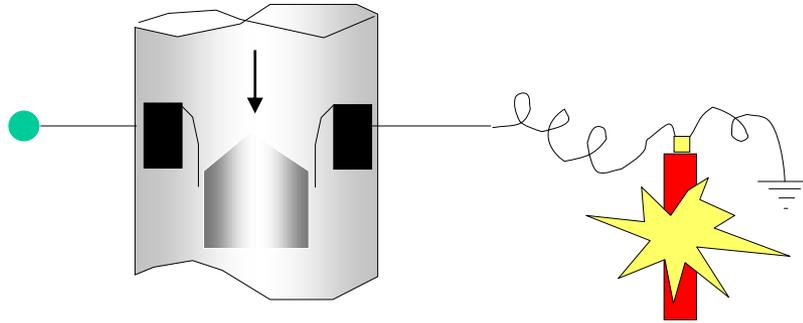


For years your company has produced a aircraft product which fits over two posts on your customers aircraft. Both the position and the diameter of the posts were closely controlled. Unfortunately, a recent production change by the customer allows a large variance in the distance between the posts. Now there is no guarantee that the part which you produce will fit over the customers posts. (The diameter of the posts is still closely held). The customer is unwilling to change the new production process, but has instead asked you to modify the part so that it will always fit snugly, without rotating. If the hole clearance is large, they can easily fit over, but they will not be snug.

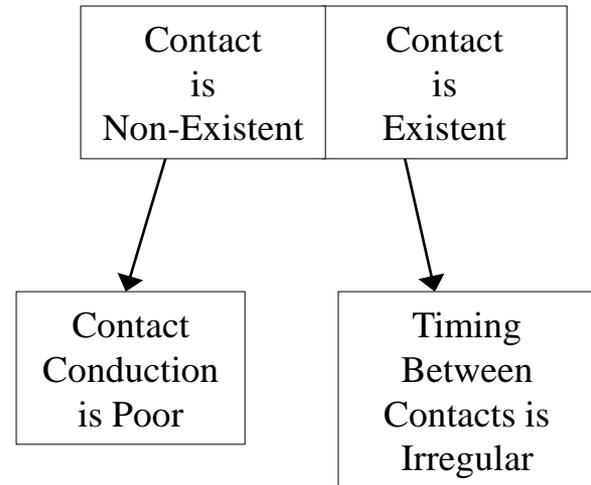


The Hole Clearance  
Needs to be  
**Loose & Tight**

# Controlled Explosions



During mining operations it is necessary to precisely time a series of explosions. One way to do this is to drop a conductive plug down an evacuated tube with electrical contacts spaced at precise intervals. When the conductive weight passes a each set of contacts, continuity is established across the contacts (across the tube) and an explosive charge is detonated. Unfortunately, in order to ensure continuity, the force of the contacts against the conductive weight needs to be high. This causes friction and consequently the timing to be erratic. Remember, this is a Flintstones timer. No further electronic circuits are available. All we have are metallic plugs and contacts. (If we already had magnetic relays, lasers and electronic timing circuits, we wouldn't be dropping balls).



There should be  
**Contact & No Contact**