TRIZ POWER TOOLS

Skill #1 Resolving Contradictions

March 2012 Edition

They need to be LARGE to get in but they are SMALL because they are young

The Skill that Will Give You the Confidence to Do the Rest

TRIZ Power Tools

Skill #1—Resolving Contradictions

March 2012Edition

TRIZ Power Tools by Collaborative Coauthors

216 Pages

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Introduction

(If you are reading the PDF format—navigate the algorithms with the "Bookmarks" to the left. L1, L2, L3 correspond to levels of the algorithm. The levels are hierarchal; you can go as deeply as required to resolve your problem. Lower levels (L1, L2) have consolidated methods. If you are using the book then use the Table of Contents for the Algorithm)

Resolving contradictions is one of the most useful and fundamental aspects of TRIZ because it greatly expands the solution space. It allows us to consider turning many more knobs than we would normally be allowed to turn. Resolving contradictions allows us to improve something without making other features worse. At the heart of most contradictions is a knob that must have two settings. For instance, we talked about a vehicle that needed to have a small volume in order to create low drag and a large volume to carry lots of cargo. This appears to be physically impossible, yet we will try to make this happen.

Common Approaches for Dealing with Contradictions

There are several approaches to dealing with contradictions:

1) Discount one or both of the conflicting properties. This is a common approach used in theological, political, negotiation or historical settings. .

2) Compromise somewhere between both conflicting properties. This is a standard approach taught in most schools and widely adopted throughout industry for resolving problems of all genre.

3) Deliver both properties to the required degree by resolving the contradiction. This is an unusual approach that can apply to problems of all type.

4) Allow only one of the properties and then compensate by turning another knob. This is also a valid approach which we will call "compensation".

The first approach of discounting one or the other conflicting properties, can be referred to as the ostrich approach or throwing the hand grenade back over the wall. Either we do not face the problem or we force someone else to deal with the problem. In this case we would either deny that the drag existed or we would deny that the volume was too small. As mentioned, this approach is less common in the world of physics, but it can happen in the realm of marketing. For this text, we will not discount either property but rather assume that we are only dealing with situations where the requirement for both properties are valid because we have thoroughly analyzed the situation

The second approach is to compromise and make the volume larger but not "too large". The problem with this thinking is that we now *guarantee risk*. If we are building the vehicle for public sale, we may find that the cost of operation is too high for some customers and the volume too low for others. In order to perform an artful compromise a lot of data needs to be collected and models built. This can be time consuming. In addition, it is likely that this risky situation that will be perpetuated in future generations. Due to these drawbacks, we will not be applying this approach in this text.

The third approach is to resolve the contradiction without compromising. Nobody, including future generations, needs to live with the problem. When we learn how to do this, we will find that there are a lot more knobs that we can consider turning to solve problems. This skill is liberating to problem solvers who find that the solution space is much larger than they supposed.

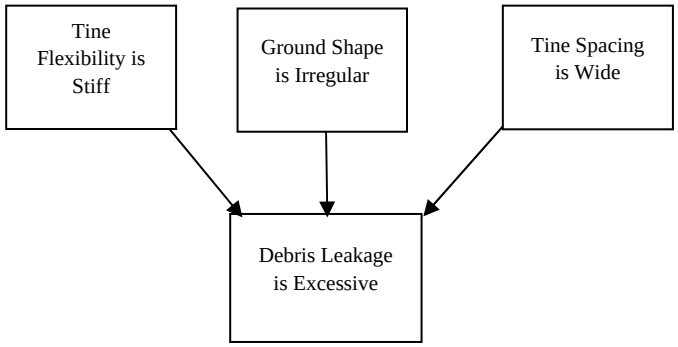
The fourth approach, compensation, is also valid, though generally less powerful than resolving contradictions. We will be further exploring this method in this text.

A Review of How we Form Contradictions

Recall that we first looked at contradictions while we were performing the causal analysis. Let us consider the situation of a common garden rake. When the rake is used to collect loose debris such as rocks and loose weeds over an uneven surface, a problem arises: The rake "leaks" some of the debris that is to be collected under the tines and several strokes are required to fully collect the debris. The dependent variable that we want to improve is "Debris Leakage". Let us now ask what the debris leakage is a function of.

Debris Leakage = f (Tine Flexibility, Ground Stiffness, Tine Spacing . . .)

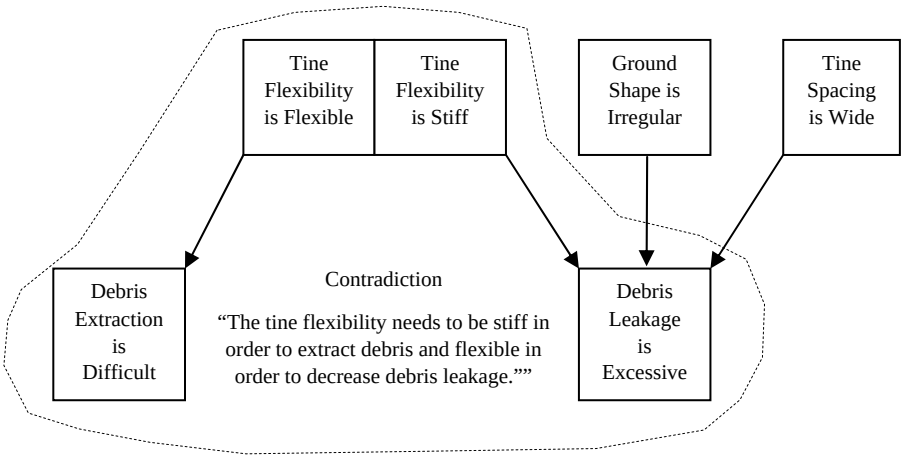
(Note that we are not considering all of the possible independent variables). This can also be shown pictorially with a causal analysis diagram. (Note that we are not showing functions at this point but only the object attributes or knobs.)

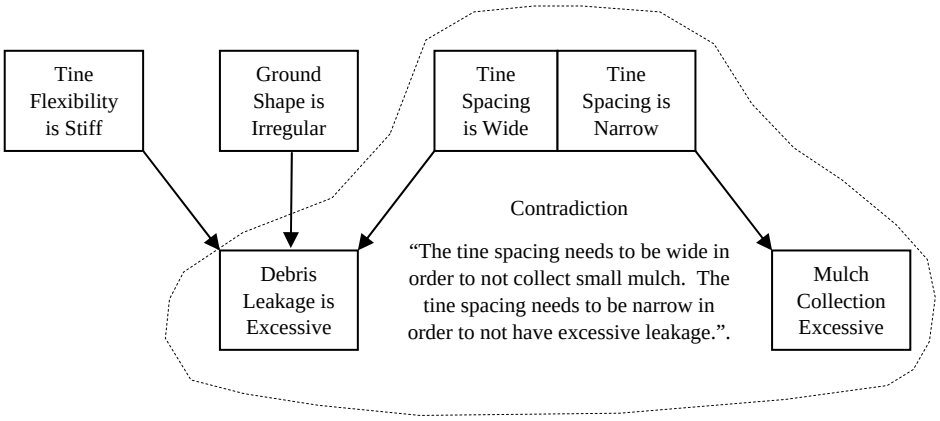


Now, let us improve the situation by turning *one* of the knobs: Tine Flexibility. (We show this by creating another box with the conflicting knob setting). Flexible tines follow the contour of the earth and collect much more effectively.

Unfortunately, other things get worse. It is more difficult to extract embedded debris from the soil and to move soil around (other functions of the rake). This difficulty can by represented by the following diagram. (For the sake of simplicity we are only considering debris extraction).

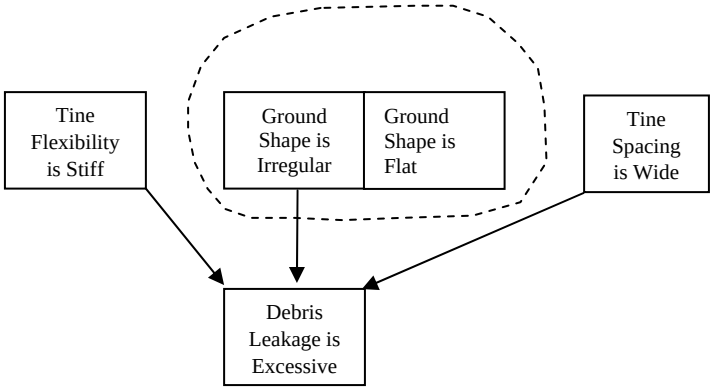
The contradiction can now be stated: "The rake tines need to be flexible in order to collect and they need to be rigid in order to extract embedded debris from the ground". Had we chosen to decrease Tine Spacing, as shown below, we would have found that the rake now collects too much useful small debris (mulch) that would ordinarily be left behind.





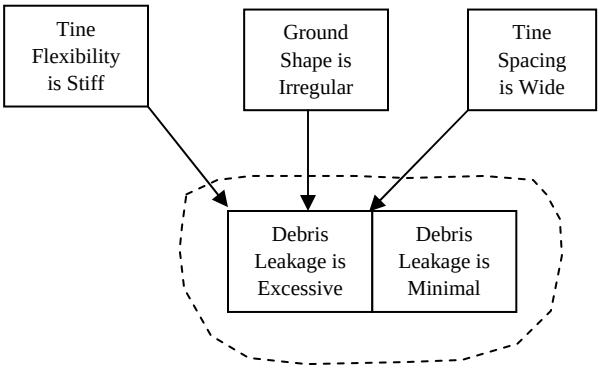
Conditions where it is More Difficult to State a Contradiction

A properly stated contradiction may *not* include something that gets worse. Suppose that we had chosen the ground shape as the knob to turn. In this case it would be clumsy and artificial to identify something that gets worse if we make the ground flat. Instead it is better to conclude that the ground shape comes in many different "flavors" other than flat.



The full contradiction can be stated, "in order to improve Debris Leakage, the Ground Shape needs to be flat, but since the ground shape comes in many different forms, it needs to be Irregular". Many contradictions arise because a knob only comes in one "flavor". While this fact does not stop us from resolving the contradiction, it does serve to show that it is not always practical to state something else that becomes worse.

A second example of a contradiction, which does not include something else getting worse, is when we try to turn an "outcome knob" without consideration for the inputs. In other words, we want to improve a *dependent variable* without regard for the independent variables or knobs that cause the problem. The contradiction can be stated "the Debris Leakage must be excessive because the ground is irregular, the tine spacing is wide and the ground is irregularly shaped.



The Debris Leakage must be minimal because that is what we want to improve"."The Debris Leakage is excessive and minimal".

Why not use the Contradiction Matrix?

In the early years of TRIZ development, Genrich Altshuller created what is called a Contradiction Matrix. The matrix was designed to help the problem solver resolve contradictions. It was created by meticulous study of "strong" patents. Altshuller noted the apparent methods of resolving difficult contradictions and categorized them into 40 Inventive Principles. By noting the type of problem that was solved and the number of times that a particular resolution principle was employed, it was possible to create a table of the "best" methods for resolving these contradictions. The table is used by choosing a variable that must be improved on one table axis and then finding the variable that gets worse on the second axis of the table. This defines a row and column of the table. At the intersection lies a cell containing the most common principles used to resolve this particular contradiction.

There has been a great deal of debate concerning the need for the Contradiction Matrix. Avid users of the matrix can often point to successful solution concepts generated by the use of the matrix. It is clear that it is possible to successfully use the Contradiction Matrix. It represents a quantum improvement over standard brainstorming methods. It is simple and compact. The user feels very creative while using it. On the other hand, many TRIZ specialists have abandoned the matrix in favor of using Separation Principles.

At the risk of sounding incomplete, we will not be using the Contradiction Matrix in this text. The main reason for this is that using Separation Principles helps enhance visualization of the solution. In order to illustrate why this is important, let's see what happens if we use the Contradiction Matrix in the pile driving example. I want to improve the driving speed without sacrificing the supporting capability of the pile. Let's say that I go to the Contradiction Matrix and it is suggested that I consider the principle of Local Quality[1] (non-uniform in space). Should I apply this principle to the pile driver, the ground or the pile? Once I decide which object to consider, I am left to consider what feature to make non-uniform? The problem solver must make assumptions and drive forward. Assumptions can limit our options, especially if we only consider what we have considered before.

Now, let's consider the use of Separation Principles. First, we begin with a carefully constructed contradiction: we need the pile to be sharp in order to drive more easily and we need it to be blunt in order to support well. Notice that we have identified both the object (the pile) and the attribute (tip shape) to consider. The Separation Principles provide a large number of methods for resolving this contradiction. If we pick the Separation Principle of Separation in Space and the sub principle of "Non-Uniform", we can directly visualize a single pile that is sharp in one location and blunt in another. For instance, the tip can be sharp, but further up the pile, it can have a blunt feature protruding. The ability to visualize a solution is actually enhanced when we make the problem "harder" by saying that the solution requires the extreme properties of "sharp" and "blunt".

New Separation Principles

Several new categories of Separation Principles are introduced which are unique and distinct from Separation in Space, Separation in Time and Separation between the Parts and the Whole. (These three are the separation principles practiced in mainstream TRIZ).

> Separate Gradually. There are cases where there is no definitive moment in time where an object or system has different properties. These properties can creep gradually until the full transformation is complete.

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1 Inventive Principle #3—Local Quality: Transition from homogeneous to heterogeneous structure of an object or outside environment (action). Different parts of an object should carry out different functions. Each part of an object should be placed under conditions that are most favorable for its operation. Genrich Altshuller, The Innovation Algorithm page 287.

Separation by Scale: both properties are expressed, but each at different scales. A piece of sandpaper is composed of rigid particles expressed at the micro-scale and flexible at the macro scale. This is different than Separation between the Parts and the Whole because with Separation in Scale, we want to express both properties, whereas in Separation between the Parts and the Whole, we only want to express one property at the macro level.

Separation by Direction: at the same moment in time and in the same space, a piece of sheet metal can be flexible in one direction and stiff in another.

Separation by Perspective: separation occurs because of unique ways of looking at the situation. An object may be small, but look large under a microscope.

Separation by Response of Fields: at the same moment and in the same space, glass can be transparent to visual light and opaque to infrared light.

Separation between Substance and Field: at the same moment and in the same space, the field coils of a motor can be stationary while its field is moving.

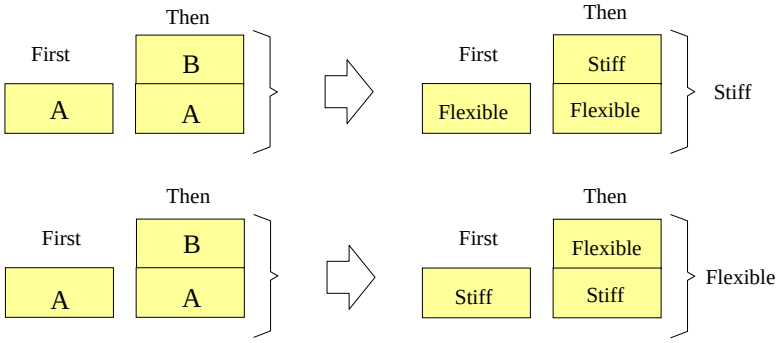
The author believes that there may yet be other groups which are distinct from time, space and separation between the parts and the whole.

When it is Difficult to use a Separation Principle

It is common that the problem solver will become confused while trying to apply one of the methods. One way around this problem is to simply brainstorm a variety of objects that use the method *and* have the contradictory properties regardless of whether they resolve the specific contradiction. This line of reasoning will sometimes clear the path to using the method.

Each method should be carefully considered before moving on. Remember that each method is a model solution. Instructions, diagrams and examples are given with each method. One of the more powerful tools are the A and B diagrams shown at the beginning of each method. Insert the conflicting words for the A and B symbols to help visualize the model solution.

There are often two ways that the diagrams can be written, try both ways as shown. An example from Separation in Time is shown above.



Recursive Improvement

Once we have solutions to the contradiction, the final stage of this step asks us to check whether our goals have been met. Are there any major risks or disadvantages left? Have we met the specification which we have made to satisfy our market? If we have not, then we must loop back and continue to improve the product or process. If we have met the goals, then it is time to move on to the next possibility. If we can find no solution to the contradiction, then we may pick another object attribute to idealize.

Law of Non-Uniform System Development

Before leaving this introduction, it is worthy of note that system development is largely regulated by the overcoming of contradictions. Systems do not improve in a pretty manner. There is constant tension between development of

one part and another. One would think that a given product, over time, would have a much more smooth development in which each part of the system becomes better and better. This was not meant to be. We refer to this as the law of non-uniform system development which states that:

—-System parts are improved in “fits and spurts”

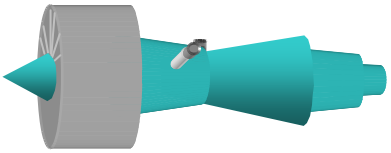
—-When one part is improved, other parts may be harmed.

—-System improvement is slowed by increasing conflicts.

—-When one part improves, other parts may appear worse by comparison.

—-The system takes on Subsystem improvements and Effects

To illustrate this, let us take a jet engine. One way to make a jet engine more efficient is to increase the temperature of the combusted gases before these gases enter the turbine part of the engine. This generally necessitates that many sub-components on the engine become hotter. The increased temperature accelerates the degradation of many subsystem components. Consequently, there is a constant struggle between increasing the efficiency of the jet engine and the reliability of its subsystems.



Note that this is fertile grounds for contradictions. Removing these contradictions will free up more resources for development of the system.

L1-Resolving Contradictions

The following algorithm is a detailed process for determining which of the Separation Principles to use. Repeated use of this algorithm will make it possible to perform this from memory and will serve to greatly reduce the time to solution. Each category of separation is considered, in turn and questions are asked to determine whether the given Separation Principles may be used.

L1-Method

Step 1: Pick high impact knobs

Step 2: Form the contradiction

--In order to (Y1 improvement) the (element) (knob or attribute) must be (setting A)

--In order to (Y2 improvement) the (element) (knob or attribute) must be (setting B)

Step 3: Solve by separating in time[2]: Consider using a carrier[3] which lends its property for a period of time and is then removed. -Consider using a transformable state[4]. Consider segmenting[5] the object and then merging or unmerging to create the two states. Consider making the element adjustable[6] so that it can have both properties at different times.

Step 4: Solve by separating in space[7]: Consider the different parts of an object. Can different parts have opposing properties[8],? Consider separating the opposing properties

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2 Separation in Time appears in Creativity as an Exact Science-The Theory of the Solution of Inventive Problems by G.S. Altshuller. Gordon and Breach. It can be found in the appendix discussing ARIZ 77

3 Inventive Principle #24—Mediator: Use an intermediary object to transfer or carry out an action. Temporarily connect the original object to one that is easily removed. Genrich Altshuller, The Innovation Algorithm page 288.

4 Inventive Principle #36—Phase Transition: Using the phenomena of phase change (i.e., a change in volume, the liberation or absorption of heat, etc.). Genrich Altshuller, The Innovation Algorithm page 289.

5 Inventive Principle #1—Segmentation: Divide an object into independent parts. Make an object sectional (for easy assembly or disassembly). Increase the degree of an object's segmentation. Genrich Altshuller, The Innovation Algorithm page 287.

6 Inventive Principle #15—Dynamicity: Characteristics of an object or outside environment, must be altered to provide optimal performance at each stage of an operation. If an object is immobile, make it mobile. Make it interchangeable. Divide an object into elements capable of changing their position relative to each other. Genrich Altshuller, The Innovation Algorithm page 288.

7 Separation in Space appears in Creativity as an Exact Science-The Theory of the Solution of Inventive Problems by G.S. Altshuller published by Gordon and Breach. It can be found in the appendix discussing ARIZ 77

8 Inventive Principle #2—Extraction: (Extracting, Retrieving, Removing). Extract the "disturbing" part or property from an object. Extract only the necessary part or property from an object. Genrich Altshuller, The Innovation Algorithm page 287.

into two objects. Consider making the object have both properties but in different places making it non-uniform[9]

Step 5: Solve by separating between the part and the whole[10]*.: Consider attaching the object to a carrier*[11] *which carries the opposing property, thus hiding the unwanted property. Consider segmenting*[12] *the element or merging*[13] *multiple elements in order to hide an unwanted property. Consider making the parts counter*[14] *each other*

Step 6: Solve by separating by Direction: Consider having one property in one direction and the other in another direction. Consider the opposite or rotary directions

9 Inventive Principle #3—Local Quality: Transition from homogeneous to heterogeneous structure of an object or outside environment (action). Different parts of an object should carry out different functions. Each part of an object should be placed under conditions that are most favorable for its operation. Genrich Altshuller, The Innovation Algorithm page 287.

10 Separation between the Parts and the Whole appears in Creativity as an Exact Science-The Theory of the Solution of Inventive Problems by G.S. Altshuller published by Gordon and Breach. It can be found in the appendix discussing ARIZ 77 Page 292

11 Inventive Principle #24—Mediator: Use an intermediary object to transfer or carry out an action. Temporarily connect the original object to one that is easily removed. Genrich Altshuller, The Innovation Algorithm page 288.

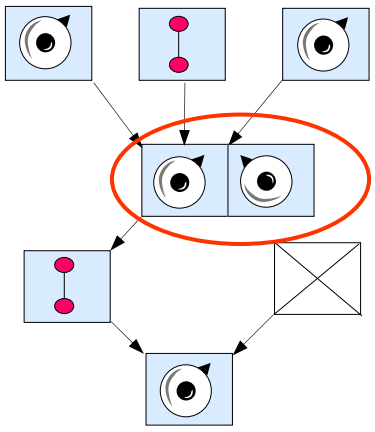
12 Inventive Principle #1—Segmentation: Divide an object into independent parts. Make an object sectional (for easy assembly or disassembly). Increase the degree of an object's segmentation. Genrich Altshuller, The Innovation Algorithm page 287.

13 Inventive Principle #5—Consolidation: Consolidate in space homogeneous objects, or objects destined for contiguous operations. Consolidate in time homogeneous or contiguous operations. Genrich Altshuller, The Innovation Algorithm page 287.

14 Inventive Principle #8—Counterweight: Compensate for the weight of an object by combining it with another object that provides a lifting force. Compensate for the weight of an object with aerodynamic or hydrodynamic forces influenced by the outside environment. Genrich Altshuller, The Innovation Algorithm page 287.

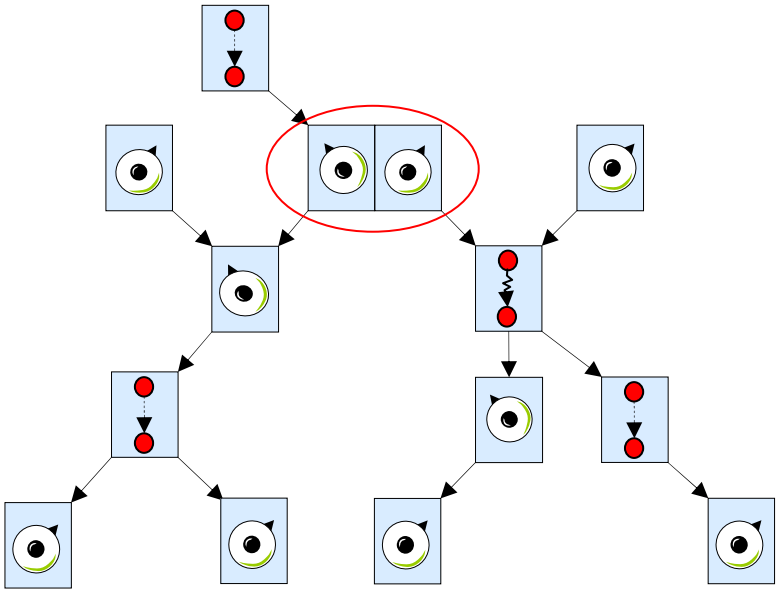
L2-Pick and Clarify High Impact Contradictions

High impact contradictions begin with high impact knobs. These are knobs that strongly affect the primary problem. With a causal analysis diagram in front of us, we can see the effect of individual knobs. It is worth a careful study of the diagram before we choose which contradictions to focus on.



By study, we can tell which knobs must be simultaneously turned to solve the problem. In general, it is better to find single knobs that can be turned far enough to achieve the needed difference. If none can be found, this is a clue that we may be approaching the limits of the system and need to evolve the system to a new physical phenomenon.

Note that many high impact knobs lie on the main paths that cause the problem, but some of these knobs don't seem like good candidates to try. In considering the acid corrosion problem, let's look at the implied contradiction for "the cost of replacement is high". For most people, this knob would not be considered because it seems to be an "outcome" rather than an independent variable. But notice that it is still a high-impact knob. The implied contradiction is "The cost of replacement is high because we are not going to alter the things that cause it to be high and the cost of replacement must be low because I don't want this expense." Notice that nothing gets worse, but the cost of replacement must be high and low. This is a valid contradiction. The solution to this contradiction might yield interesting options that would not, otherwise, be considered.



Most causal analysis diagrams will include many of these implied contradictions. Here is a warning. High impact *implied* contradictions can be forgotten or marginalized. This is because most people shy away from turning these knobs. This tendency diminishes with experience.

Some knobs are especially important "kingpins". You can recognize them because *several* alternative solution paths join together at one double box. An example form is shown to the right.

Note that one contradiction is circled. The resolution of this contradiction resolves four problems shown at the bottom of the diagram. Note that turning other knobs might solve one or two problems.

Once we have chosen the contradiction that we want to work with, now we want to write them in a form that is easier to understand. We want to write them in a sentence. As mentioned, when we turn a knob and something else gets worse, we will be able to see an alternative solution path. If nothing gets worse, then we can still form the contradiction[15]. We use the same basic method that was used in the simplified causal analysis, but this is mostly performed in the mind. We write the contradiction using the following format:

L2-Method

Step 1: Compare all the knobs on the cause effect diagram and consider which might have a greater impact. These could be high impact contradictions. Especially consider object attributes (knobs) that cause several alternate problems (Kingpins)

Step 2: Pick one attribute to concentrate on. Warning: Do not shy away from or ignore the hard knobs to turn.

Step 3: Consider the knob setting in which the main problem (Y1) goes away. This knob setting may not be the most extreme value possible, but sufficiently different that the problem would be removed for some time to come.

(Note that sometimes, combinations of object attributes must be changed to fix the main problem. Thus it may be necessary to resolve multiple contradictions at once. This is usually avoidable since there are usually sufficient knobs to work with in which this is not the case.)

Step 4: Identify what gets worse (Y2).

Step 5: In order to not have the resulting problem the knob setting must be at another setting. This knob setting may not be the most extreme value possible, but sufficiently different that the new problem would be removed for some time to come.

Step 6: form the Contradiction:

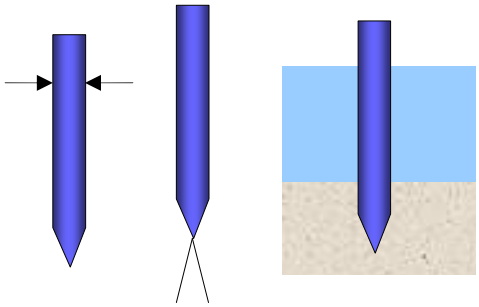
In order to (Y1 improvement) the (element) (knob or attribute) must be (setting A)

In order to (Y2 improvement) the (element) (knob or attribute) must be (setting B)

We go to this trouble for a couple of reasons. For one thing, it is easy to get confused during the resolution of the contradiction what the element is and sometimes the problem solver forgets which knob and setting they are concerned with. Note that the wording may be changed to fit the situation. For instance we might say “In order for the” instead of “In order to”. Use the wording that fits the situation.

[15] A version of this approach can be found in Creativity as an Exact Science-The Theory of the Solution of Inventive Problems by G.S. Altshuller. Gordon and Breach in the appendix which explains ARIZ 77.

Example—Pile Driving



Pile Diameter | Pile Sharpness | Ground Hardness

Step 1: Compare all the knobs on the cause effect diagram and consider which might have a greater impact. These could be high impact contradictions. Especially consider object attributes (knobs) that cause several alternate problems (Kingpins)

In this case, there are many knobs which control the driving speed of the pile. Several are mentioned to the right.

Step 2: Pick one attribute to concentrate on. Warning: Do not shy away from or ignore the hard knobs to turn.

Pile Sharpness

In this case, we will concentrate on tip sharpness. We could have chosen one of the others, but we always know that if we have too many struggles, we can go back to one of the other knobs.

Step 3: Consider the condition in which the main problems go away. This condition may not be the most extreme value possible, but sufficiently different that the problem would be removed for some time to come. Note that sometimes, combinations of object attributes must be changed to fix the main problem.

The Tip Shape is Sharp

In our case, we have chosen the tip sharpness as the attribute that we want to change. In order to improve driving speed, the tip must be very sharp. (Note that this step is a repeat of what we have already done while forming the diagram. We are now focusing in on the implied and explicit contradictions that we have already formed.)

Step 4: Identify what gets worse (Y2).

Supporting under an earthquake is what gets worse.

Step 5: In order to not have the resulting problem the knob setting must be at another setting. This knob setting may not be the most extreme value possible, but sufficiently different that the new problem would be removed for some time to come.

The pile should be blunt in order to avoid providing poor support under an earthquake load.

Step 6: Form the Contradiction.

In our pile driving example we write:

In order to (drive fast) the (pile) (tip shape) must be (sharp)

In order to (support well) the (pile) (tip shape) must be (blunt)

.

L2-Separate in Time

With Separation in Time[16] we allow for the knob setting to be at one setting at one point in time and the conflicting setting at another point in time. This separation principle is one of the most intuitive. There are also a lot of tools for separating in time. This allows us to overwhelm a contradiction so long as Separation in Time is allowed.

Unfortunately, it is not always possible to separate in time. The conditions under which both knob settings *must* occur are not allowed to overlap in time. If they must overlap, then we cannot separate in time. (However, we will make provisions for finding ways to *not* overlap).

Additionally, there are often inherent drawbacks to separation in time. Changing properties *may* require the addition of functions and their attending elements. This can add complexity to the product or service. An exception to this is if the separation can occur "on condition" without the addition of parts.

Why Start with Separation in Time?

The flow logic starts with Separation in Time because it contains the largest number of opportunities for solution. If the flow logic tells us that it cannot be used, then we have eliminated a large number of methods and can move on. After finishing each section, move on to the next, unless the flow logic indicates otherwise.

The subject of the contradiction may be an object, field or action. These are referred to as the "Element".

L2-Method

Step 1: Ask under what conditions each property is needed. Are both condition required at the same time?

Step 2: Consider using a carrier[17] which lends its property for a period of time and is then removed.

Step 3: Consider using a transformable state

Step 4: Consider segmenting[18] the object and then merging or unmerging to create the two states.

Step 5: Consider making the element adjustable[19] so that it can have both properties at different times.

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[16] Separation in Time appears in Creativity as an Exact Science-The Theory of the Solution of Inventive Problems by G.S. Altshuller. Gordon and Breach. It can be found in the appendix discussing ARIZ 77

17 Inventive Principle #24—Mediator: Use an intermediary object to transfer or carry out an action. Temporarily connect the original object to one that is easily removed. Genrich Altshuller, The Innovation Algorithm page 288.

18 Inventive Principle #1—Segmentation: Divide an object into independent parts. Make an object sectional (for easy assembly or disassembly). Increase the degree of an object's segmentation. Genrich Altshuller, The Innovation Algorithm page 287.

19 Inventive Principle #15—Dynamicity: Characteristics of an object or outside environment, must be altered to provide optimal performance at each stage of an operation. If an object is immobile, make it mobile. Make it interchangeable. Divide an object into elements capable of changing their position relative to each other. Genrich Altshuller, The Innovation Algorithm page 288.

L3-Test for Separation in Time

With so many ways to resolve contradictions, it is necessary to focus the problem solver on *which* methods might be appropriate or even possible. Each separation principle uses a test which guides the user by asking questions about the objects or fields or actions involved in the contradiction. Learning to thoughtfully answer these questions is an essential skill. Let's take the test for Separation in time.

Test

I want the (element) to be (setting A) while (condition A). I want the (element) to be (setting B) while (condition B). Must the critical conditions overlap in time? If they must overlap then you should go to Separate Gradually.

If there really is a requirement for both properties then we ask if the conditions under which they are required *must* occur at the same time. An example of this is the measuring of temperature of weevils. For those unacquainted with this classic TRIZ example, there is a need to measure the temperature of weevils with a simple apparatus, such as a common thermometer. The size of the weevil is the problem. The weevil must be large in order to insert the thermometer. Let's ask the question that we did before: must we ensure that the weevil is both large and small? While weevils do not come in this size, let's assume that by using some bizarre physical phenomenon that we could make them large, does this cause a problem? Yes, the metabolism of the weevil would change if it were large. In other words, we must ensure that the weevil is large in order to insert the thermometer and the weevil must be small in order to maintain the same metabolism. The answer to the next question helps us further.

When are the conditions that both properties must occur?

It must be (prop #1) while (condition A)

It must be (Property #2) while (condition B)

Weevil Example:

It must be (Large) while (measuring the temperature)

It must be (small) while (all the time being a weevil)

May these critical conditions be separate (not overlap) in time? The answer is "no", they must overlap in time. Therefore it is not possible to Separate in Time.

There are usually critical moments in time when one property or the other *must* exist. If these critical moments overlap in time, it is not possible to separate the contradictory properties in time. Let us take the example of driving piles into the ground. If we are interested in driving fast, we may choose to make the pile sharp. But then something gets worse. Because the tip is sharp, we need to drive it further to get the same vertical support. In this case, we have requirements for the pile to be sharp and to be blunt. We need it to be sharp for driving fast and blunt for support. In answer to the above question we would write:

It must be (sharp) when (driving)

It must be (blunt) when (supporting)

Both properties must be ensured. Now, we ask if these conditions must occur at the same time:

May these critical conditions be separate (not overlap) in time?

Clearly, the critical conditions of driving and supporting may be separated in time. Therefore, it makes sense to Separate in Time. During driving, the piles are sharp. Some time afterwards, the piles must be blunt for supporting. By using the logic flows provided in each section, the problem solver can confidently use or skip each Separation Principle.

While Separation in Time is one of the primary tools for resolving contradictions, it may not be possible or necessary. If this is the case then we can bypass this step and save ourselves a lot of work. In certain cases, Separation in Time may not be possible. We can tell that it is not possible if the conditions under which each conflicting attribute is essential (useful and necessary) overlap in time. If the conditions clearly *do not* overlap, then we can safely proceed with Separation in Time.

Be careful that you have explored various ways that the critical conditions can be separated in time. Sometimes the conditions are actions that can be broken into steps which have sequence. It may be possible to rearrange the sequence such that the conditions do not overlap.

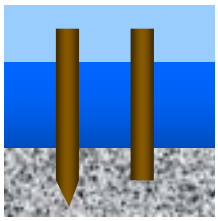
Following is the test and the various strategies for Separating in Time.

Test

I want the (element) to be (setting A) while (condition A). I want the (element) to be (setting B) while (condition B). Must the critical conditions overlap in time? If they must overlap then you should go to Separate Gradually.

Example—Pile Driving

We would like the pile to be SHARP in order to drive it more rapidly and we would like it to be BLUNT in order to support well.



Test: I want the (pile) to be (sharp) while (driving). I want the (pile) to be (blunt) while (supporting). Must the critical conditions overlap in time?

This is a clear example of a contradiction where the conditions of driving and supporting are separated by potentially large expanses of time. This is a good candidate for Separation in Time.

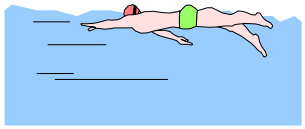
Example—The Farmer's Mush

"I can't stand cold cereal anymore!" 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 cooked cereal must be PREPARED in order to keep peace in the house and it must NOT BE PREPARED order not bother the farmer's wife.

Test: I want the (cooked cereal) to be (prepared) while (sometime before the farmer eats). I want the (cooked cereal) to be (not prepared) while (the farmer's wife is sleeping). Must the critical conditions overlap in time? Since preparation of the cereal is an action or function, we know that it is possible to break this action down into steps which can be sequenced to guarantee that no overlap between the conditions occurs. We just need to guarantee that the cereal preparation does not occur while the farmer's wife

wants to sleep. This makes this contradiction a good opportunity for Separation in Time and in particular to use Prior Action[20].

Example—Long Distance Swimming



In order to train for long swims, it is necessary to have MUCH water so that the swimmer does not need to do lots of turns. But there must be LITTLE water in order to conserve space.

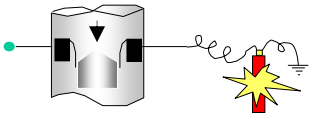
Test: I want the (water) to be (much) while (swimming). I want the (water) to be (little) while (all the time). Must the critical conditions overlap in time? Overlap occurs between "swimming" and "all the time". We will go to Separate Gradually.

Example—Traffic Light

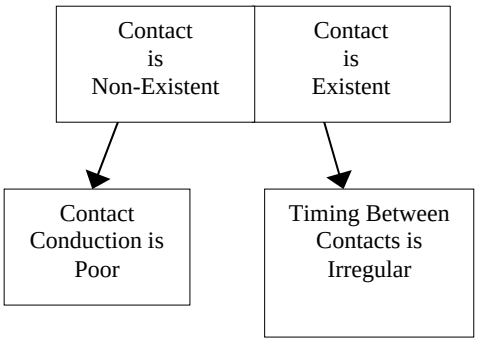
The operation of the lights in a traffic light must eventually FAIL due to the action of the current on the filament and to vibration. The traffic light must NOT FAIL in order to not cause traffic delays or make the intersection more dangerous.

Test: I want the (operation) to be (failed) while (never). I want the (operation) to be (not failed) while (operating in traffic). Must the critical conditions overlap in time? "Never" and "operating in traffic" do not overlap in time. Since operation of the light bulb is an action, this makes one of the action principles a good candidate for resolving this contradiction. **Note that many of the methods will not apply because they seek to guarantee that the unwanted setting is achieved.**

Example—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 a tube with electrical contacts spaced at precise intervals. As the conductive weight passes each set of contacts, continuity is established across the contacts 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 the timing to be erratic. The plugs must INTIMATELY CONTACT the leads in order to complete the circuit and must NOT CONTACT the leads in order to keep the timing perfect.

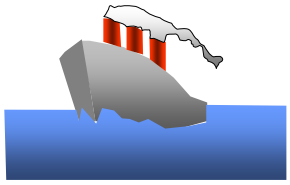


Test: I want the (plug) to be (intimately contacting) while (making contact with

20 Inventive Principle #10—Prior Action: Perform required changes to an object completely or partially in advance. Place objects in advance so that they can go into action immediately from the most convenient location. Genrich Altshuller, The Innovation Algorithm page 287.

the leads). I want the (plug contact) to be (not existing) while (falling). Must the critical conditions (making contact with the leads and falling) overlap in time? It appears that these overlap in time since the plugs never stop falling. It is concluded to go to Separate Gradually.

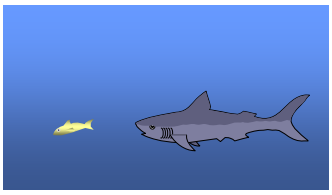
Example—Super Yacht



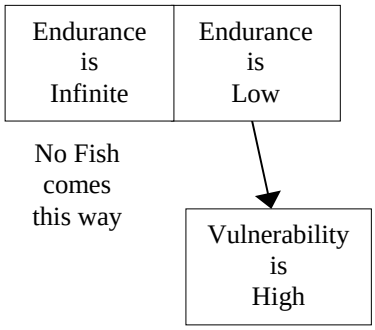
A small ship building company considers a contract to build a super yacht. The yacht is so big that only a third will fit into their dock. "We will need to build this in the open harbor." A frustrated engineer says. "We can't do that; we need the availability of lifts and tools." The Building Location: It should be IN THE HARBOR & AT THE DOCK.

Test: I want the (construction) to be (in the dock) while (the ship parts are small enough to fit in the dock). I want the (construction) to be (in the Harbor) while (the ship parts are too big for the dock). Must the critical conditions overlap in time? Since construction of the ship is an action or function, we know that it is possible to break this action down into steps which can be sequenced differently to guarantee that no overlap occurs. Also, the way that we formed the conditions makes them mutually exclusive in time. This makes this contradiction a good opportunity for Separation in Time and in particular to use Prior Action.

Example—Fish to the Rescue

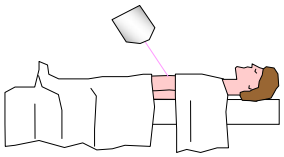


Like most large predators, a shark will follow its prey in close pursuit until the smaller prey exhausts its energy. Although the prey may be more nimble, it cannot outrun its larger foe forever. If the smaller fish could dodge and dart forever, it could easily outmaneuver the larger shark. The Fish should have INFINITE ENDURANCE in order to outrun the shark and NORMAL ENDURANCE because that is how small fish are.

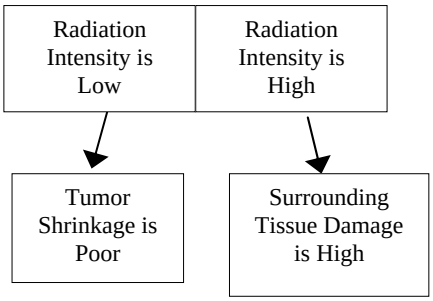


Test: I want the (fish) to be (normal endurance) while (never). I want the (fish) to be (infinite endurance) while (being chased). Must the critical conditions overlap in time? "Never" and "while being chased" do not overlap in time. Therefore we will try to separate in time. Some of the methods will appear weak because they seek to guarantee the condition of low endurance which is not essential.

Exercise—Radiation Treatment

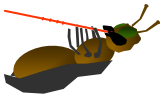


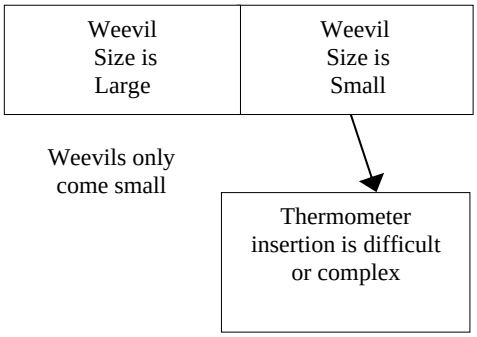
High levels of radiation can damage the structure of cells and cause them to cease functioning. This is useful in the treatment of tumors. A beam of high energy radiation is focused on the tumor. After the procedure, the tumor shrinks. Unfortunately, the tissue surrounding the tumor is also damaged by the high energy radiation. The Radiation Intensity needs to be HIGH AND LOW**.** Test for Separation in Time.



Exercise—The Lesser Weevil

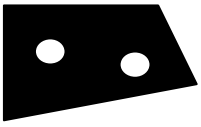
In the war on hunger, Russian scientists were studying the metabolism of the weevil. This required the scientists to be able to measure the body temperature over a period of time. Tiny temperature probes were proposed, which through the aid of a microscope could be inserted into the weevil. The cost 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 AND SMALL**.** Test for Separation in Time.

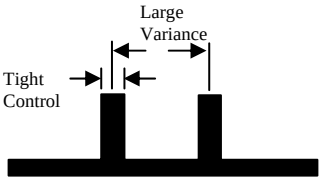




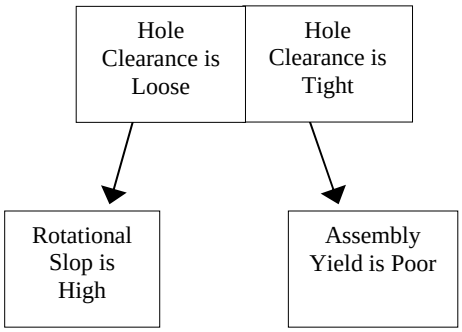
Exercise—A Post and an Outpost

For years your company has produced an aircraft product which fits over two posts on your customer's 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.

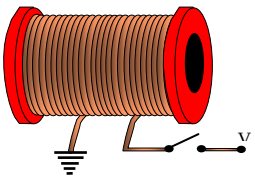




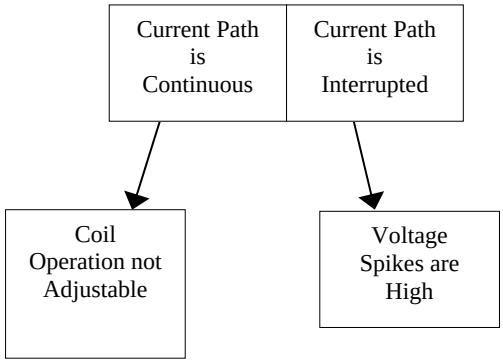
Now there is no guarantee that the part which you produce will fit over the customers posts. (The diameter of the posts is still closely held). The customer is unwilling to change the new production process, but has instead asked you to modify the part so that it will fit snuggly in the application, 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**.** Test for Separation in Time.



Exercise—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. The current path needs to be CONTINUOUS AND INTERRUPTED**.** Test for Separation in Time.



L3-Action—Prior Action

Prior action[21] *is only used for contradictions dealing with functions or actions.* Prior action does *not* mean that we simply do "something" prior to a critical event. Consider that virtually every separation principle requires that *something* be done ahead of time. What would make Prior Action different than every other separation method? This principle has the name "prior action" because some *action* related to the problem occurs prior to the normal occurrence, not because *we* take an action prior to the solution being realized.

One of the reasons that contradictions occur with actions and functions is that we mentally lock ourselves into the idea that an action is something that happens at once. When we say "we cook the egg", we typically do not consider all of the sub-actions that occur. We oil the pan, heat the pan, move the egg from the refrigerator, crack the egg, etc. In fact, all actions can be broken into sub-actions or steps which can be rearranged in sequence and time. We can

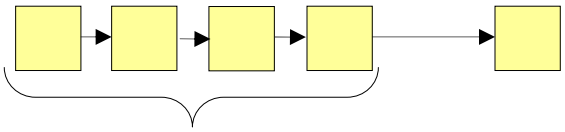
21 Inventive Principle #10—Prior Action: Perform required changes to an object completely or partially in advance. Place objects in advance so that they can go into action immediately from the most convenient location. Genrich Altshuller, The Innovation Algorithm page 287.

even interject other actions into the sequence. Some of these stages (or a part of each) should be moved into condition A and the others should occur during condition B. The redistribution of these sub-actions resolves the contradiction.

We must find a way to break the action into stages and then perform these stages when they are best suited to resolve the contradiction. Mostly, we want to perform the necessary actions in advance of when they are actually needed.

One very good way to perform an action in advance is to place a tool for the purpose of performing an action later. This represents half a step that might normally have been taken. The tool is placed to perform an action and then the full action is performed later.

Method



Some Stages Not Performed (Performed in Advance)

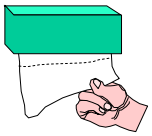
Only Part of Action Performed When Required

The contradiction attribute relates to an action or function. (Modification) of the (product) can be broken down into steps. The steps(s) of (actions performed during Condition A) are performed during (condition A) by (method or previously placed tool) in order to have (setting A). The remaining steps(s) of (remaining actions) are performed during (condition B) in order to have (setting B).

Common Example—Paper Towel Dispensing

In a public lavatory, people need to dry their hands following washing them. We are very familiar with paper towels that are perforated, but imagine what it would have been like without the perforations. The cutting of the towel would take some time in order to not make a mess. It is necessary to TEAR the spent portion of the paper towel for disposal. But imagine trying to tear off a piece of the paper towel with wet hands. We must NOT TEAR in order to save time and not make a mess for the next person.

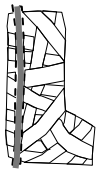
The contradiction attribute relates to an action or function. (Tearing) of the (towel) can be broken down into steps. The steps(s) of (holding and tearing) are performed during (any time previous to use) by (mechanical holding and tearing) in order to have (tearing). The remaining steps(s) of (pulling the towel) are performed during (towel use) in order to have (not tearing).



Part of the action is performed at the time that it is required (pulling).
Part is not performed when it is required, it is performed earlier (holding and cutting).
The towel is torn and not torn.

Example—Removing a Plaster Cast Following Healing

Plaster casts are somewhat difficult to remove. Insertion of tools between the flesh and the cast can be uncomfortable for the patient. The cast needs to be CUT to complete healing and for sanitation reasons and it should NOT BE CUT so as to keep the patient comfortable.



The contradiction attribute relates to an action or function. (Removing) of the (cast) can be broken down into steps. The steps(s) of (inserting

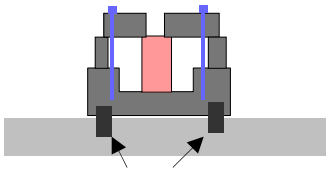
the cutting tool) are performed during (forming the cast) by (cutting tool in straw) in order to have (not cut). The remaining steps(s) of (cutting and removing the cast) are performed during (final cast removal) in order to have (cutting).

Part of the action is performed at the time that it is required (cutting and prying). Part is not performed when it is required; it is performed earlier (inserting the cutting tool). Cutting is performed and not performed.

Manufacturing Example—Rapid Setup

Manufacturers have recognized that once a numerically controlled machine is set up, it can inexpensively machine many parts. The cost comes in when the machine is first prepared for the parts. SETTING UP the machine can be very slow and tedious. NOT SETTING UP avoids adding this cost to the cost of making the parts increases the part costs, making the manufacturer less competitive.

The contradiction attribute relates to an action or function. (Setting up) of the (machined part) can be broken down into steps. The steps(s) of (adjusting) are performed during (other machining operation) by (use of a rapid-setup mount) in order to have (setting up). The remaining steps(s) of (inserting the mount into the machine) are performed during (machining time) in order to have (not setting up).



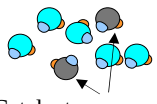
Rapid and Accurate Connection Points

Part of the action is performed at the time that it is required (performing the machining). Part is not performed when it is required; it is performed earlier (setting up the machine). The action is performed and not performed. This is known as Rapid Setup and is a common tool used to "lean" a process.

Chemical Example—Self Cleaning Oven

Self cleaning ovens accomplish their task of cleaning by requiring the operator to lock the oven and then heat it to a much higher temperature than normal. While this is somewhat easier than performing the cleaning manually, the process is wasteful of energy. The action of heating (cleaning) must be PERFORMED and NOT BE PERFORMED.

The contradiction attribute relates to an action or function. (Removal) of the (oven residue) can be broken down into steps. The steps(s) of (decomposing the residue) are performed during (normal cooking) by (use of catalysts) in order to have (not performed—the heavy work). The remaining steps(s) of (wiping the surfaces) are performed during (an empty and cool oven) in order to have (performed).



Catalysts are thinly distributed on all oven surfaces.

Administrative Example—Adult Training

The startup of a new facility can be difficult when performed in offshore situations. Many new procedures must be learned by a large amount of people. TRAINING is required so that the new procedures will be performed perfectly or the product may get a bad reputation. NOT TRAINING is required to preserve money.

The contradiction attribute relates to an action or function. (Training) of the (employees) can be broken down into steps. The steps(s) of (presentation type learning—least time consuming) are performed during (construction of the plant) by (trained instructors) in order to have (training).

The remaining steps(s) of (applying the training—most time consuming) are performed during (actual work) in order to have (not training—paid to work).

Software Example—Calculating

Long and abstract equations are often necessary for control functions. These calculations can be very time consuming and reduce the throughput of a microprocessor. It is necessary to CALCULATE in order to provide control and it is necessary to NOT CALCULATE in order to free up the processor for other functions.

(The contradiction attribute relates to an action or function. Manipulation—calculation) of the (data) can be broken down into steps. The steps(s) of (calculation) are performed during (construction of the algorithm) by (lookup table) in order to have (calculation).

The remaining steps(s) of (fetching the data) are performed during (calculation) in order to have (not calculate).

Software Example—Caching

Fetching data from disk or physical memory can be time consuming when a lot of data needs to be fetched. The data must be FETCHED in order to perform calculations and it must NOT BE FETCHED in order to take less overall time to perform the calculations.

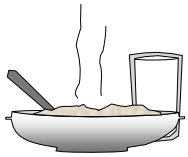
Simplified Method:

The contradiction attribute relates to an action or function. (Fetching) of the (data) can be broken down into steps. The steps(s) of (fetching from the disk) are performed during (other related manipulations) by (reading from the disk and storing in separate memory) in order to have (not fetching). The remaining steps(s) of (clocking the data into the CPU) are performed during (use of the data) in order to have (fetching).

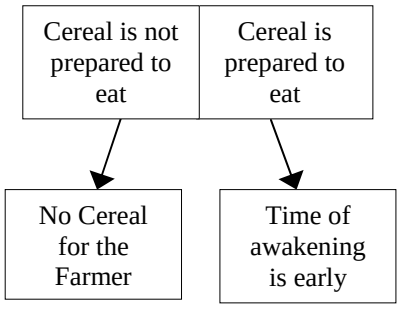
Load something before-hand into cache memory. It remains there until it is required. This means pre-fetching instructions and any static data that goes with it. Caching memory is much faster than physical memory. It is likewise much faster than pulling instructions and static data from disk.

Exercise—The Farmer's Mush

"I can't stand cold cereal anymore!" 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 cereal MUST BE PREPARED in order to nourish the farmer. It must NOT BE PREPARED in order to not fatigue the farmer's wife. Using the principle of Prior Action—Partial Action, resolve this contradiction.

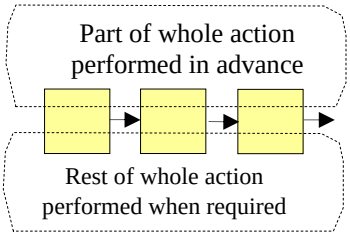


L3-Action—Partial Action

Partial action[22] [23] *is only used for contradictions dealing with functions or actions.* Unlike Prior action, this method calls for partially performing *all* of the stages beforehand. The action is thus completed later. It is "not performed" and then it is "performed" which are attributes of a function or action. Contradictions involving other interaction attributes can also be solved using this method.

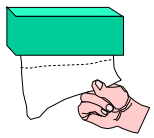
Method

The contradiction attribute relates to an action or function. (Modification) of the (product of the function) is partially performed in its entirety during (condition A) by (method) giving (setting A). The function is completed during (condition B) by (description of final action) giving (setting B).



Common Example—Paper Towel Dispensing

In a public lavatory, people need to dry their hands following washing them. We are very familiar with paper towels that are perforated, but imagine what it would have been like without the perforations. The cutting of the towel would take some time in order to not make a mess. It is necessary to TEAR the spent portion of the paper towel for disposal. But imagine trying to tear off a piece of the paper towel with wet hands. We must NOT TEAR in order to save time and not make a mess for the next person.



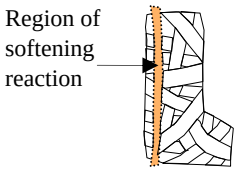
The contradiction attribute relates to an action or function. (Tearing) of the (towel) is partially performed in its entirety during (manufacture of the towel) by (perforating the towel) giving (not tearing). The function is completed during (towel use) by (pulling the towel) giving (tearing).

22 Inventive Principle #16—Partial or Excessive Action: If it is difficult to obtain 100% of a desired effect, achieve more or less of the desired effect. Genrich Altshuller, The Innovation Algorithm page 288.

Example—Removing a Plaster Cast Following Healing

Plaster casts are somewhat difficult to remove. Insertion of tools between the flesh and the cast can be uncomfortable for the patient. The cast needs to be CUT to complete healing and for sanitation reasons and it should NOT BE CUT so as to keep the patient comfortable.

The contradiction attribute relates to an action or function. (Removing) of the (cast) is partially performed in its entirety during (forming of the cast) by (pre-inserting a dissolvable material) giving (not cut). The function is completed during (removal of the cast) by (cutting the cast with a solvent) giving (cutting).



Partially cutting the cast is probably not preferable as some patients may engage in behaviors which could put stress into the cast. Precutting the cast would lower the structural integrity. However, if a material could be found that would not lose structural integrity and would lose its integrity when exposed to an unusual, yet safe, solvent (such as alcohol), it might be possible to finish the cutting by applying the solvent.

Manufacturing Example—Rapid Setup

Manufacturers have recognized that once a numerically controlled machine is set up, it can inexpensively machine many parts. The cost comes in when the machine is first prepared for the parts. SETTING UP the machine can be very slow and tedious. NOT SETTING UP avoids adding this cost to the cost of making the parts increases the part costs, making the manufacturer less competitive.

The contradiction attribute relates to an action or function. (Setting up) of the (machined part) is partially performed in its entirety during (other machining operations) by (setting up another machine) giving (setting up). The function is completed during (machining) by (running the machine) giving (not setting up).

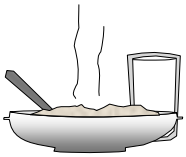
Administrative Example—Adult Training

The startup of a new facility can be difficult when performed in offshore situations. Many new procedures must be learned by a large amount of people. TRAINING is required so that the new procedures will be performed perfectly or the product may get a bad reputation. NOT TRAINING is required to preserve money.

The contradiction attribute relates to an action or function. (Training) of the (employees) is partially performed in its entirety during (operation of another plant) by (apprenticing the employees to skilled workers) giving (trained). The function is completed during (actual work) by (applying the training) giving (not paid training).

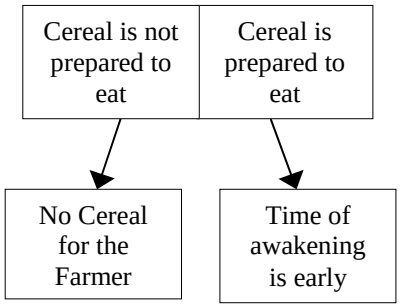
The employees are partially trained at another facility and then come to work at the new facility. (According to a chemist friend, this is what the Japanese did when they set up amino acid plants in the United States. They had the employees go back to Japan for several weeks of on-hands training).

Exercise—The Farmer's Mush



"I can't stand cold cereal anymore!" 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 cereal MUST BE PREPARED in order to nourish the farmer. It must NOT BE PREPARED in order to not fatigue the farmer's wife. Using the principle of Partial Action, resolve this contradiction.

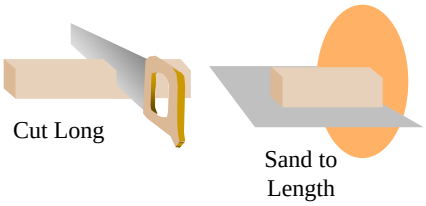


L3-Action—Excessive and Remedial Action

With Excessive and Remedial Action[24] [25] we consider a useful action that must be performed accurately and not accurately. It is a necessary function, but performing it accurately is not possible because it is too inconvenient or time consuming to perform it *accurately* at the time that it is required.

In order to solve this contradiction, the action, or part of the action, is performed excessively or even wastefully at the inconvenient time. We cut the board long, so to speak and sand it to length later.

In order to correct the negative effect caused by performing it excessively there are two approaches. In one case, a remedial action is performed that corrects the action to the required state. In the other case, the excessive action "over-flows" or crosses a threshold where it is no longer performed. In either case, the action is performed inaccurately and then accurately.



Performing a remedial action is generally not preferred, but it may be allowable if it is inexpensive or not too wasteful. The negative effects of performing and action excessively may be softened by adding a tool, beforehand, to make the correction more convenient or less costly.

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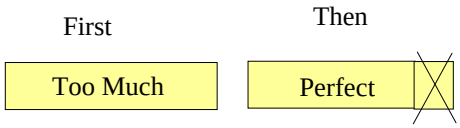
24 Inventive Principle #16—Partial or Excessive Action: If it is difficult to obtain 100% of a desired effect, achieve more or less of the desired effect. Genrich Altshuller, The Innovation Algorithm page 288.

25 STANDARD 1-1-6. If a minimum (measured, optimal) effect of action is required, but it is difficult or impossible to provide it under the conditions of the problem, use a maximum action, while the excess of the action is then removed. Excess of a substance is removed by a field, while excess of a field is removed by a substance. Example: To paint a part accurately, the part first loaded into a container with the paint, and then subjected to rotation. Excess of paint is removed due to centrifugal forces.

Method

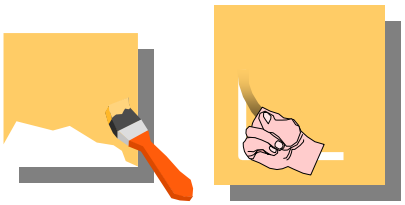


The contradiction attribute relates to an action or function that must be performed ***rapidly*** *and* ***slowly****. The function of (modifying) the (product) can be rapidly performed by the gross action of (method of performing excessively). The detailed remedial action of (remedial action) is made possible by (method) in advance or by overflowing a (threshold) threshold by (method)*

Example—Masking & Painting

The contradiction attribute relates to an action or function. Painting detailed parts or surfaces can be a very time consuming task. It is necessary to paint the parts very rapidly and INACCURATELY in order to save time and to reduce exposure of the painters to solvents, etc. But it is also necessary to perform the painting very ACCURATELY to that it looks nice.

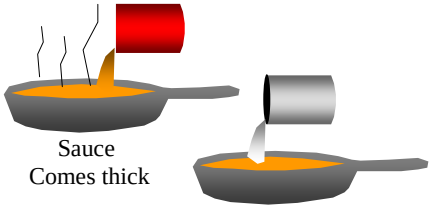
The contradiction attribute relates to an action or function. The function of (painting) the (detailed parts) can be rapidly performed by the gross action of (painting with a roller or large brush). The detailed remedial action of (removing the excess paint) is made possible by (applying masking) in advance or by overflowing a (hydrophobic) threshold by (making the unpainted areas from hydrophobic materials.)



Example—Concentrated Sauces from Pastes

Cooking sauces can be time consuming due to the lengthy time to reduce the sauce to a consistency that meets the needs of the recipe or the taste of the cook. A good example of this is tomato sauce. Fresh cut tomatoes are composed of a high percentage of water. Cooking these down to a sauce in a restaurant can be very time consuming. The creation of the sauce under the high pressure cooking conditions of a modern restaurant needs to be very rapid and INACCURATE in order to make money and it needs to be performed very ACCURATELY in order to achieve the perfect consistency for the customer.

The contradiction attribute relates to an action or function. The function of (reducing) the (tomato sauce) can be rapidly performed by the gross action of (introducing tomato paste). The detailed remedial action of (thinning the sauce) is made possible by (thickening the paste) in advance or by overflowing a (unknown) threshold by (unknown).



Example—Building Kitchen Cabinets

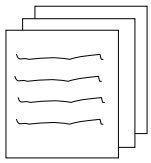
Building custom cabinets for a kitchen is time consuming. Each individual board must be sawed and glued or nailed into place. This is one reason that custom cabinets are so expensive. This puts nice cabinets out of the reach of the common person. The cabinets must be rapidly and INACCURATELY built in order to make money and they must be built very ACCURATELY in order that the customer is pleased.

The contradiction attribute relates to an action or function. The function of (building) the (cabinets) can be rapidly performed by the gross action of (installing the prebuilt cabinets). The detailed remedial action of (shimming to the correct spacing) is made possible by (providing precut or adjustable shims) in advance or by overflowing a (unknown) threshold by (unknown).

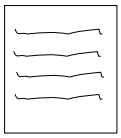
Example—Writing a Book

Stopping and starting during the creative process of writing a book interrupts the creative flow of ideas and images. The writing must be INACCURATE. Unfortunately, this leads to poor grammar, clumsy thoughts and poor punctuation. The writing needs to be performed ACCURATELY.

The contradiction attribute relates to an action or function. The function of (writing) the (book) can be rapidly performed by the gross action of (writing without stopping). The detailed remedial action of (correcting the logic, grammar and punctuation) is made possible by (a specialist and specialized software) in advance or by overflowing a (unknown) threshold by (unknown).



Excessive length for uninterrupted writing

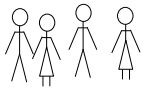


Edited to be precise

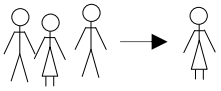
Example—Rapidly Forming a High Functioning Team

Sometimes it is difficult to put a group together which has the right skills to perform a task. This is especially true when under schedule pressure. The group needs to be ACCURATELY put together to make sure that the right skills are available and it needs to be performed INACCURATELY in order to do it in a short period of time.

The contradiction attribute relates to an action or function. The function of (forming) the (group) can be rapidly performed by the gross action of (gathering rapidly). The detailed remedial action of (selecting the most appropriate members) is made possible by (unknown) in advance or by overflowing a (capability) threshold by (filling task positions as the group arrives with the most capable person).



Group excessively large to guarantee enough participants



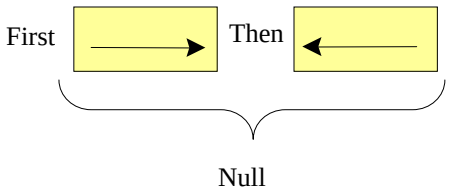
Those not required can leave

L3-Action—Prior Counteraction

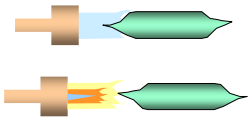
Prior Counteraction[26] is useful when a harmful action must "unavoidably" occur. This usually happens when there is an object that performs a useful function and also performs a harmful function. In order to nullify the harmful action, we perform a counter action prior to the harmful action which nullifies the harmful action. Thus, the harmful action occurs, but because of the counter action, the combined effect is that it doesn't occur. The counter action usually involves the same physical phenomenon as the action which performs the harmful function.

Method

The harmful function of (harmful function) the (element) cannot be avoided. The counter action of (counter action) is performed in advance by (method of counter action) so that when the time for the harmful action of (harmful action) the (element) it is not (harmful action).



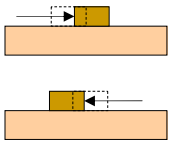
Example—Medicine Ampoule



An ampoule filled with heat sensitive medicine must be heat sealed. The heat will damage the Medicine. The medicine must be HEATED to seal the ampoule and NOT HEATED to keep from spoiling the medicine.

The harmful function of (heating) the (medicine) cannot be avoided. The counter action of (cooling the medicine) is performed in advance by (cooling with liquid nitrogen) so that when the time for the harmful action of (heating) the (medicine) it is not (heated).

Example—Movement of an Object



A periodic harmful action moves an object to a location where it is not wanted. The object must be MOVED and UNMOVED.

The harmful function of (moving) the (object) cannot be avoided. The counter action of (moving the object in the opposite direction) is performed in advance by (relocating the object) so that when the time comes for the harmful action of (moving) the (object) it is not (moved).

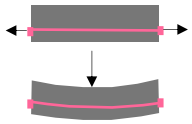
In this case, the object ends up where you wanted it in the first place.

Example—Pre-stressed Concrete

Concrete has low strength in tension and a high strength in compression. When a structure such as a bridge is built, it must support heavy loads such as commercial trucks. The span between supports is heavily loaded which causes high tension stresses on the underside of the span. This high stress is unavoidable. The tension load must be HIGH

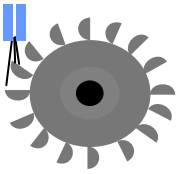
26 Inventive Principle #9—Prior Counteraction: Preload counter-tension to an object to compensate excessive and undesirable stress. Genrich Altshuller, The Innovation Algorithm page 287.

because it is “unavoidable”. The tension load must be LOW in order to keep from fracturing the concrete.



The harmful function of (loading) the (concrete span) cannot be avoided. The counter action of (applying a tension load) is performed in advance by (inserting steel columns under tension which “clamp” the span) so that when the time comes for the harmful action of (applying tension to the span) the (concrete span) it is not (loaded in tension).

Exercise—Vibrating 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 decrease 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 & ABSENT**.** Using the principle that you have just learned, resolve this contradiction. Hint: consider using the same type of action which causes the problem to counter the action. The counter action should be caused by a second stream of water.

Pressure Forces Non-Existent	Pressure Forces are High
Turbine Output is Low	Turbine blade and component life is low

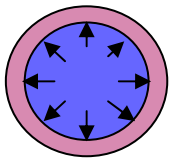
Traffic Light

The lights in a traffic light must eventually FAIL due to the action of the current on the filament and to vibration. The traffic light must NOT FAIL in order to not cause traffic delays or make the intersection more dangerous.

This is an example of an output contradiction. Most people would think of this as the Y in the function. Resolve this contradiction using The method you have just learned.

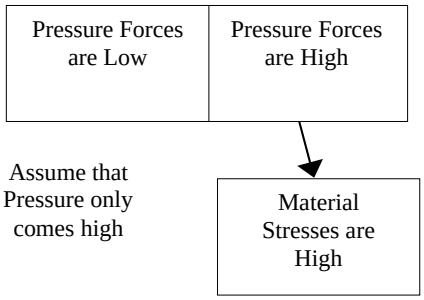
Traffic Light Operation Fails	Traffic Light Operation Doesn’t Fail
All lights will eventually fail	Note that nothing gets worse

Exercise—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**.** Using the principle that you have just learned, resolve this contradiction.



L3-Action—Countering

For Countering[27], the conflicting properties are that an action must occur and it must not occur. Both are actually desirable at the appropriate times.

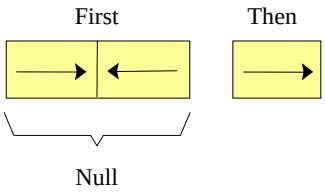
There are two possibilities. First, two strong actions counter each other and give a null action. Later, one of the actions is removed, leaving the full action of one of the original actions.

The second possibility is that one strong action exists. Later a counter action is added which gives the null action. This is typically used with actions, fields and movements.

The possibility exists to use the principle of COUNTER WEIGHT to make elements push or pull each other. A transmission element may be required between the elements. Sometimes, counter fields can overlap each other in such a way to nullify each other. The field gradients can be opposite each other to create one condition or they can be entirely opposite each other.

Method

The contradiction attribute relates to an action or function. The (element) must be (null action) during (condition A). This is accomplished by applying (counteraction). The counter action is removed during (condition B) when the full action is required.

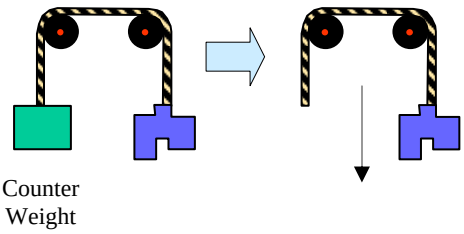


27 Inventive Principle #8—Counterweight: Compensate for the weight of an object by combining it with another object that provides a lifting force. Compensate for the weight of an object with aerodynamic or hydrodynamic forces influenced by the outside environment. Genrich Altshuller, The Innovation Algorithm page 287.

Example of Counter Weight

A heavy object must be precisely dropped, but in order to drop it precisely, it must first be positioned accurately. Positioning the object is difficult since it is so heavy.

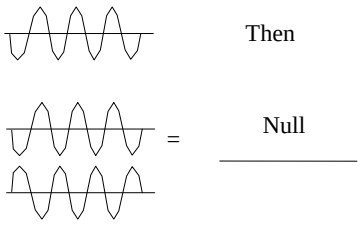
The contradiction attribute relates to an action or function. The (weight) must be (held) during (positioning). This is accomplished by applying (a counter weight or force). The counter action is removed during (dropping) when the full action is required.



Example—Cancellation of Waveforms

A signal needs to be transmitted at all times, but it must not be transmitted during resting periods.

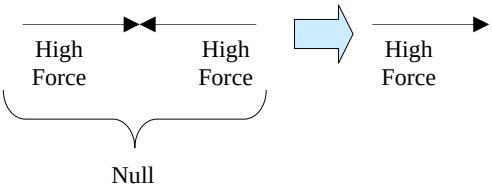
The contradiction attribute relates to an action or function. The (signal) must be (silent) during (a rest period). This is accomplished by applying (an 180 degrees out of phase signal). The counter action is removed during (communication) when the full action is required.



Example—Deadfalls and Snares

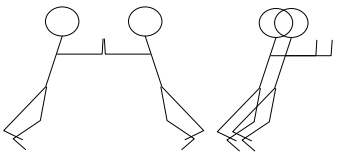
In order to kill an animal during wilderness survival, a large force must be used. However, a large force is not easily and rapidly brought into play.

The contradiction attribute relates to an action or function. The (heavy log) must be (held) during (positioning of the animal). This is accomplished by applying (a counter weight or force). The counter action is removed during (killing of the animal) when the full action is required.



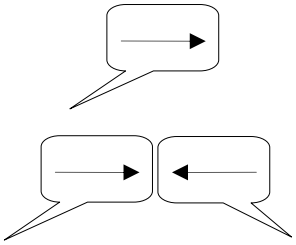
Example—Military Mock Battles

In order to be increasingly ready with the latest in military strategy, a military unit should be in battle against units prepared with the latest technology and strategies. However, there are times of peace when fighting an actual enemy is not possible.



The contradiction attribute relates to an action or function. The (military unit) must be (opposed by the latest military strategies) during (times of peace). This is accomplished by applying (pitting half of the army against itself). The counter action is removed during (times of war) when the full action is required. This is accomplished in mock military battles.

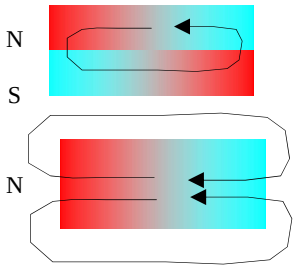
Example—Strong Pitch



At times a strong message is required from leaders. At other times it is not necessary or even harmful. In order that the main presenter of the message is not considered weak, the message must always be presented.

The contradiction attribute relates to an action or function. The (message) must be (muted) during (times when message has low priority). This is accomplished by applying (a counter argument from other leaders). The counter action is removed during (times of high priority) when the full action is required.

Example—Magnetization



The contradiction attribute relates to an action or function. The (magnetic element) must be (magnetically neutral) during (non-operation). This is accomplished by applying (counter magnetic forces). The counter action is removed during (operation) when the full action is required.

A material is magnetized with both polarities. The flux lines remain primarily internal to the magnetic material. This is called a keeper and keeps the magnetic strength high. Later, one polarity is reversed so that only one of the polarities remains. Now the flux lines are primarily external and can be used for various functions.

L3-Separation on Condition

It is more ideal to separate on condition than in time. The changing conditions must cause the change. There is no need of monitoring or active control. Thus, Separation on Condition is the Holy Grail of Separation in Time.

When we passed the test for Separating in Time, we determined the conditions (condition A) and (condition B) in which the (element attribute) needed to be (setting A) and (setting B). There are usually a number of things that change between these two conditions. One of these differences will be used to drive the change in settings. Let's take the case where the changing conditions were night and day. We ask ourselves "What changes between night and day?" The light level changes. Temperatures change. Relative humidity and insect activity changes

Elastic Stress	Gravity	Friction	Adhesion	
Buoyant Force	Hydrostatic Pressure	Jet Pressure	Surface Tension	
Centrifugal Force	Inertial Force	Coriolis Force		
Oder & Taste	Diffusion	Osmosis	Chemical Fields	
Sound	Vibrations & Oscillations	Ultrasound	Waves	
Thermal Heating or Cooling	Thermal Shocks			Information
Corona Discharge	Current	Eddie Currents	Particle Beams	Nuclear Forces
Electrostatic Fields	Magnetic Fields	Electromagnetic Fields		
Radio Waves	Micro Waves	Infrared	Visible Light	Ultraviolet	X-Ray	Cosmic

between night and day. One of these differences can now be used to change the attribute setting. Changing fields can drive the change. An unformatted list of fields is extracted from the Table of Fields in the appendix.

Simplified Method

The difference of (difference) between (condition A) and (condition B) will change the (element attribute) from (setting A) to (setting B). The (physical phenomenon or method) will be exploited to drive the change of parameters.

A	B
First Condition	On Changing Conditions

Full Method

Step 1: We have already identified the conditions under which we need to have each property or knob setting to determine whether we can Separate in Time. What are these changing conditions?

Step 2: Consult the unformatted table of fields above. What fields change in the new conditions?

Step 3: Identify the required function.

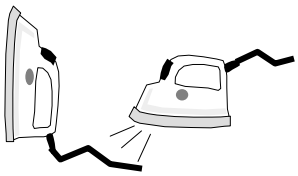
Step 4: What physical phenomena can be used to deliver the required function? If you are familiar with the methods used for identifying physical phenomena to deliver functions then use these methods. Otherwise, brainstorm physical phenomena that can be used.

Example—Clothes Iron Steam

Before steam irons, flat irons were used to iron clothes. The iron was heated first by hot coals or on a stove top, and then later it was heated by an electric current. Finally, it was desired that steam should flow. In order to conserve water we ask how the flow of steam can occur only during ironing. The flow should be FLOWING while ironing and NOT FLOWING while not ironing.

Simplified Method

The difference of (iron orientation) between (ironing) and (iron resting) will change the (water flow) from (flowing) to (not flowing). The (water level versus flow orifice level) will be exploited to drive the change of parameters.



Full Method

Step 1: We have already identified the conditions under which we need to have each property or knob setting to determine whether we can Separate in Time. What are these changing conditions? Since we have already performed this step we recognize that the change from ironing to not ironing is the changing condition. Identify the contradiction in the form shown.

Not Flow	Flow
Not Ironing	Ironing

Step 2: Consult the unformatted table of fields above. What fields change in the new conditions? From the Table of Fields, we see that adhesion (friction), inertia and gravity fields are changing.

Step 3: Identify the required function. The required function is to move a liquid.

Step 4: What physical phenomena can be used to deliver the required function? If you are familiar with the methods used for identifying physical phenomena to deliver functions then use these methods. Otherwise, brainstorm physical phenomena that can be used. In this case, it was recognized that the iron is naturally set upright to keep from burning the clothing between ironing movements.

This change of orientation naturally allows for a change of flow through an orifice. The contradiction is resolved on condition by making the water NOT FLOW when upright (not ironing) and FLOW when in the ironing position.

Example—Dark Glasses

The glasses need to be CLEAR under low lighting conditions and DARK under intense lighting conditions.

Simplified Method

The difference of (light intensity) between (low lighting) and (intense lighting) will change the (glass's light transmission) from (high transmission) to (low transmission). The (photo sensitivity) will be exploited to drive the change of parameters.

Full Method

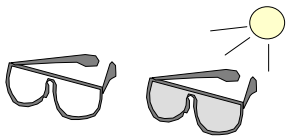
Clear	Dark
Low Light	Bright Light

Step 1: What are these changing conditions? The change from low ambient light to high ambient light is the changing condition. Identify the contradiction in the form shown.

Step 2: Consult the unformatted table of fields above.
What fields change in the new conditions? From the Table of Fields, we see light fields are changing.

Step 3: Identify the required function. The required function is to darken glass.

Step 4: What physical phenomena can be used to deliver the required function? If you are familiar with the methods used for identifying physical phenomena to deliver functions then use these methods. Otherwise, brainstorm physical phenomena that can be used. In this case, it was recognized that certain materials are photo-sensitive and change shade based upon their energy state. This phenomenon was used to change the glasses from clear to light. The contradiction is resolved on condition by making the glasses CLEAR under low ambient light and DARK under high ambient light.

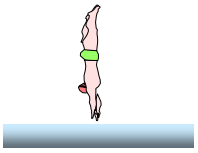


Example—Fluorescent Materials

A material must be VISIBLE under ultraviolet light and NOT VISIBLE when the light is turned off.

The difference of (ultraviolet intensity) between (light on) and (light off) will change the (material visibility) from (visible) to (not visible). The (addition of a luminescent material) will be exploited to drive the change of parameters.

xample—Diving

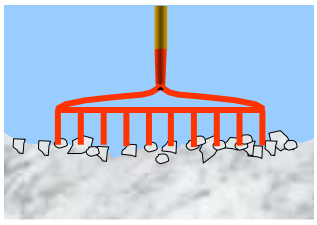


The relative “hardness” of the water must be SOFT at low entrance speed and HARD at high entrance speeds.

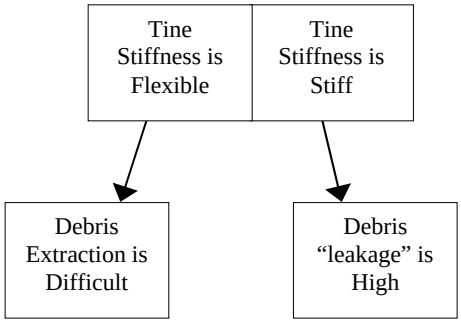
The difference of (velocity) between (low entrance speed) and (high entrance speed) will change the (feeling of water hardness) from (soft) to (hard). The (inertia of the water) will be exploited to drive the change of parameters.

When jumping from low heights, the water is SOFT. When jumping from great heights, the water is HARD.

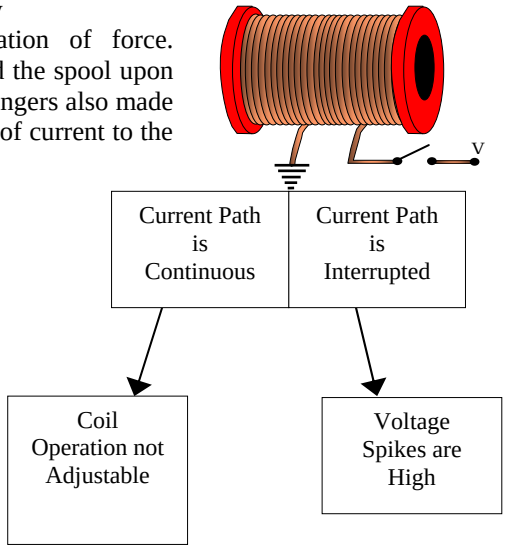
Exercise—Two Tining Rake



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**.** Using the principle that you have just learned, resolve this contradiction.



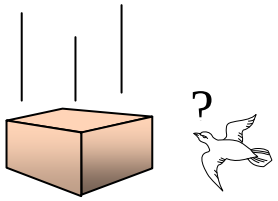
Exercise—I Just Can’t Stop



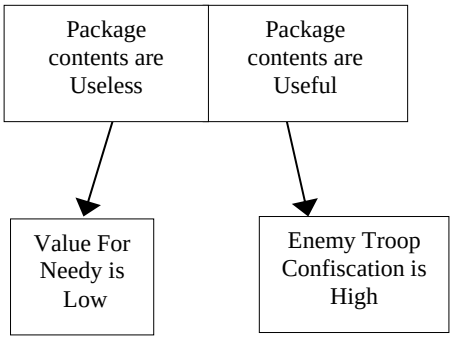
Electromagnetic coils are used for many applications which require the generation of force. Magnetic fields generated by the coil and the spool upon which the wire is wound interact with plungers also made of magnetic materials. Usually, the flow of current to the coil is initiated by throwing a switch 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. The current path needs to be CONTINUOUS AND

INTERRUPTED. Using the principle that you have just learned, resolve this contradiction.

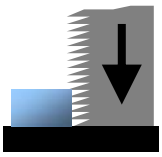
Exercise—Special Delivery



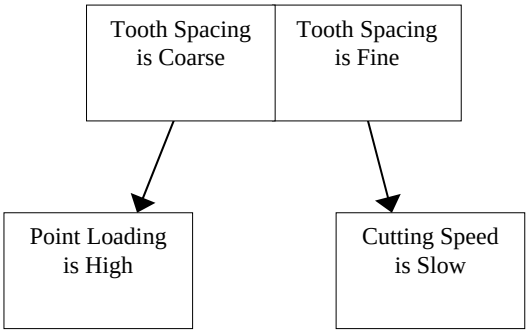
During war in a third world country, an effective means of gaining support from the local people is to give them much needed supplies such as medicine, food and clothing. In order to avoid anti-aircraft and small arms fire, the drop plane must fly high. If the package is dense and compact, it falls with 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 hoard the supplies to themselves. They quickly discover that the contents are useful and look for them. The Package Contents must be USEFUL AND USELESS Using the principle that you have just learned, resolve this contradiction.



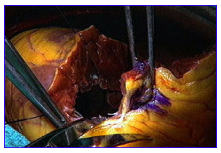
Exercise—Take Smaller Bites



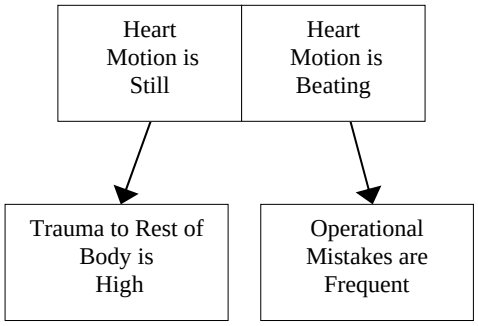
A rule of thumb for cutting a piece of metal in a band saw is to have at least three teeth on the piece of metal. This is because the point loading becomes too high. This causes bad things to happen such as breaking teeth, blades or rough cutting. On the other hand, if the teeth are too fine, the point 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. Using the principle that you have just learned, resolve this contradiction.



Exercise—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. Using the principle that you have just learned, resolve this contradiction.



L3-Separation on Condition—Transparency

This separation principle is specifically related to one attribute, transparency. The use of transparency[28] is a common TRIZ principle. It is used in a variety of ways throughout the separation principles. Here it allows for separation on condition because a transformation of transparency will automatically occur depending upon the changing conditions. Certain types of filters can selectively pass objects depending on their size or shape.

Method

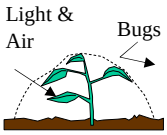
The difference of (difference) between (condition A) and (condition B) will change the (element) transparency from transparent to opaque. The (physical phenomenon or method) will be exploited to drive the change of parameters.

Example—Hinged Elements

Selectively passes solids in motion. They may stop gases, liquids and small objects. Thus hinged elements are TRANSPARENT when large objects try to pass and OPAQUE when small objects or extremely large objects try to pass.

The difference of (object size) between (large animals) and (insects or air) will change the (trap door) transparency from transparent to opaque. The (inertia of the door) will be exploited to drive the change of parameters.

Example—Mechanical Filters



Mechanical filters selectively pass small objects. Examples of these are sieves, fabrics, filament wraps and molecular

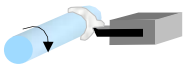
28 Inventive Principle #32—Changing the color: Change the color of an object or its environment. Change the degree of translucency of an object or its environment. Use color additives to observe an object or process which is difficult to see. If such additives are already used, employ luminescent traces or trace atoms. Genrich Altshuller, The Innovation Algorithm page 289.

sieves. Sieves are TRANSPARENT when light and air try to pass and OPAQUE when bugs try to pass.

The difference of (object size) between (light and air) and (bugs) will change the (screen) transparency from transparent to opaque. The (opening size of the screen) will be exploited to drive the change of parameters.

Example—Foams, Liquids, Floating Solids, Fluids in Motion

These selectively pass large objects. They may stop gases, other liquids and very small objects. Consider using inert materials[29] to perform this. In this example, evolving gases from a machining process are stopped by a foam barrier. The foam is TRANSPARENT to large objects and OPAQUE to small objects.

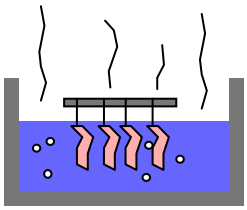


The difference of (inertia of force) between (large objects) and (small objects) will change the (separator material) transparency from transparent to opaque. The (inertia or relative force) will be exploited to drive the change of parameters.

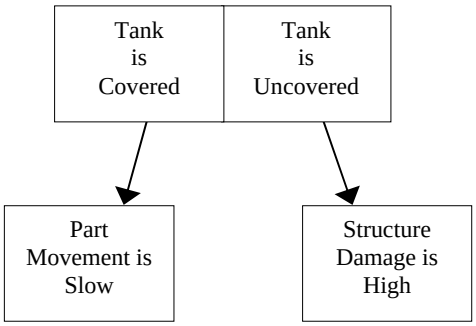
Note that whenever small inertial forces occur, there is a large resistance to transmit the small inertia body. Whenever large inertial forces occur there is a small resistance to transmit the large inertia body. This can also be a separation in space. Wherever there is a large inertia force, there is a small resistance to the large inertia body. Everywhere else, there is a high resistance to small inertia bodies.

Exercise—The Cover That Wasn't

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



Plating Tank Needs to be COVERED & UNCOVERED**.** Using the principle that you have just learned, resolve this contradiction.



29 Inventive Principle #39—Inert Environment: Replace a normal environment with an inert one. Introduce a neutral substance or additives into an object. Carry out the process in a vacuum. Genrich Altshuller, The Innovation Algorithm page 289.

L3-Transformation—Transformable States

This generally involves changing the "state" of the bulk properties of the element[30], in order to change from one conflicting property to the next. Note that broad definition of "states" which contains much more than the transition between solids, liquids and gases. The current list is not exhaustive. If you need more ways, go to the table of knobs and look under changing bulk properties. A field may change "state" by transformation to another frequency.

Critical Points
Sheer Strength
Ultimate Strength
Tip Angle
Static Friction
Adhesive Failure point
Zero Buoyancy
Triple point
Surface Tension
Resonant Frequency
Spark point
Freezing point
Boiling point
Curie temperature

Solid to Liquid to Gas
Combustible materials
Fissable
Adhesives
Explosive
Wettable
Exothermic-Endothermic
Soluble or dissolvable materials
Foams
Settable liquids--(increase of volume)
Easily breakable or abraidable
Polymerizing or de-polymerizing
Mixture decomposition --Electrolysis
Disassociation- recombination
Shape Memory Materials
Magnetic materials using Curie Effect
Molecular reorganization (diamonds)

The transformation should occur near the critical point for maximum effect. For instance, if the transformation is from liquid to gas, operating near the boiling point would allow the transformation to occur with less addition of energy. The Solution Standards give a number of practical suggestions for use of phase transitions. [31]

Method

The (element) is formed from (a transformable structure—consult the table). The (element) is (state A) during (condition A), thus making it (setting A). The (element) is (state B) during (condition B), thus making it (setting B). (The transformation) is operated near (critical point) by (method).

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30 Inventive Principle #36—Phase Transition: Using the phenomena of phase change (i.e., a change in volume, the liberation or absorption of heat, etc.). Genrich Altshuller, The Innovation Algorithm page 289.

31 STANDARD 5-3-1. Efficiency of the use of a substance without introducing other substances can be improved by changing its phase.

STANDARD 5-3-2. "Dual" properties are provided by using substances capable of converting from one phase to another according to operating conditions.

STANDARD 5-3-3. Efficiency of a system can be improved by the use of physical phenomena accompanying a phase transition. Notes: Structure of a substance, density, thermal conductivity, etc. also change along with the change of aggregate state during all types of phase transitions. In addition, during phase transitions, energy may be released or absorbed.

STANDARD 5-3-4. "Dual" properties of a system are provided by replacing a single-phase state of the substance with a dual-phase state.

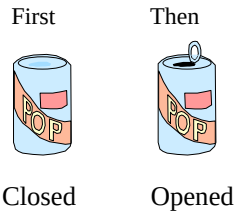
STANDARD 5-3-5. Efficiency of systems obtained as a result of replacing a substance's single- phase state with a dual-phase state can be improved by introducing interaction (physical or chemical) between parts (phases) of the system.

STANDARD 5-4-1. If an object is to be alternating between different physical states, the transition is performed by the object itself using reversible physical transformations, e.g. phase transitions, ionization-recombination, dissociation-association, etc. Note: A dynamic balance providing for the process self-adjustment or stabilization may be maintained in the dual-phase state.

Example—Soda Container

A soda container must be CLOSED completely in order to store or contain a liquid. It must be OPEN during consumption of the beverage.

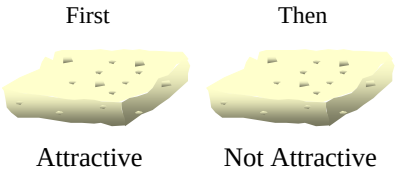
The (can seal) is formed from (an easily yielding material). The (can seal) is (unbroken) during (storage), thus making it (closed). The (can seal) is (broken) during (consumption), thus making it (open). (Yielding) is operated near (nearly torn or yield point) by (providing leverage at the point of tearing).



Example—Sponge

A cleaning product needs to be ATTRACTIVE to small debris during cleaning and NOT ATTRACTIVE to small debris during storage.

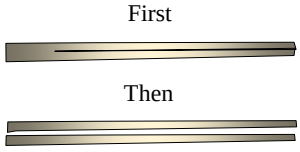
The (cleaning product) is formed from (a sponge). The (cleaning product) is (moist) during (collection of small debris) thus making it (attractive). The (cleaning product) is (dry) during (storage) thus making it (not attractive). (Adhesion) is operated near (critical surface tension) by (keeping slightly damp).



Example—Chopsticks

Chopsticks need to be JOINED for ease of dispensing in a vending machine and SEPARATE for use while eating.

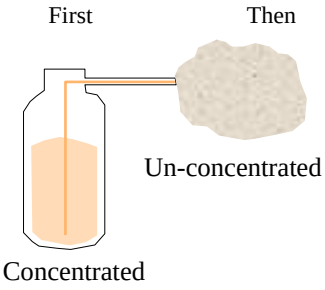
The (element) is formed from (an easily broken structure). The (chopsticks) are (unbroken) during (storage in vending machine) thus making them (joined). The (chopsticks) are (broken) during (preparation for consumption) thus making them (separate). (Breaking) is operated near (yield) by (creating a high stress crack initiation).



Example—Foam Soap

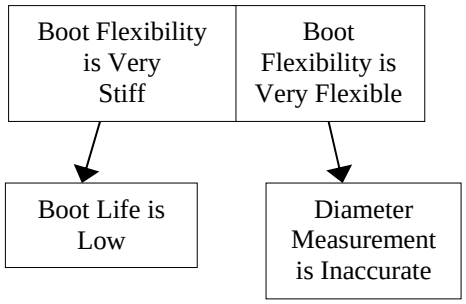
It is common for people to take much more soap than needed when dispensing soap from a liquid soap dispenser. During storage, the soap needs to be CONCENTRATED in order to take up little room. During use, it needs to be UN-CONCENTRATED in order to be easily spread on the hands.

The (soap) is formed from (a foaming liquid). The (soap) is (liquid) during (storage) thus making it (concentrated). The (soap) is (foam) during (use) thus making it (un-concentrated). (Foaming) is operated near (critical surface tension) by (proper dilution of the soap).

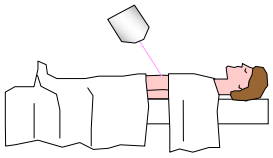


Exercise—Too Flexible

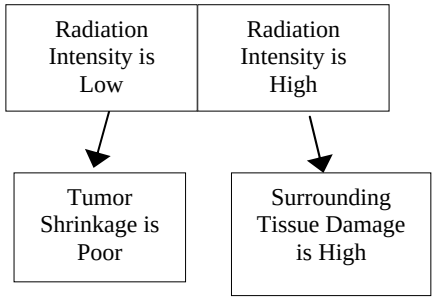
Various diameters of a thin rubber boot (which covers part of a car shift mechanism) must be measured with great accuracy at several points. Unfortunately, the micrometer which is used deforms the boot during the measurement. This makes the measurement inaccurate. How can the boot be measured more accurately? The Boot Flexibility Needs to be FLEXIBLE & STIFF. Resolve the Contradiction using the principle that you have just learned.



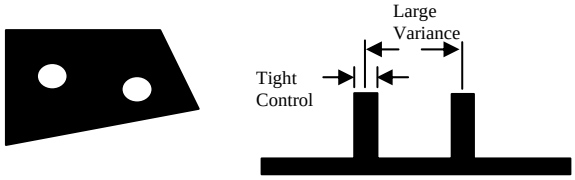
Exercise—Radiation Treatment



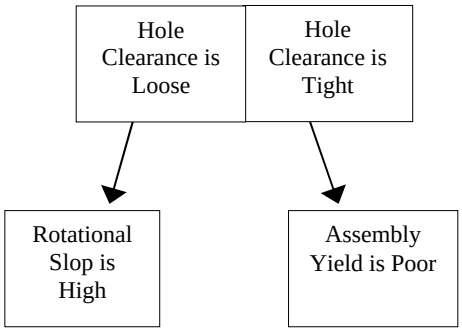
High levels of radiation can damage the structure of cells and cause them to cease functioning. This is useful in the treatment of tumors. A beam of high energy radiation is focused on the tumor. After the procedure, the tumor shrinks. Unfortunately, the tissue surrounding the tumor is also damaged by the high energy radiation. The Radiation Intensity needs to be HIGH AND LOW**.** Using the principle that you have just learned, resolve this contradiction.



Exercise—A Post and an Outpost

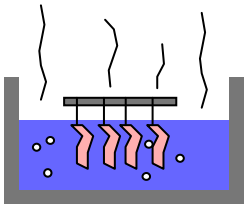


For years your company has produced an aircraft product which fits over two posts on your customer's aircraft. Both the position and the diameter of the posts were closely controlled. Unfortunately, a recent production change by the customer allows a large variance in the distance between the posts. 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 fit snuggly in the application, without rotating. If the hole clearance is large, they can easily fit over, but they will not be snug. The Hole



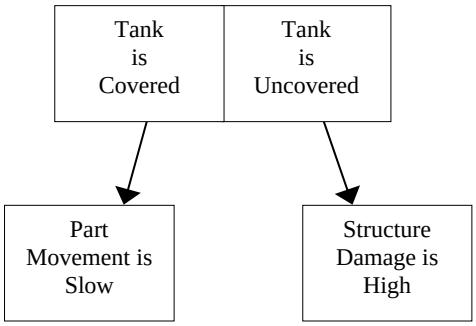
Clearance needs to be LOOSE & TIGHT Resolve this contradiction using the method you have just learned.

Exercise—The Cover That Wasn't



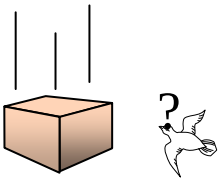
In large plating operations, the plating tanks give off large amounts of corrosive gases. Over the course of time, these gases damage the plating facility and everything in it. Covering the tanks with non-corrosive covers would greatly reduce the evolution of gases, but a cover slows down production.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

Plating Tank Needs to be COVERED & UNCOVERED**.** Using the principle that you have just learned, resolve this contradiction.

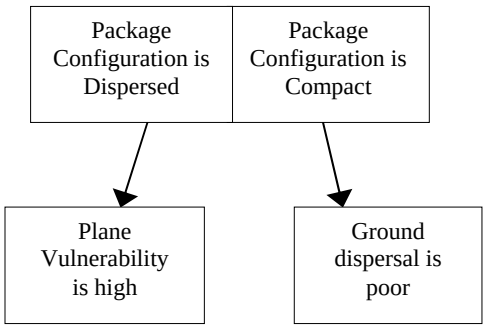


Exercise—Special Delivery II

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 hoard 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 AND DISPERSED. Using the principle that you have just learned, resolve this contradiction.



L3-Transformation—Using Fields

In the previous section, we considered changing the bulk properties of the element in question to change from one knob setting to the other. In this case, we consider the fields associated with the element in order to change between the conflicting attributes. A Table of Fields is provided. The turning on and off of fields is a good example of the inventive principle of periodic action[32].

Elastic Stress	Gravity	Friction	Adhesion
Buoyant Force	Hydrostatic Pressure	Jet Pressure	Surface Tension
Centrifugal Force	Inertial Force	Coriolis Force	
Oder & Taste	Diffusion	Osmosis	Chemical Fields
Sound	Vibrations & Oscillations	Ultrasound	Waves
Thermal Heating or Cooling	Thermal Shocks		Information
Corona Discharge	Current	Eddie Currents	Particle Beams	Nuclear Forces
Electrostatic Fields	Magnetic Fields	Electromagnetic Fields	
Radio Waves	Micro Waves	Infrared	Visible Light	Ultraviolet	X-Ray	Cosmic

Method

Using (physical phenomenon including pneumatic or hydraulic structures[33]) allows us to add a (associated field from the table) to the (element) during (condition A), makes it (setting A). (Removing or reversing) the (field) during (condition B) makes it (setting B).

First [A] Then [B] Then [A] . .

Example—Inflatable Displays

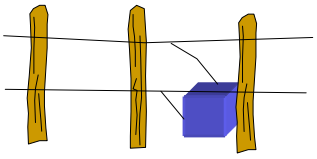
I need displays that EXIST and function as displays and NOT EXIST for easy storage.

Using (pneumatic structures) allows us to add a (pressure field) to the (display) during (displaying), makes it (exist). (Removing) the (pressure field) during (storage) makes it (not exist).

32 Inventive Principle #19—Periodic Action: Replace a continuous action with a periodic one (impulse). If the action is already periodic, change its frequency. Use pauses between impulses to provide additional action. Genrich Altshuller, The Innovation Algorithm page 288.

33 Inventive Principle #29—Pneumatic or Hydraulic Constructions: Replace solid parts of an object with a gas or liquid. These parts can now use air or water for inflation, or use pneumatic or hydrostatic cushions. Genrich Altshuller, The Innovation Algorithm page 289.

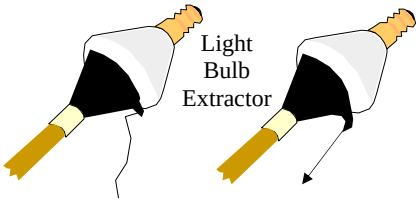
Example—Electric Fence



I need an enclosure fence which must be PAINFUL during contact in order to hold in animals, and must be HARMLESS during non contact in order to reduce operating costs.

Using (high voltage structures) allows us to add an (electric field) to the (enclosure) during (contact), makes it (painful). (Removing) the (electric field) during (non contact) makes it (harmless).

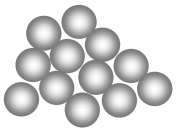
Example—Light Bulb Changer



A mechanical arm is able to reach a light bulb to change it. The arm allows for a twisting action to turn the bulb. A device is sought which allows for NOT HOLDING the bulb during positioning and HOLDING the bulb during twisting.

Using (pneumatic structures) allows us to add a (pressure field--Vacuum) to the (handle) during (removal), makes it (holding). (Removing) the (pressure field--Vacuum) during (positioning) makes it (not holding).

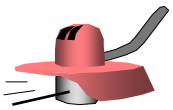
Example—Magnetic Clutch



The clutch must be RIGID during energy transfer and FLUID during periods of rest.

Using (magnetic fluids) allows us to add a (magnetic field) to the (ferromagnetic balls in the fluid) during (transfer of energy), makes it (rigid).)Removing) the (magnetic field) during (rest) makes it (fluid).

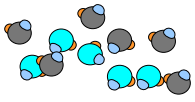
Example—Grass Trimmer



The trimmer blade needs to be STIFF in order to trim grass and small limbs. It needs to be FLEXIBLE for easy maintenance and storage.

Using (inertia of high velocity bodies) allows us to add an (inertia field) to the (blade) during (trimming grass), makes it (stiff). (Removing) the (inertia field) during (maintenance and storage) makes it (flexible).

Example—Detection of Food Particles



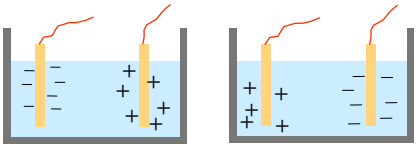
Food particles must be HIGHLY VISIBLE during inspection to show a child how to improve the brushing of teeth. The particles should be INVISIBLE at all other times so as to not embarrass the child.

Using (iridescent materials) allows us to add an (ultraviolet field) to the (particles) during (inspection), making it (highly visible). (Removing) the (ultraviolet field) during (all other times) makes it (invisible).

Common Example—Plating and Electro Polishing

While plating , the metal atoms coming from the solution tend to be attracted to areas of strong electrostatic fields. Any points on the surface of the metal that has a smaller radius will have higher fields. After the plating metal attaches itself to the surface, the surface has an even smaller radius which accelerates the process and makes the surface of the metal even more rough. If the fields were reversed, the opposite would happen and the material would be removed from the peaks. In order to deposit the plating material, the plated piece should have NEGATIVE polarity. In order for the surface to be smooth, the plated piece should have POSITIVE polarity.

Using (reversal of electric fields) allows us to add a (negative electric field) to the (plated piece) during (plating), makes it (positive polarity). (Reversing) the (negative electric field) during (polishing) makes it (positive polarity).

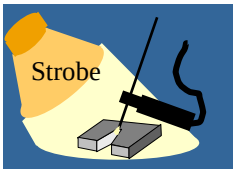


Left is Negative

Right is Negative

Example

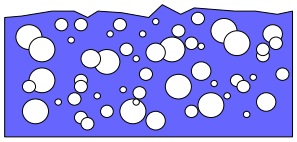
A strong light is required to ILLUMINATE the melt during an arc welding demonstration film. We should NOT ILLUMINATE the melt in order to see the arc in the film.

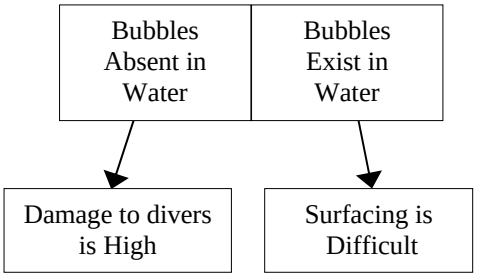


Using (a bright illumination or strobe light) allows us to add a (light field) to the (melt) during (frames showing the melt), makes it (illuminated). Removing or reversing the (light) during (frames showing the arc) makes it (not illuminated).

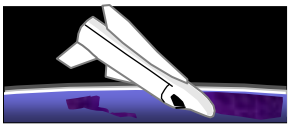
Exercise—Soft Water

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 AND ABSENT. Using the principle that you have just learned, resolve this contradiction.

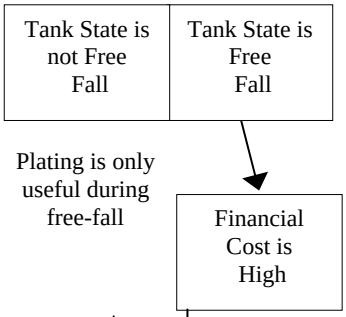




Exercise—Free-Fall Plating

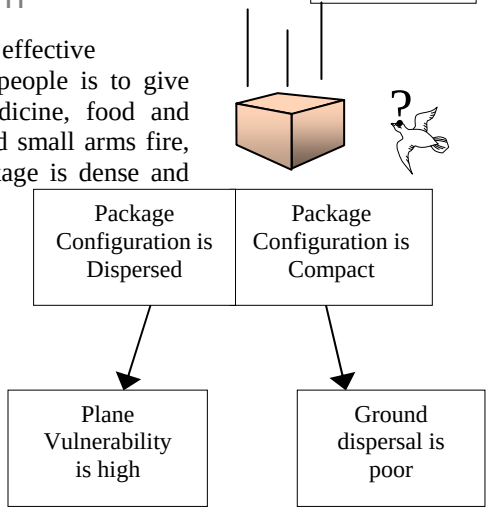


Crystals grown in a micro-gravity environment have unusual properties. Such an environment is created by objects in free-fall. A space craft in orbit about the earth achieves this same effect by being in a constant free fall state. Plating in such a free-fall state might also have unusual properties. 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. Using the principle that you have just learned, resolve this contradiction.



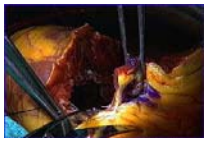
Exercise—Special Delivery II

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 hoard the supplies to themselves.

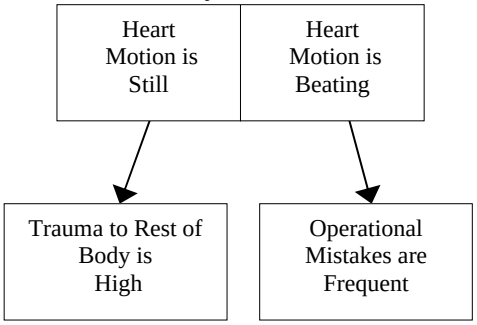


Dropping many packages gets more packages into the hands that need them, but high winds may disperse the drop if they are dropped separately. The Package Configuration must be COMPACT AND DISPERSED. Using the principle that you have just learned, resolve this contradiction.

Exercise—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**.** Using the principle that you have just learned, resolve this contradiction.

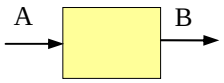


L3-Transformation—Input / Output

An object has something with one property coming in and then later, the opposite property exiting. Identify a means (function) which allows for the adjustment of the property between the input and the output. This means that a physical phenomena needs to be identified and a tool provided to deliver this physical phenomena. This method is primarily used for the transformation of a flow of objects, fields or information.

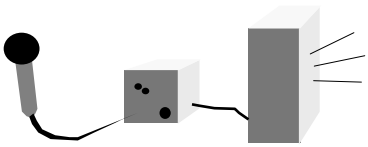
Method

The (elements) to be operated upon must be (setting A) during (condition A). A transformation of (phenomena or action) changes the (elements) to (setting B) during (condition B).



Example—Voice Modulation

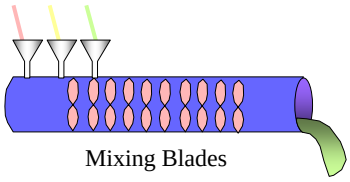
A male story teller relates the story in a MALE voice. Later he would like to interject a WOMAN'S voice into the story during the televised transmission of the show.



The (voice) to be operated upon must be (male) during (actual story telling). A transformation of (voice modulation) changes the (voice) to (female) during (transmission of the show).

Example—Mixing of Liquids

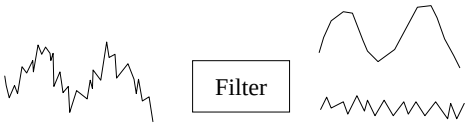
The compounds must be procured and stored as SEPARATE constituents. Later, they must be MIXED for consumption.



The (compounds) to be operated upon must be (separate) during (procurement and storage). A transformation of (mixing blades) changes the (compounds) to (mixed) during (fabrication of the final product).

Example—Signal Separation

The signals must be MIXED in order to send them from the same transmitter. They must be SEPARATED in order to understand the content.



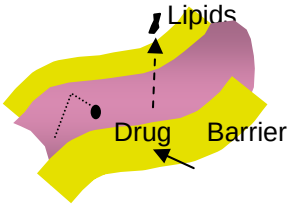
The (signal) to be operated upon must be (mixed) during (transmission). A transformation of (signal filtering) changes the (signal) to (separate) during (logging and use of the information).

Example—Spook Alley

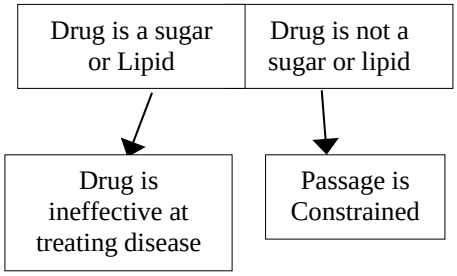
People must be calm during travel between amusements so that they can enjoy looking around and eating. They must later be SCARED in order to feel that they have properly celebrated Halloween.

The (patrons) to be operated upon must be (calm) during (travel and eating). A transformation of (scary costumes and actions) changes the (patrons) to (scared) during (travel through the amusement).

Exercise—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. Using the principle that you have just learned, resolve this contradiction.



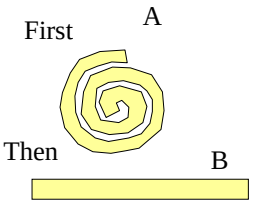
L3-Transformation—Unrolling & Stretching

This transformation considers the manipulation of one particular field, stress fields. The element is made to change shape radically by the application of external forces. Note the box to the right allows for a variety of constructions which respond readily to external forces, changing their area, volume or shape. This is probably an offshoot of transformable states which is very commonly used.

- Nesting Extenders
- Fabrics
- Extension Springs
- Constant Force Springs
- Shape Changing Molecules
- Nets
- Origami
- Scissoring Expanders

Method

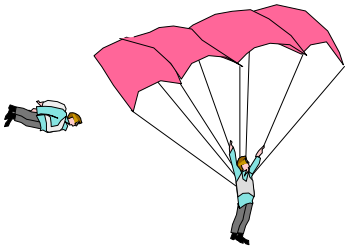
The (element) is formed from (expanding structure—see table). The (element) is (state A) during (condition A), thus making it (setting A). The (element) is (state B) during (condition B), thus making it (setting B).



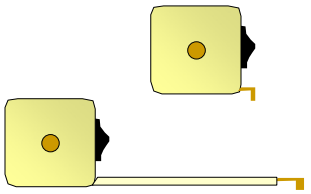
Example—Parachute

The air brake must be LOW DRAG during freefall. It must be HIGH DRAG during breaking.

The (air brake) is formed from (fabric). The (air brake) is (compacted) during (freefall), thus making it (low drag). The (airbrake) is (expanded) during (braking), thus making it (high drag).



Example—Tape Measure

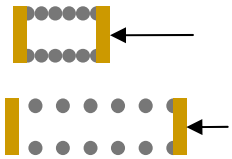


In order to be easily transported and maneuvered, the measure is COMPACT. In order to measure, the measure is LONG.

The (measure) is formed from (a rolled constant force spring). The (measure) is (rolled up) during (transport), thus making it (compact). The (measure) is (unrolled and straight) during (measurement), thus making it (long).

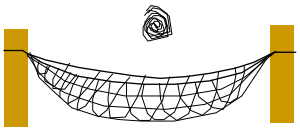
Example—Spring

The spring must have a HIGH SPRING RATE during movement to keep the masses from banging and damaging each other. The spring must have a LOW SPRING RATE during operation in order to operate correctly.



The (spring) is formed from (a spring structure). The (spring) is (collapsed to solid height) during (movement), thus making it (high spring rate). The (spring) is (operating length) during (machine operation), thus making it (low spring rate).

Example Hammock

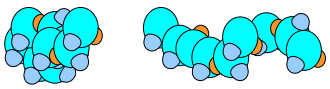


The sleeping support must be COMPACT for easy transport and LARGE AREA to support someone during rest.

The (sleeping support) is formed from (netting). The (sleeping support) is (rolled up) during (transport), thus making it (COMPACT). The (sleeping support) is (extended) during (resting conditions), thus making it (large area).

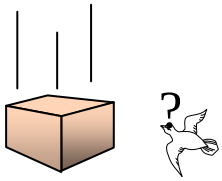
Example—Folding of Molecules

The molecules must be FOLDED during movement of the blood to the reaction site in order to not react with anything along the way. It must be UNFOLDED at the reaction site in order to perform the correct reaction.



The (molecule) is formed from (a long molecular chain). The element is (folded) during (movement to the reaction site), thus making it (low reacting). The (molecule) is (extended) during (location at the reaction site), thus making it (reactive).

Exercise—Special Delivery II



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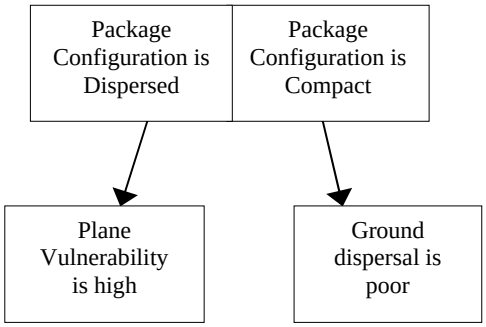
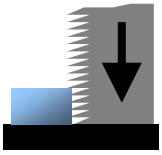
A chute opens near the end to keep the contents from being damaged. Unfortunately, enemy troops on the ground then confiscate the package and hoard the supplies to themselves.



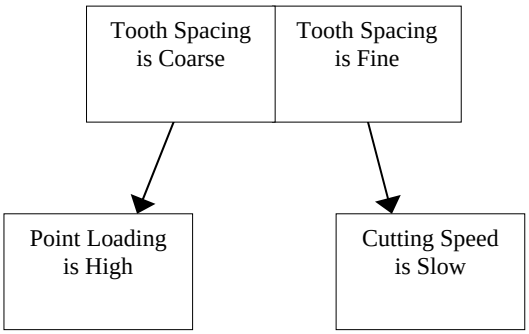
Dropping many packages gets more packages into the hands that need them, but high winds may disperse the drop if they are dropped separately. The Package Configuration must be COMPACT AND DISPERSED. Using the principle that you have just learned, resolve this contradiction.

Exercise—Take Smaller Bites II

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. Using the principle that you have just learned, resolve this contradiction.



L3-Carrier—Intermediary

An intermediary[34] is a carrier that is temporarily used and may be disposed[35] [36] of when the need is past. For the time that it is used, the combination of objects has the property of the carrier or intermediary. The intermediary or carrier lends its attribute to the element that it is attached to. The carrier can be attached and later removed or it can be attached later.

One or more objects with one property are closely associated with a "carrier" substance having the conflicting desirable property. The whole takes on the desired property of the carrier. Using carriers is one of the most powerful methods of changing the properties of objects.

If the property of the element is desirable, then they are arranged in the carrier in such a way that they are expressed at the smaller "micro" scale. Thus, both properties may be expressed or an undesirable property of the element may be hidden.

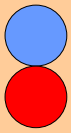
Using a carrier requires the addition of new substances which is not desirable, so try to find the least expensive carrier possible.

Simply **attaching** a carrier to the object may be sufficient to allow the carrier to "loan" its properties. This can be done in a variety of ways shown in the orange box, such as simply touching, being clamped together, adhering together, etc.

Objects with one property can be **nested**[37] inside another object having the conflicting desirable property. The whole takes on the desired property of the carrier. The carrier can be solid, liquid or gas. Consider some of the more unusual carriers in the orange box.

Attaching

- Touch
- Adhere
- Clamped
- Hinged
- Dual Phase States (like ice and water)
- Attached Composite Structures



Nesting

- Nest
- Nestle
- Paint
- Inert Environments

Mixing

- Partially Mixed
- Mixture
- Interweave
- Fabrics and Matrix
- Multi Fiber Fabrics
- Multi Property Laminates
- Mixtures of Different Molecules
- Gels (Liquids + Solids)
- Pastes (Liquids + Solids)
- Foams (solid or liquid)
- Capillary Structures (Solid + Liquid)
- Components of Solids or Liquid
- Porous Materials
- Foams

34 Inventive Principle #24—Mediator: Use an intermediary object to transfer or carry out an action. Temporarily connect the original object to one that is easily removed. Genrich Altshuller, The Innovation Algorithm page 288.

35 Inventive Principle #27—Dispose: Replace an expensive object with a cheap one, compromising other properties (i.e., longevity). Genrich Altshuller, The Innovation Algorithm page 288.

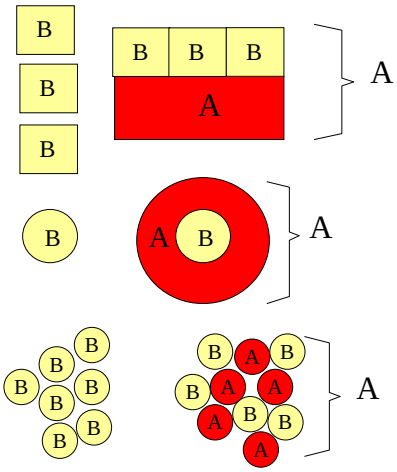
36 Inventive Principle #34—Rejecting and Regenerating Parts: After completing its function, or becoming useless, an element of an object is rejected (discarded, dissolved, evaporated, etc.) or modified during its work process. Used-up parts of an object should be restored during its work. Genrich Altshuller, The Innovation Algorithm page 289.

37 Inventive Principle #7—Nesting (Matrioshka): One object is placed inside another. That object is placed inside a third one. And so on. An object passes through a cavity in another object. Genrich Altshuller, The Innovation Algorithm page 287.

A segmented[38] carrier having a desirable property may be **mixed** with segmented or multiplied elements having the opposing undesirable property. The whole takes on the properties of the carrier. The orange box shows some of the more unusual carrier mixtures possible. Refer to these as you consider resolving your contradiction. The term "segmented carrier" has reference to liquid molecules, fibers and even larger elements such as laminate sheets. Consider finer and finer scales down to sub-atomic particles.

Method

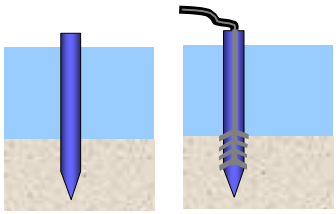
During (condition A) (an inexpensive carrier[39] object or substance) which is (setting A) is (attached to, surrounding or mixed with) (segmented or individual) (elements) which are (setting B) thus loaning its property and making the combination (setting A). No carrier is used during (condition B) making the (element) (setting B).



Example—Pile Driving

A pile needs to be SHARP during driving and BLUNT during supporting.

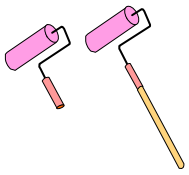
During (supporting) (concrete) which is (blunt) is (attached to) (individual) (piles) which are (sharp) thus loaning its property and making the combination (blunt). No carrier is used during (driving) making the (pile) (sharp).



Concrete is pumped into the pile and extrudes out holes, making the pile BLUNT.

Example—Paint Roller

A roller needs to be SHORT while painting lower than can be easily reached and LONG while painting higher walls.

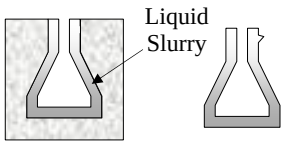


During (painting high walls) (a pole) which is (long) is (attached to) (individual) (rollers) which are (short) thus loaning its property and making the combination (long). No carrier is used during (painting at eye level) making the (roller) (short).

38 Inventive Principle #1—Segmentation: Divide an object into independent parts. Make an object sectional (for easy assembly or disassembly). Increase the degree of an object's segmentation. Genrich Altshuller, The Innovation Algorithm page 287.

39 Inventive Principle #27—Dispose: Replace an expensive object with a cheap one, compromising other properties (i.e., longevity). Genrich Altshuller, The Innovation Algorithm page 288.

Example—Porcelain Mold



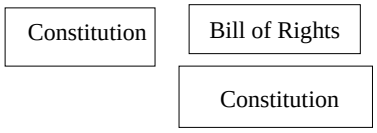
The slurry must be SUPPORTED in order to be formed into many shapes. The slurry must be UNSUPPORTED in order to be fired.

During (forming and drying) (A mold) which is (supported) is (attached to) (segmented) (slurry) which are (unsupported) thus loaning its property and making the combination (supported). No carrier is used during (firing) making the (slurry) (unsupported).

Example—Constitution

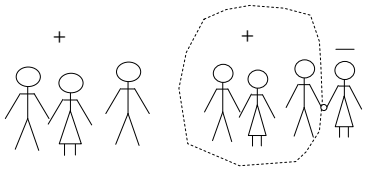
The Constitution needs to be passed RAPIDLY in order to keep a bickering union of states together. This constitution needs to be passed SLOWLY AND DELIBERATELY in order to provide a firm foundation for the future of the union.

During (subsequent deliberations) (a Bill of Rights) which is (slow and deliberate passing speed) is (attached to) (the individual) (constitution) which is (rapidly passing) thus loaning its property and making the combination (slow and deliberate passing speed). No carrier is used during (writing the constitution) making the (constitution) (rapidly passing).



Example—Increasing Group Knowledge

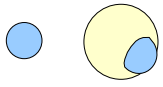
A group of people must be KNOWLEDGEABLE on a certain subject in order to answer questions from a highly influential group of customers. The group must be UNKNOWLEDGEABLE on the subject at all other times because it requires special education thus making the group too expensive.



While (questioning by influential customers) (a knowledgeable person) which is (high knowledge) is (attached to) (the individual) (group) which is (unknowledgeable) thus loaning its property and making the combination (knowledgeable). No carrier is used while (customers are not present) making the (group) (unknowledgeable).

Example—Soluble Compounds

A chemical compound must be INSOLUBLE in water during transport. In the event that an accident occurs, the compound will not be dissolved in water and can be more easily collected. During the actual application, the molecule must be SOLUBLE in water.

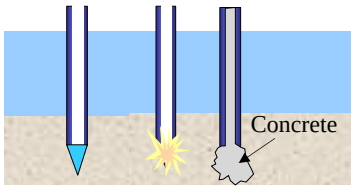


During (transportation) (an insoluble compound) which is (insoluble in water) is (attached to) (individual) (compounds) which are (soluble in water) thus loaning its property and making the combination (insoluble in water). No carrier is used during (use of the compound) making the (compound) (soluble in water).

Example—Pile Driving

The pile must be SHARP during driving and BLUNT during supporting.

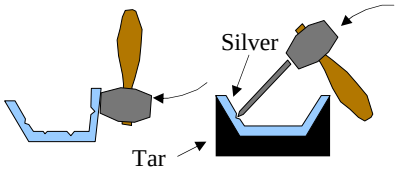
During (supporting) (a concrete bulb) which is (blunt) is (attached to) (individual) (piles) which are (blunt) thus loaning its property and making the combination (blunt). No carrier is used during (driving) making the (pile) (blunt).



First, the pile is SHARP for driving. Later the tip of the pile is exploded and concrete is pumped into the resulting cavity. The concrete carries the property of bluntness and makes the whole pile BLUNT.

Example—Engraving Thin Metallic Plates

The plane material must be FLEXIBLE in order to form it into the shape of a plate. The plate material must be INFLEXIBLE in order to scribe intricate engravings.

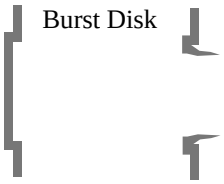


During (engraving) (tar) which is (stiff) is (attached to) (individual) (plates) which are (flexible) thus loaning its property and making the combination (stiff). No carrier is used during (forming the plate) making the (plate) (flexible).

Example—Burst Disks

During low pressure operation, the orifice needs to CONSTRAIN the gas. When the pressure becomes excessive, the orifice needs to be UNCONSTRAINED.

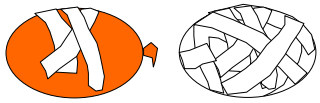
During (low pressure operation) (a weakened barrier) which is (constraining) is (attached to) (individual) (orifices) which are (un-constraining) thus loaning its property and making the combination (constraining). No carrier is used during (high pressure operation) making the (orifice) (un-constraining).



The container is weakened in such a way that if the pressure becomes too high, it bursts and allows gas to freely flow.

Example—Paper Mache

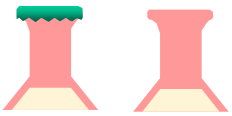
The paper mache must be SUPPORTED in order to be formed. The paper mache must be UNSUPPORTED in order to be filled with candy.



During (forming the mache) (a balloon) which is (supporting) is (attached to) (segmented) (mache) which are (un-supporting) thus loaning its property and making the combination (supporting). No carrier is used during (filling) making the (mache) (unsupported).

Example—Disposable Caps

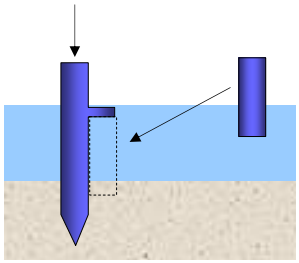
During use, the bottle must be CONSTRAINING to hold the liquid inside. During storage, the bottle must be UN-CONSTRAINING for easy pouring.



During (storage) (an inexpensive plastic cap) which is (constraining) is (attached to) (individual) (bottles) which are (un-constraining) thus loaning its property and making the combination (constraining). No carrier is used during (pouring) making the (bottle) (un-constraining).

Example—Pile Driving

A SHARP pile is required during driving. A BLUNT pile is required during supporting.



During (supporting) (a blunt pile) which is (blunt) is (attached to) (individual) (piles) which are (sharp) thus loaning its property and making the combination (blunt). No carrier is used during (driving) making the (pile) (sharp).

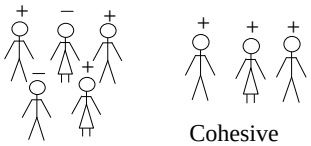
Example—Gel Products

A compound must be LIQUID in order to be easily mixed and processed with other compounds. It must be SOLID in order to hold its shape while being applied by hand.

During (application by hand) (solid particles) which are (solid and formable) are (mixed with) (segmented) (compounds) which are (liquid) thus loaning its property and making the combination (solid and formable). No carrier is used during (mixing) making the (compound) (liquid).

Example—Group Cohesion

In order to educate the group on many topics, it is necessary that the group come with many opinions that they freely share with each other. This makes the group NOT COHESIVE. The group has an important mission that they need to be united on. This makes it necessary that the group be COHESIVE.



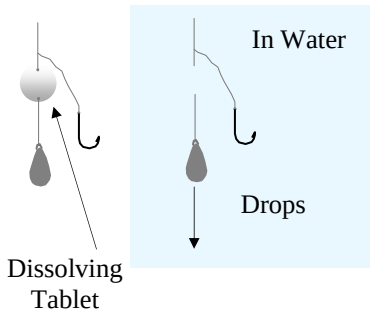
During (forming of the group) (people of different opinions) which are (non cohesive) are (mixed with) (individual) (groups) which are (cohesive) thus loaning its property and making the combination (not cohesive). No carrier is used during (the mission) making the (group) (cohesive).

Example—Fishing Weight

In order to cast the baited hook a long distance, the baited hook needs to be HEAVY. In order for the baited hook to lie on the surface of the water, the baited hook needs to be LIGHT.

During (casting) (a cheap weight connected with an inexpensive dissolving tablet) which is (heavy) is (attached to) (individual) (bait hook) which is (light) thus loaning its property and making the combination (heavy). No carrier is used during (the hook lying in the water) making the (hook) (light).

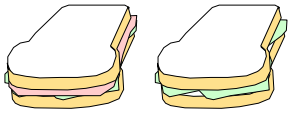
The weight is attached with a dissolving tablet. When it is thrown into the water, the tablet dissolves.



Example—Sandwiches

At large gatherings, the sandwiches must be UNIFORM for easy handling and dissemination. However, the individual tastes of those who come are not uniform. It is necessary that the sandwiches are NOT UNIFORM.

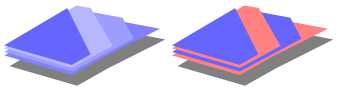
During (consumption of the sandwiches) (bread) which is (uniform) is (surrounding) (individual) (condiments) which are (not uniform) thus loaning its property and making the combination (uniform). No carrier is used during (formation of the sandwich) making the (condiments) (non-uniform).



Example—Composites

PLASTIC laminates are required during forming to create a stiff and light structure. Thin METAL laminates are required to absorb electromagnetic radiation during the use of the product.

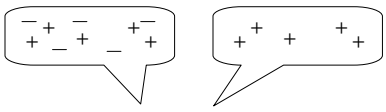
During (operation) (metallic laminates) which are (metal) are (mixed with) (segmented) (plastic laminates) which are (plastic) thus loaning its property and making the combination (metallic). No carrier is used during (forming of the plastic) making the (plastic laminates) (plastic).



Example—Confusing the Opposition

In order to confuse the group, it is necessary to convey a message which is normally CONFLICTING with the group purposes. In order to unite the group, the messages should NOT CONFLICT with the group purposes.

During (confusing the opposition) (a lot of conflicting messages) which are (conflicting with the group purposes) are (mixed with) (segmented) (overall message) which are (not conflicting with the group purposes) thus loaning its property and making the combination (conflicting with the group purposes). No carrier is used during (the time to rally the group) making the (overall message) (not conflicting with group purposes).



Exercise—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. Using the principle that you have just learned, resolve this contradiction.

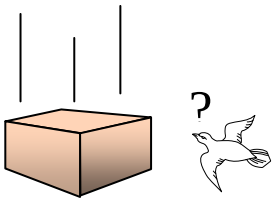
Laminate Thickness is Thick	Laminate Thickness is Thin

Laminate thickness only useful in one thickness

Handling damage is high

Exercise—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 hoard the supplies to themselves. They quickly discover that the contents are useful and look for them. The Package Contents must be USEFUL AND USELESS Using the principle that you have just learned, resolve this contradiction.



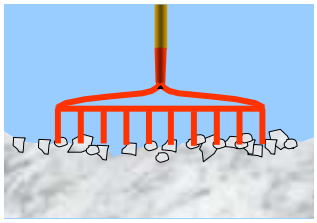
Package contents are Useless	Package contents are Useful

Value For Needy is Low

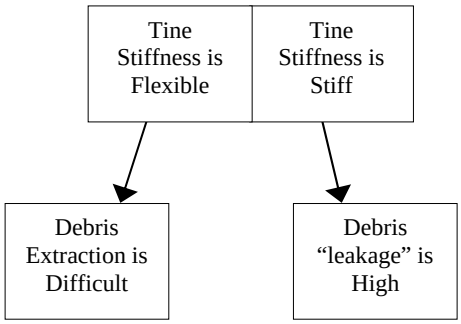
Enemy Troop Confiscation is High

Exercise—Two Tining Rake

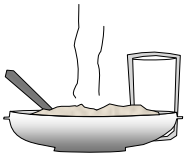
A common garden rake is somewhat inefficient when raking small debris. While riding over uneven surfaces, unwanted debris settles into the uneven surface and the tines ride over the top without collecting the debris. If the tines were more flexible, they could ride over the uneven surfaces like a leaf 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**.** Using the principle that you have just learned, resolve this contradiction.

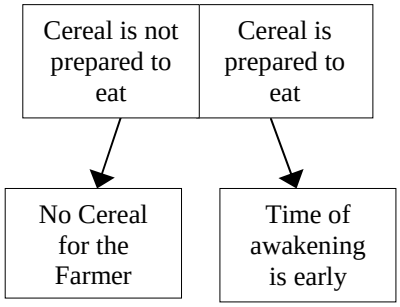


Exercise—The Farmer's Mush



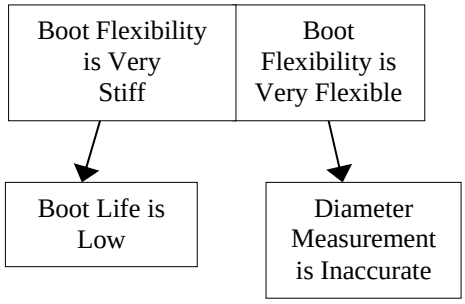
"I can't stand cold cereal anymore!" The farmer says. "Yes, but it takes a long time to make hot cereal the way that you like it! I'm not getting up any earlier to make it!" The farmer's wife complains.

The cereal MUST BE PREPARED in order to nourish the farmer. It must NOT BE PREPARED in order to not fatigue the farmer's wife. Resolve this contradiction using the method you have just learned.

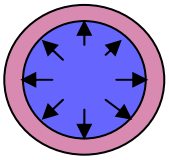


Exercise—Too Flexible

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. Resolve the Contradiction using the principle that you have just learned.



Exercise—Storing Almost Protons

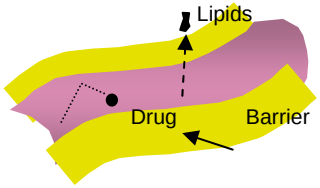


Hydrogen is very difficult to store as a gas. This is primarily because of the high gas constant. A small mass of gas can exert very high pressures when constrained to a small volume. In order to reduce the stresses in the vessel walls, the walls are made very thick. The resulting vessel weight is high (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**.** Using the principle that you have just learned, resolve this contradiction.

Pressure Forces are Low	Pressure Forces are High

Assume that Pressure only comes high → Material Stresses are High

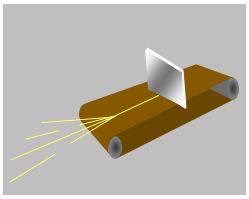
Exercise—Blood Brain Barrier



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. Using the principle that you have just learned, resolve this contradiction.

Drug is a sugar or Lipid	Drug is not a sugar or lipid
Drug is ineffective at treating disease	Passage is Constrained

Exercise—A Slight Polishing



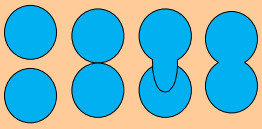
Your company polishes the edges of glass plates. Thousands of plates are polished each day. The edges of the glass plates are polished on a fast moving belt covered with abrasive materials. One day an order comes in for polishing glass plates which are only .010 inches thick. The first attempts to polish 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 THICK, but they only come THIN. Using the principle that you have just learned, resolve this contradiction.

Plate Thickness is Thick	Plate Thickness is Thin

Plate only comes in one thickness → Edge Breaking is High

L3-Merging—Interacting

Interact through a field at a distance
Interact through a "mediator" substance
Linked by Transmission
Touch
Interweave
Nest
Nestle
Interlink
Clamped
Hinged
Interfused
Fractal Constructions



The term "merging" will be used more broadly to indicate "interacting" with individual or segmented40 objects. The individual objects or segments have one desired property and the interacting objects have the opposing property. Such interactions can be achieved with the fields shown in the Table of Fields.

A mediating substance or "mediator" can also allow the individual elements to interact with each other. The mediating substance or field typically operates at the macro scale while the individual elements operate at the micro scale. Merging allows for action at a distance as well as the potential of touching, nesting41, interweaving, attaching and mixing. We also allow for fields which repulse rather than attract.

In order to drive to ideality, we would like to use existing fields if possible. An example of this would be to make the elements interlink. Mechanical fields already exist; why not allow them to perform the act of merging?

As in all of the merging methods, it may be necessary to break the element down into multiple pieces that can then interact. When an element is segmented into multiple elements, this creates new resources and properties such as adjustability.

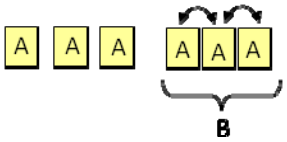
Elastic Stress	Gravity	Friction	Adhesion	
Buoyant Force	Hydrostatic Pressure	Jet Pressure	Surface Tension	
Centrifugal Force	Inertial Force	Coriolis Force		
Oder & Taste	Diffusion	Osmosis	Chemical Fields	
Sound	Vibrations & Oscillations	Ultrasound	Waves	
Thermal Heating or Cooling	Thermal Shocks			Information
Corona Discharge	Current	Eddie Currents	Particle Beams	Nuclear Forces
Electrostatic Fields	Magnetic Fields	Electromagnetic Fields		
Radio Waves	Micro Waves	Infrared	Visible	Ultraviolet	X-Ray	Cosmic

40 Inventive Principle #1—Segmentation: Divide an object into independent parts. Make an object sectional (for easy assembly or disassembly). Increase the degree of an object's segmentation. Genrich Altshuller, The Innovation Algorithm page 287.

41 Inventive Principle #7—Nesting (Matrioshka): One object is placed inside another. That object is placed inside a third one. And so on. An object passes through a cavity in another object. Genrich Altshuller, The Innovation Algorithm page 287.

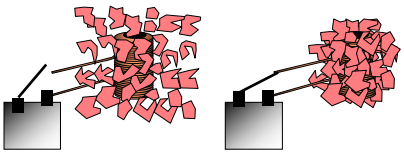
Method

Segmentation is (allowed and accomplished by what method or not allowed). During (condition A) several (segmented or individual) (elements) have the property of being (setting A) while unified or interacting through (a field, mediator, method or unified arrangement). During (condition B) the unifying interaction is absent making them (setting B).



Example—Window Shade

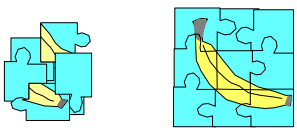
The shade is a LARGE & SQUARE while blocking light through the window. The shade is SMALL & ROUND while allowing light through the window.



Segmentation is (allowed and accomplished manufacturing methods). During (light transmission) several (segmented) (magnetic shade elements) have the property of being (small and round) while unified or interacting through (a magnetic field). During (blocking light transmission) the unifying interaction is absent making them (large and square).

Example—Picture

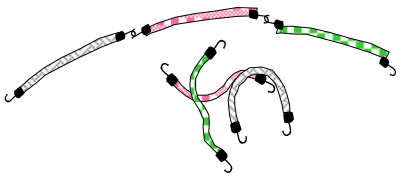
A picture must be COMPACT while stored in a box. The picture must be EXPANSIVE while being viewed as a picture.



Segmentation is (allowed and accomplished by manufacturing methods). During (construction) several (segmented) (picture pieces) have the property of being (expanded) while unified or interacting through (an interlinking stress field). During (storage) the unifying interaction is absent making them (compact).

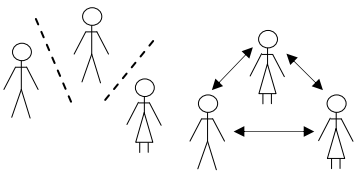
Example—Bungee Cords

Binding cords need to be LONG while securing large loads and SHORT while securing small loads.



Segmentation is (not allowed). During (securing large loads) several (individual) (cords) have the property of being (long) while unified or interacting through (mechanical interlocking). During (securing small loads) the unifying interaction is absent making them (short).

Example—Creating Group Interaction

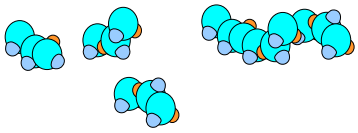


The group must be ISOLATED while contemplating individual solutions to a problem in order to not be influenced by others or groupthink. The group must be COMMUNICATIVE in order to arrive at a consensus to go forward.

Segmentation is (not allowed). During (coming to a consensus) several (individual) (group members) have the property of being (communicative) while unified or interacting through (a field of communication). During (contemplation of solutions) the unifying interaction is absent making them (isolated).

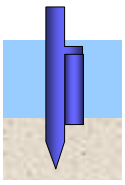
Example—Merging Polymer Chains

During conditions requiring low damping, the fluid in the rotational damper has LOW VISCOSITY. During conditions requiring high damping the fluid has a HIGH VISCOSITY.



Segmentation is (not allowed). During (high damping) several (individual) (polymer chains) have the property of being (high viscosity) while unified or interacting through (an electrostatic field). During (low damping) the unifying interaction is absent making them (low viscosity).

Example—Pile Driving



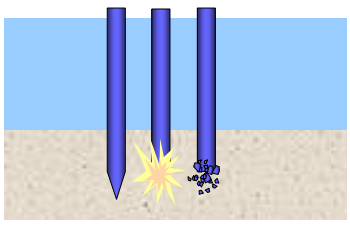
The pile must be SHARP while driving and BLUNT while supporting.

Segmentation is (not allowed). During (supporting) several (individual) (piles) have the property of being (blunt) while unified or interacting through (a mechanical nesting field). During (driving) the interaction is absent making them (sharp).

Example—Pile Driving

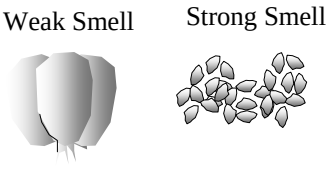
We need the pile to be SHARP while driving and we need it to be BLUNT while supporting.

Segmentation is (allowed and accomplished by an explosive charge). During (driving) several (individual) (piles) have the property of being (sharp) while unified or interacting through (a mechanical field). During (supporting) the unifying interaction is absent making them (blunt).



Example—Mincing Garlic

Fresh garlic has a very strong odor. Storing garlic in its own natural wrapper provides a very WEAK smell. This is perfect for storing the garlic in a living area. During cooking, it needs a STRONG smell to impart taste.

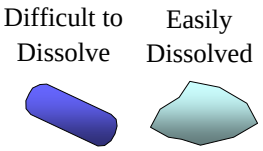


Segmentation is (allowed and accomplished by cutting or crushing). During (storage) several (individual) (garlic segments) have the property of being (weak) while unified or interacting through (mechanical field). During (cooking) the unifying interaction is absent making them (strong).

Example—an Easily Swallowed Pill

Many medications must be EASILY DISSOLVED in the stomach. Unfortunately, many medications that easily dissolve in the stomach also easily dissolve in the mouth, which creates a strong and undesirable taste. The pill should be DIFFICULT TO DISSOLVE in the mouth.

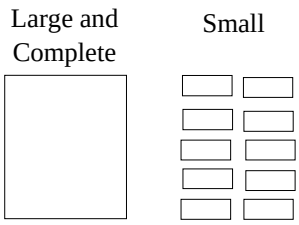
Segmentation is (allowed and accomplished by a tasty binder that is dissolved by saliva). During (swallowing) several (individual) (pills) have the property of being (difficult to dissolve) while unified or interacting through (unifying mechanical field). During (digestion) the unifying interaction is absent making them (easily dissolved).



Example—Small Scripts

While practicing for a play, the actors are given play scripts to learn the parts, but there is a problem. The speaking parts and the choreography need to be learned very rapidly. The FULL script is required for the actors to understand where they perform relative to everyone else, but it is not practical to carry the full script with them when they are dancing about the stage. The scripts must be PARTIAL while they are dancing.

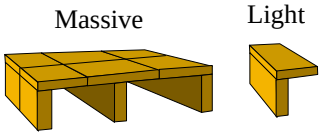
Segmentation is (allowed and accomplished by cutting them out). During (learning) several (individual) (scripts) have the property of being (full) while unified or interacting through (a unified arrangement). During (dancing) the unifying interaction is absent making them (partial).



Example—Massive Table

We need a MASSIVE table to give a feel of stability.
The table must be LIGHT in order to be moved from time to time.

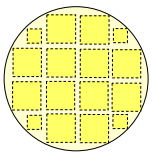
Segmentation is (allowed and accomplished by designing the table as separate pieces). During (use) several (segmented) (table pieces) have the property of being (massive) while unified or interacting through (an interlocking table or fastening elements). During (transportation) the unifying interaction is absent making them (light).



Example—Die Processing

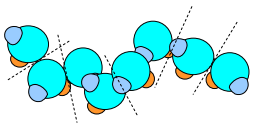
A ROUND wafer is round because the ingot from which it is produced is round. The individual die are SQUARE .

Segmentation is (allowed and accomplished by cleaving). During (die processing) several (segmented) (wafers) have the property of being (round) while unified or interacting through (a unifying mechanical field). During (packaging) the unifying interaction is absent making them (square).



Example—Cleaving DNA

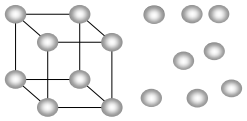
In order for DNA to be extracted, it must be COMPLETE molecules. In order to multiply the various parts of the DNA, it must be PARTIAL segments.



Segmentation is (allowed and done by chemically snipping the DNA). During (extraction) several (segmented) (DNA) have the property of being (complete) while unified or interacting through (unifying chemical bonds). During (multiplication) the unifying interaction is absent making them (partial).

Example—Acid

At first, the acid is in CRYSTALLINE form for safe transportation and storage. Later it is in LIQUID for use in chemical reactions.



Segmentation is (allowed and accomplished dissolving). During (storage and transport) several (segmented) (acid molecules) have the property of being (crystalline) while unified or interacting through (chemical bonds). During (reacting) the unifying interaction is absent making them (liquid).

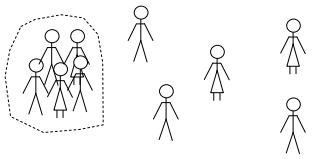
Example—Separation of Signals

We need ONE SIGNAL because we have only one transmitter, but we need SEVERAL SIGNALS because we need to convey different types of information.

Segmentation is (allowed and accomplished by signal filters). During (transmission) several (segmented) (signals) have the property of being (one signal) while unified or interacting through (a unifying arrangement). During (viewing or listening) the unifying interaction is absent making them (several signals).

Example—Law Enforcement Rules

A group of law enforcement officers are more efficiently guided by CENTRAL CONTROL when they are in close proximity. When they are performing their duty, it becomes more effective for the officers to be AUTONOMOUS rather than waiting on a central control to tell them what to do in ever-changing and dangerous circumstances.



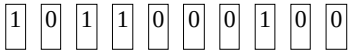
Segmentation is (not allowed). During (close proximity) several (individual) (officers) have the property of being (centrally controlled) while unified or interacting through (a communication field). During (performing duty) the unifying interaction is absent making them (autonomous).

Note that giving the officers rules helps them to be more autonomous.

Example—Packing Words for Transport

While conveying the data, the data should be in COMPACT form. During calculations, the digital data should be EASILY MANIPULATED.

Segmentation is (not allowed). During (transport) several (individual) (bits) have the property of being (compact) while unified or interacting through (a unified arrangement). During (calculation) the unifying interaction is absent making them (easily manipulated).



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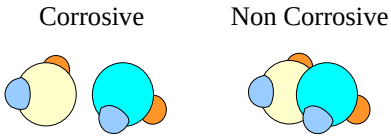
Chemistry Example—Non-Corrosive By-Products

After a CORROSIVE chemical is used in a reaction, there are usually small amounts of the corrosive components that remain in the byproducts. The byproducts are used in other reactions making it necessary to store them for long periods of time. Unfortunately, they have a tendency to leak or corrode nearby articles. The by-products need to be NON-CORROSIVE.

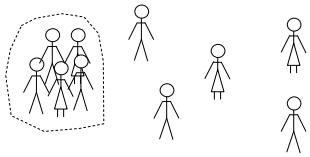
Segmentation is (not allowed). During (storage) several (individual) (compounds) have the property of being (non corrosive) while unified or interacting through (chemical bonds). During (further reactions) the unifying interaction is absent making them (corrosive).



Example—Avoiding Group Think

In order to gain opinions that are more DIVERSE, the opinions should be gathered while the group is separated. In order to come to a final consensus, the group ideas need to be UNIFORM.

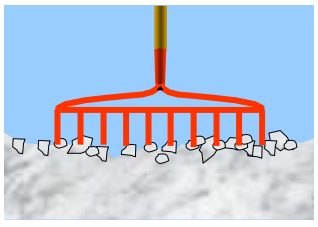
Several (people) can be used. During (the generation of a consensus opinion) the grouped (individuals) are (uniform). Separating the (people) before (idea generation) makes them (diverse).



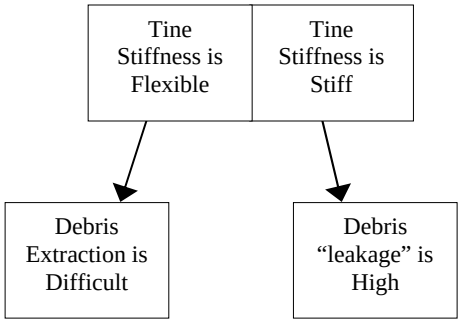
Segmentation is (not allowed). During (generation of a consensus opinion) several (individual) (people) have the property of being (uniform) while unified or interacting through (a communication field). During (idea generation) the unifying interaction is absent making them (diverse).

Exercise—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.

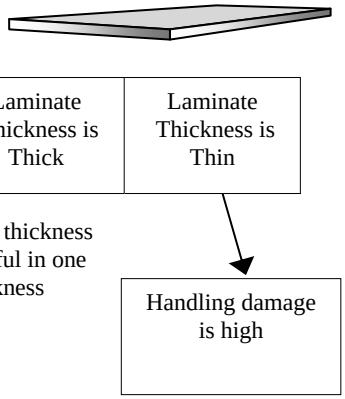


On the other hand, if the tines are flexible, then the rake is not useful for extracting embedded debris or for moving earth about. The Tine Flexibility should be FLEXIBLE & STIFF**.** Using the principle that you have just learned, resolve this contradiction.



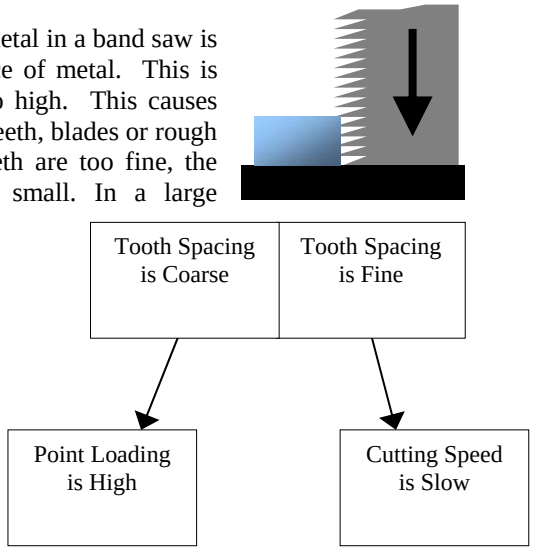
Exercise—Metallic Film

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**.** Using the principle that you have just learned, resolve this contradiction.



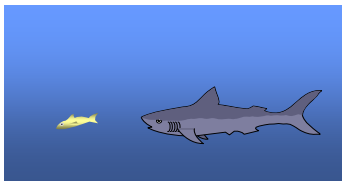
Exercise—Take Smaller Bites

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. Using the principle that you have just learned, resolve this contradiction.



Exercise—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 in order to outrun the shark and NORMAL ENDURANCE because that is how small fish are. Resolve the contradiction by using the method you have just learned.



Endurance is Infinite	Endurance is Low

No Fish Comes this way → Vulnerability is High

Exercise—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 THICK, but they only come THIN. Using the principle that you have just learned, resolve this contradiction.

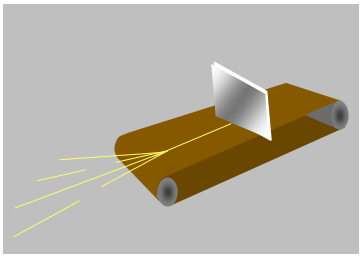
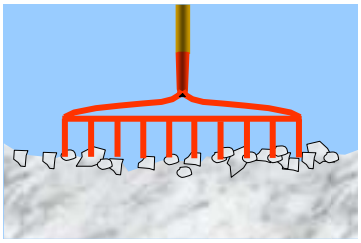


Plate Thickness is Thick	Plate Thickness is Thin

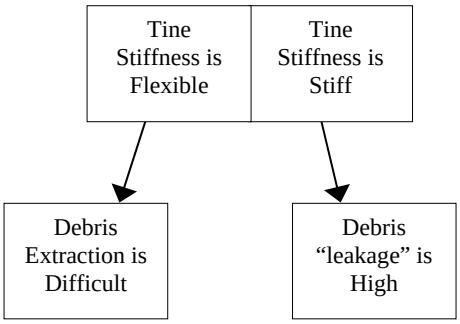
Plate only comes in one thickness → Edge Breaking is High

Exercise—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.

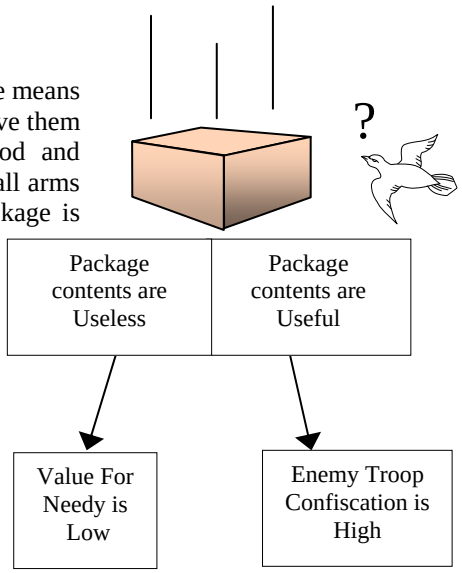


On the other hand, if the tines are flexible, then the rake is not useful for extracting embedded debris or for moving earth about. The Tine Flexibility should be FLEXIBLE & STIFF**.** Using the principle that you have just learned, resolve this contradiction.



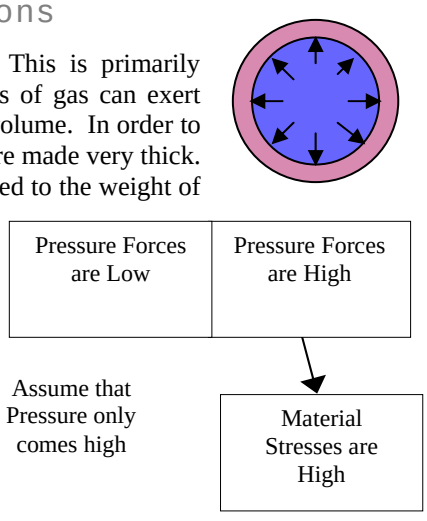
Exercise—Special Delivery

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 hoard the supplies to themselves. They quickly discover that the contents are useful and look for them. The Package Contents must be USEFUL AND USELESS. Using the principle that you have just learned, resolve this contradiction.



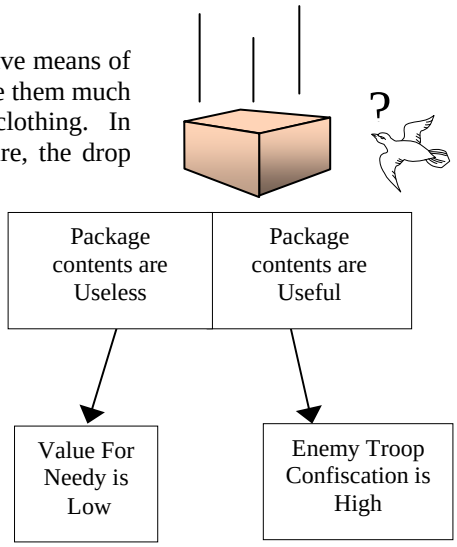
Exercise—Storing Almost Protons

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**.** Using the principle that you have just learned, resolve this contradiction.



Exercise—Special Delivery

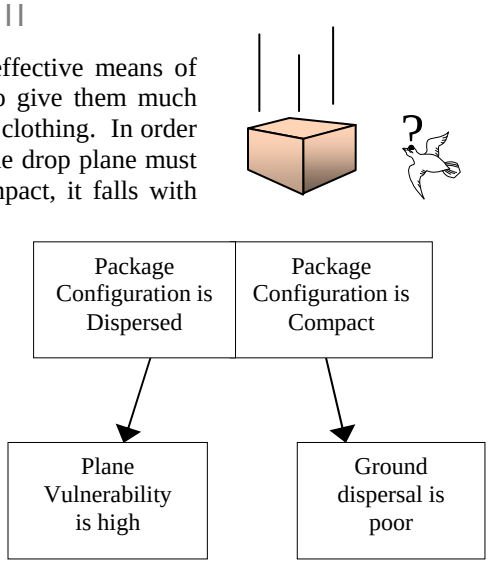
During war in a third world country, an effective means of gaining support from the local people is to give them much needed supplies such as medicine, food and clothing. In order to avoid anti-aircraft and small arms fire, the drop plane must fly high. If the package is dense and compact, it falls with 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 hoard the supplies to themselves. They quickly discover that the contents are useful and look for them. The Package Contents must be USEFUL AND USELESS. Using the principle that you have just learned, resolve this contradiction.



Exercise—Special Delivery II

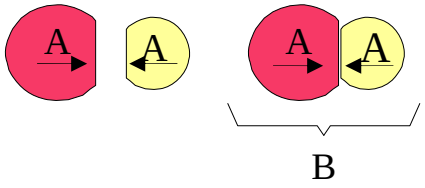
During war in a third world country, an effective means of gaining support from the local people is to give them much needed supplies such as medicine, food and clothing. In order to avoid anti-aircraft and small arms fire, the drop plane must fly high. If the package is dense and compact, it falls with 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 hoard 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 AND DISPERSED. Using the principle that you have just learned, resolve this contradiction.



L3-Merging—Countering

Here, thought is given as to how objects may be configured, oriented or designed to oppose each other[42]. Even though they can oppose each other, while separate, they all have the same setting. When combined, they take on the opposing property.

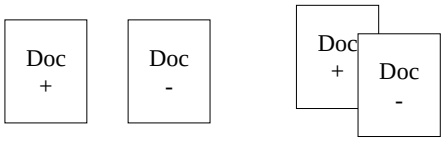


Method

Elements are configured, oriented or designed to oppose each other by (method). Separating the (elements) during (condition A) makes them (setting A). During (condition B) the merged (elements) oppose each other making them (setting B).

Example—Opposing Messages

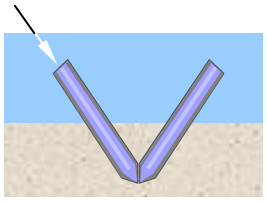
The messages need to be VERY POTENT in order to create discussion among the students. In order to help the students calm down and see both sides of the issue, they should have NULL POTENCY.



Elements are configured, oriented or designed to oppose each other by (making them of strongly opposing opinions). Separating the (messages) during (discussion) makes them (very potent). During (group discussion) the merged (messages) oppose each other making them (null potency).

Example—Pile Driving

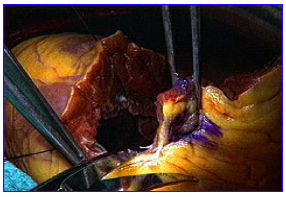
During driving the pile needs to be SHARP in order to drive fast. During supporting, the pile needs to be BLUNT in order to support well.



Elements are configured, oriented or designed to oppose each other by (orienting them to oppose each other). Separating the (piles) during (driving) makes them (sharp). During (supporting) the merged (piles) oppose each other making them (blunt).

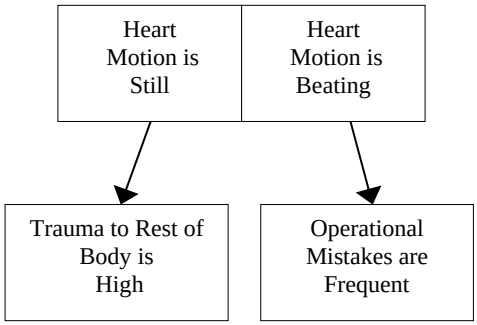
Exercise—the Beat Goes On

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.



42 Inventive Principle #8—Counterweight: Compensate for the weight of an object by combining it with another object that provides a lifting force. Compensate for the weight of an object with aerodynamic or hydrodynamic forces influenced by the outside environment. Genrich Altshuller, The Innovation Algorithm page 287.

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**.** Using the principle that you have just learned, resolve this contradiction.

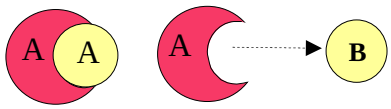


L3-Merging—Extraction

The principle of extraction[43] also occurs in Separation in Space. During separation in space, one part of the element in question takes on one property while the rest of the element takes on the opposing properties. This is different from segmentation/merging tools where the whole takes on one property while separate and the opposite property when merged. This principle is particularly handy when the system can be broken into functional units. A crucial part of the original element is made easily removable. During one condition the system is separated in space using the principle of extraction. The separated part has one property and the rest has the opposing property. When the elements are remerged, the extracted element resumes the opposing property of the rest of the system.

Method

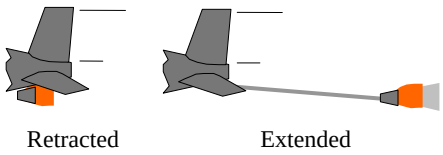
The (element) has several identifiable pieces. During (condition A) the (crucial piece) is separated making it (Setting A). During (condition B) the (crucial piece) is reunited making it (Setting B).



Common Example—Refueling of Aircraft in Flight

The fueling system must be EXTENDED during refueling in order to contact the refueling aircraft. The fueling system must be RETRACTED during normal flight in order to have low drag.

The (fueling system) has several identifiable pieces. During (refueling) the (intake nozzle) is separated making it (extended). During (normal flight) the (intake nozzle) is reunited making it (retracted).

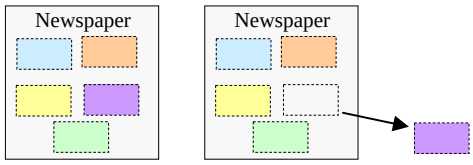


43 Inventive Principle #2—Extraction: (Extracting, Retrieving, Removing). Extract the "disturbing" part or property from an object. Extract only the necessary part or property from an object. Genrich Altshuller, The Innovation Algorithm page 287.

Common Example—Newspaper Coupons

The newspaper must be AT HOME for convenient reading. The newspaper must be AT THE STORE for reference while shopping.

The (newspaper) has several identifiable pieces. During (shopping) the (product ads) are separated making it (at the store). During (reading) the (newspaper) is reunited making it (at home).



Common Example—Prison

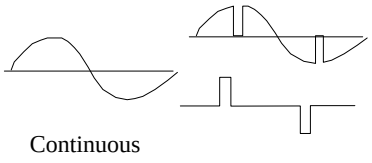
A time may be reached in which some individuals prove to society that they are not capable of such freedoms. A convicted felon is dangerous and is REJECTED by society while being reformed . Everyone needs the chance to prove themselves capable of living with others. If a felon is reformed, he needs to be NURTURED by society in order to integrate.

The (society) has several identifiable pieces. During (reformation) the (convicted felon) is separated making it (rejected). During (probation) the (felon) is reunited making it (nurtured).

Example—Digital Signals

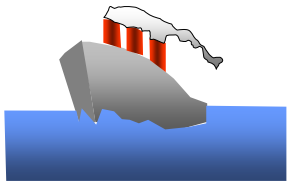
In order for all electromagnetic signals to travel through space, they must live part of their life as “analog” signals. These are continuous waveforms that travel in predictable ways and maintain their form in space and time. Digital waveforms require square features which are actually the combination of many continuous waveforms. As they travel through space, the change of amplitude of these various components are less predictable. In order to travel in an orderly manner, the waveform shape must be SMOOTH or continuous. In order for the waveform to be useful, it must be SQUARE or discontinuous.

The (signal) has several identifiable pieces. During (use) the (extracted peaks) are separated making it (square or discontinuous). During (transmission) the (extracted peaks) are reunited making it (smooth and continuous).

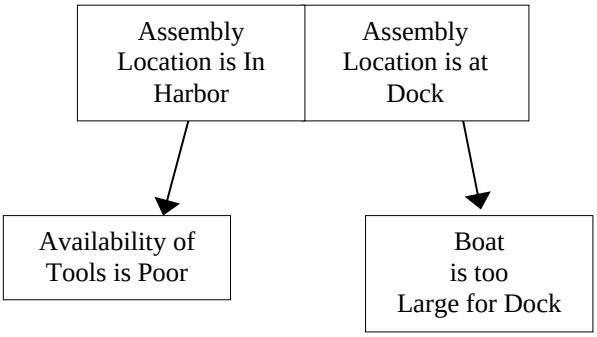


Exercise—Super Yacht

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: It should be IN THE HARBOR & AT THE DOCK. Using the principle that you have just learned, resolve this contradiction.

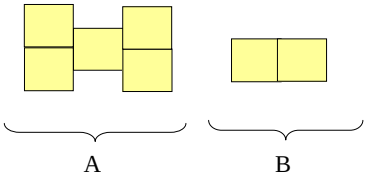


L3-Merging—Adjustable Numbers

An element is segmented or multiple elements are used in order to make the system adjustable[44]. The multiple parts can be brought into use in the number which is sufficient to be adequate for the conditions. This is quite similar to rearranging and unfolding and to merging except that the number of elements to be merged are adjustable and usually some are reserved for use when they are necessary.

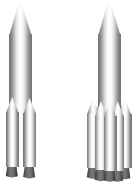
Method

Multiple (elements) are available for adjustable use. During (condition A) many (elements) are used to give (Setting A). During (condition B) few elements are used to give (Setting B).



Example—Adjustable Rocket Thrust

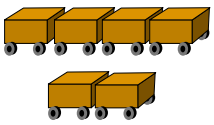
The rocket only requires LOW THRUST for a small payload. Later it requires HIGH THRUST for large payloads.



Multiple (thrusters) are available for adjustable use. During (large payloads) many (thrusters) are used to give (high thrust). During (small payloads) few elements are used to give (low thrust).

Example—Adjustable Train Length

The train needs HIGH CAPACITY for transporting large amounts of goods. It requires LOW CAPACITY for lesser goods.



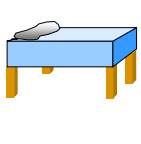
Multiple (cars) are available for adjustable use. During (carrying lots of goods) many (cars) are used to give (high capacity). During (carrying few goods) few elements are used to give (low capacity).

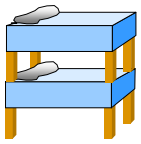
44 Inventive Principle #15—Dynamicity: Characteristics of an object or outside environment, must be altered to provide optimal performance at each stage of an operation. If an object is immobile, make it mobile. Make it interchangeable. Divide an object into elements capable of changing their position relative to each other. Genrich Altshuller, The Innovation Algorithm page 288.

Example—Adjustable Beds

LOW SLEEPING CAPACITY is required for few patients. HIGH SLEEPING CAPACITY are required for multiple patients.

Multiple (beds) are available for adjustable use. During (multiple patients) many (beds) are used to give (high sleeping capacity). During (few patients) few elements are used to give (low sleeping capacity).

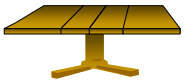




Example—Adjustable Table Size

A LARGE table is required for many guests and a SMALL table is required for few guests.

Multiple (table leafs) are available for adjustable use. During (many guests) many (table leafs) are used to give (a large table). During (few guests) few elements are used to give (a small table).

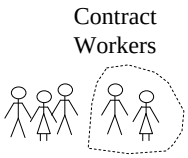


Example—Adjustable Work Force

During high sales HIGH PRODUCTION THROUGHPUT is required. During low sales LOW PRODUCTION THROUGHPUT is required.

Multiple (workers) are available for adjustable use. During (high sales) many (workers) are used to give (high production throughput). During (low sales) few elements are used to give (low production throughput).

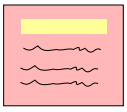
This is effectively accomplished through the use of contract workers.

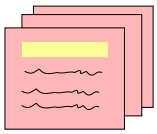


Example—Adjustable Instructions

The instructions need to be SIMPLE in order to be understood by observers of a contest. They need to be DETAILED in order to be understood by the judges of the contest.

Multiple (instructions) are available for adjustable use. During (judging) many (instructions) are used to give (detailed). During (observation) few elements are used to give (understanding).





L3-Rearranging—Two Objects

Use two separate objects. The objects are the same in most respects except that they have conflicting properties. First one is used and then the other. This method of separating in time is often overlooked because it seems too simple. It is more powerful than it looks.

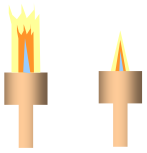
Method

Two distinct (elements) are used. During (condition A) the (setting A) one is used. During (condition B) the (setting B) one is used.

Example—Gas Torch

A LARGE flame is required for cutting thick plates. A SMALL flame is required for cutting thin plates.

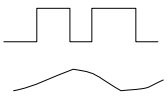
Two distinct (flames) are used. During (cutting thick plates) the (large) one is used. During (cutting thin plates) the (small) one is used.



Example—Different Types of Signals

An ANALOG signal is used to transmit long distances. A DIGITAL signal is used to transmit short distances.

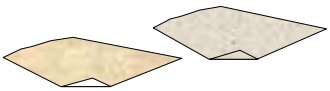
Two distinct (signals) are used. During (long distance transmission) the (analog) one is used. During (short distance transmission) the (digital) one is used.



Example—Sand Paper

COARSE sandpaper is required to shape the wood. FINE sandpaper is required to smooth the surface of the wood.

Two distinct (sandpapers) are used. During (shaping the wood) the (coarse) one is used. During (smoothing the wood) the (fine) one is used.

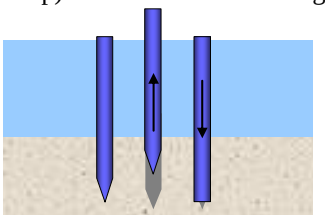


Example—Pile Driving

A SHARP pile is required during driving. A BLUNT pile is required during supporting.

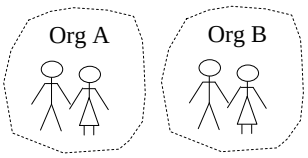
Two distinct (piles) are used. During (driving) the (sharp) one is used. During (supporting) the (blunt) one is used.

Following driving, the sharp pile which is specifically designed for driving is extracted and the blunt one is driven into the resulting hole. Additionally, the sharp pile can have other features for driving such as strength, low mass and high stiffness which make the pile driving more rapid.



Example—Offsetting Organizations

A THOROUGH group is required to get the analysis correct. A SUPERFICIAL group is required to determine what experts should be called in.



Two distinct (groups) are used. During (determining the experts) the (superficial) one is used. During (analysis) the (thorough) one is used.

Example—Offsetting Messages

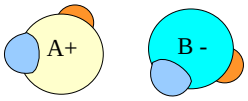
The message needs to be DIRECT to the group to make sure it is understood and it needs to be INDIRECT to the individual to be kind.

Two distinct (messages) are used. During (group meeting) the (direct) one is used. During (individual meetings) the (indirect) one is used.

Example—Different Compounds

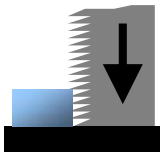
A NON-POLAR solvent must be used to dissolve the grease. A POLAR solvent must be used to remove the salt residue.

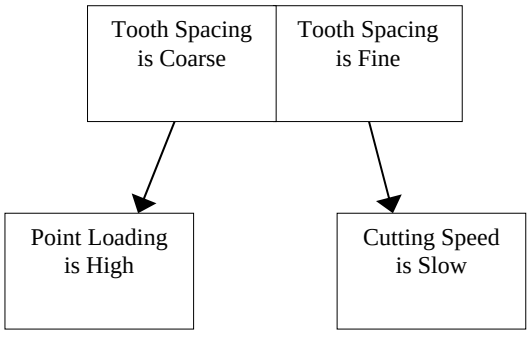
Two distinct (solvents) are used. During (grease removal) the (non-polar) one is used. During (salt removal) the (polar) one is used.



Exercise—Take Smaller Bites

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. Using the principle that you have just learned, resolve this contradiction.



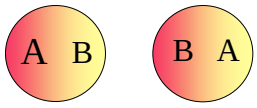


L3-Rearranging—Reorienting Non-Uniform

A single element has both conflicting properties, thus it is not uniform[45]. For one condition, the element is oriented in such a way that one property becomes useful. For the second condition, it is oriented so that the conflicting property becomes useful. Some examples of non-uniform properties are levers, standing waves, concentrated additives, especially active additives.

Method

Part of a single (element) is (Setting A) while another part is (Setting B). During (condition A) the non-uniform (element) is oriented so that (Setting A) is emphasized. During (condition B) the (element) is reoriented so that (Setting B) is emphasized.

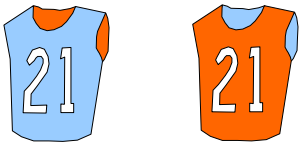


One Orientation | The Other

Common Example—Sports Uniforms

In order to tell the difference between members of one sports team and another, it is helpful to have different color jerseys. This is especially important during practice where teams may be rearranged frequently for different plays. Having two jerseys is expensive and requires the constant care of both jerseys. In this case, the sports jerseys need to be RED and they need to be BLUE.

Part of a single (uniform) is (red) while another part is (blue). During (playing on one team) the non-uniform (uniform) is oriented so that (red) is emphasized. During (playing on another team) the (uniform) is reoriented so that (blue) is emphasized.

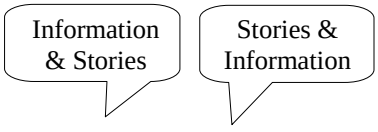


Blue | Red

Common Example—Reinforcing a Point

While teaching a subject, it is necessary to gain the audience's attention with a memorable opening story or situation. As the lesson progresses, it is necessary to give information which may not be as interesting as the opening story. In order to retain the information, the infromation needs to be reviewed at a later date. All that may be remembered is the memorable story which is now unattached in the mind of the student. The reinforced lesson must be both STORIES and INFORMATION

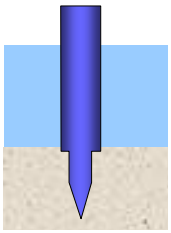
Part of a single (lesson) is (stories) while another part is (information). During (teaching) the non-uniform (lesson) is oriented so that (information) is emphasized. During (review) the (lesson) is reoriented so that (stories) are emphasized.



45 Inventive Principle #3—Local Quality: Transition from homogeneous to heterogeneous structure of an object or outside environment (action). Different parts of an object should carry out different functions. Each part of an object should be placed under conditions that are most favorable for its operation. Genrich Altshuller, The Innovation Algorithm page 287.

Example—Pile Driving

The pile needs to be SHARP in order to drive rapidly and it needs to be BLUNT in order to give good vertical support.

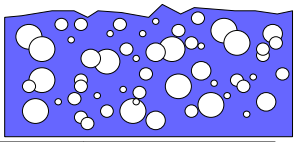


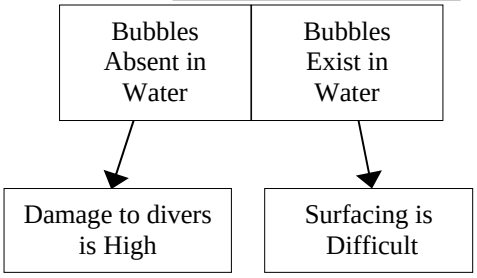
Part of a single (pile) is (sharp) while another part is (blunt). During (driving) the non-uniform (pile) is oriented so that (sharp) is emphasized. During (supporting) the (pile) is reoriented so that (blunt) is emphasized.

By driving the pile, the blunt part comes into play at the right time to ensure that the pile can provide sufficient lateral support.

Exercise—Soft Water

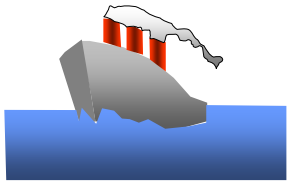
The addition of bubbles to diving pools is a good way to keep diving injuries to a minimum. This is especially true when diving from great heights. Unfortunately, the diver is no longer buoyant in the water and finds it difficult to surface after a dive. The Bubbles need to be EXISTENT AND ABSENT. Using the principle that you have just learned, resolve this contradiction.

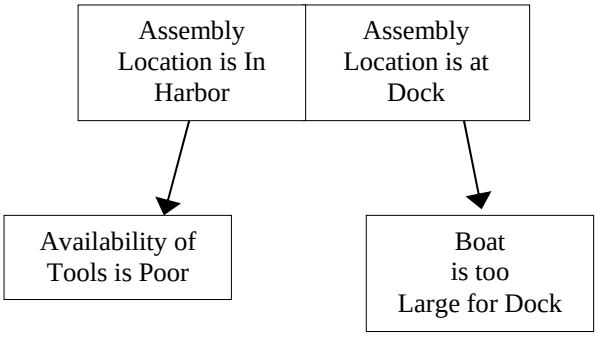




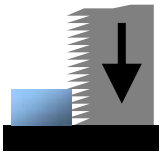
Exercise—Super Yacht

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: It should be IN THE HARBOR & AT THE DOCK. Using the principle that you have just learned, resolve this contradiction.

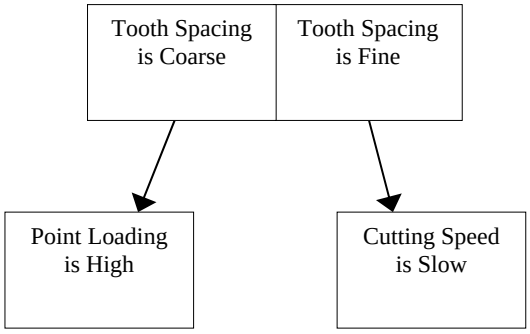




Exercise—Take Smaller Bites



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. Using the principle that you have just learned, resolve this contradiction.



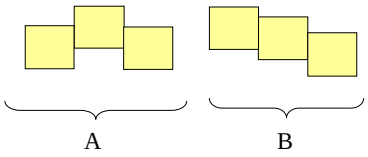
L3-Rearranging—Rearranging & Unfolding Parts

An element is segmented[46] or multiple elements are used. The multiple parts have one arrangement which gives them one property. When the parts are rearranged, they take on the conflicting property. If possible, the changing conditions should cause the transformation to occur. Nesting[47] parts often allows for pieces to fit compactly together.

Hinged
Unfolding
Origami
Nesting

Method

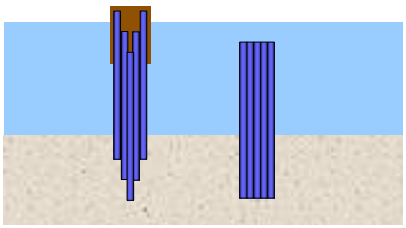
(Multiple or segmented elements) are coordinated together. During (condition A) the pieces are oriented so that they are collectively (Setting A). During (condition B) the pieces are oriented so that they are collectively (Setting B).



Example—Pile Driving

The pile must be SHARP while driving and BLUNT while supporting.

(Segmented Piles) are coordinated together. During (driving) the pieces are oriented so that they are collectively (sharp). During (supporting) the pieces are oriented so that they are collectively (blunt).



The pile is made of multiple nested tubes

46 Inventive Principle #1—Segmentation: Divide an object into independent parts. Make an object sectional (for easy assembly or disassembly). Increase the degree of an object's segmentation. Genrich Altshuller, The Innovation Algorithm page 287.

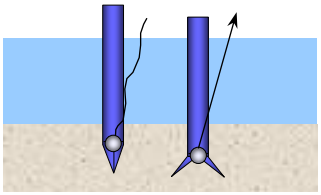
47 Inventive Principle #7—Nesting (Matrioshka): One object is placed inside another. That object is placed inside a third one. And so on. An object passes through a cavity in another object. Genrich Altshuller, The Innovation Algorithm page 287.

which are shaped into a SHARP point by a cap which sits on top. Later, the cap is removed and the outer layers are driven until they are flush with the point, thus becoming BLUNT.

Example—Pile Driving

The pile must be SHARP while driving and BLUNT while supporting.

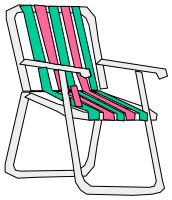
(Segmented Piles) are coordinated together. During (driving) the pieces are oriented so that they are collectively (sharp). During (supporting) the pieces are oriented so that they are collectively (blunt).



The pile has parts that can be arranged to make it either sharp or blunt. A mechanism controls the shape. When the pile is being driven, it is SHARP. When the pile reaches a certain depth, the mechanism is released and the pile becomes BLUNT with further driving.

Example—Folding Chair

A camping chair must be COMPACT in order to be easily transported. During use, a chair typically occupies a LARGE VOLUME.

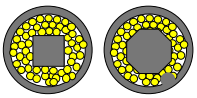


(Segmented chair elements) are coordinated together. During (transportation) the pieces are oriented so that they are collectively (compact). During (use) the pieces are oriented so that they are collectively (large volume like a chair).

Example—Self-Adjusting Nut Driver

In order to be universal, a nut driver must be SHAPE A when a shape A nut is driven. The driver must be SHAPE B when a shape B nut is used.

(Segmented driver head elements) are coordinated together. During (driving a shape A nut) the pieces are oriented so that they are collectively (shape A). During (driving a shape B nut) the pieces are oriented so that they are collectively (shape B).

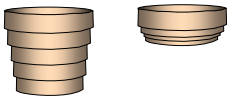


The nut driver is composed of many pins packed closely together but allowed to retract into case, thus conforming to the shape of nut which is being turned.

Example—Expandable Cup

The cup needs to be CUP-SHAPED during drinking and it needs to be COMPACT during transportation and storage.

(Segmented cup pieces) are coordinated together. During (storage and transportation) the pieces are oriented so that they are collectively (compact). During (drinking) the pieces are oriented so that they are collectively (cup-shaped).



The cup is formed of many nested segments. The cup can be formed into a CUP SHAPE or collapsed into a COMPACT shape.

Example—Collapsible Pointer

A pointer needs to be LONG for ease of pointing. It needs to be SHORT to fit into a pocket.

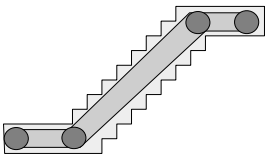
(Segmented pointer pieces) are coordinated together. During (storage in pocket) the pieces are oriented so that they are collectively (short). During (pointing) the pieces are oriented so that they are collectively (long).

The pointer is formed of many nested segments. It can be collapsed to be SHORT or extended to make it LONG.

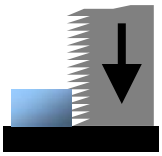
Example—Escalator

The moving stairs need to be STAIR-SHAPED during lifting. They need to be FLAT during entry and exit in order for safety.

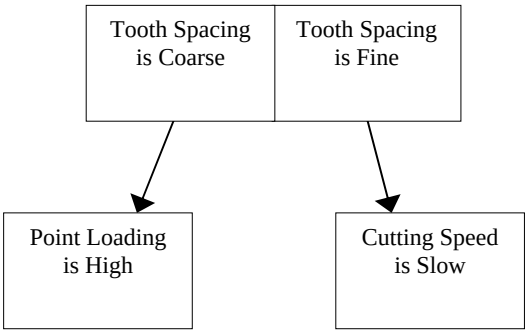
(Multiple stair steps) are coordinated together. During (entry or exit) the pieces are oriented so that they are collectively (flat). During (lifting) the pieces are oriented so that they are collectively (stair-shaped).



Exercise—Take Smaller Bites



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. Using the principle that you have just learned, resolve this contradiction.



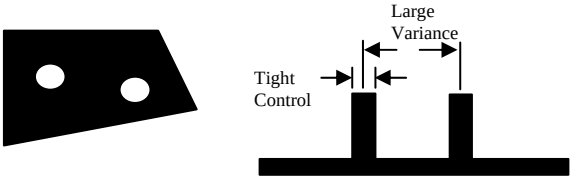
Exercise—Traffic Light

The lights in a traffic light must eventually FAIL due to the action of the current on the filament and to vibration. The traffic light must NOT FAIL in order to not cause traffic delays or make the intersection more dangerous.

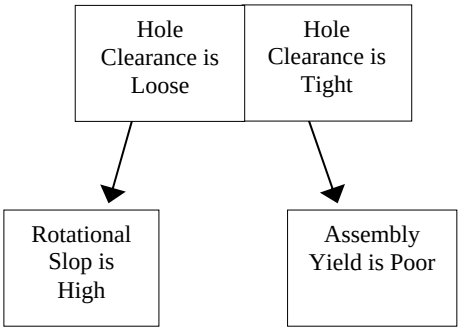
This is an example of an output contradiction. Most people would think of this as the Y in the function. Resolve this contradiction using the method you have just learned.

Traffic Light Operation Fails	Traffic Light Operation Doesn't Fail
All lights will eventually fail	Note that nothing gets worse

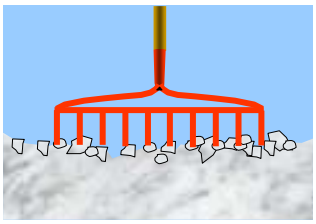
Exercise—A Post and an Outpost



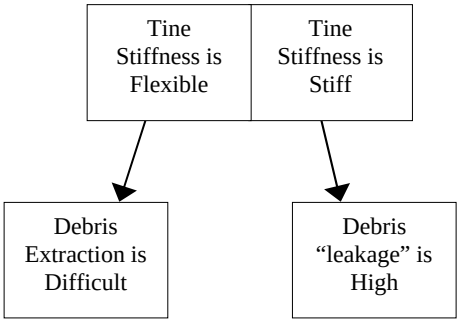
For years your company has produced an aircraft product which fits over two posts on your customer's aircraft. Both the position and the diameter of the posts were closely controlled. Unfortunately, a recent production change by the customer allows a large variance in the distance between the posts. 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 fit snuggly in the application, 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 Resolve this contradiction using the method you have just learned.



Exercise—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. Using the principle that you have just learned, resolve this contradiction..

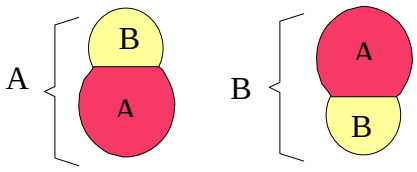


L3-Rearranging—Reorienting Attachments

Two objects are attached, each having conflicting properties. In one orientation, the whole has the property of one of the attached elements. In another orientation the whole has the conflicting property. Note that this is first a Separation in Space. The reorientation then makes this into a Separation in Time.

Method

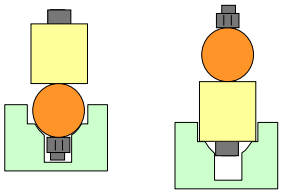
Two (objects) which are (Setting A) and (Setting B) are attached to each other. During (condition A) the pieces are oriented so that (Setting A) comes into play. During (condition B) the pieces are oriented so that (Setting B) comes into play.



Example—Fixed and Rotating Fixtures

The gimbal needs to be ROTATABLE during operation A. It needs to be FIXED during operation B.

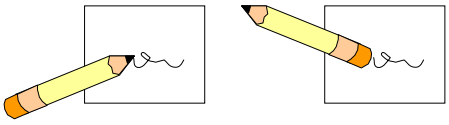
Two (gimbals) which are (rotatable) and (fixed) are attached to each other. During (condition A) the pieces are oriented so that (rotatable) comes into play. During (condition B) the pieces are oriented so that (fixed) comes into play.



Example—Pencil and Eraser

The writing instrument needs to WRITE while the writing process is proceeding well. It must ERASE when writing errors occur.

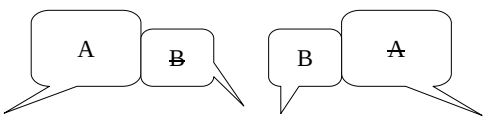
Two (writing instruments) which are (writing) and (erasing) are attached to each other. During (writing) the pieces are oriented so that (writing) comes into play. During (errors) the pieces are oriented so that (erase) comes into play.



Example—Sales Pitch

A new employee needs to be able to give SALES PITCH A when an impulsive customer enters the showroom and SALES PITCH B when an analytical customer enters the showroom.

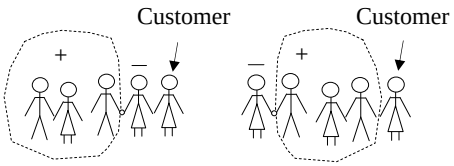
Two (sales pitches) which are (sales pitch A) and (sales pitch B) are attached to each other. During (impulsive customer) the pieces are oriented so that (sales pitch A) comes into play. During (analytical customers) the pieces are oriented so that (sales pitch B) comes into play.



Example—Customer Relations

The effect of meeting a customer meeting another company for the first time can be greatly influenced by whether the customer is introduced to a group with poor customer appeal or to an individual with GOOD CUSTOMER APPEAL. When the customer is getting to know the capabilities of the company, those with POOR CUSTOMER APPEAL can showcase their abilities without ill effect.

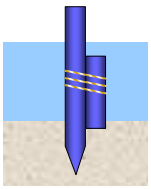
Two (groups) which have (good customer appeal) and (poor customer appeal) are attached to each other. During (meeting the customer) the pieces are oriented so that (good customer appeal) comes into play. During (showcasing talents) the pieces are oriented so that (poor customer appeal) comes into play.



Example—Pile Driving

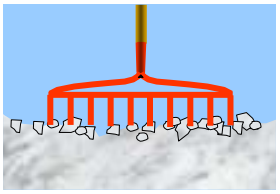
The pile must be SHARP while driving and BLUNT while supporting.

Two (piles) which are (sharp) and (blunt) are attached to each other. During (driving) the pieces are oriented so that (sharp) comes into play. During (supporting) the pieces are oriented so that (blunt) comes into play.

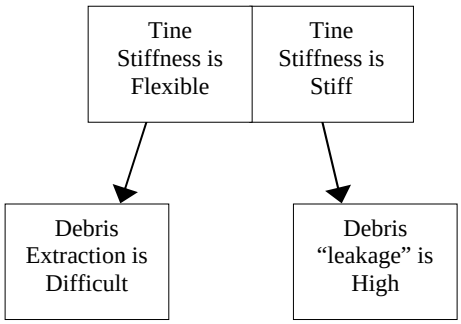


This is a true reorientation because the blunt part does not touch the soil in the beginning. The act of driving brings the blunt surface into play.

Exercise—Two Tining Rake



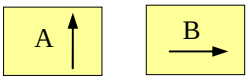
A common garden rake is somewhat inefficient when raking small debris. While riding over uneven surfaces, unwanted debris settles into the uneven surface and the tines ride over the top without collecting the debris. If the tines were more flexible, they could ride over the uneven surfaces like a leaf 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**.** Using the principle that you have just learned, resolve this contradiction.



L3-Rearranging—Changing Direction

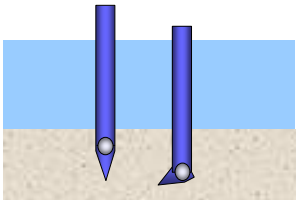
This is accomplished by first separating in direction and then reorienting the directions to change the properties in time.

Method



Changing directions of (crucial feature) allows the setting to be changed. During (condition A) the (crucial feature) is oriented so that (Setting A) comes into play. During (condition B) the (crucial feature) changes direction so that (Setting B) comes into play.

Example—Pile Driving

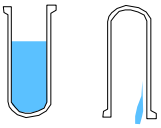


The pile must be SHARP while driving and BLUNT while supporting.

Changing directions of (the pile point) allows the setting to be changed. During (driving) the (pile point) is oriented so that (sharp) comes into play. During (supporting) the (pile point) changes direction so that (blunt) comes into play.

Example—Beaker

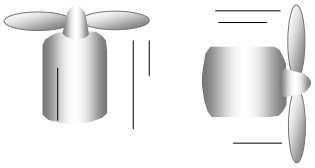
The beaker must CONSTRAIN THE FLUID for productive work. The beaker must NOT CONSTRAIN THE FLUID during rinsing.



Changing directions of (whole beaker) allows the setting to be changed. During (productive work) the (beaker) is oriented so that (constraining the fluid) comes into play. During (rinsing) the (beaker) changes direction so that (not constraining the fluid) comes into play.

Example—Rotating Wing Aircraft

The aircraft needs high UPWARDS LIFT when taking off and landing in order to be able to operate in limited space. The aircraft requires high LATERAL FORCE when flying in order to move rapidly.

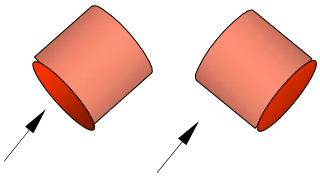


Changing directions of (the propeller) allows the setting to be changed. During (takeoff and landing) the (propeller) is oriented so that (upward lift) comes into play. During (flying) the (propeller) changes direction so that (lateral force) comes into play.

Example—Cylindrical Shape

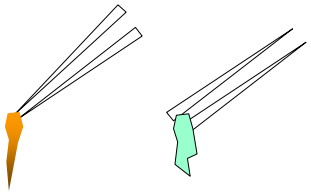
The object needs to be ROUND during insertion in order to enter the hole and seat properly. The object needs to be SQUARE so as to not fall into the holes prematurely during assembly preparation.

Changing directions of (object) allows the setting to be changed. During (insertion) the (object) is oriented so that (round) comes into play. During (assembly preparation) the (object) changes direction so that (square) comes into play.



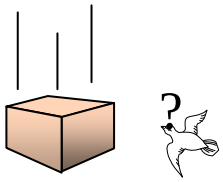
Example—Chopsticks

The chopsticks must be SANITARY in order to serve food to people and they must be UNSANITARY since they have been used in people's mouths.

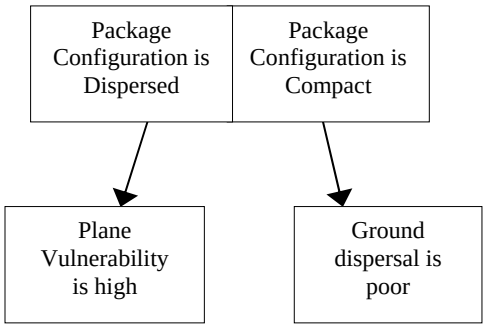


Changing directions of (chopsticks) allows the setting to be changed. During (serving) the (chopsticks) are oriented so that (sanitary) comes into play. During (eating) the (chopsticks) changes direction so that (unsanitary) comes into play.

Exercise—Special Delivery II

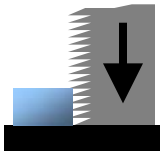


During war in a third world country, an effective means of gaining support from the local people is to give them much needed supplies such as medicine, food and clothing. In order to avoid anti-aircraft and small arms fire, the drop plane must fly high. If the package is dense and compact, it falls with 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 hoard the supplies to themselves.

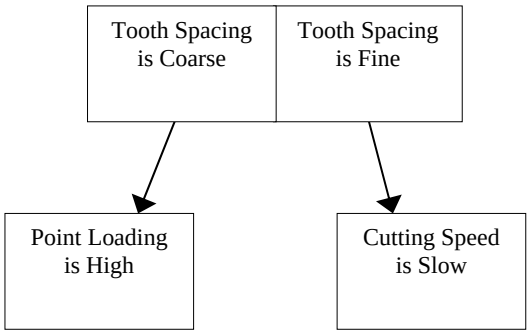


Dropping many packages gets more packages into the hands that need them, but high winds may disperse the drop if they are dropped separately. The Package Configuration must be COMPACT AND DISPERSED. Using the principle that you have just learned, resolve this contradiction.

Exercise—Take Smaller Bites



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. Using the principle that you have just learned, resolve this contradiction.

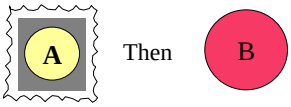
L3-Copy or Facsimile

The copy[48] or facsimile has the essential properties of the original object while under one condition. Later, the original object is required for the condition where the conflicting property is required.

Photographs Movies Paint Coverings Molds Time lapse photos Impressions	Silhouettes Castings Resists Projections Computer Model Dummies

Method

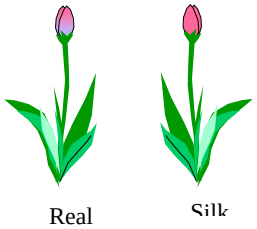
The (essential part) of the (element) can be copied into a (copy name—consider the above list). During (condition A) the (copy name) is (Setting A). During (condition B) the (original) is (Setting B).



Example—Silk Flowers

During the winter the flowers must be COLD TOLERANT. During the summer the flowers must be NOT COLD TOLERANT because flowers are like that, especially certain varieties.

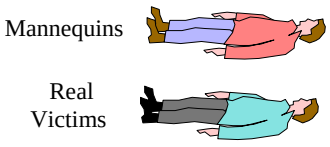
The (look) of the (flower) can be copied into a (silk flower). During (winter) the (silk flower) is (cold tolerant). During (summer) the (real flower) is (not cold tolerant).



Example—Training Props

While training emergency response personnel, the people being worked on should be RESILIENT in order not to injure them with incorrect procedures, but they must be FRAGILE during an emergency because this is unavoidable.

The (operation of the lungs and heart) of the (people) can be copied into a (mannequin). During (training) the (mannequin) is (resilient). During (emergencies) the (accident victim) is (fragile).



Example—Dummy Runs

The machined parts must be INEXPENSIVE while setting up the machine in order to not waste money on parts that will not be used. During production the parts must be EXPENSIVE because they come that way and it is unavoidable.

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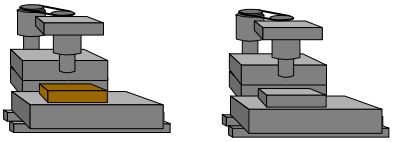
48 Inventive Principle #26—Copying: A simplified and inexpensive copy should be used in place of a fragile original or an object that is inconvenient to operate. If a visible optical copy is used, replace it with an infrared or ultraviolet copies. Replace an object (or system of objects) with their optical image. The image can then be reduced or enlarged. Genrich Altshuller, The Innovation Algorithm page 288.

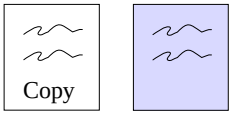
The (part feature) of the (machined parts) can be copied into a (wood block). During (setup) the (dummy piece) is (inexpensive). During (production) the (machined parts) are (expensive).



Example—Tax Preparation

The tax form must be MESSY during preparations because there will be mistakes and corrections. The tax return must be LEGIBLE when filed in order to avoid mistakes by those who must process the form.

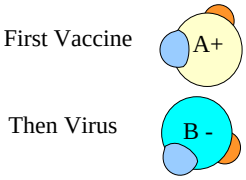
The (information) of the (tax form) can be copied into a (paper copy). During (preparation) the (paper copy) is (messy). During (filing) the (tax form) is (legible).



Example—Vaccine

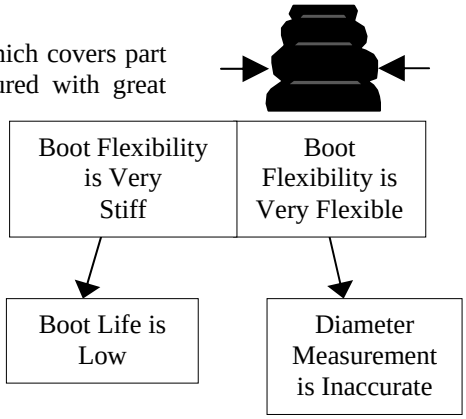
In order to train the body to fight a disease during treatment, the virus must be HARMLESS so as not to do harm to the body. When the patient comes into contact with the real virus it will be HARMFUL because that is how viruses really are.

The (outside shape) of the (virus) can be copied into a (vaccine). During (treatment) the (vaccine) is (harmless). During (contact with the disease) the (virus) is (harmful).



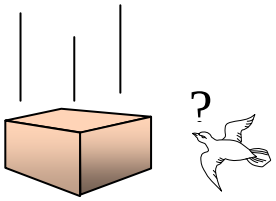
Exercise—Too Flexible

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. Resolve the Contradiction using the principle that you have just learned.

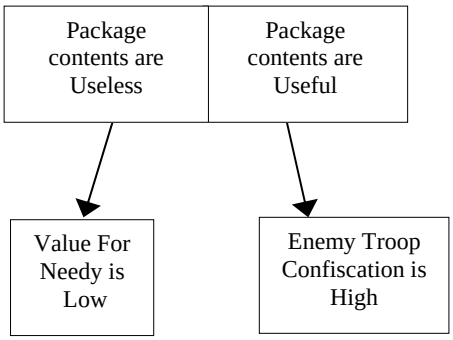


Exercise—Special Delivery

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 hoard the supplies to themselves. They quickly discover that the contents are useful and look for them. The Package Contents must be USEFUL AND USELESS Using the principle that you have just learned, resolve this contradiction.



L2-Separate Gradually

Separate Gradually[49] usually begins with one property and ends with the other. The first actions only yield a partial resolution of the contradiction. This is different than Separation in Time because during Separation in Time, we strive to change the property from one to the other at once. Here we are content to do this stepwise, even if it takes only a moment to do this.

Following is the test and the various strategies for Separating Gradually.

L2-Method

Brainstorm ways to separate the contradictory properties gradually.

L3-Test for Separate Gradually

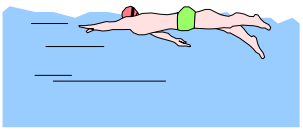
Test:

Will a complete resolution of the contradiction allow starting with (setting A) and ending with (setting B) or its equivalent? If "yes" then try to Separate Gradually. Otherwise, go to Separate in Space.

Example—Long Distance Swimming

In order to train for long swims, it is necessary to have MUCH WATER so that the swimmer does not need to do lots of turns. But this is impractical to do in the pool because there is LITTLE WATER.

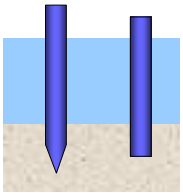
TEST FOR SEPARATE GRADUALLY:



Will a complete resolution of the contradiction allow starting with (little) (water) and ending with (much) (water) or its equivalent? This would be allowable so we will try to separate gradually.

Example—Pile Driver

The pile needs to be SHARP while driving and BLUNT while supporting.



TEST FOR SEPARATE GRADUALLY:

Will a complete resolution of the contradiction allow starting with (sharp) (piles) and ending with (blunt) (piles) or their equivalent? This would be allowable so we will try to separate gradually.

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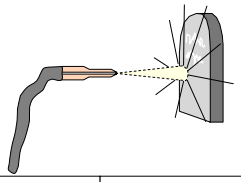
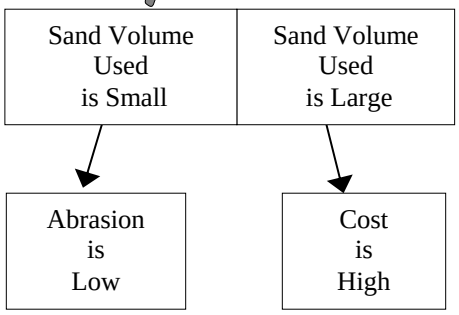
49 Separating Gradually may be construed to have appeared in Creativity as an Exact Science-The Theory of the Solution of Inventive Problems by G.S. Altshuller published by Gordon and Breach. It can be found in the appendix discussing ARIZ 77 Page 292 It is described as "using transitory states in which contradictory properties either coexist or appear alternately. While this is not a great description and does not appear to anticipate such principles as repeated use, it does allow for transitory appearance of both conflicting properties.

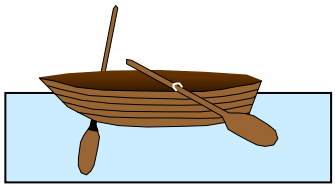
Exercise—Eternal Sand



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 the sand which is used must be LARGE AND SMALL. Test for Separate Gradually.

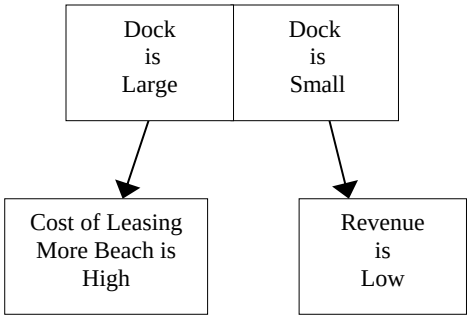


Exercise—What's Up Dock



"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**.** Test for Separate Gradually.

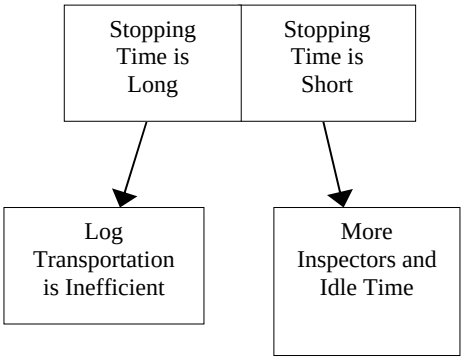


Exercise—Log Jam

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. Test for Separate Gradually.

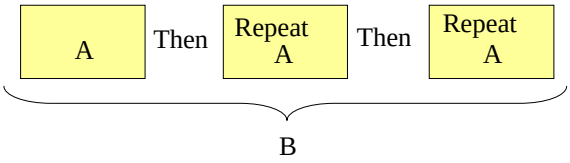


L3-Repeated Use

A variable is used repeatedly, perhaps after being recovered. Usually this involves a repeated or circular process which **requires a constant or periodic reconditioning of the reused materials to restore them to working condition**[50]**.** This means that a physical phenomena needs to be identified which reconditions and a tool to deliver this physical phenomena.

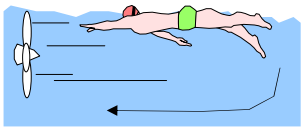
Method

(Setting A) (element) is used over and over which is equivalent to (setting B) (element). (Method of reconditioning) is used to make this happen.



Example—Lap Pool

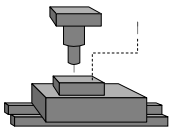
In order to train for long swims, it is necessary to have MUCH water so that the swimmer does not need to do lots of turns. But this is impractical to do in the pool because there is LITTLE water.



(Little) (water) is used over and over which is equivalent to (much) (water). (Recirculation of the water) is used to make this happen.

Example—Continuous use of Machinery

In order to make a lot of parts, many production machines are required. In order to not spend a lot of money, FEW production machines are required.



(Few) (production machines) are used over and over which is equivalent to (many) (production machines). (Continuous use) is used to make this happen.

This is an example of the useful TRIZ tool of UNINTERRUPTED USEFUL EFFECT.

Example—Space Capsule

In space a LOT of air is required for the astronauts to breathe. Unfortunately, there is only a little air available and expanding the amount of compressed air would increase the weight of the capsule too much.

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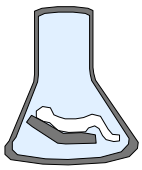
50 Inventive Principle #34—Rejecting and Regenerating Parts: After completing its function, or becoming useless, an element of an object is rejected (discarded, dissolved, evaporated, etc.) or modified during its work process. Used-up parts of an object should be restored during its work. Genrich Altshuller, The Innovation Algorithm page 289.

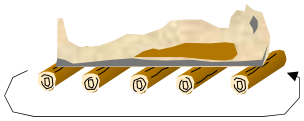
(Little) (air) is used over and over which is equivalent to (much) (air). (Method of reconditioning) is used to make this happen.



This is an example of the useful TRIZ tool of REGENERATION.

Example—Moving Heavy Statues

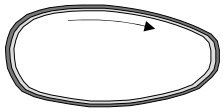
In order to move a heavy statue, a LOT of logs are required in a line leading to the site. Unfortunately, FEW logs are available.



(Few) (logs) are used over and over which is equivalent to (many) (logs). (Replacing worn logs) is used to make this happen.

Example—Belt

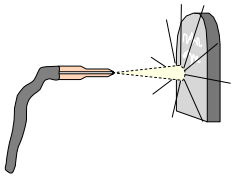
In order to rotate a pulley a LOT of rope is required. Unfortunately, only LITTLE rope is available.



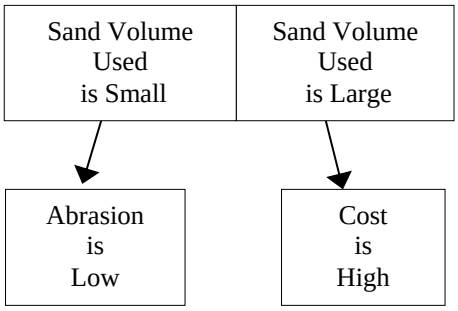
(A short) (rope) is used over and over which is equivalent to (a long) (rope). (Occasional maintenance) is used to make this happen.

This is an example of the TRIZ tool of SPHEROIDALITY[51].

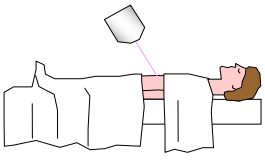
Exercise—Eternal Sand



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 the sand which is used must be LARGE AND SMALL. Using the principle that you have just learned, resolve this contradiction.



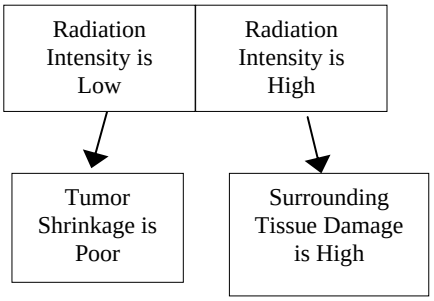
Exercise—Radiation Treatment



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.

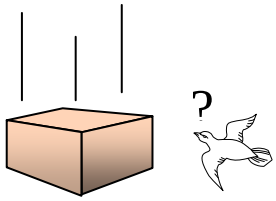
51 Inventive Principle #14—Spheroidality: Replace linear parts with curved parts, flat surfaces with spherical surfaces, and cube shapes with ball shapes. Use rollers, balls, spirals. Replace linear motion with rotational motion ; utilize centrifugal force. Genrich Altshuller, The Innovation Algorithm page 287.

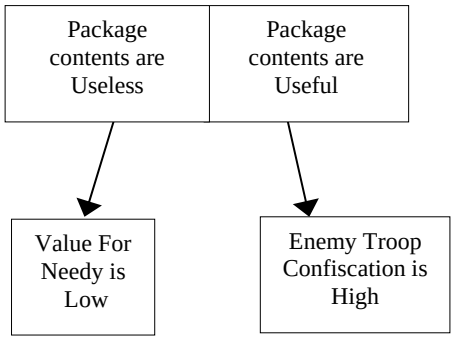
Unfortunately, the tissue surrounding the tumor is also damaged by the high energy radiation. The Radiation Intensity needs to be HIGH AND LOW**.** Using the principle that you have just learned, resolve this contradiction.



Exercise—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 hoard the supplies to themselves. They quickly discover that the contents are useful and look for them. The Package Contents must be USEFUL AND USELESS Using the principle that you have just learned, resolve this contradiction.

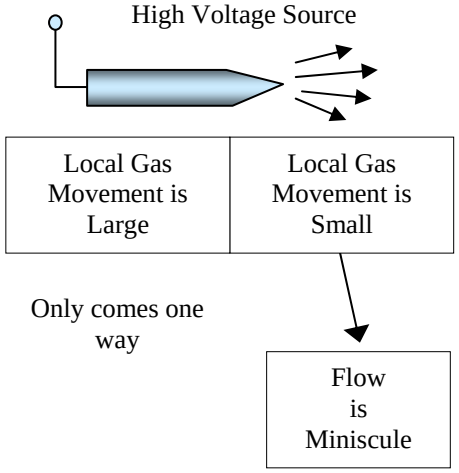




Exercise—Molecular Wind Pump

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. Using the principle that you have just learned, resolve this contradiction.

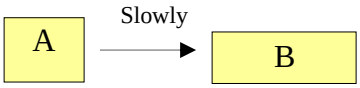


L3-Maturing / Proliferation

Some contradictions are resolved very slowly. In this case, we must wait until something grows up. This implies a self-organizing structure. It may be possible to do this without living structures…

Method

The (element) is capable of self organization through (method). During (condition A) the (element) starts as (setting A). Over time the (element) matures or proliferates to become (setting B) during (condition B).

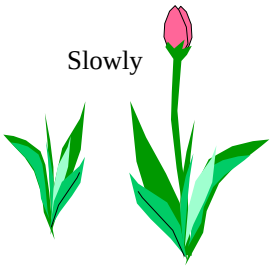


Example—Growing Plants

The shade producer needs to be SMALL when the plant is small so that the plant gets sufficient light. The shade producer needs to be LARGE when the plant is large to avoid sunburn during the heat of the summer.

The (shade producer) is capable of self organization through (biological growth). During (the time that the plant is small) the (shade producer) starts as (small). Over time the (shade producer) matures or proliferates to become (large) during (the time that the plant needs a lot of shade).

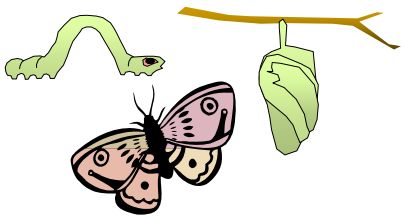
A second shade plant is grown with the first plant. Both grow together and the shade producer is always capable of allowing sufficient light through to the plant that requires shade.



Example—Caterpillar and Butterfly

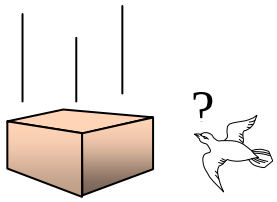
The caterpillar must be SLOW AND METHODICAL when it is young in order to gather food. It must be FAST during adulthood in order to find a suitable mate.

The (caterpillar) is capable of self organization through (biological growth). During (youth) the (caterpillar) starts as (slow). Over time the (caterpillar) matures or proliferates to become (fast) during (search for mate).

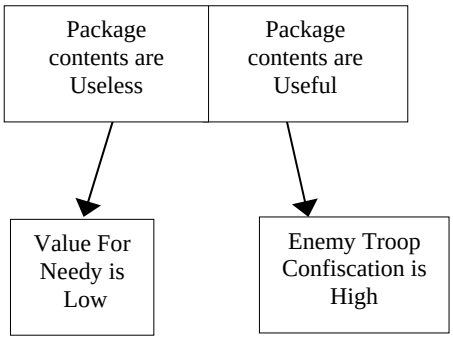


Exercise—Special Delivery

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 hoard the supplies to themselves. They quickly discover that the contents are useful and look for them. The Package Contents must be USEFUL AND USELESS Using the principle that you have just learned, resolve this contradiction.

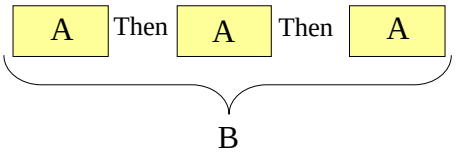


L3-Separate Use

The elements, having one setting, come into use one-at-a-time. Over the course of time the whole effect is opposite to the individual pieces. This is very similar to Separation Between the Parts and the Whole. The difference is that the parts build up over time.

Method

Individual (elements) which are (setting A) come into play gradually during (condition A). In the end, the sum effect is (setting B).



Example—Paper Plates

The plates need to be DURABLE in order to make it through many meals. The plates need to be LOW LIFE in order to be inexpensive.

Individual (plates) which are (low life) come into play gradually during (many meals). In the end, the sum effect is (durable) (plates).

This is an example of CHEAP SHORT LIFE[52] one of the original principles of invention.

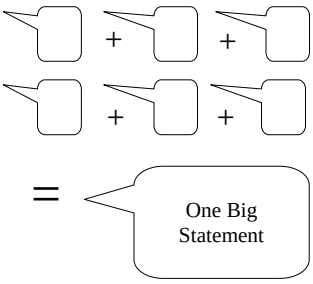
Example—Small Explosions

The explosions need to SMALL during the demolition because that is all that is available. They need to be LARGE in order to move a lot of earth.

Individual (explosions) which are (small) come into play gradually during (excavation). In the end, the sum effect is a (large) (explosion).

Example—Big Impact Statements

Only SMALL impact statements are possible in the available time slots. But the impact of the statement needs to be LARGE.

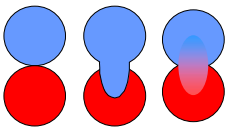


52 Inventive Principle #27—Dispose: Replace an expensive object with a cheap one, compromising other properties (i.e., longevity). Genrich Altshuller, The Innovation Algorithm page 288.

Individual (statements) which are (small impact) come into play gradually during (available time slots). In the end, the sum effect is (a large impact statement).

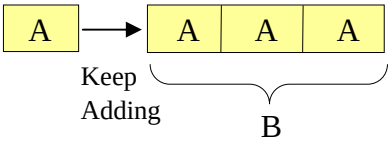
L3-Gradually Merged

Gradually merged elements slowly take on the opposite property of the individual elements. Objects may be segmented[53] to allow for this method. Arrange the individual parts so that the merged whole has the conflicting property of the individual parts. Added parts can do more than touch. They can nest[54], interweave or mix together. They can also merge at the micro level. Partial actions can also be merged to give a full action.



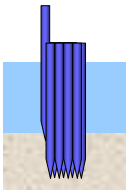
Method

Multiple or segmented (elements) are available. Gradually merging the (setting A) (elements) during (condition A) results in the equivalent of (setting B) (elements).



Example—Pile Driver

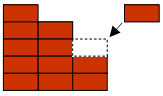
The piles need to be THIN during driving and THICK to support the load.



Multiple or segmented (piles) are available. Gradually merging the (thin) (piles) during (driving) results in the equivalent of (thick) (piles).

Example—Large Brick Structure

The structure needs to be SMALL because the only structural elements to build it are small bricks. It needs to be LARGE because the final structure needs to be large.



Multiple or segmented (structures) are available. Gradually merging the (small) (structures) during (building) results in the equivalent of (large) (structures).

Example—Reservoir

LARGE AMOUNTS of water are required for farms. SMALL AMOUNTS of water are all that is available during the winter.

Multiple or segmented (water) is available. Gradually merging the (small amounts of) (water) during (the winter) results in the equivalent of (large amounts of) (water).

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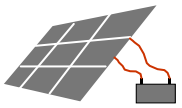
53 Inventive Principle #1—Segmentation: Divide an object into independent parts. Make an object sectional (for easy assembly or disassembly). Increase the degree of an object's segmentation. Genrich Altshuller, The Innovation Algorithm page 287.

54 Inventive Principle #7—Nesting (Matrioshka): One object is placed inside another. That object is placed inside a third one. And so on. An object passes through a cavity in another object. Genrich Altshuller, The Innovation Algorithm page 287.

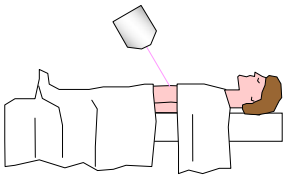
Example—Storage of Solar Energy

SMALL AMOUNTS of electricity are available during the day. LARGE AMOUNTS of electricity are required during the evening.



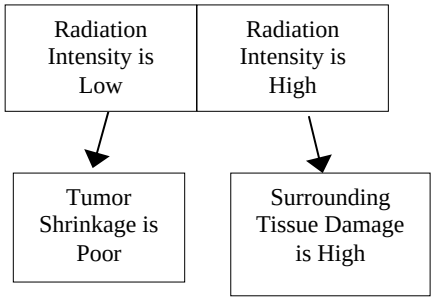
STORAGE: Multiple or segmented (amounts of electricity) are available. Gradually merging the (small amounts of) (energy) during (the day) results in the equivalent of (large amounts of) (energy in a battery system).

Exercise—Radiation Treatment

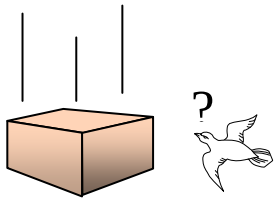


High levels of radiation can damage the structure of cells and cause them to cease functioning. This is useful in the treatment of tumors. A beam of high energy radiation is focused on the tumor.

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 AND LOW**.** Using the principle that you have just learned, resolve this contradiction.



Exercise—Special Delivery



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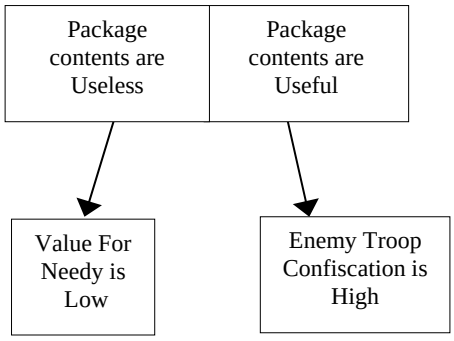
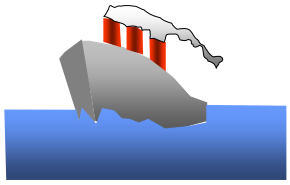
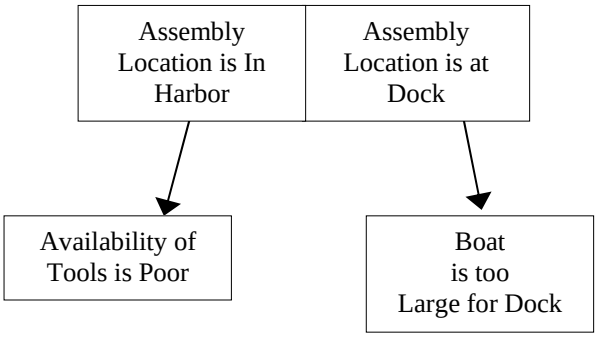


Exercise—Super Yacht



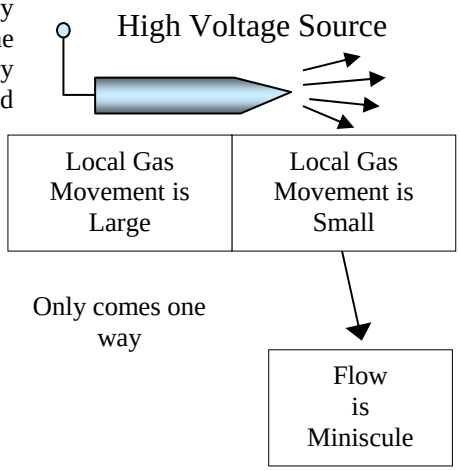
A small ship building company considers a contract to build a super yacht. The yacht is so big that only a third will fit into their dock. "We will need to build this in the open harbor." A frustrated engineer says. "We can't do that; we need the availability of lifts and tools."



The Building Location: It should be IN THE HARBOR & AT THE DOCK. Using the principle that you have just learned, resolve this contradiction.

Exercise—Molecular Wind Pump

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.



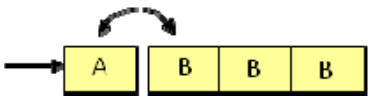
The Local Gas Movement should be SMALL & LARGE. Using the principle that you have just learned, resolve this contradiction.

L3-Merging—Merged Interaction

Parts are slowly merged with the system. As they are added, they are transformed to the new property by what is already there.

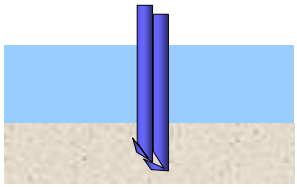
Method

Multiple or segmented (elements) are available. Each (setting A) (element) that is merged during (condition A) with the already merged (elements) become (setting B) by (method).



Example—Pile Driving

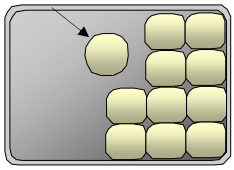
The pile needs to be SHARP while driving and BLUNT while supporting.



Multiple or segmented (piles) are available. Each (sharp) (pile) that is merged during (driving) with the already merged (piles) become (blunt) by (pushing down on a ledge protruding with a lip).

Example—Square Bread Rolls

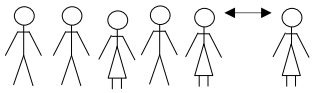
The rolls need to be ROUND because they are easier to form this way. They need to be SQUARE because that they store easier that way.



Multiple or segmented (rolls) are available. Each (round) (roll) that is merged with the already merged (rolls) become (square) by (pushing them together).

Example—Training a Group

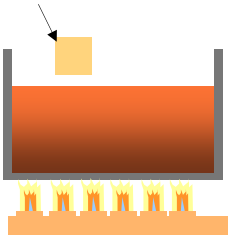
The group needs to be UNTRAINED because the only available trainees are untrained. The group needs to be TRAINED in order to be productive.



Multiple or segmented (group members) are available. Each (untrained) (group member) that is merged with the already merged (group members) become (trained) by (training from those already there).

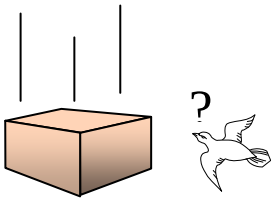
Example—Melting a Metal

The metal needs to be SOLID since the only available metal is solid. It needs to be LIQUID in order to facilitate production.



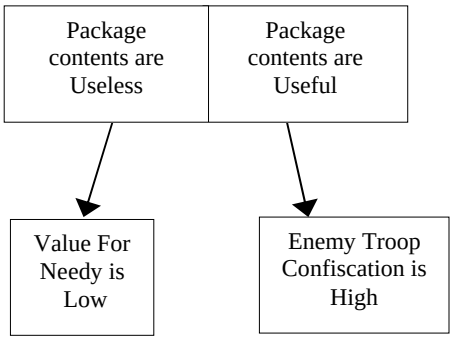
Multiple or segmented (metal elements) are available. Each (solid) (metal element) that is merged with the already merged (metal elements) become (liquid) by (being melted by the previously melted elements).

Exercise—Special Delivery

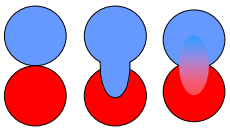


During war in a third world country, an effective means of gaining support from the local people is to give them much needed supplies such as medicine, food and clothing. In order to avoid anti-aircraft and small arms fire, the drop plane must fly high. If the package is dense and compact, it falls with 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 hoard the supplies to themselves. They quickly discover that the contents are useful and look for them. The Package Contents must be USEFUL AND USELESS Using the principle that you have just learned, resolve this contradiction.

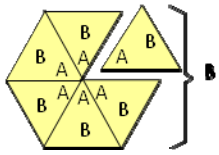


L3-Gradually Hidden / Exposed



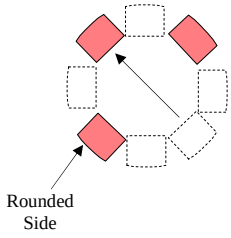
This method applies only to elements that already have both properties, but one of the properties is undesirable and we want it to go away. In order to do this, we hide the property that we don't want with parts of the other elements that have the property that we do want. Notice in the figure at the right that all of the negative signs are hidden in the middle. They are completely surrounded by the parts of the element that are positive. Consequently, the whole element appears to have the positive property. This usually applies to multiple elements (same, similar or dissimilar) which have an undesirable property. Remember that elements can do more than simply touch. They can also interweave or nest[55] within each other. They can be mixed as well. Consider different orientations.

Method



The (element) already has both properties. (Setting A) is desirable and (setting B) is undesirable. The (elements) are gradually merged in a way that hides (setting B) until the whole is (setting A).

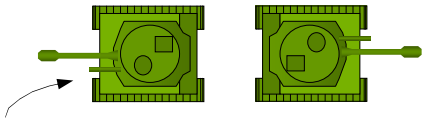
Example—Square and Round Shapes



The element already has both properties. (Round) is desirable and (square) is undesirable. The (shapes) are gradually merged in a way that hides (square) until the whole is (round).

Example—Unprotected Tanks

Each tank is PROTECTED from the front and VULNERABLE from the rear when no other forms of protection are available.



The (tank) already has both properties. (protected) is desirable and (vulnerable) is undesirable. The (tanks) are gradually merged in a way that hides (vulnerable) until the whole is (protected).

As tanks arrive and "circle up" newly arriving tanks back up to other tanks thus hiding the vulnerability that each tank has inherently.

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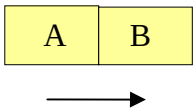
55 Inventive Principle #7—Nesting (Matrioshka): One object is placed inside another. That object is placed inside a third one. And so on. An object passes through a cavity in another object. Genrich Altshuller, The Innovation Algorithm page 287.

L3-Gradually Transformed

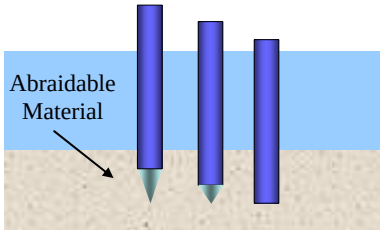
Separation in Time considers the bulk transformation of objects to change their properties. Often, this transformation is gradual. This gradual change can be useful under certain conditions. As in all cases where we Separate Gradually, we begin with one property and end with the other. Unfortunately, the knob setting must pass through the compromise state. This may work in some instances, but makes this tool less powerful.

Method



The (element) (critical region) is made from (transformable material). During (condition A) the (element) transforms from (setting A) to (setting B).

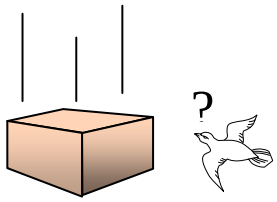
Example—Pile Driving



The pile must be SHARP while driving and BLUNT while supporting.

The (pile) (tip) is made from (abraidable material). During (driving) the (pile) transforms from (sharp) to (blunt).

Exercise—Special Delivery



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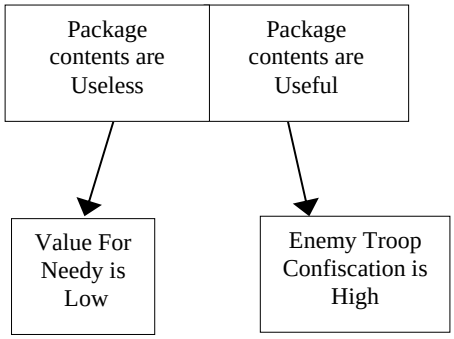


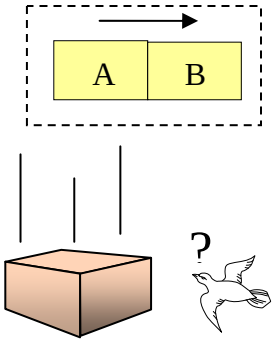
If the package is dense and compact, it falls with pinpoint accuracy. A chute opens near the end to keep the contents from being damaged. Unfortunately, enemy troops on the ground then confiscate the package and hoard the supplies to themselves. They quickly discover that the contents are useful and look for them. The Package Contents must be USEFUL AND USELESS Using the principle that you have just learned, resolve this contradiction.

L3-Gradually Added Fields

Separation in Time considers the addition of fields to objects to change their properties. Often, this transformation is gradual. A more gradual change can be useful under certain conditions. As in all cases where we Separate Gradually, we begin with one property and end with the other. Unfortunately, the knob setting must pass through the compromise state. This may work in some instances, but makes this tool less powerful.

Method

The (element) (critical region) can be changed from (setting A) to (setting B) by gradually adding a (field type) field. During (condition A) the (element) transforms from (setting A) to (setting B).



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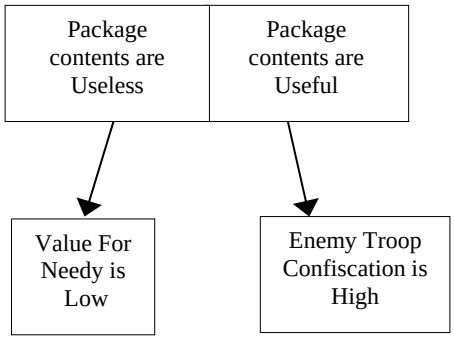

L2-Separate in Space

Separation in Space[56] was one of the earliest discovered methods of resolving contradictions. At one critical moment in time BOTH properties are expressed. For instance, when a book is being read, it is required that the pages be stiff in order to lay flat and for the ease in handling the book. At the same moment in time, it is required that the pages be flexible in order to be easily turned. This is effectively accomplished by making some pages stiff and the rest of the pages flexible. Some of the most bedeviling problems are resolved by using separation in space. The fact that some objects require two conflicting properties at the same critical instant makes a problem seem hard. Notice that the methods progress from completely separate objects to identifying locations within an object or space with conflicting properties.

Following is the test and the various strategies for Separating in Space.

L2-Method

Step 1: Ask under what conditions each property is needed. Are both condition required in the same space?

Step 2: Consider the different parts of an object. Can different parts have opposing properties?

Step 3: Consider separating the opposing properties into two objects

Step 4: Consider making the object have both properties but in different places making it non-uniform[57]

L3-Test for Separation in Space

We have already demonstrated that we can have a test for Separation in Time. This test can save a lot of time looking through the various methods. We would like to do the same thing with Separation in Space. This test will help us to determine whether Separation in space is feasible. If both settings must occur in the same space then it is probably not possible to use this method.

Test:

During (critical time) (setting A) is essential (where condition A exists). (Setting B) is essential (where condition B exists). Must these conditions (and settings) overlap in space? If yes then go to Separate between the Parts and the Whole.

If one of the conditions is never essential (useful and necessary) then the condition where this applies is any place that it is allowable. Note that some of the methods will only weakly apply when one of the conditions is not essential.

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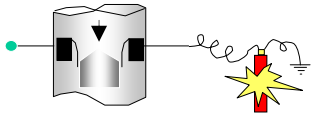
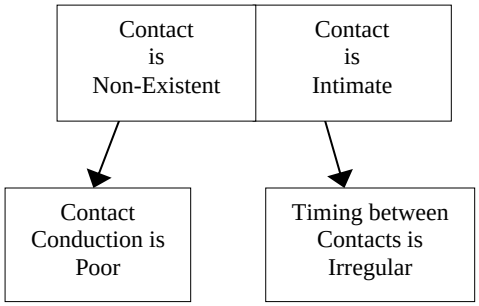
56 Separation in Space appears in Creativity as an Exact Science-The Theory of the Solution of Inventive Problems by G.S. Altshuller published by Gordon and Breach. It can be found in the appendix discussing ARIZ 77

57 Inventive Principle #3—Local Quality: Transition from homogeneous to heterogeneous structure of an object or outside environment (action). Different parts of an object should carry out different functions. Each part of an object should be placed under conditions that are most favorable for its operation. Genrich Altshuller, The Innovation Algorithm page 287.

Example—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 a tube with electrical contacts spaced at precise intervals. As the conductive weight passes each set of contacts, continuity is established across the contacts 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 the timing to be erratic. The plug must CONTACT the leads in order to complete the circuit and must NOT CONTACT the leads in order to keep the timing perfect.

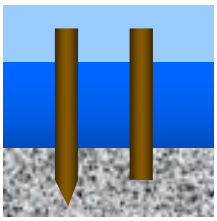


This is a great problem because it looks so impossible. Note that the problem is stated in a way that leads the problem solver to believe there is only one object. "The plug" must intimately contact and not contact. We never know how a problem will come to us and the assumptions that will be thrust upon us, either by ourselves or others.

TEST FOR SEPARATION IN SPACE:

During (the moment that the plug passes a critical point in space) (intimate contact) is essential (where the conductor must conduct across the contacts). (No contact) is essential (at any location where there is no interaction with the part of the plug that interacts with the contacts). Must these conditions (and settings) overlap in space? If there is no interaction whatsoever then there is no need for overlap. We conclude that there may be a possibility of separating in space.

Example—Pile Driving

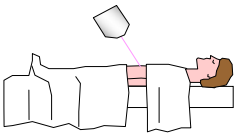


We would like the pile to be SHARP in order to drive it more rapidly and we would like it to be BLUNT in order to support well.

TEST FOR SEPARATION IN SPACE:

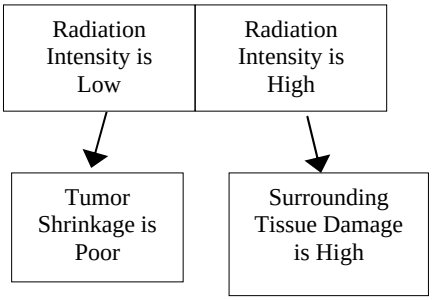
During (supporting) (bluntness) is essential (where a supporting structure exists to keep it from falling over). (Sharpness) is essential where (nowhere) exists. These conditions do not overlap in space. However, since sharpness is essential nowhere we need to determine where it is allowable. It is allowable anywhere the vertical support is sufficient to carry the vertical load that the sharp pile cannot carry. The sharp pile is mostly carrying the lateral loads.

Exercise—Radiation Treatment

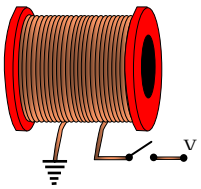


High levels of radiation can damage the structure of cells and cause them to cease functioning. This is useful in the treatment of tumors. A beam of high energy radiation is focused on the tumor.

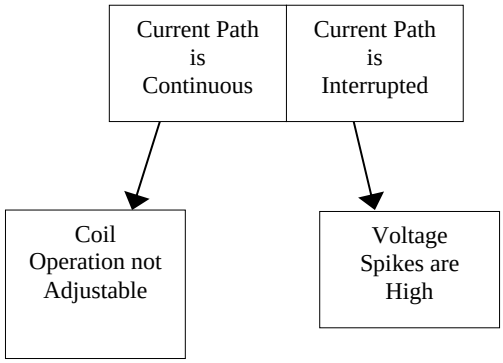
After the procedure, the tumor shrinks. Unfortunately, the tissue surrounding the tumor is also damaged by the high energy radiation. The Radiation Intensity needs to be HIGH AND LOW**.** Test for Separation in Space.



Exercise—I Just Can't Stop



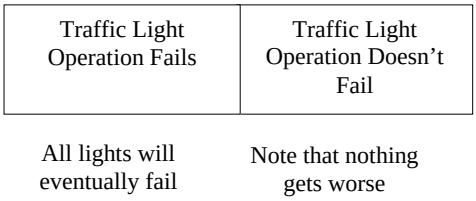
Electromagnetic coils are used for many applications which require the generation of force. Magnetic fields generated by the coil and the spool upon which the wire is wound interact with plungers also made of magnetic materials. Usually, the flow of current to the coil is initiated by throwing a switch 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. The current path needs to be CONTINUOUS AND INTERRUPTED**.** Test for Separation in Space.



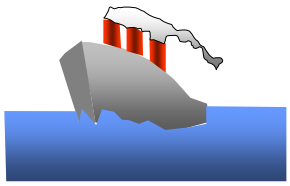
Exercise—Traffic Light

The lights in a traffic light must eventually FAIL due to the action of the current on the filament and to vibration. The traffic light must NOT FAIL in order to not cause traffic delays or make the intersection more dangerous.

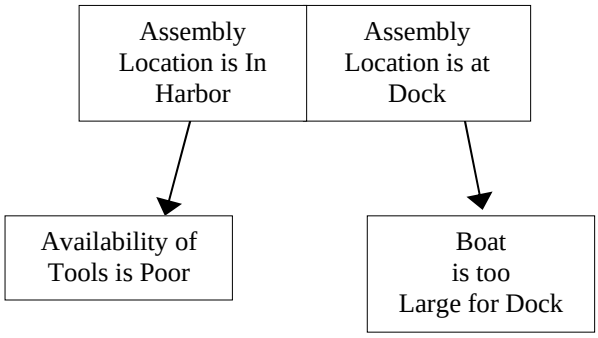
This is an example of an output contradiction. Most people would think of this as the Y in the function. Test for Separation in Space.



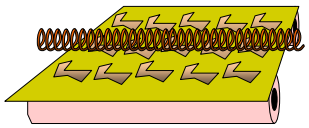
Exercise—Super Yacht



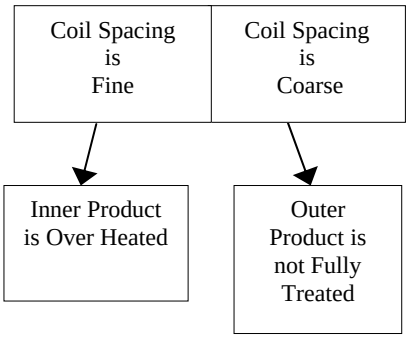
A small ship building company considers a contract to build a super yacht. The yacht is so big that only a third will fit into their dock. "We will need to build this in the open harbor." A frustrated engineer says. "We can't do that; we need the availability of lifts and tools." The Building Location: It should be IN THE HARBOR & AT THE DOCK. Test for Separation in Space.



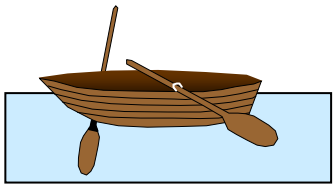
Exercise—Blistering Coils



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 finer, the outer product could be fully treated. However, the product at the center of the belt is over-heated. The Coil Spacing should be FINE & COARSE. Test for Separation in Space.

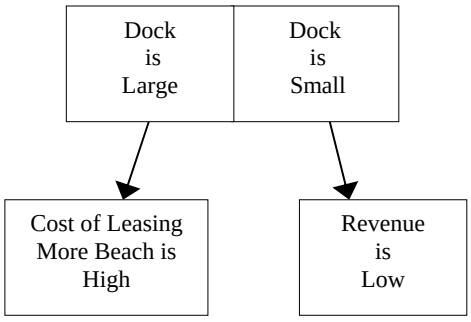


Exercise—What's Up Dock

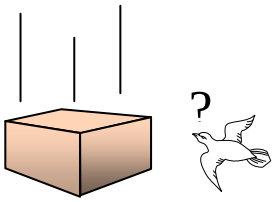


"We'll make a fortune" the small investor said. "When they build the houses around this lake, everyone will want a place to dock their boats and we got the last parcel on the lake".

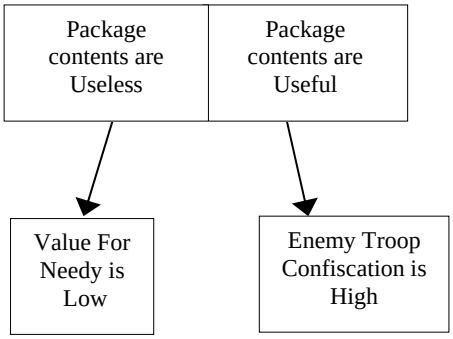
Yes, but it is too small to store many boats" his wife complained. "And we are not allowed to build the dock out more than 20 yards". "I know" she continued "We can fill every available square foot with dock and boats!" "We still will not be able to store enough boats to make money" the investor said after making a few calculations. The Dock should be SMALL & LARGE**.** Test for Separate in Space.



Exercise—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 hoard the supplies to themselves. They quickly discover that the contents are useful and look for them. The Package Contents must be USEFUL AND USELESS Test for Separation in Space.

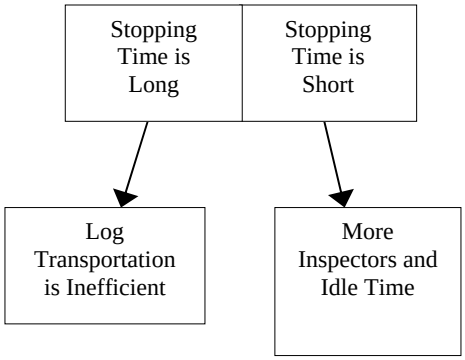


Exercise—Log Jam

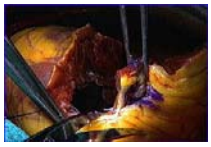
Every few hours, a train enters the depot with several cars full of logs. It is the job of the inspector to measure each log diameter. Unfortunately the train does not stay long. So far, the problem has been solved by hiring many inspectors.

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.

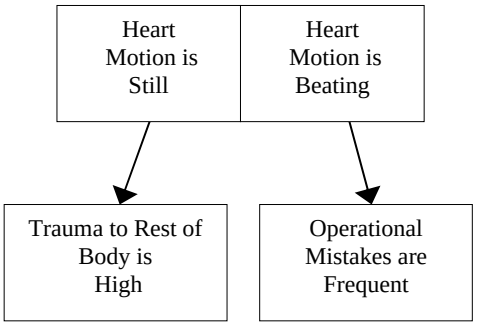
The Stopping Time Needs to be LONG & SHORT. Test for Separation in Space.



Exercise—the Beat Goes On



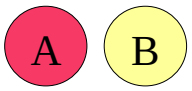
Heart surgery is sometimes required for battlefield wounds to the heart. Small pieces of shrapnel become lodged in the heart muscle. Usually, the heart is stopped, temporarily, to repair it since it is very difficult to operate on a beating heart. This stoppage of blood flow is very traumatic for the 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**.** Test for Separation in Space.



L3-Two Objects

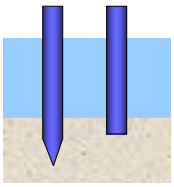
TWO objects exist with conflicting properties. This is a very powerful method of resolving contradictions, but it is often neglected because it seems too simple. It is often described as what a small child might suggest to solve a conflict. "If I need a doggie to be big and small, why not have TWO doggies?" Certainly, in some settings, this would be too costly, but there are many situations where this makes perfect sense and should not be ignored.

Method



If more than one type of (element) is allowed, one (element) is (setting A) and a nearby (element) is (setting B).

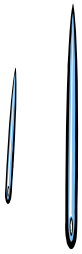
Example—Pile 'Driving



The pile must be SHARP in order to drive rapidly and BLUNT in order to support well.

If more than one type of (pile) is allowed, one (pile) is (sharp) and a nearby (pile) is (blunt).

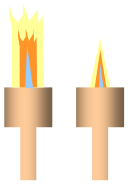
Example—Needles



The needle needs to be LARGE in order to sew thick and heavy pieces of cloth together. They need to be SMALL in order to sew thin fine cloth together.

If more than one type of (needle) is allowed, one (needle) is (large) and a nearby (needle) is (small).

Example—Torches



The torch needs to have a HIGH FLAME in order to cut thick pieces of metal. It needs to be a LOW FLAME in order to do intricate cutting of thin pieces.

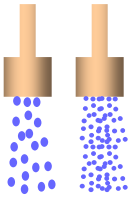
If more than one type of (torch) is allowed, one (torch) is (high flame) and a nearby (torch) is (low flame).

Example—Sandpaper

Sandpaper needs to be COARSE to form wood and FINE for finishing.

If more than one type of (piece of sandpaper) is allowed, one (piece of sandpaper) is (coarse) and a nearby (piece of sandpaper) is (fine).

Example—Construction Site Sprayer

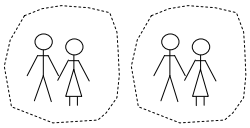


The spray nozzle needs to spray HEAVY DROPLETS in order to wet the ground but FINE MIST in order to settle flying dust.

If more than one type of (spray nozzle) is allowed, one (spray nozzle) is (heavy droplets) and a nearby (spray nozzle) is (fine mist).

Example—Military Division of Labor

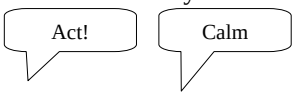
The military group needs to have a PEACE KEEPING MISSION in order to keep factions from harming each other. The military group needs to have a COMBAT MISSION in order to defeat the enemy.



If more than one type of (military group) is allowed, one (military group) has a (peace keeping mission) and a nearby (military group) has a (combat mission).

Example—Instructions for the Flu

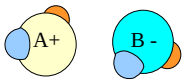
The message must INCITE TO ACTION in order that people will react and get flu shots. The message must REQUEST CALMNESS in order to avoid mass hysteria.



If more than one type of (message) is allowed, one (message) is (inciting to action) and a nearby (message) is (requesting calmness).

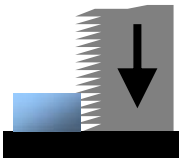
Example—Woodworking Chemicals

The compound must STRIP epoxy in order to clean parts. The compound must HARDEN epoxy in order to make the epoxy durable.

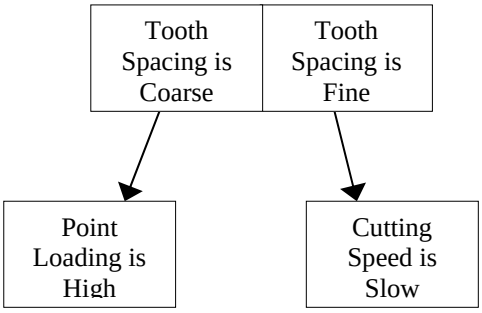


If more than one type of (compound) is allowed, one (compound) must (strip epoxy) and a nearby (compound) must (harden epoxy).

Exercise—Take Smaller Bites



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. Using the principle that you have just learned, resolve this contradiction.



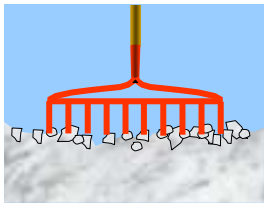
Exercise—Traffic Light

The lights in a traffic light must eventually FAIL due to the action of the current on the filament and to vibration. The traffic light must NOT FAIL in order to not cause traffic delays or make the intersection more dangerous.

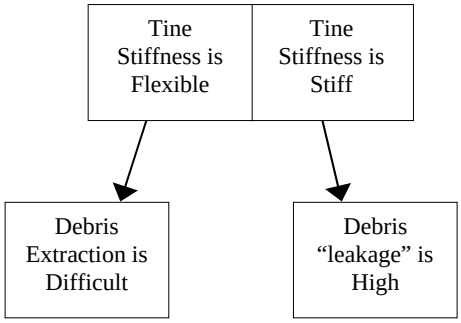
This is an example of an output contradiction. Most people would think of this as the Y in the function. Resolve this contradiction using the method you have just learned.

Traffic Light Operation Fails	Traffic Light Operation Doesn't Fail
All lights will eventually fail	Note that nothing gets worse

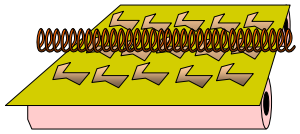
Exercise—Two Tining Rake



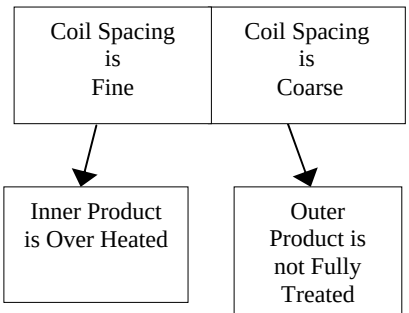
A common garden rake is somewhat inefficient when raking small debris. While riding over uneven surfaces, unwanted debris settles into the uneven surface and the tines ride over the top without collecting the debris. If the tines were more flexible, they could ride over the uneven surfaces like a leaf 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**.** Using the principle that you have just learned, resolve this contradiction.



Exercise—Blistering Coils

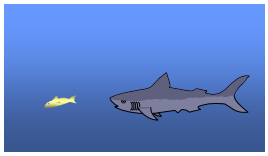


Product on an assembly line must pass under a heating coil in order to be fully treated. The product that passes under the center part of the coil is fully treated, but the product that passes under the coil at the edge of the conveyor belt is not fully treated. If the coil spacing was finer, the outer product could be fully treated. However, the product at the center of the belt is over-heated. The Coil Spacing should be FINE & COARSE. Using the principle that you have just learned, resolve this contradiction.

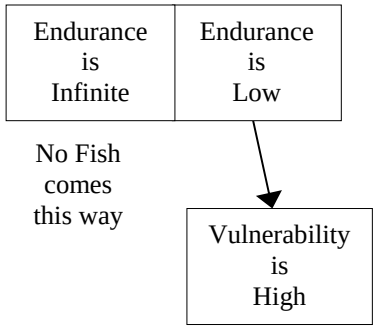


Exercise—Fish to the Rescue

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 in order to outrun the shark and NORMAL ENDURANCE because that is how small fish are. Resolve the contradiction by using the method you have just learned.

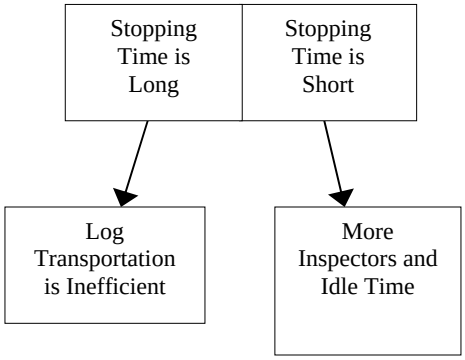


Exercise—Log Jam

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. Using the principle that you have just learned, resolve this contradiction.

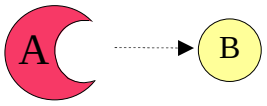


L3-Extraction

Using the principal of Extraction[58], the element with conflicting properties is broken into different functional elements. One part of the component must be separated out and given the conflicting property. The separation is necessary to give the element the conflicting property. In order to make this happen, a means must be envisioned which allows the extracted part to interact with the element parts that it has been separated from. This interaction link is what makes Extraction different from the Two Objects method.

Method

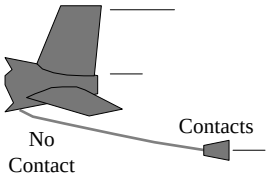
If the (element) can be separated into functional parts: The separated (element part) is (setting A). The (rest of the element parts) are (setting B). The separated parts interact through (means).



58 Inventive Principle #2—Extraction: (Extracting, Retrieving, Removing). Extract the "disturbing" part or property from an object. Extract only the necessary part or property from an object. Genrich Altshuller, The Innovation Algorithm page 287.

Example—Aircraft Refueling

During the refueling of aircraft it is necessary for the tanker to CONTACT the aircraft that is being refueled. The tanker must NOT CONTACT the refueled aircraft in order to avoid crashing.

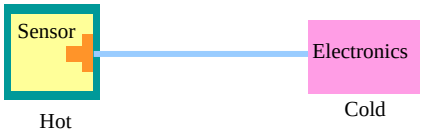


If the (tanker) can be separated into functional parts: The separated (fueling nozzle) is (in contact with the refueled craft). The (rest of the aircraft) is (not in contact). The separated parts interact through (a long refueling line).

Example—Oven Sensor

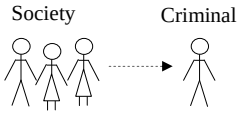
The electronics of an oven sensor must be COLD in order to last a long time. But, the electronics must get HOT in order to sense the temperature.

If the (electronics) can be separated into functional parts: The separated (electronic sensor) is (hot). The (rest of the electronics) are (cold). The separated parts interact through (wires).



Example—Dealing with Criminals

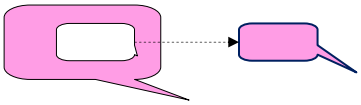
Society is DANGEROUS because criminal acts occur on a daily basis. Society must be BENIGN in order to have peaceful lives.



If the (society) can be separated into functional parts: The separated (criminal) is (dangerous). The (rest of society) is (benign). The separated parts interact through (the legal system).

Example—Quotes

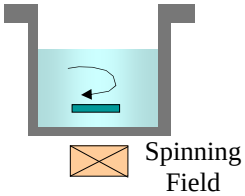
A statement needs to be BRIEF in order to be impactful and not bore the audience. However, statements by many important people are LONG WINDED.



If the (statement) can be separated into functional parts: The separated (quote) is (brief). The (rest of the statement) is (long winded). The separated parts interact through (footnotes).

Example—Stirring Acid

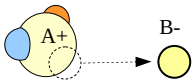
In order to stir acid, a stirring element must EXIST IN THE ACID. In order to have a long life, the stirring element must NOT EXIST IN THE ACID.



If the (acid stirrer) can be separated into functional parts: The separated (stirring element) is (existing in the acid). The (rest of the stirrer) does (not exist in acid). The separated parts interact through (a magnetic coupling).

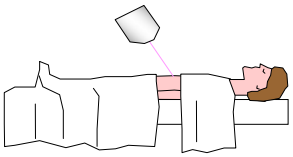
Example—Extraction of Element

A compound must have PROPERTY A in order to perform function A. It must have PROPERTY B in order to perform function B.

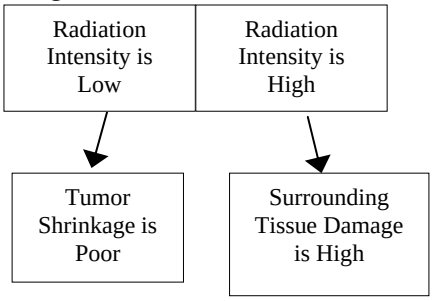


If the (compound) can be separated into functional parts: The separated (compound part) is (setting A). The (rest of the compound) are (setting B). The separated parts interact through (electrostatic fields).

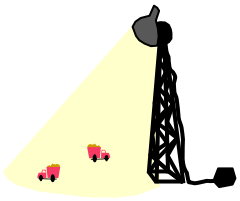
Exercise—Radiation Treatment



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 AND LOW**.** Using the principle that you have just learned, resolve this contradiction.



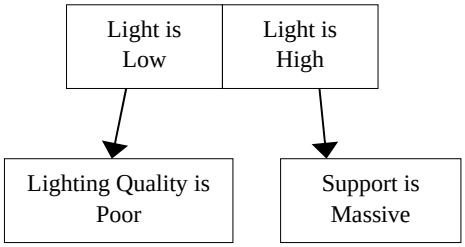
Exercise—Construction Lights



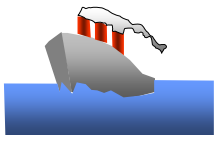
During large construction projects, it is desirable to light a work area the size of many football fields. It would be desirable to have one very large and high light.

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. Using the principle that you have just learned, resolve this contradiction.

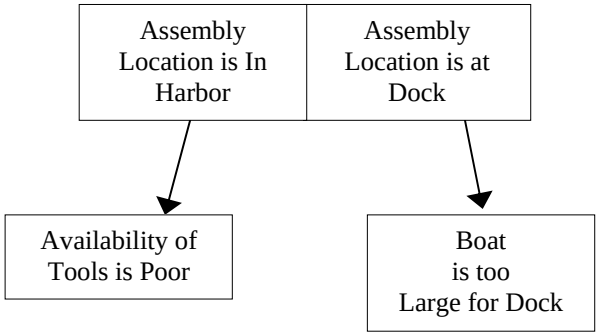


Exercise—Super Yacht

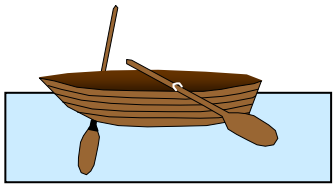


A small ship building company considers a contract to build a super yacht. The yacht is so big that only a third will fit into their dock. "We will need to build this in the open harbor." A frustrated engineer says. "We can't do that; we need the availability of lifts and tools."

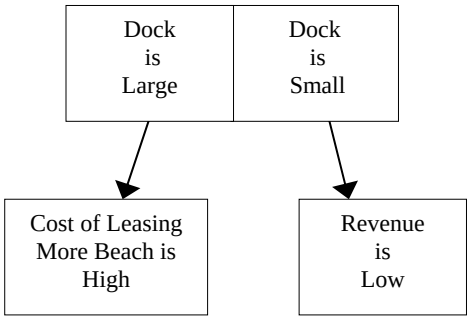
The Building Location: It should be IN THE HARBOR & AT THE DOCK. Using the principle that you have just learned, resolve this contradiction.



Exercise—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**.** Using the principle that you have just learned, resolve this contradiction.

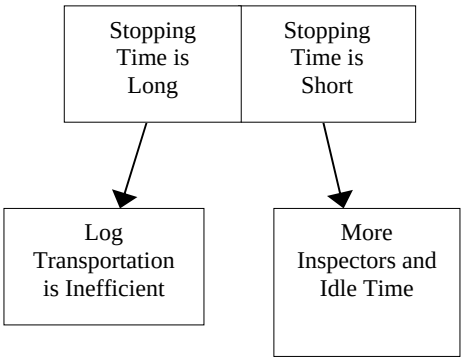


Exercise—Log Jam

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. Using the principle that you have just learned, resolve this contradiction.



L3-Mixture

Particles or segmented[59] elements having both properties are mixed together. Both properties are existent and expressed at the same time at a smaller scale. Both properties are ready to act at any moment. Neither is hidden or at a smaller scale. For this reason, this is different than separation between the parts and the whole. Composites[60] are a good example of mixtures.

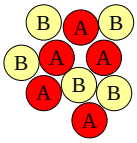
The orange box shows some of the more unusual mixtures possible. Refer to these as you consider resolving your contradiction. Consider finer and finer scales down to sub-atomic particles.

Mixture

- Partially Mixed
- Mixture
- Interweave
- Fabrics and Matrix
- Multi Fiber Fabrics
- Multi Property Laminates
- Mixtures of Different Molecules
- Gels (Liquids + Solids)
- Pastes (Liquids + Solids)
- Foams (solid or liquid)
- Capillary Structures (Solid + Liquid)
- Components of Solids or Liquid
- Porous Materials
- Foams

Method

(Inexpensive particles or segmented elements) which are (setting A) are (mixed with) (particles or segmented elements) which are (setting B).

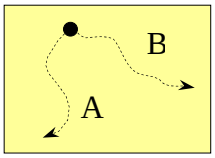


L3-Path

If motion or shape is involved in the conflicting properties, it is entirely possible that the property may have a value on one path and the conflicting value on another path.

Method

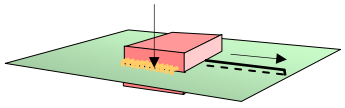
On a path (path location A) the (element knob) is (setting A). On a path (path location B) the (element knob) is (setting B).



Example—Circuit Board

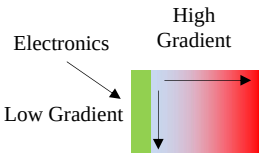
In general, it is desirable to have SHORT paths everywhere on a circuit board. This helps greatly when it comes to high-speed circuits where timing is quite critical. Sometimes, however, there is a need for a LONG path.

On a path (through the board) the (wire length) is (short). On a path (around the board) the (wire length) is (long).



Example—Heat Sensor

The temperature gradient needs to be HIGH in order to create a voltage potential with a thermopile. The temperature differential needs to be LOW in order to not stress the attached electronic components.



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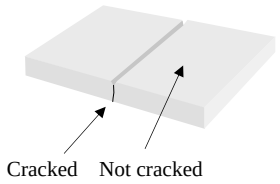
59 Inventive Principle #1—Segmentation: Divide an object into independent parts. Make an object sectional (for easy assembly or disassembly). Increase the degree of an object's segmentation. Genrich Altshuller, The Innovation Algorithm page 287.

60 Inventive Principle #40—Composite Materials: Replace homogeneous materials with composite ones. Genrich Altshuller, The Innovation Algorithm page 289.

On a path (along the axis) the (temperature gradient) is (high). On a path (across the end of the sensor) the (temperature gradient) is (low).

Example—Sidewalk Cracks

Sidewalk cracks must EXIST due to the high tension stresses caused during heat expansion and contraction. Sidewalk cracks must NOT EXIST because that would be aesthetically unacceptable. (Notice that we are not changing any knobs that would remove the tendency to crack. Here is a good example of an "outcome" knob which must and must not be turned.)

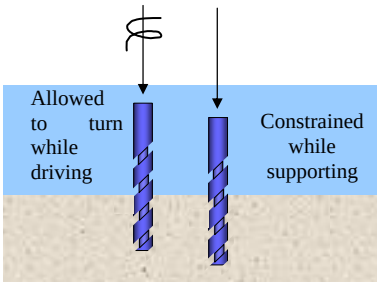


On a path (along a notch) the (existence of crack) is (existing). On a path (in all other locations) the (existence of the crack) does (not exist).

Example—Pile Driving

The pile frontal area must be SMALL in order to drive rapidly. The frontal area must be LARGE in order to support well.

On a path (rotating along the axis of the pile) the (frontal area) is (small). On a path (linearly along the axis) the (frontal area is) is (large).

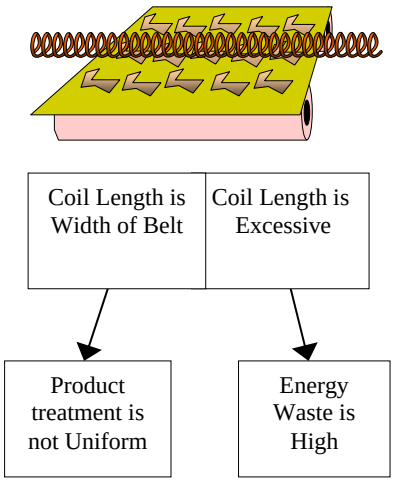


This is somewhat of a whimsical means of making a pile blunt and not blunt. If the pile is formed into a screw-like shape and the end is sharply formed, then it will twist as it goes in. Along this path, the pile frontal area is SMALL. However, when it is constrained and not allowed to turn then all of the material between the spirals makes the pile frontal area LARGE. The pile would require a very coarse pitch to allow it to be pounded in.

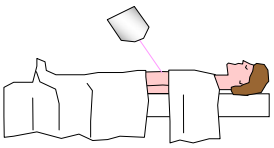
Exercise—Blistering Coils II

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.

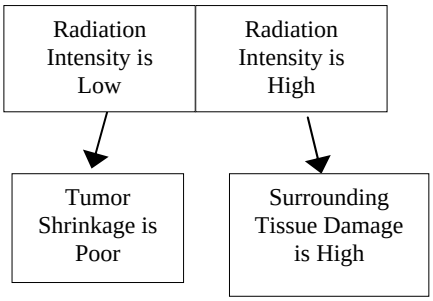
The Coil Length should be EXCESSIVE & THE WIDTH OF THE BELT. Using the principle that you have just learned, resolve this contradiction.



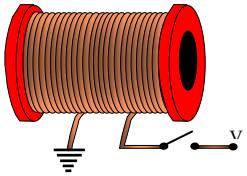
Exercise—Radiation Treatment



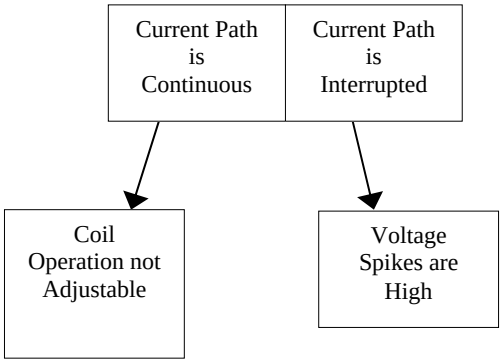
High levels of radiation can damage the structure of cells and cause them to cease functioning. This is useful in the treatment of tumors. A beam of high energy radiation is focused on the tumor. After the procedure, the tumor shrinks. Unfortunately, the tissue surrounding the tumor is also damaged by the high energy radiation. The Radiation Intensity needs to be HIGH AND LOW**.** Using the principle that you have just learned, resolve this contradiction.



Exercise—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. The current path needs to be CONTINUOUS AND INTERRUPTED**.** Using the principle that you have just learned, resolve this contradiction.

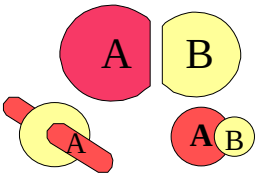


L3-Interact / Guide / Nestle / Penetrate

An extension of attaching conflicting objects to each other, we can find ways to make the objects interact by allowing them to interact from a distance, guide each other, nestle[61] within or go through each other. This may be necessary when we want reduced physical contact with the conflicting objects. Remember that these objects still have both properties expressed at the same time.

61 Inventive Principle #7—Nesting (Matrioshka): One object is placed inside another. That object is placed inside a third one. And so on. An object passes through a cavity in another object. Genrich Altshuller, The Innovation Algorithm page 287.

Method

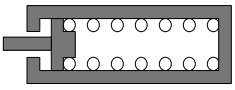


The (element) is (setting A). The interacting (object) is (setting B). The objects (interact / guide / nestle or go through each other).

Example—Spring in Housing

The spring needs to be STIFF in order to not buckle when compressed long distances. It needs to be FLEXIBLE in order to have a low spring rate for proper operation.

The (spring) is (flexible). The interacting (spring housing) is (stiff). The objects (go through each other).



This idea was arrived at by considering a flexible spring inside of a stiff spring. The stiff spring can be shaped in whatever shape is required to allow movement of the inner spring. The outer spring mentally morphs into a housing which is the ultimate stiff outer spring.

Example—Electric Motor

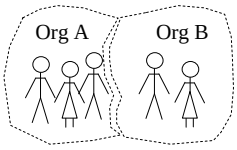
The electric motor circuit needs to be CONDUCTIVE in order to supply electricity to the electro-magnets on the armature. The circuit needs to be INSULATING in order to turn off current to some electro-magnets on the armature. At the same moment in time, the motor circuit should be both insulating and conductive.

The (circuit) is (conductive). The interacting (surrounding air) is (insulating). The objects (nestle) each other.

The only electrically conductive path is through the brushes. Since the air is insulating. This allows the electro-magnets on the armature to be selectively activated as the armature turns.

Example—Co-located Security Group

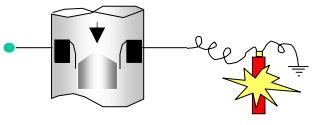
The research center must be DEDICATED TO RESEARCH in order to perform the research properly. It needs to be DEDICATED TO SECURITY in order to avoid security breaches. Being both is too time consuming on the part of the researchers.



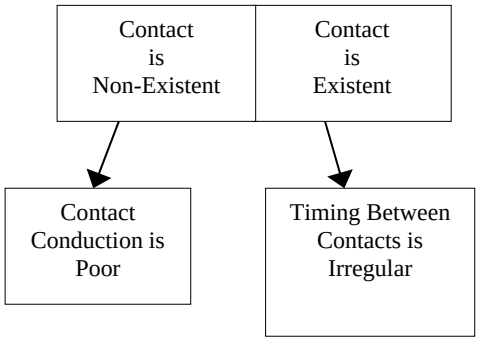
The (research center) is (dedicated to research). The interacting (security group) is (dedicated to security). The objects (nestle).

Exercise—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 a tube with electrical contacts spaced at precise intervals. As the conductive weight passes each set of contacts, continuity is established across the contacts and an explosive charge is detonated.

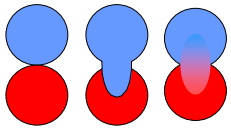


Unfortunately, in order to ensure continuity, the force of the contacts against the conductive weight needs to be high. This causes the timing to be erratic. The plugs must CONTACT the leads in order to complete the circuit and must NOT CONTACT the leads in order to keep the timing perfect. Resolve this conflict using the method that you have just learned.



L3-Attached Objects

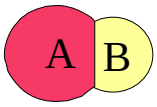
One element has the desired property. It is attached to another element having the conflicting property. This is different from a carrier. With a carrier, all parts take on the property of the carrier. In this case, both conflicting properties are necessary and expressed at the same time. Another object can be attached or the element can be separated into functional parts.



- Inert carriers
- Dual states-same material
- Dual phase substances
- Thin Films
- Paint
- Nested parts
- Attached parts
- Mixed somewhat

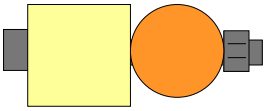
Method

The (element or element part) is (setting A). The attached (object) is (setting B).



Example—Reflector

The reflector needs to be FLAT in order to reflect a strong signal back. It needs to be SPHERICAL in order to reflect a weak signal.



The (reflector) is (square). The attached (reflector) is (spherical).

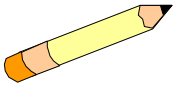
Example—Apron

The apron needs to be FLUID REPULSING in order to not absorb spray paint. It needs to be FLUID ABSORBING in order to wipe off paint that gets onto the hands or arms of the sprayer.

The (apron) is (fluid repulsing). The attached (towel) is (fluid absorbing).

Example—Pencil

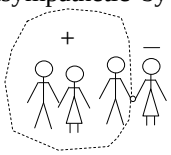
The pencil must be CAPABLE OF WRITING in order to place marks on paper. It must be CAPABLE OF ERASING in order to take marks from a paper.



The (pencil) is (capable of writing). The attached (eraser) is (capable of erasing).

Example—Police Interrogation Teams

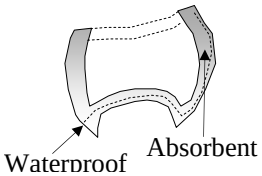
The interrogation team needs to be SYMPATHETIC to the individual being interviewed in order to have a trusting relationship with someone when the person wants to talk. The team needs to be UNSYMPATHETIC because police are generally unsympathetic by nature and also in order to reinforce the idea that the person being interrogated is in trouble.



The (team) is (unsympathetic). The attached (interrogator) is (sympathetic).

Example—Diapers

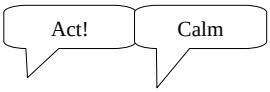
The diaper must be ABSORBENT in order to draw moisture away from the body. It must be WATERPROOF in order to not allow fluid leakage.



The (diaper) is (absorbent). The attached (exterior waterproof lining) is (waterproof).

Example—Instructions for the Flu

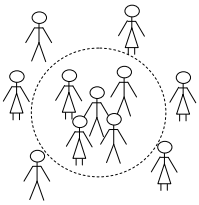
The message must INCITE TO ACTION in order that people will react and get flu shots. The message must REQUEST CALMNESS in order to avoid mass hysteria.



The (message) is (intended to incite to action). The attached (message) is (requesting calmness).

Example—Organization

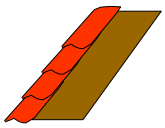
The military needs to be ORGANIZED in order to coordinate activities. It needs to be AUTONOMOUS in order to conduct specialized missions.



The (military organization) is (centrally organized). The attached (special forces) is (autonomous).

Example—Roof Tiles

The roof needs to be WOOD in order to construct with hand tools. It needs to be CERAMIC in order to repel water.



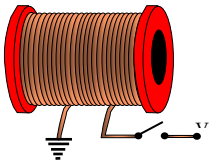
The (roof) is (wood). The attached (tiles) are (ceramic).

Example—Toothbrush

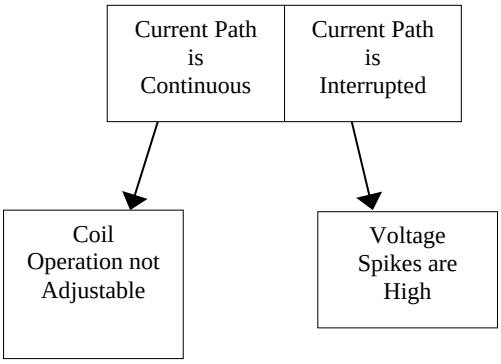
The bristles must be FLEXIBLE to conform to the teeth and disturb the plaque on the teeth. They must be RIGID in order to be guided by a hand.

The (handle) is (rigid). The attached (bristles) are (flexible).

Exercise—I Just Can't Stop



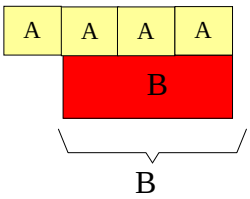
Electromagnetic coils are used for many applications which require the generation of force. Magnetic fields generated by the coil and the spool upon which the wire is wound interact with plungers also made of magnetic materials. Usually, the flow of current to the coil is initiated by throwing a switch 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. The current path needs to be CONTINUOUS AND INTERRUPTED**.** Using the principle that you have just learned, resolve this contradiction.



L3-Partly Carried

Here again is a combination of Separation Principles. A carrier [62]is attached to only part of the elements to give them the opposing property. The part to which the carrier is not attached retains the opposing property.

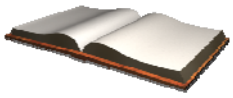
Method



Several (elements) can be used. Some of the (elements) which are (setting A) are attached to a (carrier) which is (setting B). The (carrier) and attached (elements) are collectively (setting B). The (elements or element parts) which are not carried are still (setting A).

Example—Pages in a Book

The pages need to be STIFF in order for the reader to control the pages while turning each page. The pages need to be FLEXIBLE in order to easily turn them.



Several (pages) can be used. Some of the (pages) which are (flexible) are attached to a (binding) which is (stiff). The (binding) and attached (pages) are collectively (stiff). The (parts of the pages) which are not carried are still (flexible).

62 Inventive Principle #24—Mediator: Use an intermediary object to transfer or carry out an action. Temporarily connect the original object to one that is easily removed. Genrich Altshuller, The Innovation Algorithm page 288.

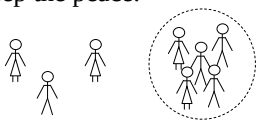
Example—Carpet Fibers

The carpet fibers need to be STIFF in order to stay together and look new all of the time. They need to be FLEXIBLE in order to feel soft to the touch.

Several (fibers) can be used. Some of the (fibers) which are (flexible) are attached to a (sheath) which is (stiff). The (sheath) and attached (fibers) are collectively (stiff). The (part of the fibers) which are not carried are still (flexible).

Example—Combat vs. Peace Keeping

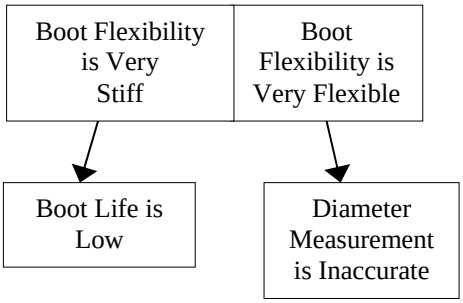
The military peace keepers need to be COMBAT READY in case of rapid enemy deployments. It needs to be SECURITY READY in order to keep the peace.



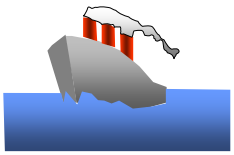
Several (military personnel) can be used. Some of the (military personnel) which are (peace keepers) are attached to a (combat organization) which is (combat ready). The (combat organization) and attached (peace keepers) are collectively (combat ready). The (peace keepers) which are not carried are still (security ready).

Exercise—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. Resolve the Contradiction using the principle that you have just learned.

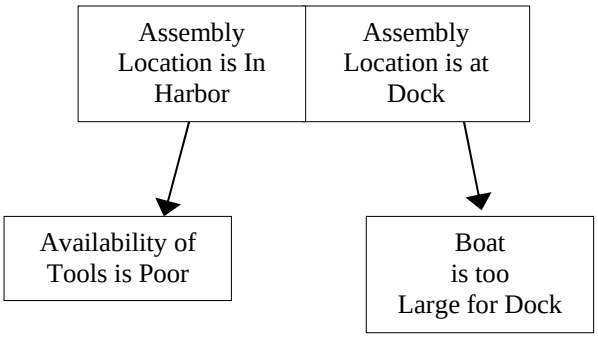


Exercise—Super Yacht



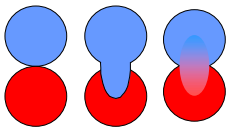
A small ship building company considers a contract to build a super yacht. The yacht is so big that only a third will fit into their dock. "We will need to build this in the open harbor." A frustrated engineer says. "We can't do that; we need the availability of lifts and tools." The Building Location: It should be IN THE HARBOR & AT THE DOCK.

Using the principle that you have just learned, resolve this contradiction.



L3-Partly Merged or Interacting

This is a combination of Separation between the Parts and the Whole and Separation in Space. Some parts having one property interact or merge with other parts and therefore take on the opposing property. Any parts remaining retain their original opposing property.

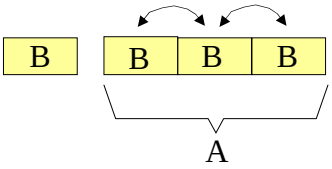


Merge
Nestle
Interlink—may require reshaping
Linked by Transmission
Hinged

Elastic Stress	Gravity	Friction	Adhesion
Buoyant Force	Hydrostatic Pressure	Jet Pressure	Surface Tension
Centrifugal Force	Inertial Force	Coriolis Force	
Oder & Taste	Diffusion	Osmosis	Chemical Fields
Sound	Vibrations & Oscillations	Ultrasound	Waves
Thermal Heating or Cooling	Thermal Shocks		Information
Corona Discharge	Current	Eddie Currents	Particle Beams	Nuclear Forces
Electrostatic Fields	Magnetic Fields	Electromagnetic Fields	
Radio Waves	Micro Waves	Infrared	Visible	Ultraviolet	X-Ray	Cosmic

Method

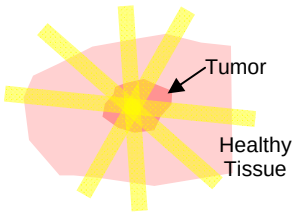
Several (elements) can be used. They partially merge or interact by (method of merging or interaction). The partly merged (elements or part of the elements) are (setting A). All that are unmerged are (setting B).



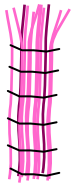
Example—Killing Tumors

The beam intensity must by HIGH INTENSITY in order to kill the tumor. It must be LOW INTENSITY in order to not kill the surrounding tissue.

Several (beams) can be used. They partially merge or interact with each other by (crossing the beams). The partly merged (section of the beams) is (high intensity). All that are unmerged are (low intensity).



Example—Carpet Fibers

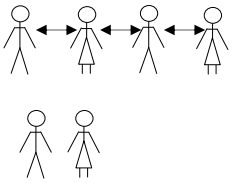


The carpet fibers need to be STIFF in order to stay together and look new all of the time. They need to be FLEXIBLE in order to feel soft to the touch.

Several (fibers) can be used. They partially merge or interact by (tying one fiber around the others). The partly merged (fiber strands) are (stiff). All that are unmerged are (flexible).

Example—Group Education

The group of doctors should be TRAINED in a certain medical procedure in order to more effectively treat patients. The group of doctors should remain UNTRAINED in order to reduce the costs of training.



Several (doctors) can be used. They partially merge or interact by (teaching each other the medical procedure). The partly merged (doctors) are (trained). All that are unmerged are (UNTRAINED).

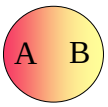
L3-Non-Uniform

A SINGLE ELEMENT has both conflicting properties. (It is not uniform). The brown box at the right gives a number of possible ways to create non-uniform conditions. Note that transformation devices have one property at the input and the conflicting property at the output. Finding a way to make an object non-uniform allows for fewer objects to be used. This can decrease the cost of the objects. In mainstream TRIZ, this method is often referred to as Local Quality.

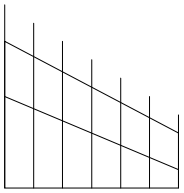
- Transformers (electric, levers, etc.)
- Standing Waves
- Concentrated Additives
- Especially active Additives

Method

Only one (element) is allowed. One part of the (element) is (setting A). Another part of the same (element) is (setting B).



Example—Fence



The fence needs to be TALL in order to keep large animals from escaping. It needs to be SHORT in order to stop small animals from escaping and to be less expensive.

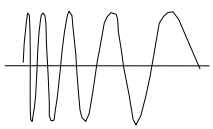
Only one (fence) is allowed. One part of the (fence) is (tall). Another part of the same (fence) is (short).

Clearly, the large animals must not be allowed to move to the short end of the fence.

Example—Space Object Size Detector

A signal burst is sent into space at a target to determine its size. If the object is much smaller than the wavelength, there is little reflection. The signal wavelength must be SHORT in order to detect small objects. The signal wavelength must be LARGE in order to detect large objects.

Only one (signal burst) is allowed. One part of the (signal burst) is (short wavelength). Another part of the same (signal burst) is (long wavelength).

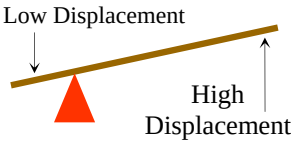


In this case, the wavelength can be varied throughout the burst. At any given moment in time, the burst has different wavelengths at different locations as it travels through space. The size of an object can be approximated by looking at the wavelength of the signal that is reflected back.

Example—Lever

An actuator is powered by magneto-strictive materials which have high force outputs but low displacements. The actuator needs to have HIGH movement in order move long displacements. It needs to have LOW movement because the actuator is only capable of small movement.

Only one (beam) is allowed. One part of the (beam) is (slow). Another part of the same (beam) is (fast).

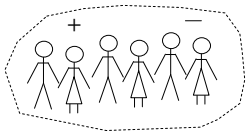


Instruments that transform energy are often good examples of Non-Uniform Separation in Space. A lever is LOW FORCE and FAST at the input and HIGH FORCE and SLOW at the output.

Example—Non-Uniform Group

In order to be comfortable liberals must be surrounded by other LIBERALS. However in certain areas of the country the majority of people are CONSERVATIVES. Therefore liberals are surrounded by them.

Only one (group) is allowed. One part of the (group) is (liberals). Another part of the same (group is (conservatives).



When given the opportunity, individuals in a group of people will tend to locate themselves where they feel most comfortable within the group. This makes the group non-uniform.

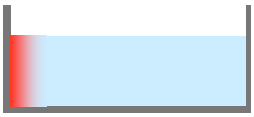
Example—Non-Uniform Story

The story must be a LOVE STORY to attract women. It must be and ACTION STORY in order to attract men.

Only one (story) is allowed. One part of the (story) is (a love story). Another part of the same (story) is (an action story).

Often a story or a message will begin very differently than it ends. For instance, a murder mystery may start with a very pleasant description of a community and end with the disclosure that a murderer has always lived with them.

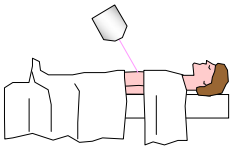
Example—Bacteria Stain



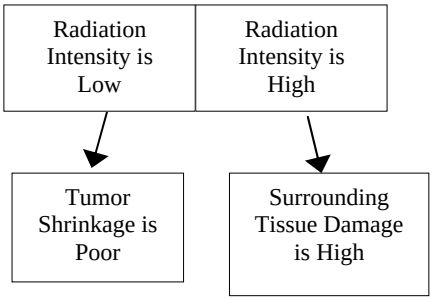
For a study on pool bacteria, a dye must be introduced which stains the bacteria. The dye must be CONCENTRATED in order to stain the bacteria that exist on one small wall of the pool. It must be DILUTE in order to not stain the other walls.

Only one (stain) is allowed. One part of the (stain) is (concentrated). Another part of the same (stain) is (dilute).

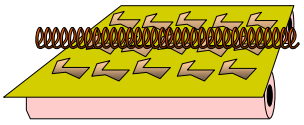
Exercise—Radiation Treatment



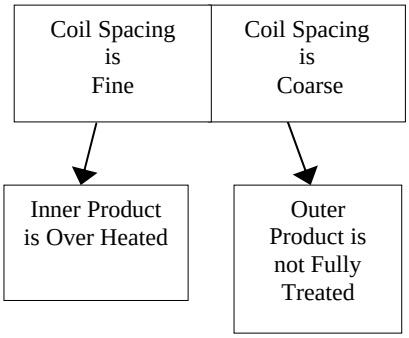
High levels of radiation can damage the structure of cells and cause them to cease functioning. This is useful in the treatment of tumors. A beam of high energy radiation is focused on the tumor. After the procedure, the tumor shrinks. Unfortunately, the tissue surrounding the tumor is also damaged by the high energy radiation. The Radiation Intensity needs to be HIGH AND LOW**.** Using the principle that you have just learned, resolve this contradiction.



Exercise—Blistering Coils



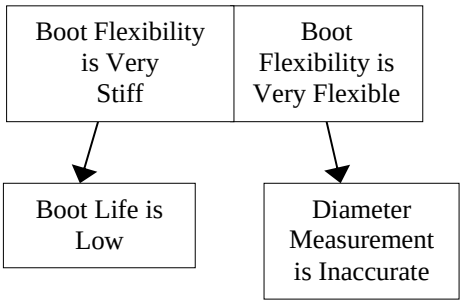
Product on an assembly line must pass under a heating coil in order to be fully treated. The product that passes under the center part of the coil is fully treated, but the product that passes under the coil at the edge of the conveyor belt is not fully treated. If the coil spacing was finer, the outer product could be fully treated. However, the product at the center of the belt is over-heated. The Coil Spacing should be FINE & COARSE. Using the principle that you have just learned, resolve this contradiction.



Exercise—Too Flexible

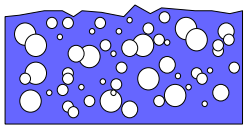
Various diameters of a thin rubber boot (which covers part of a car shift mechanism) must be measured with great accuracy at several points. Unfortunately, the micrometer which is used deforms the boot during the measurement.

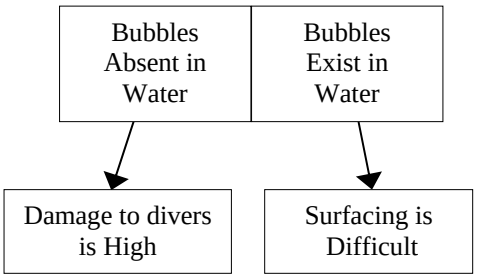
This makes the measurement inaccurate. How can the boot be measured more accurately? The Boot Flexibility Needs to be FLEXIBLE & STIFF. Resolve the Contradiction using the principle that you have just learned.



Exercise—Soft Water

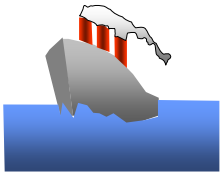
The addition of bubbles to diving pools is a good way to keep diving injuries to a minimum. This is especially true when diving from great heights. Unfortunately, the diver is no longer buoyant in the water and finds it difficult to surface after a dive. The Bubbles need to be EXISTENT AND ABSENT. Using the principle that you have just learned, resolve this contradiction.

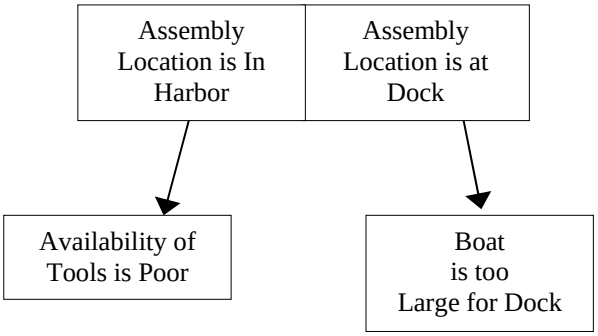




Exercise—Super Yacht

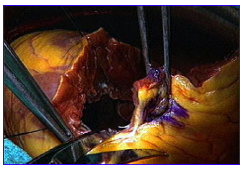
A small ship building company considers a contract to build a super yacht. The yacht is so big that only a third will fit into their dock. "We will need to build this in the open harbor." A frustrated engineer says. "We can't do that; we need the availability of lifts and tools." The Building Location: It should be IN THE HARBOR & AT THE DOCK. Using the principle that you have just learned, resolve this contradiction.



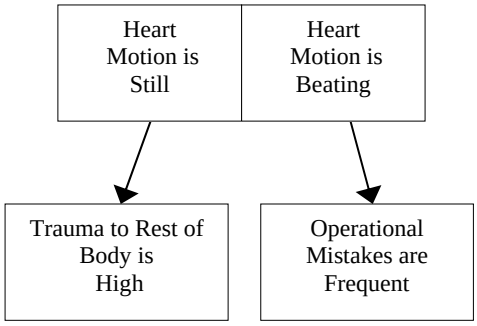


Exercise—the Beat Goes On

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**.** Using the principle that you have just learned, resolve this contradiction.



L3-Facsimile

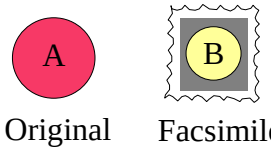
- Photographs
- Movies
- Paint Coverings
- Molds
- Time lapse photos
- Impressions
- Silhouettes
- Castings
- Resists
- Projections
- Computer Models

A facsimile[63] or representation of the object has the opposing properties of the actual object. To the right are a number of possible facsimiles. These various methods represent only the important feature of the object that we are interested in.

Note that this is actually a method for Separating in Space but it is grouped here for convenience and because the test works well to support this method.

Method

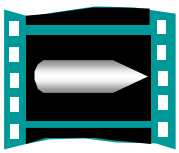
The (element) is unfortunately (setting A). But we can change its (appearance, sound, feel, smell or effect) to seem like it is (setting B) when using (a type of facsimile that represents the important attributes).



Example—Movie

The bullet in flight is FAST because that is how they come. The bullet must be SLOW in order to see how it enters the target.

The (bullet) is unfortunately (fast). But we can change its (appearance) to seem like it is (slow) when using (a movie of the bullet).

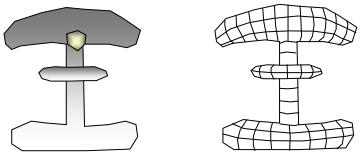


Example—Modeling of Explosion

The explosion is very FAST which makes it difficult to measure many characteristics throughout the explosion area. It needs to be very SLOW in order to go around to the different regions and measure the important attributes.

63 Inventive Principle #26—Copying: A simplified and inexpensive copy should be used in place of a fragile original or an object that is inconvenient to operate. If a visible optical copy is used, replace it with an infrared or ultraviolet copies. Replace an object (or system of objects) with their optical image. The image can then be reduced or enlarged. Genrich Altshuller, The Innovation Algorithm page 288.

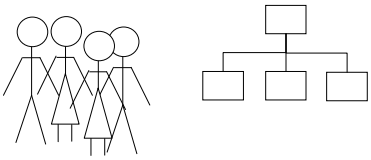
The (explosion) is unfortunately (fast). But we can change its (appearance) to seem like it is (slow) when using (a model of the explosion).



Example—Organization Model

An actual organization must be ALTERED SLOWLY in order to not make mistakes and cause resentment. It is necessary to ALTER RAPIDLY in order to consider the different possibilities.

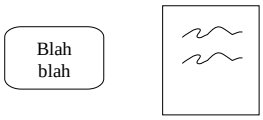
The (organization) is unfortunately (altered slowly). But we can change its (appearance) to seem like it is (rapidly altered) when using (an organizational chart).



Example—Meeting Notes

The actual meeting may be very LONG and drawn out. It needs to be SHORT in order to not take a lot of management time.

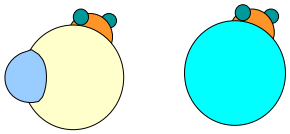
The (meeting duration) is unfortunately (long). But we can change its (appearance) to seem like it is (short) when using (a meeting summary).



Example—Vaccine

In order to obtain immunity, a VIRUS gives that the correct bodily response. Unfortunately, a virus can be deadly so NO VIRUS must be used to keep people safe.

The (virus) is unfortunately (a virus). But we can change its (effect) to seem like it is (not a virus) when using (a vaccine).

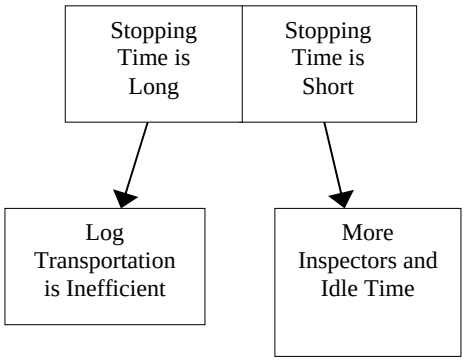


Exercise—Log Jam

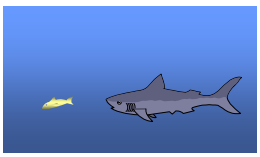
Every few hours, a train enters the depot with several cars full of logs. It is the job of the inspector to measure each log diameter. Unfortunately the train does not stay long. So far, the problem has been solved by hiring many inspectors.

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.

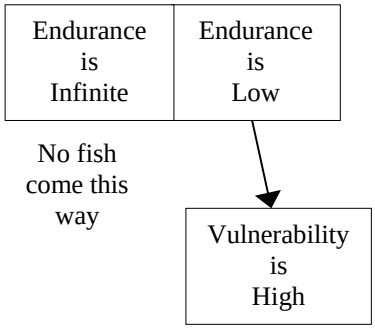
The Stopping Time Needs to be LONG & SHORT. Using the principle that you have just learned, resolve this contradiction.



Exercise—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 in order to outrun the shark and NORMAL ENDURANCE because that is how small fish are. Resolve the contradiction by using the method you have just learned.



L3-Selective Countering

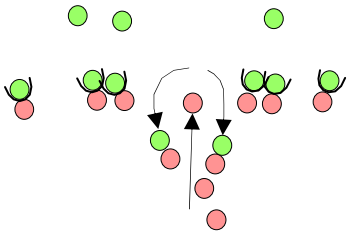
Blocking actions, forces or fields can exist in one location. In another location these actions, forces or fields do not exist. The counteraction[64] nullifies the action in that region so the conflicting attributes have a setting in one region and the null setting in another.

Method

For actions, forces or extrinsic attributes that depend upon interactions such as beauty. Part of the (element) has (countering forces, fields or actions) in one location. In another location of the (element) the counter (counter forces, fields or actions) do not exist.

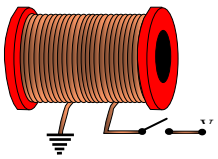
Example—Football Play

The line needs to HOLD FAST in order that quarterback is not overwhelmed. The line needs to GIVE WAY in order to create an opening for the ball carrier.



For actions, forces or extrinsic attributes that depend upon interactions such as beauty. Part of the (offensive line) has (blocking) in one location. In another location of the (offensive line) the (blocking actions) do not exist.

Exercise—I Just Can't Stop

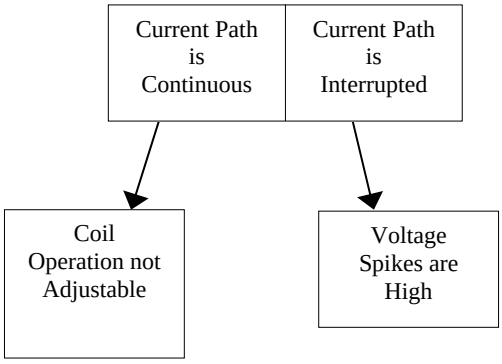


Electromagnetic coils are used for many applications which require the generation of force. Magnetic fields generated by the coil and the spool upon which the wire is wound interact with plungers also made of magnetic materials.

Usually, the flow of current to the coil is initiated by throwing a switch which allows electrons to begin flowing.

64 Inventive Principle #8—Counterweight: Compensate for the weight of an object by combining it with another object that provides a lifting force. Compensate for the weight of an object with aerodynamic or hydrodynamic forces influenced by the outside environment. Genrich Altshuller, The Innovation Algorithm page 287.

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. The current path needs to be CONTINUOUS AND INTERRUPTED. Using the principle that you have just learned, resolve this contradiction.



L3-On Condition

Opposing conditions separated in space create situations where an element automatically has conflicting properties by being located in the opposing locations.

Method

One (element) is (location creating condition A) rendering it (setting A). Another (element) is (location creating condition B) rendering it (setting B)

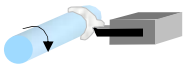
Example—Boat Mooring

The boat must be MOBILE in order to fish or enjoy other recreation. The boat must be IMMOBILE in order to not drift off when unoccupied.

One (boat) is (in the water) rendering it (mobile). Another (boat) is (on the land) rendering it (immobile).

Example—Foams, Liquids, Floating Solids, Fluids in Motion

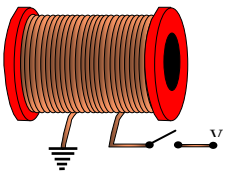
These selectively pass large objects. They may stop gases, other liquids and very small objects. Consider using inert materials to perform this. In this example, evolving gases from a machining process are stopped by a foam barrier. The foam is TRANSPARENT to large objects and OPAQUE to small objects.

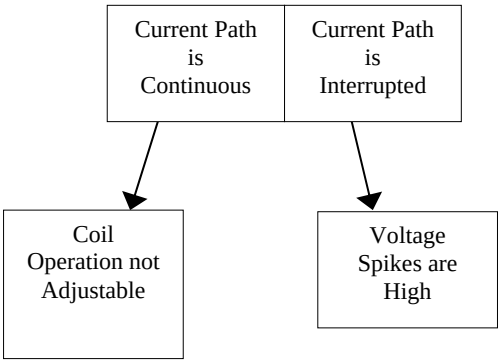


One (high inertia body) is (through the foam) rendering it (transparent). Another (small inertia body) is (anywhere the large inertia body is not located) rendering it (opaque).

Note that wherever there is a large inertia force, there is a small resistance to the large inertia body. Everywhere else, there is a high resistance to small inertia bodies. This can also be a separation in time. Whenever small inertial forces occur, there is a large resistance to transmit the small inertia body. Whenever large inertial forces occur there is a small resistance to transmit the large inertia body.

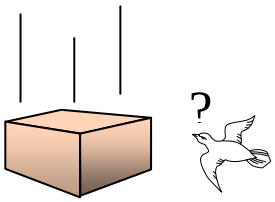
Exercise—I Just Can't Stop

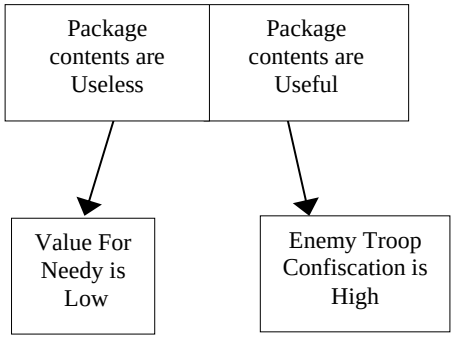




Electromagnetic coils are used for many applications which require the generation of force. Magnetic fields generated by the coil and the spool upon which the wire is wound interact with plungers also made of magnetic materials. Usually, the flow of current to the coil is initiated by throwing a switch 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. The current path needs to be CONTINUOUS AND INTERRUPTED**.** Using the principle that you have just learned, resolve this contradiction.

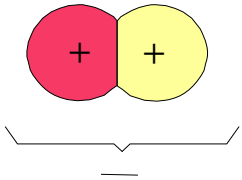
Exercise—Special Delivery





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 hoard the supplies to themselves. They quickly discover that the contents are useful and look for them. The Package Contents must be USEFUL AND USELESS Using the principle that you have just learned, resolve this contradiction.

L2-Separate Between the Parts and the Whole



Separation between the Parts and the Whole[65] is uniquely different from Separation in Time and space. At the same critical moment in time and in the same space, a grouping of objects can have a collective property and its parts can have the opposing property.[66]

Using the principle, we may either hide one of the properties or express both. Whether we express both properties or hide one of them depends upon how we arrange the parts. If we arrange them so that the parts cannot interact with other elements or in a way that minimizes the interactions, then one of the properties may be hidden or disposed of. If we arrange them so that the parts can interact at their respective scales then both properties can be expressed.

This separation principle is particularly useful when one desires to hide or dispose of one of the properties. In this case, we arrange the elements so that we minimize critical interactions. We may do this by actually hiding the elements. Some may ask "When does it occur that only one of the conflicting properties is useful?" There are two common conditions. The first condition is when an "outcome" must and must not occur. For example, something is broken but it must not be broken. Another condition is when an element only comes in "one flavor". For instance, something must be large, but it only comes as small entities. In each of these cases, it may be possible to hide the undesirable "flavor" or outcome.

On the other hand it may be desirable to express both properties, one is expressed at a larger scale, where it is needed, and the other is expressed at a smaller scale where it is needed. We will refer to the larger scale as the "macro" scale and the smaller scale as the "micro" scale for brevity, though the two scales may be quite similar and the "micro" scale may be quite large. A piece of sandpaper is flexible at the macro scale in order to conform to large objects. The small abrasive particles are stiff at the smaller scale in order to gouge into the surface of the wood. Note that the parts are arranged in such a way that they can interact and thus the micro properties can be expressed.

Following is the test and the various strategies for Separating between the Parts and the Whole.

L2-Method

Step 1: At a critical moment in time does one of the properties need to be hidden or is one property required at the macro scale and the other property required at a smaller scale?

Step 2: Consider attaching the object to a carrier which carries the opposing property, thus hiding the unwanted property

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65 Separation between the Parts and the Whole appears in Creativity as an Exact Science-The Theory of the Solution of Inventive Problems by G.S. Altshuller published by Gordon and Breach. It can be found in the appendix discussing ARIZ 77 Page 292

66 STANDARD 3-1-5. Efficiency of bi- and poly-systems can be improved by distributing incompatible properties among the system and its parts. This is achieved by using a two-level structure in which the system as a whole has a certain property A, while its parts (particles) have property anti-A. Example: A working part of a vice is made of segmented plates capable of moving relatively each other. Parts of various shapes can be gripped quickly.

Step 3: Consider segmenting[67] *the element or merging multiple elements in order to hide an unwanted property*

Step 4: Consider making the parts counter[68] *each other*

L3-Test for Separation between the Parts and the Whole

This is one of the simplest tests for separation principles. The purpose of separating between the parts and the whole is to only end up with one important property. In the end, only one of the settings will be expressed, the macro property.

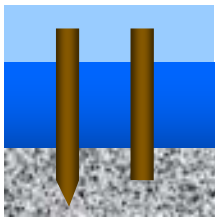
Test:

Step 1: At a critical moment in time, should either (setting A) or (setting B) be hidden or minimized to solve the problem?

Step 2: At a critical moment in time, do I want (setting A) and (setting B) to be expressed at different scales?

Step 3: If the answer to 1 and 2 is "no", go to separation by direction. Otherwise, separate between the parts and the whole.

Example—Pile Driving



We would like the pile to be SHARP in order to drive it more rapidly and we would like it to be BLUNT in order to support well.

Test for Separation between the Parts and the Whole:

Step 1: At a critical moment in time, should either (blunt) or (sharp) be hidden or minimized to solve the problem? No, there is no critical time in which both settings should be hidden or minimized.

Step 2: At a critical moment in time, do I want (sharp) and (blunt) to be expressed at different scales? No, there is no time in which we would desire both bluntness and sharpness.

Step 3: If the answer to 1 and 2 is "no", go to separation by direction. Otherwise, separate between the parts and the whole. Since the answer to both is "no" we would go to separation by direction.

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67 Inventive Principle #1—Segmentation: Divide an object into independent parts. Make an object sectional (for easy assembly or disassembly). Increase the degree of an object's segmentation. Genrich Altshuller, The Innovation Algorithm page 287.

68 Inventive Principle #8—Counterweight: Compensate for the weight of an object by combining it with another object that provides a lifting force. Compensate for the weight of an object with aerodynamic or hydrodynamic forces influenced by the outside environment. Genrich Altshuller, The Innovation Algorithm page 287.

Example—Traffic Light

The lights in a traffic light must eventually FAIL due to the action of the current on the filament and to vibration. The traffic light must NOT FAIL in order to not cause traffic delays or make the intersection more dangerous.

This is an example of an output contradiction. Most people would think of this as the Y in the function Y=f(X1, X2, X3…). They show up as implicit contradictions on the causal analysis diagrams. Something must be undesirable and desirable, without reference to what is causing the undesirable behavior.

Test for Separation between the Parts and the Whole:

Step 1: At a critical moment in time, should either (failed) or (not failed) be hidden or minimized to solve the problem? Yes, if bulb failure was minimized during any time after failure of a light bulb that would solve the problem and it would be sufficient.

Step 2: At a critical moment in time, do I want (sharp) and (blunt) to be expressed at different scales? No, there is no critical time that both properties are essential

Step 3: If the answer to 1 and 2 is “no”, go to separation by direction. Otherwise, separate between the parts and the whole. The answer to 1 is “yes” so we will try to separate between the parts and the whole.

Example—Sand Paper

We require a RIGID structure in order to cut the surface of the wood, but we require a FLEXIBLE material in order to conform to the rounded contours of the wood project that we are making.

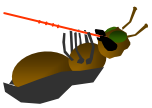
Test for Separation by Scale:

Step 1: At a critical moment in time, should either (rigid) or (flexible) be hidden or minimized to solve the problem? No, we want the sanding system to be both flexible and stiff.

Step 2: At a critical moment in time, do I want (flexible) and (rigid) to be expressed at different scales? Yes, I want flexibility to be expressed at the macro scale and rigidity be expressed at the micro scale.

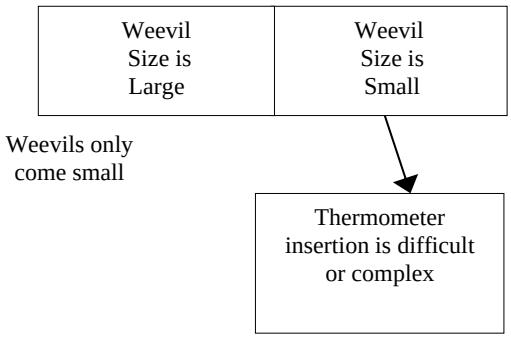
Step 3: If the answer to 1 and 2 is “no”, go to separation by direction. Otherwise, separate between the parts and the whole. The answer to 2 is yes so we will try to separate between the parts and the whole.

Exercise—The Lesser Weevil

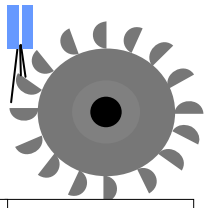


In the war on hunger, Russian scientists were studying the metabolism of the weevil. This required the scientists to be able to measure the body temperature over a period of time. Tiny temperature probes were proposed, which through the aid of a microscope could be inserted into the weevil. The cost 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 AND SMALL**.** Test for Separation between the Parts and the Whole.

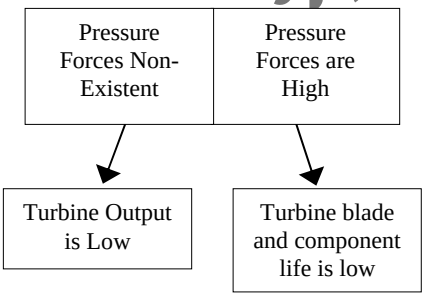


Exercise—Vibrating Water Wheel



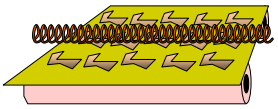
Consider an aluminum water wheel. Inlet flow strikes the blades after accelerating in the nozzle, transferring energy and momentum to the blade and wheel. During energy transfer the blade is bent slightly and released causing it to vibrate.

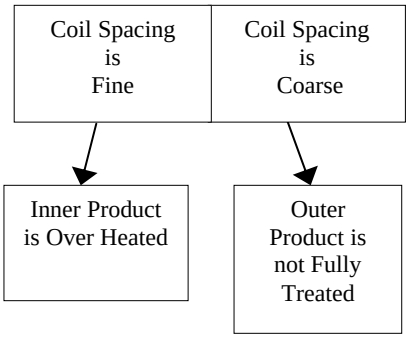
The resulting alternating stresses decrease the life of the turbine blades. If the pressure forces were eliminated, so would the vibration. (Assume a constant speed). The Pressure Forces should be HIGH & ABSENT**.** Test for Separation between the Parts and the Whole.



Exercise—Blistering Coils

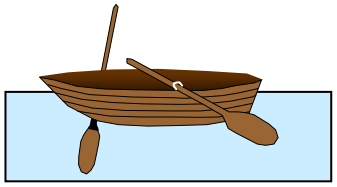
Product on an assembly line must pass under a heating coil in order to be fully treated. The product that passes under the center part of the coil is fully treated, but the product that passes under the coil at the edge of the conveyor belt is not fully treated. If the coil spacing was finer, the outer product could be fully treated. However, the product at the center of the belt is over-heated. The Coil Spacing should be FINE & COARSE. Test for Separation between the Parts and the Whole.



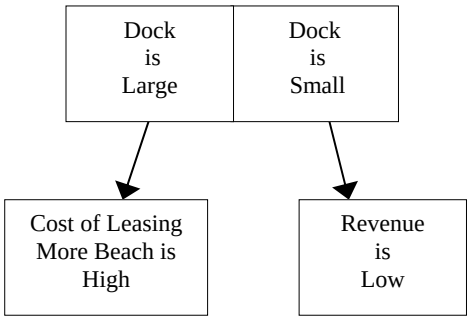


Exercise—What's Up Dock

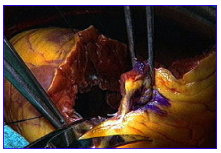
"We'll make a fortune" the small investor said. "When they build the houses around this lake, everyone will want a place to dock their boats and we got the last parcel on the lake".



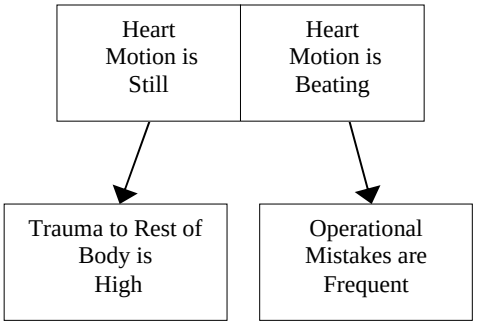
"Yes, but it is too small to store many boats" his wife complained. "And we are not allowed to build the dock out more than 20 yards". "I know" she continued "We can fill every available square foot with dock and boats!" "We still will not be able to store enough boats to make money" the investor said after making a few calculations. The Dock should be SMALL & LARGE**.** Test for Separation between the Parts and the Whole.



Exercise—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**.** Test for Separation between the Parts and the Whole.

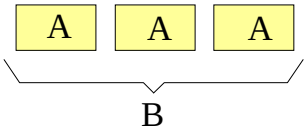


L3-Formation

Multiplied or segmented[69] elements have one desirable property. These elements are separate and placed into a formation that gives the whole system of elements the opposing property. If both properties are expressed then the individual parts should be arranged to allow interaction. The individual parts do not interact with each other (that would be merging). The macro property occurs because of the formation. Scale down multiplied versions if necessary.

Method

(Segmented or individual) (elements) are (setting A). The (elements) are arranged into a formation which (describe working formation). This formation has the macro effect of being (setting B). (Setting A) is (expressed or hidden).



69 Inventive Principle #1—Segmentation: Divide an object into independent parts. Make an object sectional (for easy assembly or disassembly). Increase the degree of an object's segmentation. Genrich Altshuller, The Innovation Algorithm page 287.

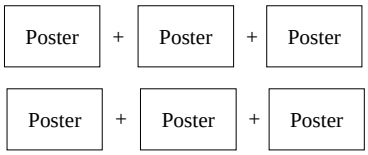
Example—Square and Round

The individual shapes are unfortunately ROUND. We would like them to be SQUARE.

(Individual) (shapes) are (round). The (shapes) are arranged into a formation which (approximate the shape of a square). This formation has the macro effect of being (square). (Roundness) is (hidden).

Example—Large Impact Posters

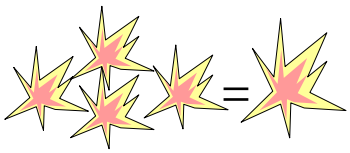
The individual posters need to be LOW IMPACT so as to not arouse suspicions that they were created by activists. They need to be HIGH IMPACT in order to have the desired effect on the visitors that attend the poster session.



(Individual) (posters) are (low impact). The (posters) are arranged into a formation which (takes the viewer from one poster to the next). This formation has the macro effect of being (high impact). (Low impact) is (expressed).

Example—Small Explosions

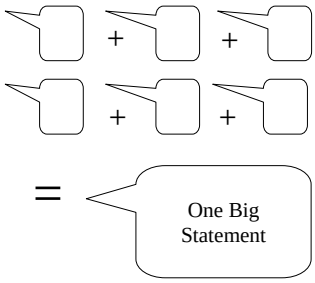
A LARGE explosion is necessary to move a lot of earth. Unfortunately, only SMALL explosive charges are available.



(Individual) (explosions) are (small). The (explosions) are arranged into a formation which (is sufficiently close to have the required effect). This formation has the macro effect of being (large). (Smallness) is (hidden).

Example—Small Advertisements

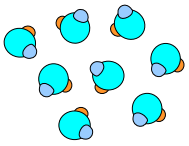
Only SMALL impact statements are possible in the available advertising spaces on the page. But the impact of the statement needs to be LARGE.



(Individual) (statements) are (small impact). The (statements) are arranged into a formation which (strategically placed on the page to give maximum visual impact). This formation has the macro effect of being (large impact). (Small impact) is (hidden).

Example—Exchanging Hydrogen

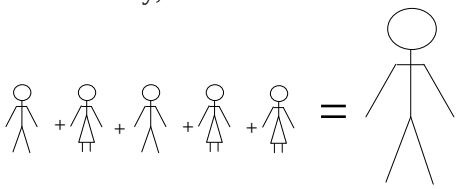
The individual sulfuric acid molecules need to be SMALL in order to attach to the hydrogen ions. They need to be LARGE in order to move large quantities of hydrogen.



(Individual) (sulfuric acid molecules) are (small). The (sulfuric acid molecules) are arranged into a formation which (has random but uniform dispersion in an aqueous solution). This formation has the macro effect of being (large). (Smallness) is (expressed).

Example—Big Person

The person needs to be LARGE to lift the log. Unfortunately, all we have is AVERAGE size people.



(Individual) (people) are (average sized). The (people) are arranged into a formation which (line up along the log). This formation has the macro effect of being (large). (Average sized) is (hidden).

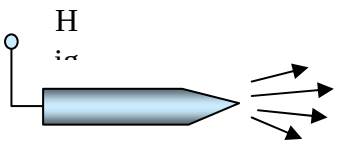
Example—Square and Round

The individual shapes need to be ROUND in order to perform their proper function. They need to be SQUARE in order to fit nicely into an inexpensive box.

(Individual) (shapes) are (round). The (shapes) are arranged into a formation which (is the approximate shape of a square). This formation has the macro effect of being (square). (Roundness) is (expressed).

Exercise—Molecular Wind Pump

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.



Local Gas Movement is Large	Local Gas Movement is Small

Only comes one way

Flow is Miniscule

The Local Gas Movement should be SMALL & LARGE. Using the principle that you have just learned, resolve this contradiction.

Exercise—Traffic Light

The lights in a traffic light must eventually FAIL due to the action of the current on the filament and to vibration. The traffic light must NOT FAIL in order to not cause traffic delays or make the intersection more dangerous.

This is an example of an output contradiction. Most people would think of this as the Y in the function. Resolve this contradiction using the method you have just learned.

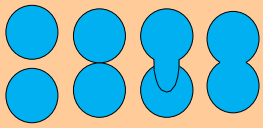
Traffic Light Operation Fails	Traffic Light Operation Doesn't Fail
All lights will eventually fail	Note that nothing gets worse

L3-Merging

The term "merging[70]" will be used more broadly to indicate "interacting" with individual or segmented[71] objects. The individual objects or segments have one desired property and the interacting objects have the opposing property. Such interactions can be achieved with the fields shown in the Table of Fields.

A mediating substance or "mediator" can also allow the individual elements to interact with each other. The mediating substance or field typically operates at the macro scale while the individual elements operate at the micro scale. Merging allows for action at a distance as well as the potential of touching, nesting[72], interweaving, attaching and mixing. We also allow for fields which repulse rather than attract.

Interact through a field at a distance
Interact through a "mediator" substance
Linked by Transmission
Touch
Interweave
Nest
Nestle
Interlink
Clamped
Hinged
Interfused
Fractal Constructions



In order to drive to ideality, we would like to use existing fields if possible. An example of this would be to make the elements interlink. Mechanical fields already exist; why not allow them to perform the act of merging?

Elastic Stress	Gravity	Friction	Adhesion	
Buoyant Force	Hydrostatic Pressure	Jet Pressure	Surface Tension	
Centrifugal Force	Inertial Force	Coriolis Force		
Oder & Taste	Diffusion	Osmosis	Chemical Fields	
Sound	Vibrations & Oscillations	Ultrasound	Waves	
Thermal Heating or Cooling	Thermal Shocks			Information
Corona Discharge	Current	Eddie Currents	Particle Beams	Nuclear Forces
Electrostatic Fields	Magnetic Fields	Electromagnetic Fields		
Radio Waves	Micro Waves	Infrared	Visible	Ultraviolet	X-Ray	Cosmic

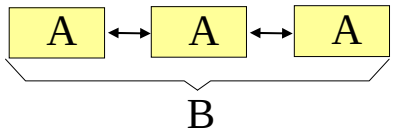
70 Inventive Principle #5—Consolidation: Consolidate in space homogeneous objects, or objects destined for contiguous operations. Consolidate in time homogeneous or contiguous operations. Genrich Altshuller, The Innovation Algorithm page 287.

71 Inventive Principle #1—Segmentation: Divide an object into independent parts. Make an object sectional (for easy assembly or disassembly). Increase the degree of an object's segmentation. Genrich Altshuller, The Innovation Algorithm page 287.

72 Inventive Principle #7—Nesting (Matrioshka): One object is placed inside another. That object is placed inside a third one. And so on. An object passes through a cavity in another object. Genrich Altshuller, The Innovation Algorithm page 287.

As in all of the merging methods, it may be necessary to break the element down into multiple pieces that can then interact. When an element is segmented into multiple elements, this creates new resources and properties such as adjustability[73].

Method



(Segmented or individual) (elements) have the property of being (setting A). When made to interact with each other by (field, mediator, method or arrangement), the overall effect is (setting B). (Setting A) is (expressed or hidden).

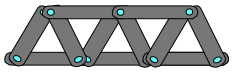
Example—Car Chain

The anti-slip device must be STIFF in order to dig into the ice on the road. It must be FLEXIBLE in order to wrap around the tire.

(Segmented) (anti-slip devices) have the property of being (stiff). When made to interact with each other by (interlocking), the overall system is (flexible). (Stiffness) is (expressed).

Example—Pinned Truss System of Support

The structure must BE UNABLE TO TRANSFER A MOMENT in order to more easily calculate the loads throughout the structure. The structure must CAPABLE OF CARRYING MOMENTS in order to transfer the load correctly.



(Segmented) (structural elements) have the property of being (unable to transfer a moment). When made to interact with each other through (pins), the overall effect is (capable of carrying a moment). (Unable to transfer a moment) is (expressed).

Example—Bicycle Chain

The transmission must be RIGID in order to not yield on the sprockets and it must be FLEXIBLE to wrap around the sprockets.

(Segmented) (transmission elements) have the property of being (rigid). When made to interact with each other by (hinging pins), the overall effect is (flexible). (rigid) is (expressed).

Example—Square and Round Shapes

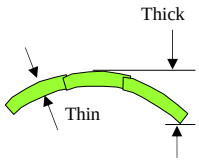
The individual shapes need to be ROUND in order to perform their proper function. They need to be SQUARE in order to fit nicely into an inexpensive box.

73 Inventive Principle #15—Dynamicity: Characteristics of an object or outside environment, must be altered to provide optimal performance at each stage of an operation. If an object is immobile, make it mobile. Make it interchangeable. Divide an object into elements capable of changing their position relative to each other. Genrich Altshuller, The Innovation Algorithm page 288.

(Individual) (shapes) have the property of being (round). When made to interact with each other by (being merged in a square shape), the overall effect is (square). (Round) is (expressed).

Example—Shell Structure

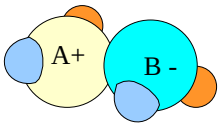
The structure needs to be THIN in order to be light. It needs to be THICK in order to be structurally sound.



(Segmented) (structural areas) have the property of being (thin). When made to interact with each other by (merging into a shell structure), the overall effect is (thick). (Thinness) is (expressed).

Example—Covalently Bonded Compounds

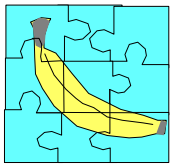
The molecules need to be CHARGED and NEUTRAL.



(Individual) (ions) have the property of being (charged). When made to interact with each other by (ionic bonding), the overall effect is (neutrally charged). (Being charged) is (hidden).

Example—Puzzle

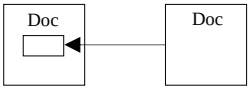
Each piece of the puzzle displays A PARTIAL PICTURE. What is required for viewing is AWHOLE PICTURE.



(Segmented) (picture pieces) have the property of being (a partial picture). When made to interact with each other by (interlocking), the overall effect is (a whole picture). (Being a partial picture) is (hidden).

Example—Interacting Documents

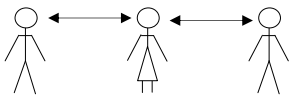
The individual specifications are INCOMPLETE making them difficult to understand. What is needed is a COMPLETE specification.



(Individual) (specifications) have the property of being (incomplete). When made to interact with each other by (a connecting database), the overall effect is (complete). (Incomplete) is (hidden).

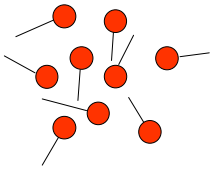
Example—Interacting Sales People Spread Information

Sales people in the group are UNKNOWLEDGEABLE. This is a disadvantage while working with customers. They must be KNOWLEDGABLE.



(Individual) (sales people) have the property of being (unknowledgeable). When made to interact with each other by (merging), the overall effect is (knowledgeable). (unknowledgeable) is (hidden).

Example—Gas Velocity



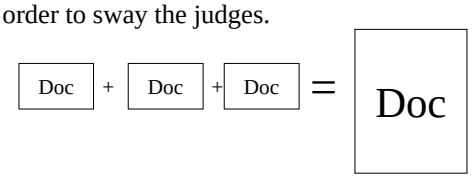
The beaker of liquid needs to be VERY STILL during an experiment. However, it is made of individual molecules which each have HIGH VELOCITIES.

(Individual) (molecules) have the property of being (high velocity). When made to interact with each other by (colliding), the overall effect is (collectively still at the macro level). (High velocity) is (hidden).

Example—Large Impact Affidavit

The affidavits have LITTLE IMPACT since they are only from average people describing small incidents of problems. This is the only way that they come. The affidavit needs to have MAJOR IMPACT in order to sway the judges.

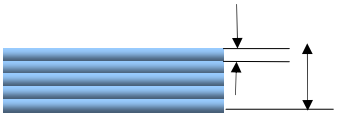
(Individual) (affidavits) have the property of being (small impact). When made to interact with each other by (merging into a book), the overall effect is (major impact). (Small impact) is (hidden).



Example—Thin and Thick Plates

At the critical moment of drilling, the plates need to be THICK. They need to be THIN because that is how they are supplied to the machining center.

(Individual) (plates) have the property of being (thin). When made to interact with each other by (merging into a clamped stack), the overall effect is (thick). (Thin) is (hidden).



Note that we use merging in Separation in Time. This might as well have been a case where there was a necessary reason for the plates to be thin in order to provide a useful function. We note, however, that at the critical time of drilling, the thinness is no longer useful and we need to discard this setting. We get to the same solution as in Separation in Time.

Example—Stiff Spring

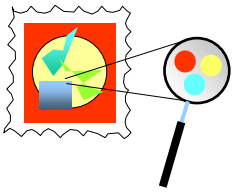
We need the spring to be STIFF but, unfortunately, we only have FLEXIBLE SPRINGS.

(Individual) (springs) have the property of being (flexible). When made to interact with each other by (several rows of springs where the springs share the load in parallel), the overall effect is (stiff). (Flexible) is (hidden).

Example—Colored Printing

The stamp needs to be MANY COLORS but there are only FEW COLORS.

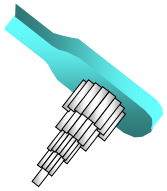
(Individual) (colors) have the property of being (few colors). When made to interact with each other by (groupings of areas where the fraction of each color is different), the overall effect is (many colors). (\Few colors) is (hidden).



Example Toothbrush

The bristles must be BLUNT because of the cutoff machine. But they must be SHARP in order to move the plaque.

(Individual) (levels of bristles) have the property of being (blunt). When made to interact with each other by (merging into a cone shape), the overall effect is (sharp). (Blunt) is (hidden).



Example—Superbolt

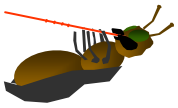
The tensioning bolt must have SMALL TENSION in order to have low installation torques. The tension bolt must have LARGE TENSION in order to tension large loads.

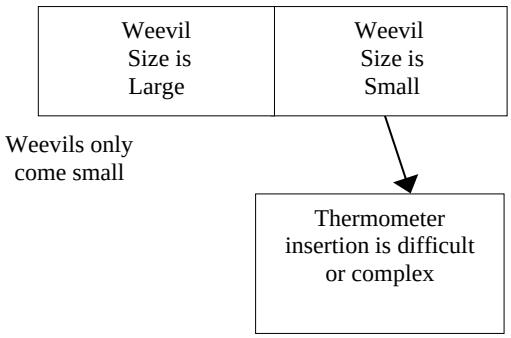
(Individual) (small bolts) have the property of being (small tension). When made to interact with each other by (merging into a circle), the overall effect is (large tension). (small tension) is (hidden).

This device is made by Superbolt company.

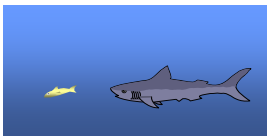
Exercise—The Lesser Weevil

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 AND SMALL**.** Using the principle that you have just learned, resolve this contradiction.

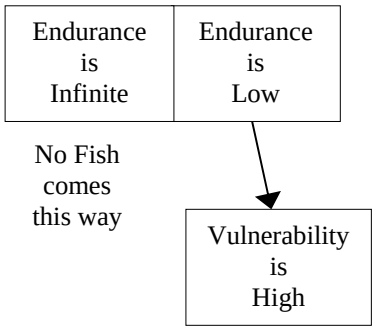




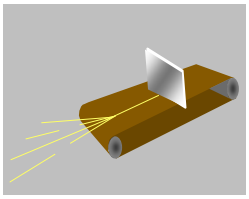
Exercise—Fish to the Rescue



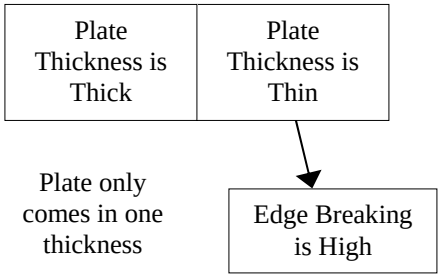
Like most large predators, a shark will follow its prey in close pursuit until the smaller prey exhausts its energy. Although the prey may be more nimble, it cannot outrun its larger foe forever. If the smaller fish could dodge and dart forever, it could easily outmaneuver the larger shark. The Fish should have INFINITE ENDURANCE in order to outrun the shark and NORMAL ENDURANCE because that is how small fish are. Resolve the contradiction by using the method you have just learned.



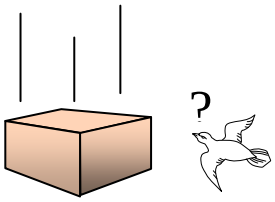
Exercise—A Slight Polishing



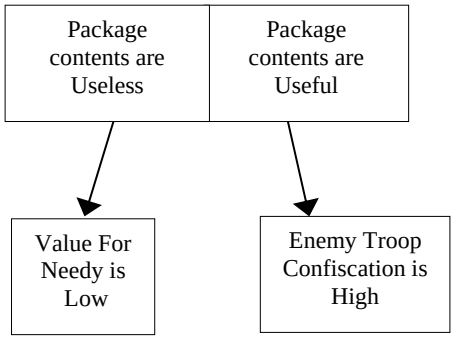
Your company polishes the edges of glass plates. Thousands of plates are polished each day. The edges of the glass plates are polished on a fast moving belt covered with abrasive materials. One day an order comes in for polishing glass plates which are only .010 inches thick. The first attempts to polish 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 THICK, but they only come THIN. Using the principle that you have just learned, resolve this contradiction.



Exercise—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 hoard the supplies to themselves. They quickly discover that the contents are useful and look for them. The Package Contents must be USEFUL AND USELESS Using the principle that you have just learned, resolve this contradiction.



Exercise—Traffic Light

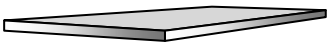
The lights in a traffic light must eventually FAIL due to the action of the current on the filament and to vibration. The traffic light must NOT FAIL in order to not cause traffic delays or make the intersection more dangerous.

Using the principle that you have just learned, resolve this contradiction.

Light Is not Failed	Light is Failed

Lights will fail eventually → Traffic Control is Hectic

Exercise—Metallic Film

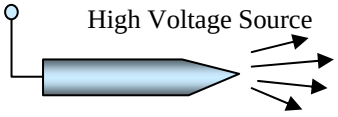


In the production of metallic laminates, Thick metallic films are produced by successively rolling the metal between rollers until it reaches the desired thickness. The resulting film is rolled up into large rolls which are easily manipulated. When making ultra thin films for laminates, new problems 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. Using the principle that you have just learned, resolve this contradiction.

Laminate Thickness is Thick	Laminate Thickness is Thin

Laminate thickness only useful in one thickness → Handling damage is high

Exercise—Molecular Wind Pump



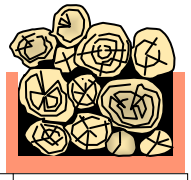
A molecular wind is created by applying a very high voltage source to a very sharp object. The electrostatic field gradient at the tip is very high. Any stray electrons in the gas (knocked off by a stray gamma ray for example) are accelerated by the field and collide with other molecules causing an avalanche 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.

Local Gas Movement is Large	Local Gas Movement is Small

Only comes one way → Flow is Miniscule

The Local Gas Movement should be SMALL & LARGE. Using the principle that you have just learned, resolve this contradiction.

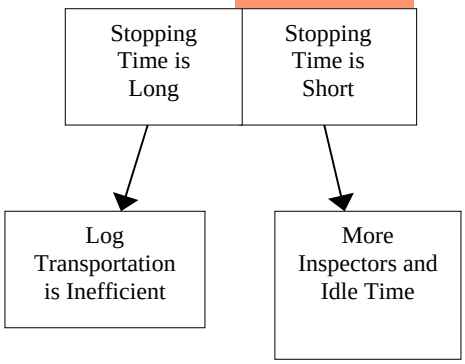
Exercise—Log Jam



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. Using the principle that you have just learned, resolve this contradiction.



L3-Carrier

One or more objects with one property are closely associated with a "carrier[74]" substance having the conflicting desirable property. The whole takes on the desired property of the carrier. Using carriers is one of the most powerful methods of changing the properties of objects.

If the property of the element is desirable, then they are arranged in the carrier in such a way that they are expressed at the smaller "micro" scale. Thus, both properties may be expressed or an undesirable property of the element may be hidden.

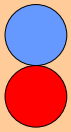
Using a carrier requires the addition of new substances which is not desirable, so try to find the least expensive carrier possible.

Simply **attaching** a carrier to the object may be sufficient to allow the carrier to "loan" its properties. This can be done in a variety of ways shown in the orange box, such as simply touching, being clamped together, adhering together, etc.

Objects with one property can be **nested**[75] inside another object having the conflicting desirable property. The whole takes on the desired property of the carrier. The carrier can be

Attaching

- Touch
- Adhere
- Clamped
- Hinged
- Dual Phase States (like ice and water)
- Attached Composite Structures



Nesting

- Nest
- Nestle
- Paint
- Inert Environments

Mixing

- Partially Mixed
- Mixture
- Interweave
- Fabrics and Matrix
- Multi Fiber Fabrics
- Multi Property Laminates
- Mixtures of Different Molecules
- Gels (Liquids + Solids)
- Pastes (Liquids + Solids)
- Foams (solid or liquid)
- Capillary Structures (Solid + Liquid)
- Components of Solids or Liquid
- Porous Materials
- Foams

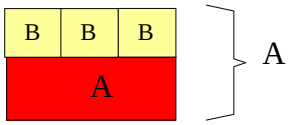
74 Inventive Principle #24—Mediator: Use an intermediary object to transfer or carry out an action. Temporarily connect the original object to one that is easily removed. Genrich Altshuller, The Innovation Algorithm page 288.

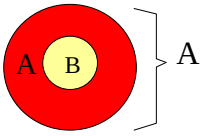
75 Inventive Principle #7—Nesting (Matrioshka): One object is placed inside another. That object is placed inside a third one. And so on. An object passes through a cavity in another object. Genrich Altshuller, The Innovation Algorithm page 287.

solid, liquid or gas. Consider some of the more unusual carriers in the orange box.

A segmented[76] carrier having a desirable property may be **mixed** with segmented or multiplied elements having the opposing undesirable property. The whole takes on the properties of the carrier. The orange box shows some of the more unusual carrier mixtures possible. Refer to these as you consider resolving your contradiction. The term "segmented carrier" has reference to liquid molecules, fibers and even larger elements such as laminate sheets. Consider finer and finer scales down to sub-atomic particles.

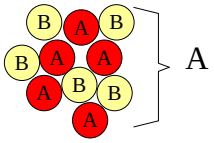
Method





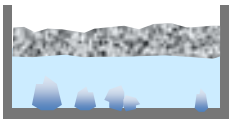
(An inexpensive carrier object or substance) which is (setting A) is (attached to, surrounding or mixed with) (segmented or individual) (elements) which are (setting B) thus loaning its property and making the combination (setting A) at the macro scale. (Setting B) is (hidden or expressed at the micro scale).

Example—Separating Rocks from Mulch



Rocks do not readily separate themselves from mulch. It would be much better if the mulch were LIQUID rather than SOLID.

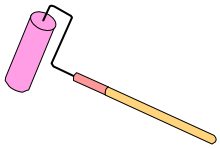
(Water) which is (liquid) is (mixed with) (individual) (mulch elements) which are (solid) thus loaning its property and making the combination (liquid) at the macro scale. (Solidness) is (hidden)



The rocks fall through easily.

Example—Paint Roller

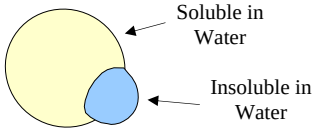
In order to paint ceilings, it is desirable that the paint rollers are LONG. Unfortunately, they come with SHORT handles.



(A pole) which is (long) is (attached to) (individual) (rollers) which are (short) thus loaning its property and making the combination (long) at the macro scale. (Shortness) is (hidden).

Example—Soluble Molecule

An herbicide which is INSOLUBLE IN WATER has to dissolve in water in order to be sprayed, but in order to dissolve in water it must be SOLUBLE IN WATER.

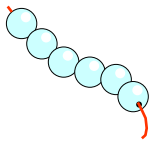


(A molecule) which is (soluble in water) is (attached to) (individual) (herbicide molecules) which are (insoluble in water) thus loaning its property and making the combination (soluble in water) at the macro scale. (Insolubility in water) is (hidden).

76 Inventive Principle #1—Segmentation: Divide an object into independent parts. Make an object sectional (for easy assembly or disassembly). Increase the degree of an object's segmentation. Genrich Altshuller, The Innovation Algorithm page 287.

Example—Beads on a String

Pearls are beautiful but they are STIFF and do not conform to the person that they are adorning. They must be FLEXIBLE.

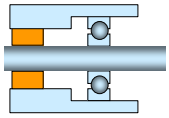


(A string) which is (flexible) is (attached to) (individual) (pearls) which are (stiff) thus loaning its property and making the combination (flexible) at the macro scale. (Stiffness) is (hidden).

Example—Backup Bearing

All bearings must eventually be FAILED but since it has a critical function it must NOT BE FAILED.

(A backup bushing) which is (not failed) is (attached to) (individual) (ball bearings) which are (failed) thus loaning its property and making the combination (not failed) at the macro scale. (Failed) is (hidden).



A bushing and a ball bearing are combined. The ball bearing performs the function with low friction until it fails and then the bushing takes over. The bearing has failed but the whole assembly has not failed. This is an example of a PREVIOUSLY PLACED CUSHION[77].

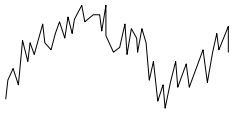
Example—Sand Paper

We require a RIGID structure in order to cut the surface of the wood, but we require a FLEXIBLE material in order to conform to the rounded contours of the wood project that we are making.

(Paper) which is (flexible) is (attached to) (segmented) (abrasive particles) which are (rigid) thus loaning its property and making the combination (flexible) at the macro scale. (Rigidness) is (expressed at the micro scale).

Example—Carrier Signals

A carrier wave can have HIGH FREQUENCY signals riding on LOW FREQUENCY signals. The property of low frequency is expressed at a large scale while the high frequency signal is expressed at a smaller scale.



(A signal) which is (low frequency) is (attached to) (individual) (signals) which are (high frequency) thus loaning its property and making the combination (low frequency) at the macro scale. (High frequency) is (expressed at the micro scale).

Example—Medicine Capsule

The small pellets of medicine are HARD TO SWALLOW due to their taste, but they need to be EASILY SWALLOWED in order to be an effective medicine.

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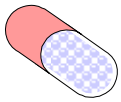
77 Inventive Principle #11—Cushion in Advance: Compensate for the relatively low reliability of an object with emergency measures prepared in advance. Genrich Altshuller, The Innovation Algorithm page 287.

(A gel capsule) which is (easily swallowed) is (surrounding) (segmented) (medicine) which are (hard to swallow) thus loaning its property and making the combination (easy to swallow) at the macro scale. (Hard to swallow) is (hidden).



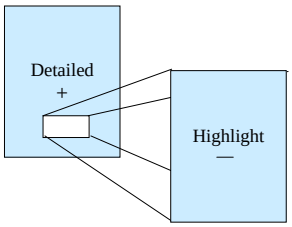
Example—Fossil Preservation

The fossil must be DURABLE in order to be transported long distances. However, the fossil as it comes out of the ground is FRAGILE.

(A plaster and gauze coating) which is (durable) is (surrounding) (individual) (fossils) which are (fragile) thus loaning its property and making the combination (durable) at the macro scale. (Fragility) is (hidden).

Example—Highlighting Instructions

The instructions need to be BRIEF in order to have quick action. The instructions need to be LENGTHY in order to get an accurate response.



(Short instructions) which are (brief) are (surrounded by) (individual) (instructions) which are (lengthy) thus loaning its property and making the combination (brief) at the macro scale. (Lengthy) is (expressed at the micro scale).

Note that in this example, the carrier is surrounded by the non-carrier item. When people look at the instructions, the first thing that they see are the brief instructions which get them going.

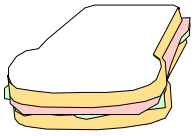
Example—the Car Makes You Look Good

An UNATTRACTIVE person wants to be ATTRACTIVE.

(A car) which is (attractive) is (surrounding) (individual) (people) which are (unattractive) thus loaning its property and making the combination (attractive) at the macro scale. (Unattractiveness) is (hidden).

Example—Hiding Parts of a Sandwich

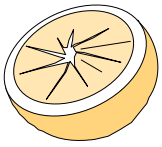
The condiments of a sandwich are MESSY. However, they must NOT BE MESSY in order to feed a large group of people in a nice setting.



(Bread) which is (not messy) is (surrounding) (individual) (condiments) which are (messy) thus loaning its property and making the combination (not messy) at the macro scale. (Messiness) is (hidden).

Example—Citrus Fruit

Citrus fruit needs to be NUTRITIOUS in order to feed large animals. In order that insects do not eat it must be POISONOUS TO INSECTS.

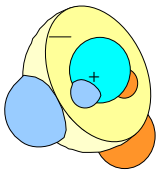


(A peel) which is (poisonous to insects) is (surrounding) (individual) (fruits) which are (nutritious) thus loaning its property and making the

combination (poisonous) at the macro scale. (Nutritious) is (expressed at the micro scale).

Example—Nested Molecule

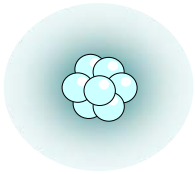
An herbicide which is INSOLUBLE IN WATER has to dissolve in water in order to be sprayed, but in order to dissolve in water it must be SOLUBLE IN WATER.



(A molecule) which is (soluble in water) is (surrounding) (individual) (herbicide molecules) which are (insoluble in water) thus loaning its property and making the combination (soluble in water) at the macro scale. (Insolubility in water) is (hidden).

Example—Atom—Fast Electrons Over a Slow and Massive Nucleus

The atomic structure needs to be ACTIVE in order to interact with other atomic structures. It needs to be INERT in order to stay in one location.



(Electrons) which are (active) are (surrounding) (individual) (nuclei) which are (inert) thus loaning its property and making the combination (active) at the macro scale. (Inertness) is (expressed at the micro scale).

Example—Hair Gel

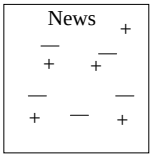
A hair setting liquid (adhesive) must be an easily FORMABLE SOLID in order to be spread by the hands in the hair. Unfortunately, it is a NON-FORMABLE LIQUID.

(Colloidal silicon dioxide—nano glass) which is (a formable solid) is (mixed with) (segmented) (hair-setting liquid) which is (a non-formable liquid) thus loaning its property and making the combination (a formable solid) at the macro scale. (Non-formable liquid) is (hidden).

Example—Unbiased Truth?

While purporting to be completely unbiased and a model for telling both sides of the story, a newspaper can easily become an advocate for some editorial point that the editors or journalists would like to make.

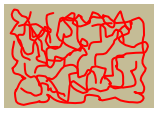
Editors at a nationally syndicated paper would like to report on a story but also make an editorial point. They want to give MESSAGE A. Unfortunately, the events surrounding the article do not directly support message A. If the simple facts were reported, the article would give MESSAGE B. How can the newspaper make its editorial point and still just report "the news"? (It is recognized that this is a somewhat subversive example meant to sensitize reasonable people to what may be happening around them.)



(A number of small editorial articles or advertisements) which are (message A) are (mixed with) (segmented) (news articles) which are (message B) thus loaning its property and making the combination (message A) at the macro scale. (Message B) is (expressed at the micro scale).

Example—Conductive Plastic

An article must be made from plastic which is an ELECTRICAL INSULATOR in order to make it less expensively with injection molding. The article must be made from metal or graphite which is an ELECTRICAL CONDUCTOR in order to electrically plate it. The property of insulator is not required at all.



(Particles of graphite) which are (electrically conductive) are (mixed with) (segmented) (plastic matrix) which is (an insulator) thus loaning its property and making the combination (electrically conducting) at the macro scale. (Electrically insulating) is (hidden).

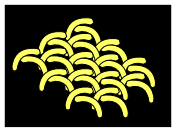
Example—High Strength Concrete

Concrete has high compressive strength but LOW TENSILE STRENGTH. This is almost always an undesirable property for a building material. The concrete needs to have HIGH TENSILE STRENGH for a variety of structures including stucco.

(Glass fibers) which are (high tensile strength) are (mixed with) (segmented) (cement) which is (low tensile strength) thus loaning its property and making the combination (high tensile strength) at the macro scale. (Low tensile strength) is (hidden).

Example—Composite fabric

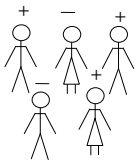
A medical material is sought which has many of the properties of nylon but is also THERMALLY CONDUCTIVE. Unfortunately, nylon fabrics are THERMAL INSULATORS.



(An aluminum fiber) which is (thermally conductive) is (mixed with) (segmented) (nylon fibers) which are (thermally insulating) thus loaning its property and making the combination (thermally conductive) at the macro scale. (Thermally insulating) is (hidden).

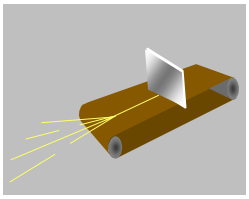
Example—Collectively Informed

Each person is individually UNINFORMED which is undesirable. But they need to be INFORMED in order to carry out the necessary tasks.



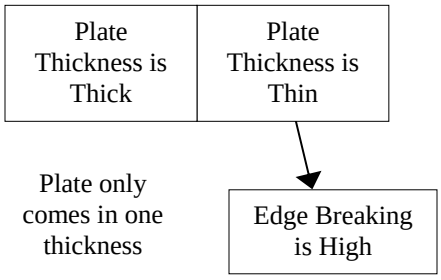
(Individuals) which are (informed) are (mixed with) (individual) (people) which are (uninformed) thus loaning their property and making the combination (informed) at the macro scale. (Uninformed) is (hidden).

Exercise—A Slight Polishing



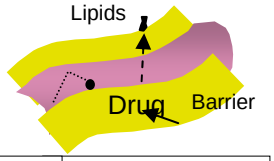
Your company polishes the edges of glass plates. Thousands of plates are polished each day. The edges of the glass plates are polished on a fast moving belt covered with abrasive materials. One day an order comes in for polishing glass plates which are only .010 inches thick. The first attempts to polish the edges are catastrophic. The edges are chipped so badly that the plates are unusable.

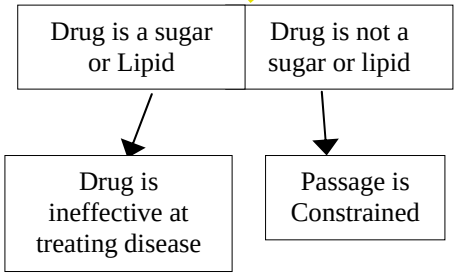
Due to the high volume of plates which are normally processed, it is not practical to change the machinery. The problem would go away if the plates were THICK, but they only come THIN. Using the principle that you have just learned, resolve this contradiction.



Exercise—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. Using the principle that you have just learned, resolve this contradiction.

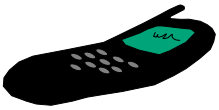


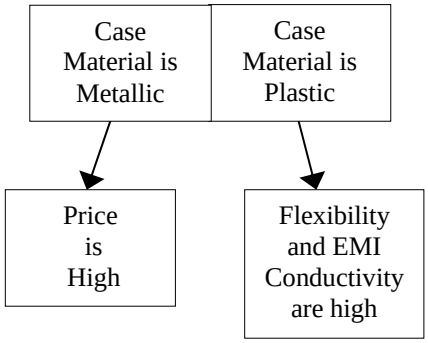


Exercise—A Limit to Cell Phones

Cell phone cases have become increasingly thinner. This reduces the weight and cost of raw materials. The traditional method of production has been injection molding. But, injection molding has reached several limits. The pressures required to inject into increasingly narrow passages is very high. Additionally, the cases are required to do more. They must be as rigid as metal and conductive like metal to reduce electromagnetic interference, yet they should be made from light moldable materials like plastic.

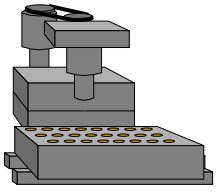
The cases should be METALLIC & PLASTIC. Using the principle that you have just learned, resolve this contradiction.



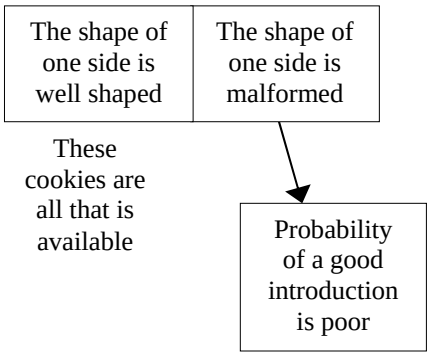


Exercise—Ugly Cookies

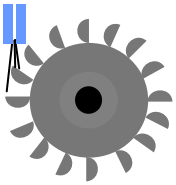
A production line for gourmet cookies has just been brought on line and has been in production for several days. The plant manager's wife inspects the cookies and discovers that they do not look like her home-made recipe. They are well shaped on one side but malformed on the other. "The equipment will 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 cookies should be MALFORMED & WELL SHAPED. Using the principle that you have just learned, resolve this contradiction.

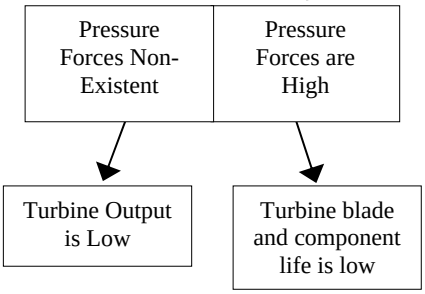


Exercise—Vibrating Water Wheel



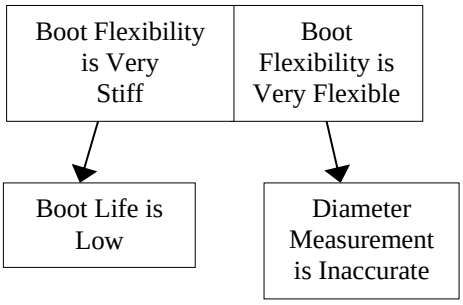
Consider an aluminum water wheel. Inlet flow strikes the blades after accelerating in the nozzle, transferring energy and momentum to the blade and wheel. During energy transfer the blade is bent slightly and released causing it to vibrate.

The resulting alternating stresses decrease 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 & ABSENT**.** Using the principle that you have just learned, resolve this contradiction.



Exercise—Too Flexible

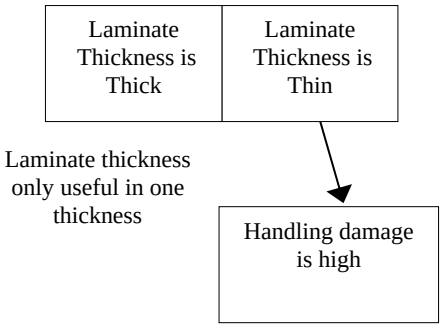
Various diameters of a thin rubber boot (which covers part of a car shift mechanism) must be measured with great accuracy at several points. Unfortunately, the micrometer which is used deforms the boot during the measurement. This makes the measurement inaccurate. How can the boot be measured more accurately? The Boot Flexibility Needs to be FLEXIBLE & STIFF. Resolve the Contradiction using the principle that you have just learned.



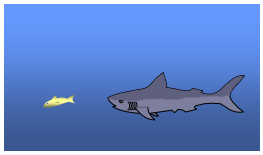
Exercise—Metallic Film

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.

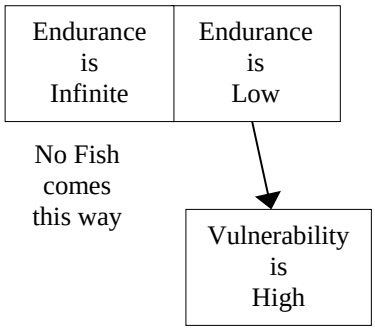
When making ultra thin films for laminates, new problems arise. Because the film is so thin, both the production and manipulation becomes difficult. The tolerance between rollers becomes unreasonable and handling damage becomes very high. The laminate must be THICK & ULTRA-THIN. Using the principle that you have just learned, resolve this contradiction.



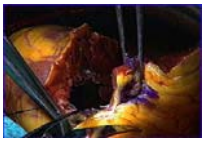
Exercise—Fish to the Rescue



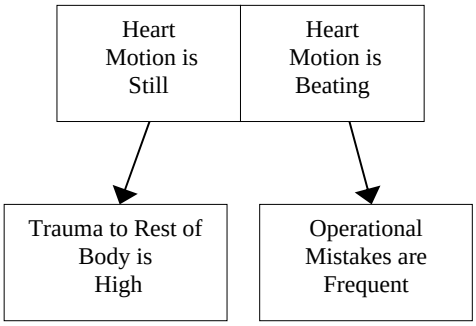
Like most large predators, a shark will follow its prey in close pursuit until the smaller prey exhausts its energy. Although the prey may be more nimble, it cannot outrun its larger foe forever. If the smaller fish could dodge and dart forever, it could easily outmaneuver the larger shark. The Fish should have INFINITE ENDURANCE in order to outrun the shark and NORMAL ENDURANCE because that is how small fish are. Resolve the contradiction by using the method you have just learned.



Exercise—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. Using the principle that you have just learned, resolve this contradiction.



Exercise—Traffic Light

The lights in a traffic light must eventually FAIL due to the action of the current on the filament and to vibration. The traffic light must NOT FAIL in order to not cause traffic delays or make the intersection more dangerous.

This is an example of an output contradiction. Most people would think of this as the Y in the function. Resolve this contradiction using the method you have just learned.

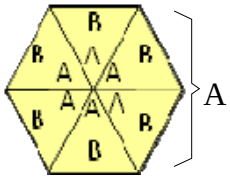
Traffic Light Operation Fails	Traffic Light Operation Doesn't Fail
All lights will eventually fail	Note that nothing gets worse

L3-Hiding Part

Multiple elements are involved. Each element *already* has *both* conflicting properties separated in space. One of the conflicting properties is undesirable. The elements are merged in such a fashion that the undesirable feature of each element is hidden and only the desirable property is expressed. This may be possible when the element has the desired property in the slightest degree. Remember that this method should not be considered unless the existing elements already have both the desirable and undesirable properties.

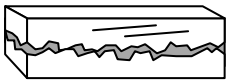
Method

Each individual (elements) already has the undesirable property of (setting A) and the desirable property of (setting B), even in the slightest degree. The (elements) are merged (into a configuration that hides setting A—try different orientations) thus giving the general property of (setting B).



Example—Hiding Roughness

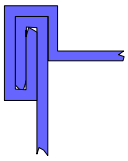
A sheet of granite has one side which is SMOOTH and the other side is ROUGH. We want a table that is entirely smooth.



Each individual (sheet) already has the undesirable property of (rough) and the desirable property of (smooth), even in the slightest degree. The (sheets) are merged (back to back with the rough sides inward) thus giving the general property of (smooth).

Example—Hiding Sharp Edges of a Can

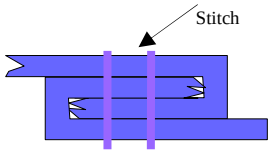
A can has the non-uniform condition of being partly SHARP (enough to cut skin) and mostly NOT SHARP.



Each individual (can part) already has the undesirable property of (being sharp) and the desirable property of (not being sharp), even in the slightest degree. The (can parts) are merged (by rolling the edges up in a seam) thus giving the general property of (being not sharp).

Example—Hiding Frayed Edges of Cloth

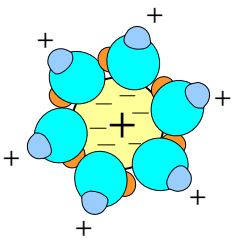
Most cloth has the undesirable property of being FRAYED at the edges. The rest is NOT FRAYED. The edges are rolled up and sewed into seams.



Each individual (piece of cloth) already has the undesirable property of (being frayed) and the desirable property of (not frayed), even in the slightest degree. The (pieces of cloth) are merged (by rolling the edges together and sewing them into seams) thus giving the general property of (not frayed).

Example—Hidden Molecular Poles

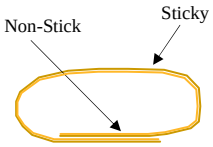
A molecule must be POSITIVELY CHARGED in order to have strong intermolecular effects. The molecules must be both NEGATIVELY AND POSITIVELY CHARGED in order to maintain a neutral polarity.



Each individual (molecule) already has the undesirable property of (negatively charged) and the desirable property of (positively charged), even in the slightest degree. The (molecules) are merged (around a strong positive charge so that only the negative charges are exposed) thus giving the general property of (positively charged to molecules close by).

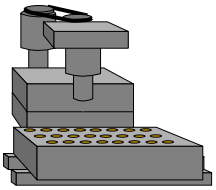
Example—Tape

The tape needs to be STICKY in order to stick objects to the wall for decoration. Unfortunately, the tape is NON-STICKY on one side.



Each individual (piece of tape) already has the undesirable property of (non sticky) and the desirable property of (sticky), even in the slightest degree. The (tape) is merged (into a rolled surface) thus giving the general property of (sticky). Note that this is done with one object.

Exercise—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 cookies should be MALFORMED & WELL SHAPED. Using the principle that you have just learned, resolve this contradiction.

The shape of one side is well shaped	The shape of one side is malformed

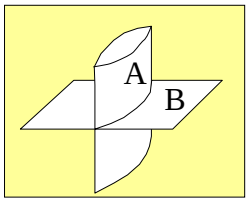
These cookies are all that is available

→ Probability of a good introduction is poor

L3-New Dimension

The properties of a section of an object can have very different properties from the whole object. This is important because our thinking may be trapped in one dimension and the answer lies in another. The property in one dimension is undesirable. The property in the other dimension is desirable[78].

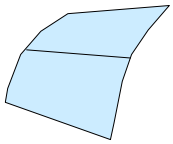
Method:



The (element) has the property of being (setting A). Going (up or down) in dimension gives the (element) the property of being (setting B) since (explanation).

Example—Curved surface

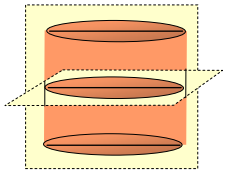
The panel needs to be STRAIGHT in order to have low aerodynamic drag. It needs to be CURVED in order to conform to the frame of the aircraft.



The (panel) has the property of being (curved). Going (down) in dimension gives the (panel) the property of being (straight) since (a section through the panel is a straight line which is sufficient in the direction of air flow).

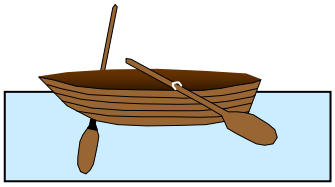
Example—Cylinder Section

A cylindrical section of a capacitor has SMALL ELECTRICAL STORAGE AREA, but the capacitor must have a LARGE ELECTRICAL STORAGE AREA.

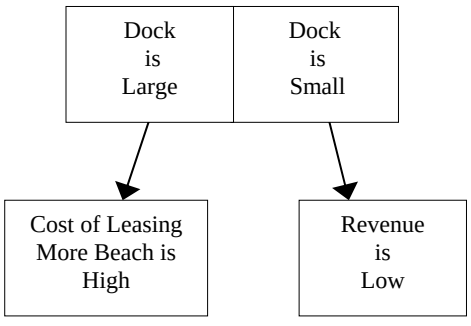


The (capacitor) has the property of being (small electrical storage area). Going (up) in dimension gives the (capacitor) the property of being (large electrical storage area) since (a lot of area can be packed into a very small volume, depending on the dielectric strength of the dielectric material that is used)

Exercise—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



78 Inventive Principle #17—Transition Into a New Dimension: Transition one-dimensional movement, or placement, of objects into two- dimensional ; two-dimensional to three-dimensional, etc. Utilize multi-level composition of objects. Incline an object, or place it on its side. Utilize the opposite side of a given surface. Project optical lines onto neighboring areas, or onto the reverse side, of an object. Genrich Altshuller, The Innovation Algorithm page 288.

making a few calculations. The Dock should be SMALL & LARGE**.** Using the principle that you have just learned, resolve this contradiction.

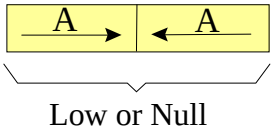
L3-Countering

Two strong actions are capable of yielding a null action if they are oriented to cancel each other[79]. This principle is typically used with actions, fields or forces that have direction. If more than one element can be used, then two of these elements can be oriented so as to counter each other. Alternately, another opposite action can be introduced which counters the action. Consider the possible countering methods shown in the tan box.

- Opposing Element
- Counter Weight with Transmission means
- Negative Spring Rate
- Negative rate of change of lever arm
- Counter Field Gradient

Method

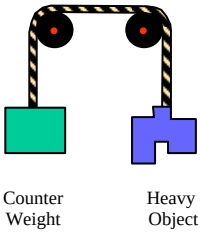
The (element) (force, field, field gradient or action) has a direction with the undesirable property of (setting A). Countering the (force, field, field gradient or action) with (a counter measure) gives the desirable (setting B--Low or Null).



Example—Counter Weight

A HEAVY automobile transmission is difficult to move about. It must have NULL weight.

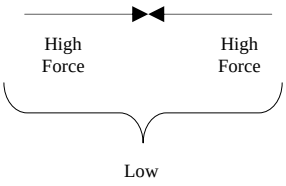
The (transmission) (weight) has a direction with the undesirable property of (heavy). Countering the (weight) with (a counter weight with transmission cable) gives the desirable (null weight).



Example—Counter Force

A spring has a very HIGH preload due to its high spring rate and working conditions. However, it must have a very LOW preload in the application.

The (spring) (preload force) has a direction with the undesirable property of (high force). Countering the (preload force) with (another high rate spring preload) gives the desirable (low force).

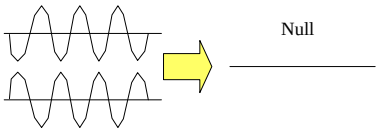


Example—Counter Signal

A HIGH AMPLITUDE signal must be rapidly turned off to become a NULL signal. Unfortunately, the signal can turn on rapidly but decays slowly when turned off.

79 Inventive Principle #8—Counterweight: Compensate for the weight of an object by combining it with another object that provides a lifting force. Compensate for the weight of an object with aerodynamic or hydrodynamic forces influenced by the outside environment. Genrich Altshuller, The Innovation Algorithm page 287.

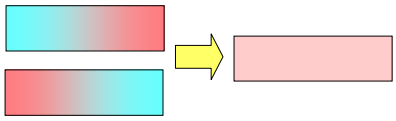
The (signal) (amplitude) has a direction with the undesirable property of (high amplitude). Countering the (amplitude) with (a counter signal 180 degrees out of phase) gives the desirable (null signal).



Example—Counter Gradient

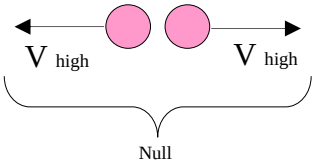
Due to temperature stratification in a heat exchanger, the exiting air has a HIGH THERMAL GRADIENT. In order for temperature sensors to give accurate readings of the bulk temperature of the air, there should be NO THERMAL GRADIENT.

The (air) (temperature gradient) has a direction with the undesirable property of (high thermal gradient). Countering the (temperature gradient) with (a counter thermal gradient) gives the desirable (low thermal gradient).



Example—Counter Momentum

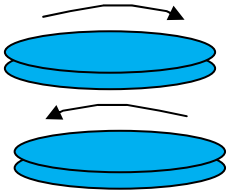
High velocity movements of large objects within a camera can cause the camera to move. A HIGH VELOCITY Motion is required but undesirable. There must be NULL VELOCITY movement.



The (camera element) (motion) has a direction with the undesirable property of (high velocity). Countering the (motion) with (a high velocity motion of a counter weight in the opposite direction) gives the desirable (null velocity of the system).

Example—Flywheel Reaction Forces

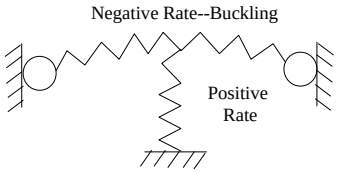
A flywheel is used to store energy in a vehicle. The flywheel rotates at very high speed. When the vehicle turns a corner or changes incline, the gyroscopic action of the flywheel generates large forces which act on the vehicle. These large forces are undesirable. The flywheel generates HIGH REACTION FORCES but in order to not stress the structure, we need LOW REACTION FORCES.



The (flywheel) (gyroscopic force) has a direction with the undesirable property of (high reaction force). Countering the (gyroscopic force) with (a high reaction force) gives the desirable (low reaction force).

Two gyroscopes cancel each other's reaction forces.

Example—Non Buckling Column

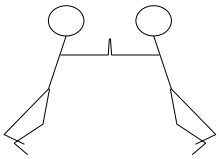


During the axial loading of long thin structures, the phenomenon of buckling can occur. It occurs catastrophically because as the column buckles, the effective axial spring rate drops. In other words, the further you push it, the less it pushes back. This is referred to as a negative spring rate. The column has a HIGH NEGATIVE RATE. In order to safely support high forces, the column should have a LOW OR POSITIVE RATE.

The (column) (spring rate) has a direction with the undesirable property of (high negative rate). Countering the (spring rate) with (a high positive rate spring) gives the desirable (low or positive rate).

Example—Organization Strengths

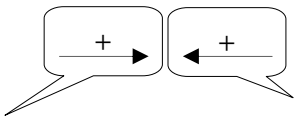
A HIGH implementation speed can become a weakness in certain conditions, especially when trying to sync up with other organizations that are not as fast. The organization needs to be operating a LOW implementation speed.



The (organization) (implementation speed) has a direction with the undesirable property of (high). Countering the (speed) with (another part of the organization trying to implement in a different direction) gives the desirable (low organizational speed).

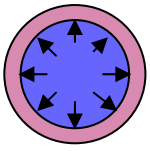
Example—Nullifying an Argument

A STRONG statement has been made by someone high up in an organization. The statement came across too strongly and only represented his point of view. The statement should be WEAK.

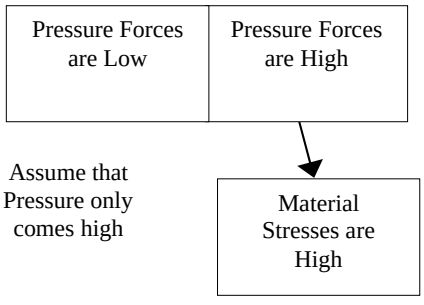


The (statement) (effect) has a direction with the undesirable property of (strong). Countering the (effect) with (a strong counter statement from another high official in the organization) gives the desirable (weak effect).

Exercise—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**.** Using the principle that you have just learned, resolve this contradiction.

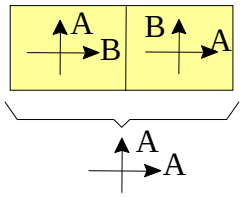


L3-Complementary Directions

When objects have the required property in only one direction, they can be combined with another element that has the same property in only one direction. These become complimentary and allow the required property in both directions.

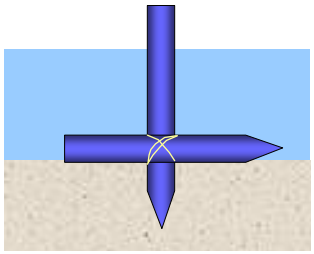
Method

Each (element) is (setting A) which is desirable in one direction and (setting B) which is undesirable in another direction. Combining two or more (elements) and orienting them in a complementary fashion makes the combination (setting A) in both directions.



Example—Pile Driving

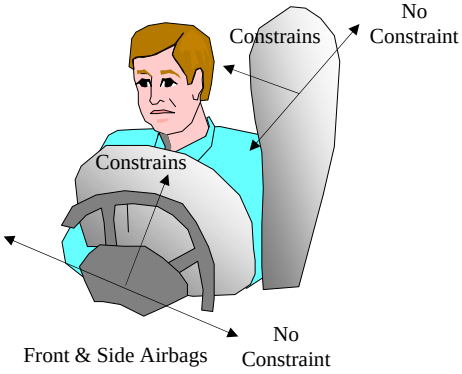
The pile must be SHARP in order to drive and Blunt in order to support.



Each (pile) is (blunt) which is desirable in one direction and (sharp) which is undesirable in another direction. Combining two or more (piles) and orienting them in a complementary fashion makes the combination (blunt) in both directions.

Example—Car Airbags

A car airbag CONSTRAINS in one direction only. In the other direction there is NO CONSTRAINT. It is desirable that the airbags can constrain in both directions.



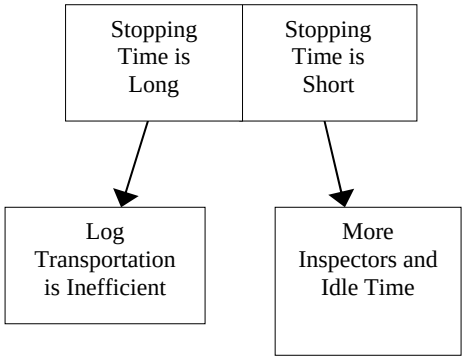
Each (airbag) is (constraining) which is desirable in one direction and (not constraining) which is undesirable in another direction. Combining two or more (airbags) and orienting them in a complementary fashion makes the combination (constraining) in both directions.

Exercise—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. Using the principle that you have just learned, resolve this contradiction.

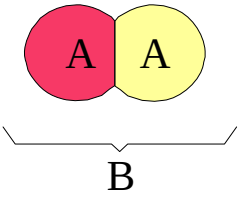


L3-Coordinated Parts

A functional part with one property coordinates or cooperates with another part having a complimentary function and the same property. The whole has the conflicting property. In this case, we want both properties expressed.

Method

Adjustable[80] *(elements) have the property of being (setting A). When coordinated with each other by (method), the overall effect is (setting B). (Setting A) is (expressed or hidden).*

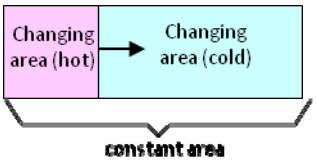


Example—Water Faucet

Many water faucets have separate hot and cold water knobs. If one CHANGES the flow of the hot water, in order to adjust the temperature, the total flow must NOT CHANGE.

Adjustable (flow areas) have the property of being (changing). When coordinated with each other by (a coordinated partition), the overall effect is (NOT CHANGE). (CHANGES) is (expressed).

Imagine that the water is flowing out of the page through each respective flow area. As the partition moves, the percent of cold and hot changes, but the combined flow area remains constant.

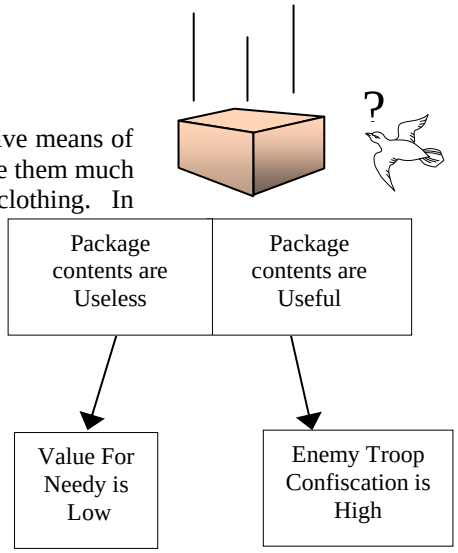


A coordinated partition between the hot and cold flow areas moves back and forth so that the net area does not change.

80 Inventive Principle #15—Dynamicity: Characteristics of an object or outside environment, must be altered to provide optimal performance at each stage of an operation. If an object is immobile, make it mobile. Make it interchangeable. Divide an object into elements capable of changing their position relative to each other. Genrich Altshuller, The Innovation Algorithm page 288.

Exercise—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 hoard the supplies to themselves. They quickly discover that the contents are useful and look for them. The Package Contents must be USEFUL AND USELESS. Using the principle that you have just learned, resolve this contradiction.



L2-Separate by Direction

An object can have conflicting properties in different directions in the same space and at the same time. This is one of the most powerful separation principles. A simple example of this is a rope. When pulled in the direction of tension, the rope is stiff. However, if you try to push a rope, it is flexible. Many objects already have a separation of the opposing properties by direction but we have not exploited this separation.

Following is the test and the various strategies for Separating by Direction.

L2-Method

Does one of the conflicting properties already exist in a different direction or can it be modified to be so?

--Consider having one property in one direction and the other in another direction.

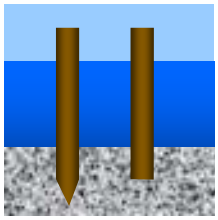
--Consider the opposite or rotary directions

L3-Test for Separation by Direction

Test:

Does one of the conflicting properties already exist in a different direction or can it be modified to be so? If "no" then continue to separate by perspective. Otherwise try to separate by direction.

Example—Pile Driving

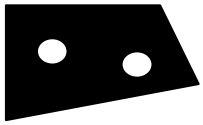


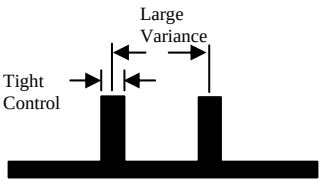
The pile should be SHARP for driving and BLUNT for supporting.

Test: Does one of the conflicting properties already exist in a different direction or can it be modified to be so?

The pile is already blunt in its sides. We conclude to try to separate by direction.

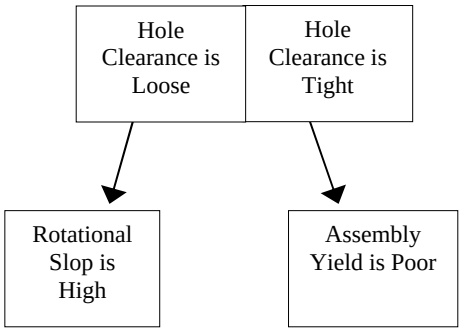
Exercise—A Post and an Outpost



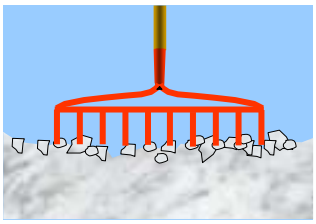


For years your company has produced an aircraft product which fits over two posts on your customer's aircraft. Both the position and the diameter of the posts were closely controlled. Unfortunately, a recent production change by the customer allows a large variance in the distance between the posts. Now there is no guarantee that the part which you produce will fit over the customers posts.

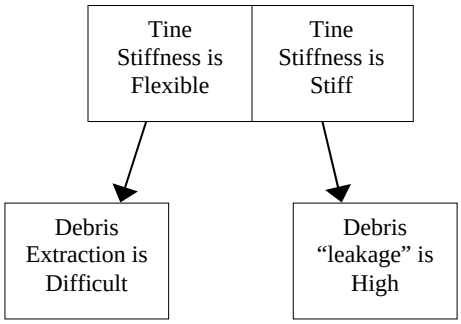
(The diameter of the posts is still closely held). The customer is unwilling to change the new production process, but has instead asked you to modify the part so that it will fit snuggly in the application, without rotating. If the hole clearance is large, they can easily fit over, but they will not be snug. The Hole Clearance needs to be LOOSE & TIGHT. Test for Separation by Direction.



Exercise—Two Tining Rake

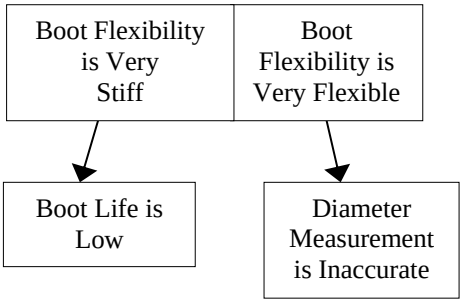


A common garden rake is somewhat inefficient when raking small debris. While riding over uneven surfaces, unwanted debris settles into the uneven surface and the tines ride over the top without collecting the debris. If the tines were more flexible, they could ride over the uneven surfaces like a leaf 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. Test for Separation by Direction.

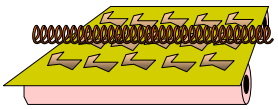


Exercise—Too Flexible

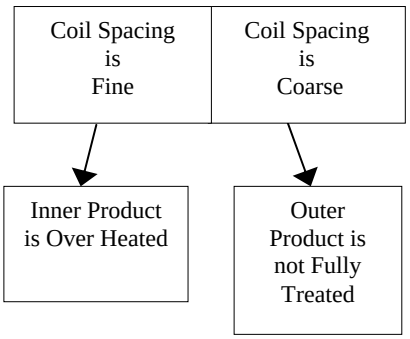
Various diameters of a thin rubber boot (which covers part of a car shift mechanism) must be measured with great accuracy at several points. Unfortunately, the micrometer which is used deforms the boot during the measurement. This makes the measurement inaccurate. How can the boot be measured more accurately? The Boot Flexibility Needs to be FLEXIBLE & STIFF. Resolve the Contradiction using the principle that you have just learned.



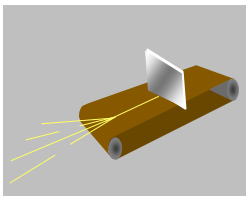
Exercise—Blistering Coils



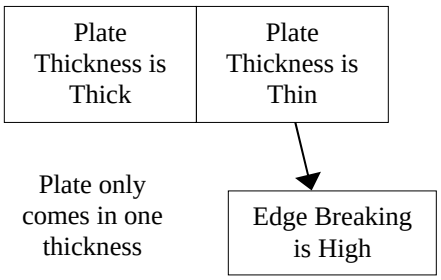
Product on an assembly line must pass under a heating coil in order to be fully treated. The product that passes under the center part of the coil is fully treated, but the product that passes under the coil at the edge of the conveyor belt is not fully treated. If the coil spacing was finer, the outer product could be fully treated. However, the product at the center of the belt is over-heated. The Coil Spacing should be FINE & COARSE. Using the principle that you have just learned, resolve this contradiction.



Exercise—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 THICK, but they only come THIN. Test for Separation by Direction.

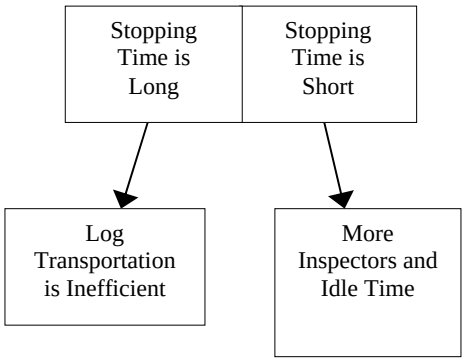


Exercise—Log Jam

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.

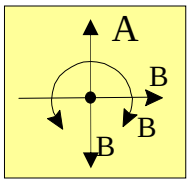
The Stopping Time Needs to be LONG & SHORT. Test for Separation by Direction.



L3-Direction

Separation by direction allows one property to exist in one direction and the opposing property to exist in other directions. If one mentally goes through the rough directions of opposing, right angle and rotary directions, something will often come to mind. It is easy to forget some of the directions in the heat of problem solving.

Method

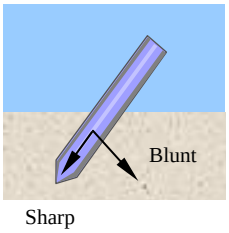


The (element) is (setting A) (in direction A). The (element) (is already or can become) (setting B) (in the opposite direction or at right angles or in the rotary direction) if (new conditions—give explanation if required).

Example—Pile Driving

The pile needs to be SHARP in order to drive rapidly and BLUNT in order to support well.

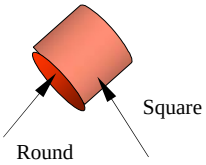
The (pile) is (sharp) (in the direction of driving). The (pile) (is already) (blunt) (at right angles) if (the supporting force is directed in the sideward direction).



A pile is naturally blunt in all directions but the driving direction which is SHARP. If the pile is driven at an angle, it immediately creates a dull surface for vertical support. If several are joined crosswise, the net effect is a very BLUNT support after driving.

Example—Square and Round Shapes

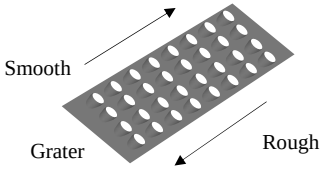
A cylinder needs to be ROUND for function A and SQUARE for function B.



The (cylinder) is (round) (when viewed from the end). The (cylinder) (is already) (square) (at right angles).

Example—Food Grater

In order to grate the food, the blades must be SHARP. In order to reposition the food for grating it should be SMOOTH.



The (grater) is (sharp) (in the direction of grating). The (grater) (can become) (smooth) (in the opposite direction) if (the cutting blades allow the food to slide over without cutting when the food is being moved in the opposite direction of grating).

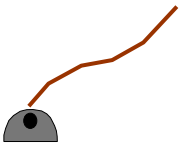
Example—Board

The board needs to be THICK in order to span a wall. It needs to be THIN in order to conserve wood and cost less.

The (board) is (thin) (in the vertical direction). The (board) (can become) (thick) (at right angles).

Example—Package Binding

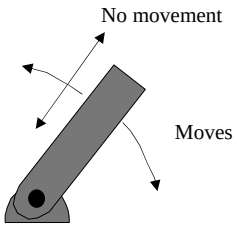
The binding needs to be STIFF in order to constrain the package tightly. It needs to be STIFF for easy positioning and to wrap around any shape.



The (binding) is (stiff) (in the direction of winding the package). The (binding) (can become) (flexible) (at right angles if (it is made thin enough).

Example—Structural Member

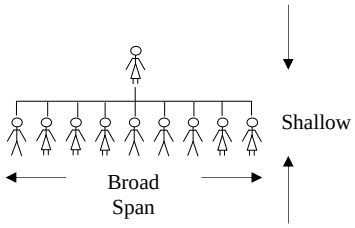
The structural member needs to have HIGH MOVEMENT in order to be easily assembled and join other structural members. It should have LOW MOVEMENT in order to not move under high loads.



The (structural element) is (low movement) (in all directions but rotary). The (structural element) (can become) (high movement) (in the rotary direction) if (supported by a pin).

Example—Organizational Size

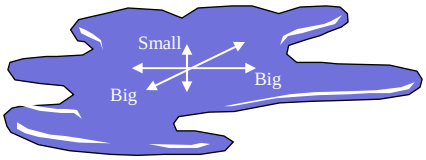
The organizational structure needs to be very SMALL in order to communicate rapidly. It needs to be LARGE in order to get a lot of work done.



The (organizational structure) is (small) (from the top to the bottom of the organization). The (organizational structure) (can become) (large) (at right angles) if (the span of control is greatly increased).

Example—Pond

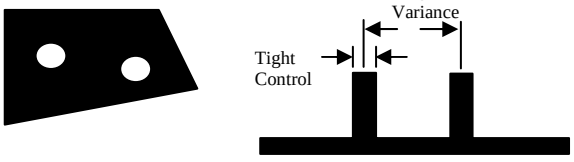
A pond at a housing development needs to be LARGE so that a lot of houses can enjoy a waterfront. It needs to be SMALL in order to conserve water.



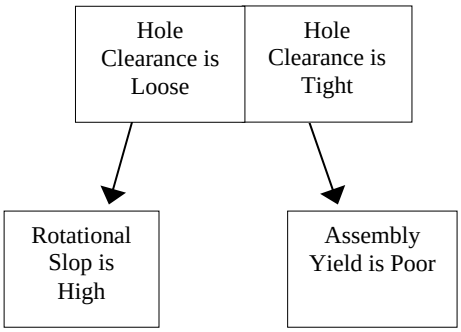
The (pond) is (large) (in all horizontal directions). The (pond) (can become) (small) (in the vertical direction) if (the pond is made to be somewhat shallow).

Exercise—A Post and an Outpost

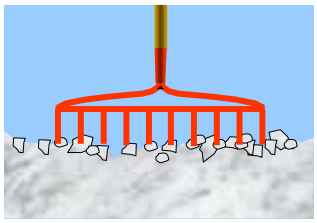
For years your company has produced an aircraft product which fits over two posts on your customer's aircraft.



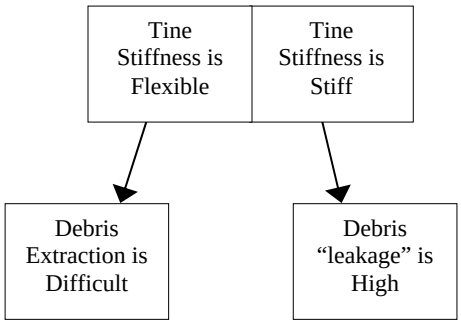
Both the position and the diameter of the posts were closely controlled. Unfortunately, a recent production change by the customer allows a large variance in the distance between the posts. Now there is no guarantee that the part which you produce will fit over the customers posts. (The diameter of the 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 fit snuggly in the application, 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 Resolve this contradiction using the method you have just learned.



Exercise—Two Tining Rake

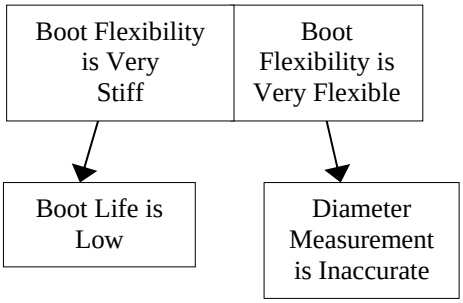


A common garden rake is somewhat inefficient when raking small debris. While riding over uneven surfaces, unwanted debris settles into the uneven surface and the tines ride over the top without collecting the debris. If the tines were more flexible, they could ride over the uneven surfaces like a leaf 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. Using the principle that you have just learned, resolve this contradiction.

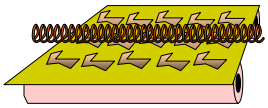


Exercise—Too Flexible

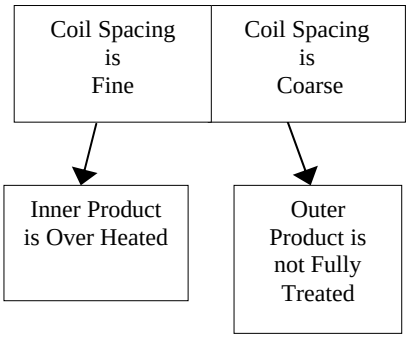
Various diameters of a thin rubber boot (which covers part of a car shift mechanism) must be measured with great accuracy at several points. Unfortunately, the micrometer which is used deforms the boot during the measurement. This makes the measurement inaccurate. How can the boot be measured more accurately? The Boot Flexibility Needs to be FLEXIBLE & STIFF. Resolve the Contradiction using the principle that you have just learned.



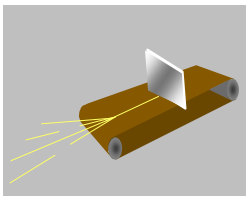
Exercise—Blistering Coils



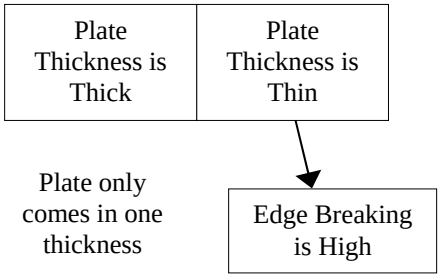
Product on an assembly line must pass under a heating coil in order to be fully treated. The product that passes under the center part of the coil is fully treated, but the product that passes under the coil at the edge of the conveyor belt is not fully treated. If the coil spacing was finer, the outer product could be fully treated. However, the product at the center of the belt is over-heated. The Coil Spacing should be FINE & COARSE. Using the principle that you have just learned, resolve this contradiction.



Exercise—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 THICK, but they only come THIN. Using the principle that you have just learned, resolve this contradiction.

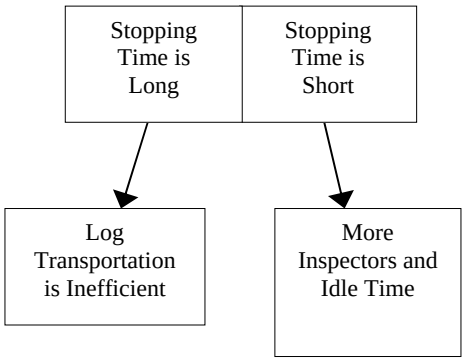


Exercise—Log Jam

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. Using the principle that you have just learned, resolve this contradiction.



L2-Separate by Perspective

In general, Separation by Perspective means that an object's properties are dependent on perception. This means that the element under consideration does not have to change its property. It is good enough to simply look like it has the opposite property.

We use many different senses to perceive, the most common being sight. However, we are not limited to this sense. It may be good enough to sound like, smell like or feel like it has the opposite property.

Following is the test and the various strategies for Separating by Perspective.

L2-Method

Brainstorm ways that one of the contradictory properties only appears to exist.

L3-Test for Separation by Perspective

Test:

Is it sufficient to only appear to have one of the knob settings? If "no" then continue on to Separate by Frame of Reference. Otherwise try to separate by perspective.

Example—Pile Driving

The pile should be SHARP for driving and BLUNT for supporting.

Test: Is it sufficient too only appear to have one of the knob settings? No, it is not good enough. We need both properties to actually exist in the piles. We will go on to Separation by Perspective

Example—Microscope

Bacterium comes SMALL, but in order for proper inspection, it needs to be LARGE.

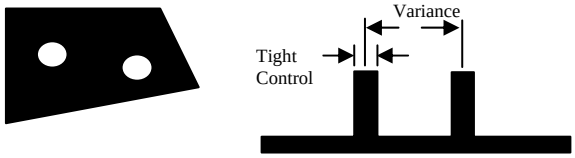
Test: Is it sufficient too only appear to have one of the knob settings? Yes, the object only needs to appear to be large in order to be inspected. We will try to separate by perspective.

Example—Fake Marble

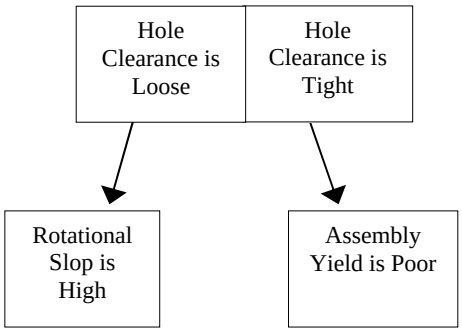
We need a column to be MARBLE in order to appear ornate. We need it to be WOOD because that is all that we have.

Test: Is it sufficient too only appear to have one of the knob settings? Yes, in this case, if it only appears to be marble, that is sufficient. We will try to separate by perspective.

Exercise—A Post and an Outpost

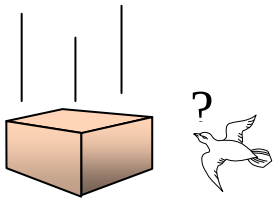


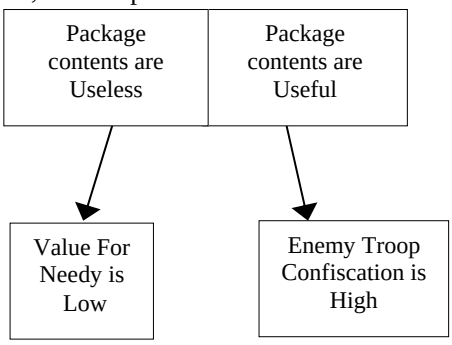
For years your company has produced an aircraft product which fits over two posts on your customer's aircraft. Both the position and the diameter of the posts were closely controlled. Unfortunately, a recent production change by the customer allows a large variance in the distance between the posts. 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 fit snuggly in the application, 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. Test for Separation by Perspective.



Exercise—Special Delivery

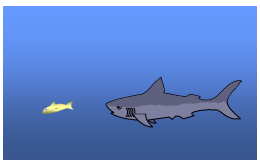
During war in a third world country, an effective means of gaining support from the local people is to give them much needed supplies such as medicine, food and clothing. In order to avoid anti-aircraft and small arms fire, the drop plane must fly high. If the package is dense and compact, it falls with 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 hoard the supplies to themselves. They quickly discover that the contents are useful and look for them. The Package Contents must be USEFUL AND USELESS Test for Separation by Perspective.



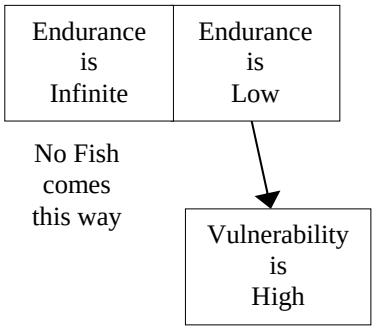


Exercise—Fish to the Rescue

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.

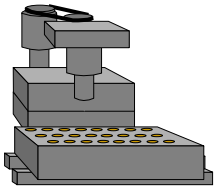


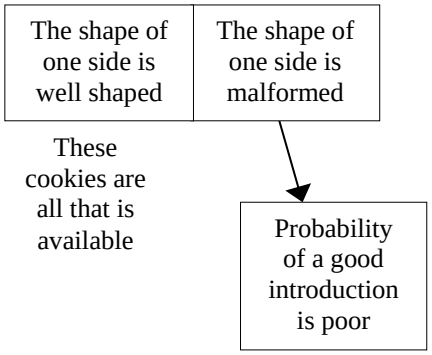
The Fish should have INFINITE ENDURANCE in order to outrun the shark and NORMAL ENDURANCE because that is how small fish are. Test for Separation by Perspective.



Exercise—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 cookies should be MALFORMED & WELL SHAPED. Test for Separation by Perspective.



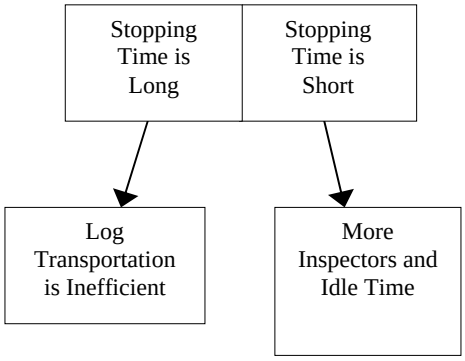


Exercise—Log Jam

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. Test for Separation by Direction.

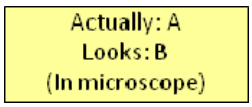


L3-How you Look or Perceive

Find physical phenomena that allow you to look at the Element in a different way. Remember that perception is not based on sight alone, but every sense.

Method

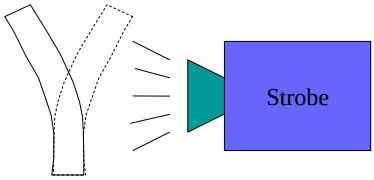
The (element) is naturally and unfortunately (setting A). It (looks like, sounds like, feels like or smells like) it is (setting B) when (a method of measurement or detection is used).



Example—Strobe Light

A vibrating object is RAPIDLY MOVING all of the time. In order to observe its shape, it needs to be STATIONARY.

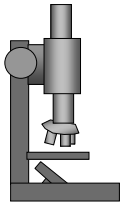
The (vibrating object) is naturally and unfortunately (moving). It (looks like) it is (stationary) when (a strobe scope is used to illuminate it when it is at any given position of its normal cycle).



Example—Microscope

Bacterium comes SMALL, but in order for proper inspection, it needs to be LARGE.

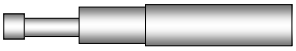
The (bacterium) is naturally and unfortunately (small). It (looks like) it is (large) when (viewed under a microscope).



Example—Telescope

A ship needs to be CLOSE in order to see the flags that it is displaying. Unfortunately, it is very DISTANT.

The (ship) is naturally and unfortunately (distant). It (looks like) it is (close) when (viewed through a telescope).



Exercise—Traffic Light

The lights in a traffic light must eventually FAIL due to the action of the current on the filament and to vibration. The traffic light must NOT FAIL in order to not cause traffic delays or make the intersection more dangerous.

This is an example of an output contradiction. Most people would think of this as the Y in the function. Resolve this contradiction using The method that you have just learned.

Traffic Light Operation Fails	Traffic Light Operation Doesn't Fail
All lights will eventually fail	Note that nothing gets worse

Exercise—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.

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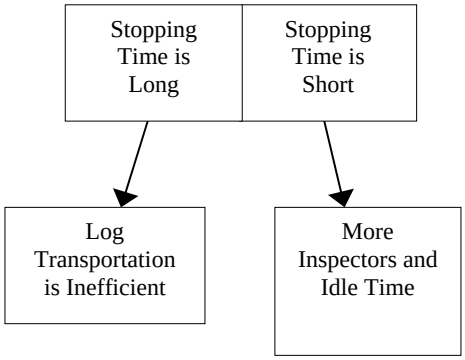
The Stopping Time Needs to be LONG & SHORT. Using the principle that you have just learned, resolve this contradiction.



L3-Looks Like

With this separation tool, it is good enough to look like the object has the conflicting property as opposed to actually having it. Note that this is actually a method for Separation in Space but grouped here for convenience.

Method

The (element) is unfortunately (setting A). But we can change its (appearance, sound, feel or smell) to seem like (setting B) when using (paint[81], a substitute or covering fake object, camouflage, substitute smells, substitute taste, substitute sound).

Example—Fake Marble

The panel must be MARBLE in order to be decorative. Unfortunately, all that we have is WOOD.

The (panel) is unfortunately (wood). But we can change its (appearance) to seem like (marble) when using (paint).

This is an example of the mainstream TRIZ principle of USING PAINT.

Example—Camouflage

The duck blind needs to be NATURAL AUTUMN LEAVES in order to not alert the ducks. It needs to be FABRIC AND METAL in order to set up and take down easily.

81 Inventive Principle #32—Changing the color: Change the color of an object or its environment. Change the degree of translucency of an object or its environment. Use color additives to observe an object or process which is difficult to see. If such additives are already used, employ luminescent traces or trace atoms. Genrich Altshuller, The Innovation Algorithm page 289.

The (blind) is unfortunately (fabric and metal). But we can change its (appearance) to seem like (natural autumn leaves) when using (camouflage).

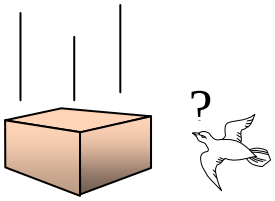
This is an example of the inventive TRIZ principle of USING PAINT[82].

Example—Hair Wig

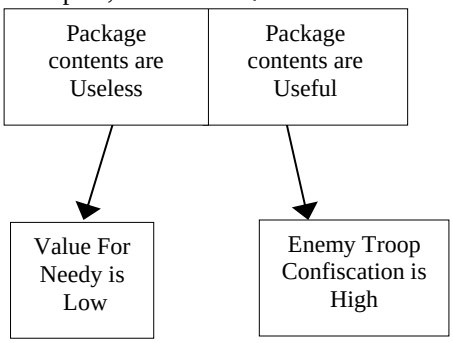
The hair is unfortunately BLACK. In order to perform the part in a play, the hair must be BLOND.

The (hair) is unfortunately (black). But we can change its (appearance) to seem like (blond) when using (a covering fake object).

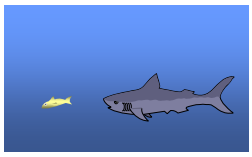
Exercise—Special Delivery



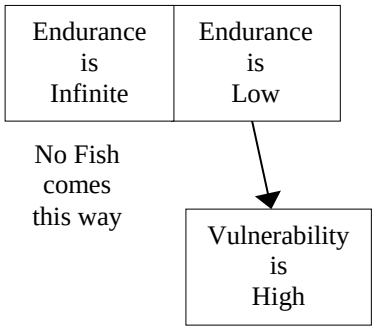
During war in a third world country, an effective means of gaining support from the local people is to give them much needed supplies such as medicine, food and clothing. In order to avoid anti-aircraft and small arms fire, the drop plane must fly high. If the package is dense and compact, it falls with 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 hoard the supplies to themselves. They quickly discover that the contents are useful and look for them. The Package Contents must be USEFUL AND USELESS Using the principle that you have just learned, resolve this contradiction.



Exercise—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 in order to outrun the shark and NORMAL ENDURANCE because that is how small fish are. Resolve the contradiction by using the method you have just learned.



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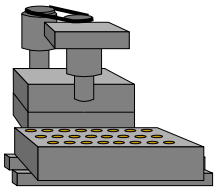
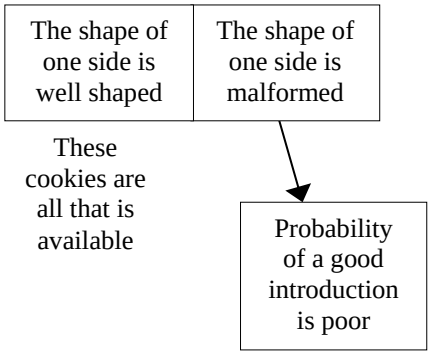
Exercise—Ugly Cookies



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 cookies should be MALFORMED & WELL SHAPED. Using the principle that you have just learned, resolve this contradiction.

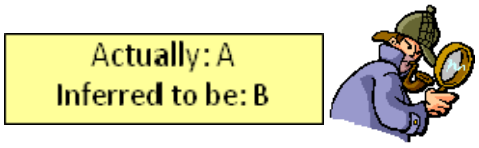


L3-Inference

The property state of an object is strictly implied by the property of another object. Logic tells us that only one state can be implied, even though the original has a very different state.

Method

The (element) is unfortunately (setting A). But we can change its (appearance, sound, feel or smell or effect) to seem like it is (setting B) by (a method to infer that it is setting B).



Example—Double Deception

An agreement is made that one person will place a black and a white pebble into a bag. If the second person draws a white pebble, then an unsavory event will occur. The first person, with evil intent, puts two black pebbles into the bag. The second person sees this, unknown to the first. Exposing the fraud of the first person is not an option. The best that can happen is if the second person draws a WHITE pebble from the bag, but this is not possible. It must be BLACK because that is all that can occur.

The (pebble) is unfortunately (black). But we can change its (appearance) to seem like it is (white) by (drawing a black pebble from the bag and not showing it, but dropping it on the ground among white and black pebbles. By inference, they can see which one was picked by looking into the bag and finding the second black pebble. Everyone infers that a white pebble was withdrawn.).

Exercise—Traffic Light

The lights in a traffic light must eventually FAIL due to the action of the current on the filament and to vibration. The traffic light must NOT FAIL in order to not cause traffic delays or make the intersection more dangerous.

Traffic Light Operation Fails	Traffic Light Operation Doesn't Fail
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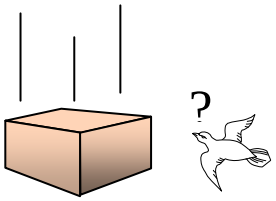
Exercise—Special Delivery



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 hoard the supplies to themselves. They quickly discover that the contents are useful and look for them. The Package Contents must be USEFUL AND USELESS Using the principle that you have just learned, resolve this contradiction.

Package contents are Useless	Package contents are Useful
Value For Needy is Low	Enemy Troop Confiscation is High

L2-Separate by Frame of Reference

Separation by Frame of Reference means that an object's properties are dependent on the frame of reference from which they are considered. For instance, I am sitting at my desk. None of my bodily movements are rapid. However, the earth is rotating very rapidly and my speed compared to the frame of reference of the sun is quite rapid. More rapid yet would be my speed compared to objects that are rotating counter to the earth's rotation on its axis or about the sun. At the same moment in time and in the same space, my speed is very rapid or very slow, depending upon the frame of reference.

No test is given for Separating by Frame of Reference because properties are *always* subject to the frame of reference that is assumed. If we cannot find an inertial frame of reference, we can almost always identify what the property is being compared to. Let's take some random examples. An object must not be "stinky" but it comes that way. We can always ask, stinky compared to what? What is your frame of reference? An onion is stinky compared to grape jelly, but is not nearly as stinky as a skunk. An onion is no longer stinky in a room filled with the odor of skunk. If I say that the oven is hot, what is this in reference to? A cooking oven may be hot compared to the temperatures required to bake a soufflé; but it is not hot compared to the baking temperature of bread. If we switch and bake bread in the oven, it is no longer considered hot. In each of these cases, we allow ourselves to change the frame of reference so that the conditions may be satisfied. Note that it is not the element that we are considering that is going to be changed, but rather the frame of reference that it is being compared to.

Unlike Separation by Perspective, this is more than just appearing to satisfy the conflicting requirements. A property can actually be changed by changing the frame of reference.

L2-Method

Brainstorm ways to resolve the contradictory properties by comparison to something else that changes or to switch to a new frame of reference.

L3-By Comparison

All knob settings are relative to something. Rather than change the element which cannot or should not be changed, the relative object is changed instead. In this case, if you change the actual element under consideration, *that is definitely the wrong answer*. The attribute of the second element that you must change is the frame of reference that is unconsciously used to tell us what an object's properties are. Most people would say that a needle is small without thinking about what it is compared to. Usually it is considered small because a human has to make use of it and it is small compared to human fingers, often making it difficult to manipulate. It is uncommon to consider what we compare things to. It would drive us insane if we always had to always consider that.

- Strong Acidifiers (Strong compared to Small Objects and Weak compared to Large objects)

Method

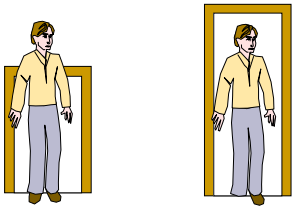
The (element) is already (setting A) when compared to (property of element 2). Changing (element 2) by (method of changing the property of element 2) makes the (element) (setting B).

A: Compared to Property Element 2
B: Compared to changed property

Example—Production Sets

The actor is SHORT because that is the way that he comes. But he needs to be TALL in order to play the part.

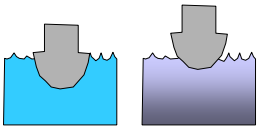
The (actor) is already (short) when compared to (the size of surroundings and other actors). Changing (the surroundings and other actors) by (miniaturizing the set props and putting the actor on a raised platform) makes the (actor) (tall).



Example—Buoyancy of an Object

A measurement float needs to be BUOYANT in order to be more visible above the surface of the liquid. Unfortunately, the float is quite heavy because it is made from a dense plastic and is therefore NOT BUOYANT.

The (measurement float) is already (not buoyant) when compared to (the density of the liquid it is floating in). Changing (the liquid it is floating in) by (changing to a much more dense liquid) makes the (measurement float) (buoyant).



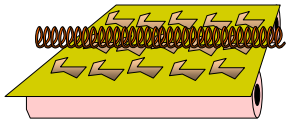
Example—Cheap and Expensive

A product is very EXPENSIVE in the market that it is in, but it needs to be INEXPENSIVE in order to sell.

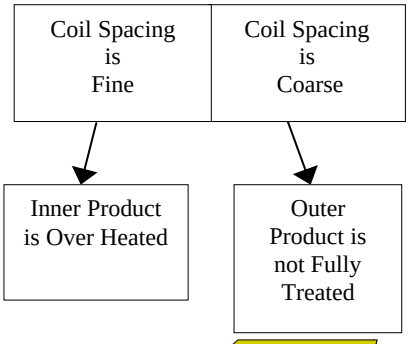
The (product) is already (expensive) when compared to (the desires of the given market). Changing (the market) by (moving to a different market) makes the (product) (inexpensive).

$$

Exercise—Blistering Coils

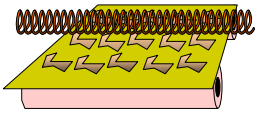


Product on an assembly line must pass under a heating coil in order to be fully treated. The product that passes under the center part of the coil is fully treated, but the product that passes under the coil at the edge of the conveyor belt is not fully treated. If the coil spacing was finer, the outer product could be fully treated. However, the product at the center of the belt is over-heated. The Coil Spacing should be FINE & COARSE. Using the principle that you have just learned, resolve this contradiction.

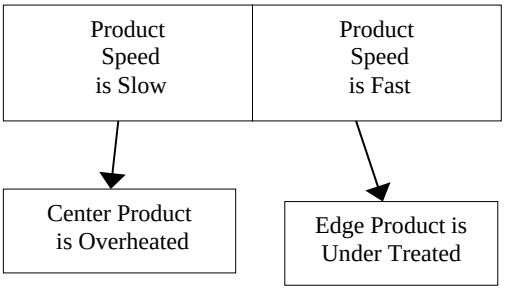


Exercise—Blistering Coils III

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.



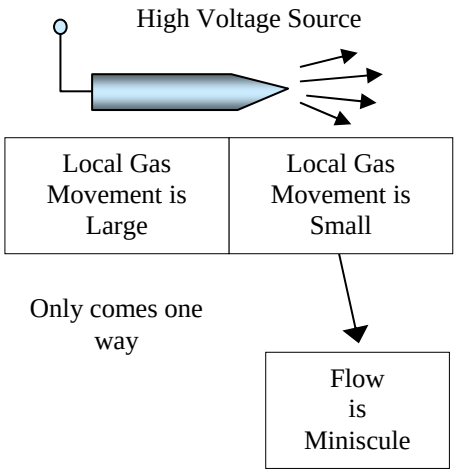
If the product speed were slower at the edges, the product will be uniformly heated as it passes under the coil.



If the product is slowed down, the center pieces will be over heated. The ~~belt~~ speed should be SLOW & FAST**.** Using the principle that you have just learned, resolve this contradiction. (Hint, belt is crossed through for a reason. In using this principle a change to the belt speed must not be a part of the solution).

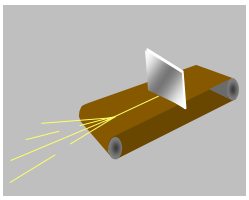
Exercise—Molecular Wind Pump

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.

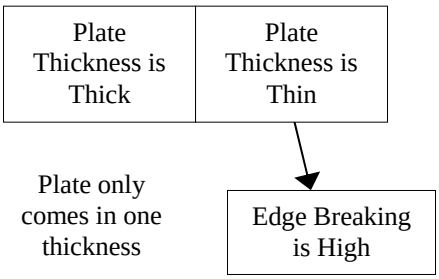


The Local Gas Movement should be SMALL & LARGE. Using the principle that you have just learned, resolve this contradiction.

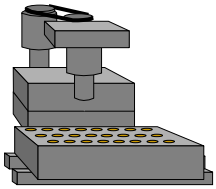
Exercise—A Slight Polishing



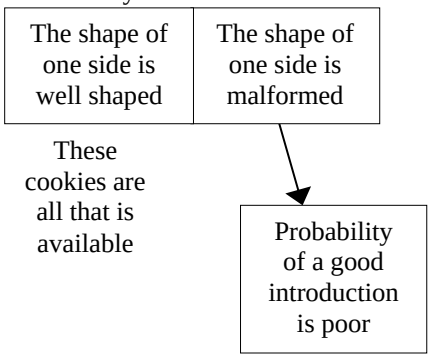
Your company polishes the edges of glass plates. Thousands of plates are polished each day. The edges of the glass plates are polished on a fast moving belt covered with abrasive materials. One day an order comes in for polishing glass plates which are only .010 inches thick. The first attempts to polish 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 THICK, but they only come THIN. Using the principle that you have just learned, resolve this contradiction.



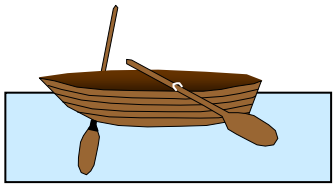
Exercise—Ugly Cookies



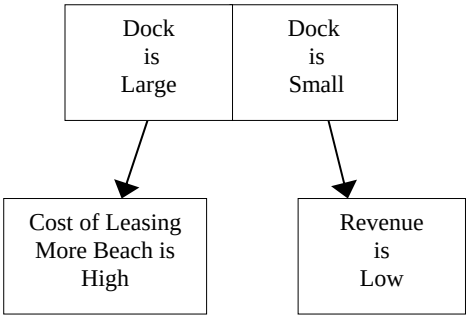
A production line for gourmet cookies has just been brought on line and has been in production for several days. The plant manager's wife inspects the cookies and discovers that they do not look like her home-made recipe. They are well shaped on one side but malformed on the other. "The equipment will 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 cookies should be MALFORMED & WELL SHAPED. Using the principle that you have just learned, resolve this contradiction.



Exercise—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**.** Using the principle that you have just learned, resolve this contradiction.

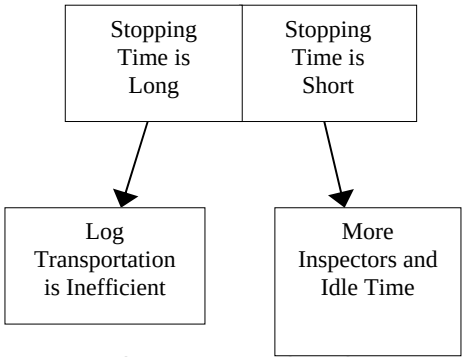


Exercise—Log Jam

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.

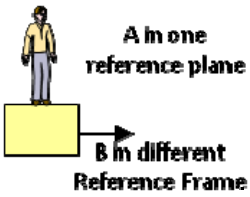
The Stopping Time Needs to be LONG & SHORT. Using the principle that you have just learned, resolve this contradiction.



L3-Inertial or Spatial Frame of Reference

The properties can be very different depending on your inertial or spatial frame of reference or the coordinate system being used. Physicists often have to consider the inertial frame of reference when calculating an object's properties. In particular, things can be very different depending upon your linear or rotational velocity. Likewise a problem can look very different when considering your spatial frame of reference. What is your position relative to the object? Are you near or far away? Less common would be applications where we would consider the type of coordinate system. Are we using Cartesian coordinates or Polar coordinates?

Method

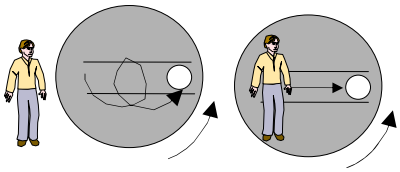


The (element) is already (setting A) when compared to (inertial, rotational, spatial or coordinate system frame of reference). Changing the frame of reference by (method) makes the (element) (setting B).

Example—Rotating Platform

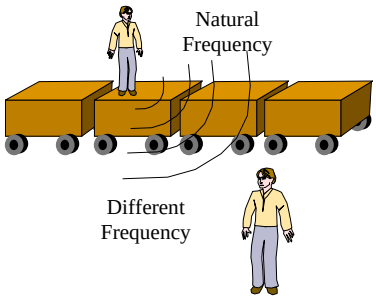
A ball rolls in a track on a rotating platform. The movement of the object is unfortunately CURVED. It needs to be LINEAR in order to be useful.

The (ball) is already (curved motion) when compared to (a stationary, non rotating frame of reference). Changing frame of reference by (observing the motion of the ball while rotating with the platform) makes the (ball) (linear motion).



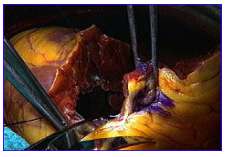
Example—Moving Train

In order to accurately determine which component on the vehicle is failing, the frequency needs to correlate to the NATURAL FREQUENCY of the failed component. The frequency if NOT THE NATURAL FREQUENCY of the failed component when heard by an observer as the vehicle approaches.



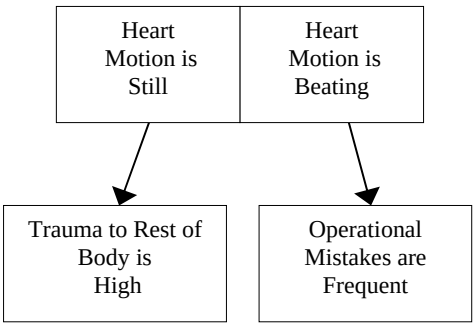
The (vehicle sound) is already (not the natural frequency) when compared to (the velocity of the approaching vehicle). Changing the frame of reference by (getting on the vehicle) makes the (vehicle sound) (the natural frequency).

Exercise—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**.** Using the principle that you have just learned, resolve this contradiction.



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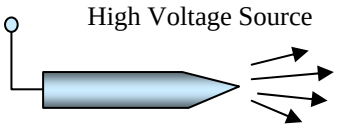

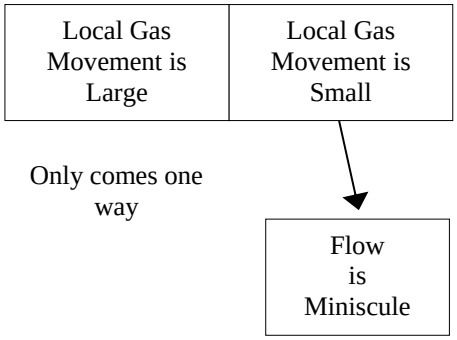

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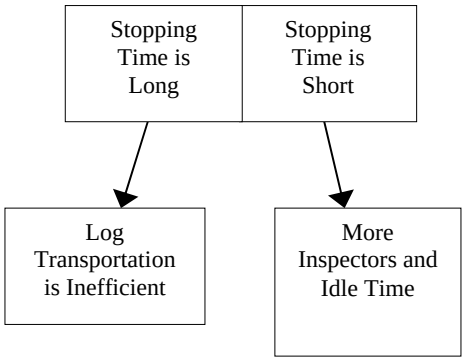

L2-Separate by Response of Fields

In the same space and at the same time, two different fields or field regimes can respond differently to the shape or bulk properties of an object. One field or field region may be changed whereas the other is left relatively unchanged. This method of resolving contradictions is primarily for contradictions dealing with how different field regions or fields respond to substances and their bulk, surface or construction properties. The field may respond differently at the substance which generates, transmits or accepts the field.

It is important to realize that this method or resolving contradictions is used *only* with the response of fields to substances that inhabit the space where the field exists. Consequently, the primary test for Separation by Response of Fields is to ask whether the contradiction is directly related to the response of fields.

What this means is that you have already done a good job of identifying a field response property that must have two settings. This *should* have occurred in causal analysis. This emphasizes the importance of performing your causal analysis in such a way that you examine field properties and the response of fields to various substances very carefully. You would have already asked "What is the field response properties related to the improvement that you are looking for?" The field response properties could be associated with gradient, intensity, conductance, etc. Once you know the field response properties that help the improvement, you ask "What happens if I adjust the field response properties to resolve the problem? What gets worse?" If something gets worse, then you identify what the field properties need to be in order to make sure that the thing which gets worse does not happen. Now you have the required contradiction and you are ready to consider separating by field response. If you have already gone to this much work, potential solutions should be right at hand. You know that the field response should be A and it should be B. Then it is a matter of finding a substance or construction that can achieve both settings A and B.

L2-Method

Step 1: Is the contradiction related to the way that a substance and field interact?

Step 2: If so, brainstorm ways to separate the contradictory fields by having the substance react differently to different field regimes. Each field regime corresponds to a different condition

--Consider the use of transparent materials[83].

L3-Test for Separation by Response of Fields

Test:

Are both properties (knob settings) directly related to a substance and the way that fields (particularly super-imposed fields) respond to that substance? If "yes" then continue to the next part of the test. If "no" then continue on to Separation between Substance and Field. Complete the following, while identifying separate fields or field regions which make these statements true:

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83 Inventive Principle #32—Changing the color: Change the color of an object or its environment. Change the degree of translucency of an object or its environment. Use color additives to observe an object or process which is difficult to see. If such additives are already used, employ luminescent traces or trace atoms. Genrich Altshuller, The Innovation Algorithm page 289.

It is essential that:

The field response to the (substance in the operating region) must be (setting A) for (field region A or field A)

The field response to the (substance in the operating region) must be (setting B) for (field region B or field B)

Is it essential that field region or field A and B overlap? If they must overlap, then jump to Separation between Substance and Field.

Example—Light Bulb

The light must CONDUCT through the pressure barrier in order to be visible. The light must NOT CONDUCT through the pressure barrier in order to not give off ultraviolet radiation.

Test: Are both properties (knob settings) directly related to a substance and the way that fields (particularly super-imposed fields) respond to that substance? Yes, both conducting and not conducting are related to a substance and the way that light fields respond to that substance. Complete the following, while identifying separate fields or field regions which make these statements true:

It is essential that:

The field response to the (pressure barrier) must be (conducting) for (visible light)

The field response to the (pressure barrier) must be (not conducting) for (UV light)

Is it essential that field region or field A and B overlap? No, it is not essential that they overlap. We will try to use separation by field response.

Note that the spectrum of light can be separated into different field regions by frequency. This is the key to separation by field response: find two regions of the same field type that respond differently to the same substance or substance construction. This search for different field regions is the primary knowledge gained in this step. This is where mental effort is required.

Example—Race Car Fender

Many racing vehicles would benefit aerodynamically from aerodynamically shaped fenders. The problem is that the fenders block visibility of the tires during turns. The drivers watch the tires to detect the response of the wheels to the track. The volume of the fender must transmit the image of the wheel but must not transmit the air.[84] The fender must CONDUCT light in order to see the tires and it must NOT CONDUCT light because it is a fender and light does not pass through it.

Test: Are both properties (knob settings) directly related to a substance and the way that fields (particularly super-imposed fields) respond to that substance? Yes, the properties of conducting and not conducting are related to the substance of the fender and how light respond to it. Complete the following, while identifying separate fields or field regions which make these statements true:

It is essential that:

[84] The Innovation Algorithm by Genrich Altshuller page 99

The field response to the (fender) must be (conducting) for (light)

The field response to the (fender) must be (not conducting) for (air pressure)

Is it essential that field region or field A and B overlap? No, light and air pressure are not essential to overlap. We will try to separate by response of the field.

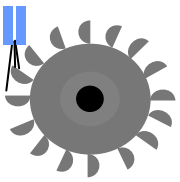
Example—Pile Driving

The pile needs to be SHARP in order to drive rapidly and it needs to be BLUNT in order to support well.

Test: Are both properties (knob settings) directly related to a substance and the way that fields (particularly super-imposed fields) respond to that substance? While sharp and blunt could be indirectly related to the fields, we should have identified that the stress fields need to be directed outward in order to drive the pile rapidly and allow for the soil to be moved aside. The fields need to be directed downward in order that the soil has nowhere to go. This allows for high compression forces which support the structure. Rapidly applied forces would need to somehow push sideways and slowly applied fields would direct the force downwards.

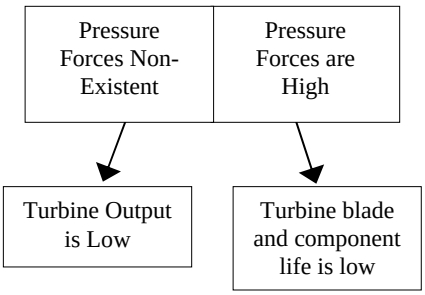
This, however, is *not* the question that we are grappling with. Instead, we are looking at the physical attributes of the object which are blunt and sharp. Since these do not directly relate to fields, we will not try to separate by Field Response.

Exercise—Vibrating Water Wheel



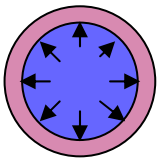
Consider an aluminum water wheel. Inlet flow strikes the blades after accelerating in the nozzle, transferring energy and momentum to the blade and wheel. During energy transfer the blade is bent slightly and released causing it to vibrate.

The resulting alternating stresses decrease 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 & ABSENT**.** Test for Separation by Field Response.

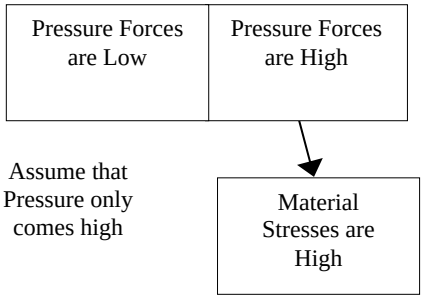


Exercise—Storing Almost Protons

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**.** Test for separation by response of fields.



L3-Separate by Response of Fields

We have already identified the field regions or fields that must respond differently. What is left to find is a material, coating or structure which changes the field response of the two regions sufficiently to resolve the contradiction. Each field region or field must respond differently to the chosen substance, coating or structure.

Considering different *field regions* is the most common and preferred method. Identifying different *fields* would indicate that the difference in fields was not caught during the cause effect stage. Since this is possible and made more likely by doing a less thorough job of causal analysis, we allow for considering different fields. We should remember, however, that the primary and preferred method of separating by Response of Fields is to consider different field regions.

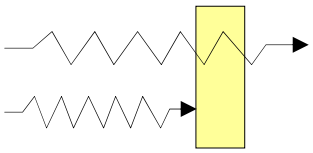
The table to the right shows a variety of substances which can change the way that a field is generated, transmitted and received.

- Optically transparent materials
- Resonant structures
- Field shape changing materials
- Field gradient changing materials
- Reflective or channeling structures
- Filters
- Frequency or color changing
- Speed changing
- Phase changing
- Polarization changing
- Field Type changing
- Field absorption changing materials

Method

The response of (field region A or field A) to (material, coating or structure) is (setting A). The response of (field region B or field B) to (material, coating or structure) is (setting B).

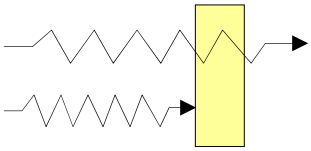
Example—Different Conductive Response—Light Bulb



The gas barrier must be CONDUCTING in order to illuminate the work area. The gas barrier must be NON-CONDUCTING in order to avoid ultraviolet radiation.

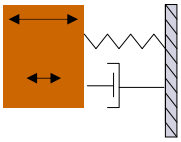
The response of (visible light) to (glass) is (conducting). The response of (ultraviolet light) to (glass) is (non-conducting).

Example—Different Conductive Response—Spring-Mass-Damper



A mechanical vibratory field must CONDUCT through the operating region in order to perform useful work. It must NOT CONDUCT through the operating region in order to avoid excessive wear.

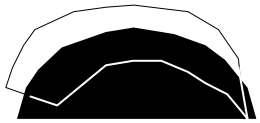
The response of (low frequency vibration) to (a spring-mass-damper system) is (conducting). The response of (high frequency vibration) to (a spring-mass-damper system) is (non-conducting).



A spring-mass-damper will selectively pass frequencies lower than the resonant frequency and absorb frequencies higher than the resonant frequency.

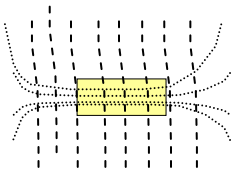
Example—Different Conductive Response—Race Car Fender

The fender must CONDUCT light in order to see the tires and it must NOT CONDUCT light because it is a fender and light does not pass through it.



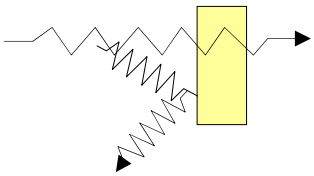
The response of (an optical field) to (a transparent fender) is (conducting). The response of (a pressure field) to (a transparent fender) is (non conductive).

Example—Different Gradient Response—Magnetic Material



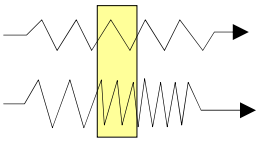
The response of (a gravitational field) to (a magnetic material) is (a uniform gradient). The response of (a magnetic field) to (a magnetic material) is (a high or non-uniform gradient).

Example—Different Path Response—Mirror



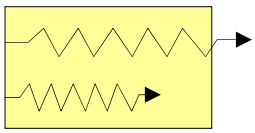
The response of (x-ray) to (a mirror) is (unaltered movement). The response of (optical light) to (a mirror) is (reflected altered movement).

Example—Red Color Filter



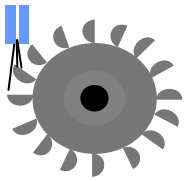
The response of (red light) to (a red filter) is (unaltered transmission or amplitude). The response of (orange light) to (a red filter) is (reduced transmission or amplitude).

Example—Different Speed Response—Glass



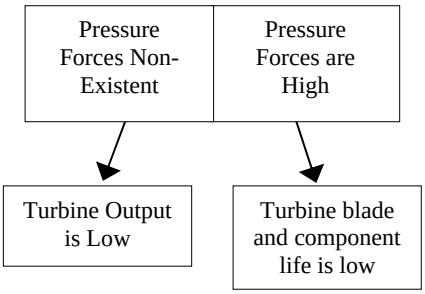
The response of (green light) to (optical glass) is (higher speed). The response of (blue light) to (optical glass) is (lower speed).

Exercise—Vibrating Water Wheel

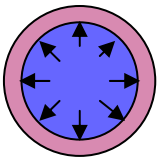


Consider an aluminum water wheel. Inlet flow strikes the blades after accelerating in the nozzle, transferring energy and momentum to the blade and wheel. During energy transfer the blade is bent slightly and released causing it to vibrate.

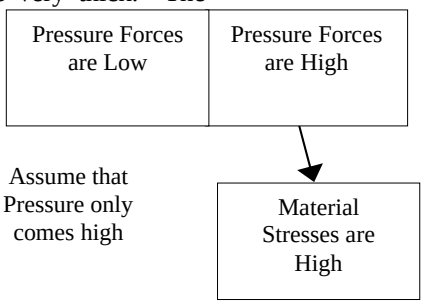
The resulting alternating stresses decrease the life of the turbine blades. If the pressure forces were eliminated, so would the vibration. (Assume a constant speed). The Pressure Forces should be HIGH & ABSENT**.** Using the principle that you have just learned, resolve this contradiction.



Exercise—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**.** Using the principle that you have just learned, resolve this contradiction.

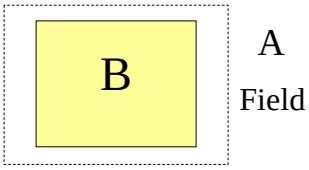


L2-Separate Between the Substance and the Field

Separating between the substance and the field is the last separation strategy that we will consider. In this strategy, the substance has one property (knob setting) and the field has the conflicting property. In order to do this, we have to know the field and substance that is associated with the conflicting properties. Let's say that we have two fluids that must be mixed and not mixed. It is necessary to mix the two fluids in order for the mixture to come to the same temperature. In this case, the substance and field associated with the conflicting properties is a fluid substance and a thermal field. Once we have established this, all that is left is to determine which has which conflicting property.

L2-Method

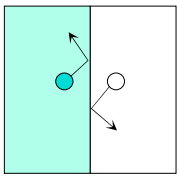
The field element associated with the conflict is (a field element). The substance element associated with the conflict is (a substance element). The (field element) is (setting A) and the (substance element) is (setting B). This is accomplished by (architecture).



Example—Heat Exchanger

Two fluids must be MIXED THOUROUGHLY in order that a temperature sensor can read the correct average temperature of the fluids. However, they must be UNMIXED in order that one fluid does not pollute the other.

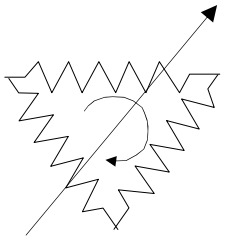
The field element associated with the conflict is (a thermal field). The substance element associated with the conflict is (both fluids). The (thermal field) is (thoroughly mixed) and the (fluids) are (unmixed). This is accomplished by (a fluid barrier that allows the fluids to be unmixed, but the thermal fields to mix thoroughly. This is usually referred to as a head exchanger). Shown to the right is a representation of a barrier between two fluids. The thermal fields can cross, but the fluids cannot.



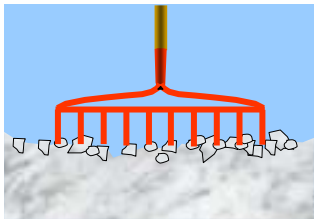
Example—Rotating Field in an Electric Motor

The field coils must ROTATE in order apply forces to turn the armature. The field coils must remain STATIONARY in order to keep the complexity of the field coils low.

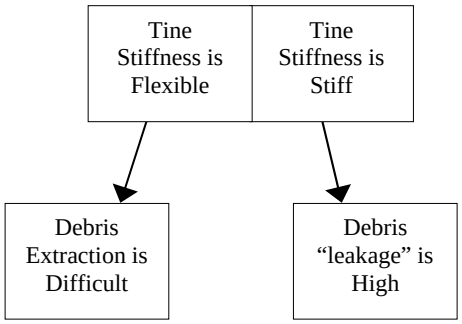
The field element associated with the conflict is (a magnetic field). The substance element associated with the conflict is (the field coils). The (magnetic field) is (rotating) and the (coils) are (stationary). This is accomplished by (switching on the coils in a predetermined sequence. The magnetic field direction appears to rotate, depending on the sequence of the switching).



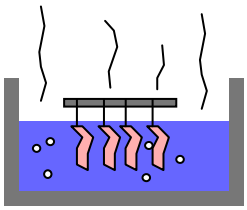
Exercise—Two Tining Rake



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**.** Using the principle that you have just learned, resolve this contradiction.

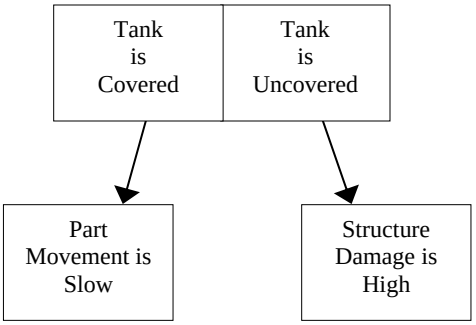


Exercise—The Cover That Wasn't



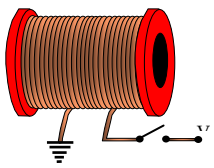
In large plating operations, the plating tanks give off large amounts of corrosive gases. Over the course of time, these gases damage the plating facility and everything in it. Covering the tanks with non-corrosive covers would greatly reduce the evolution of gases, but a cover slows down production.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

Plating Tank Needs to be COVERED & UNCOVERED**.** Using the principle that you have just learned, resolve this contradiction.

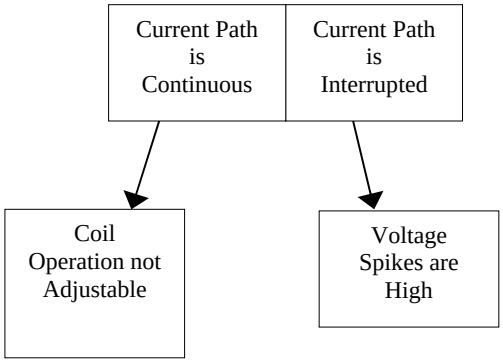


Exercise—I Just Can't Stop

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.

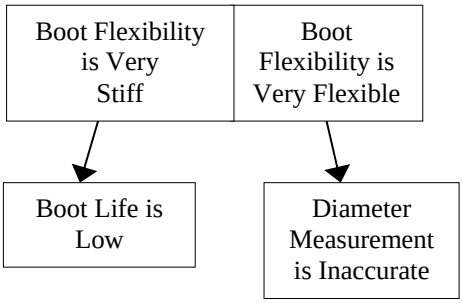


The electrons do not want to stop moving, but "bunch up" causing high voltages. In many applications this causes difficulties such as sparking (deteriorating brushes and switches or causing electromagnetic pulses) or high voltages across other elements. The current path needs to be CONTINUOUS AND INTERRUPTED**.** Using the principle that you have just learned, resolve this contradiction.

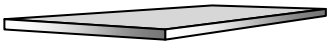


Exercise—Too Flexible

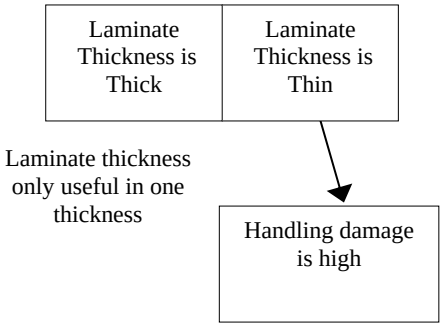
Various diameters of a thin rubber boot (which covers part of a car shift mechanism) must be measured with great accuracy at several points. Unfortunately, the micrometer which is used deforms the boot during the measurement. This makes the measurement inaccurate. How can the boot be measured more accurately? The Boot Flexibility Needs to be FLEXIBLE & STIFF. Resolve the Contradiction using the principle that you have just learned.



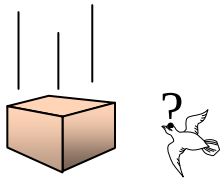
Exercise—Metallic Film



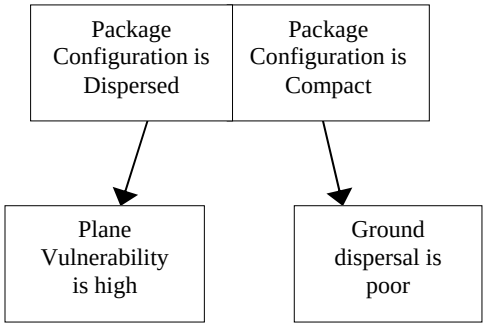
In the production of metallic laminates, Thick metallic films are produced by successively rolling the metal between rollers until it reaches the desired thickness. The resulting film is rolled up into large rolls which are easily manipulated. When making ultra thin films for laminates, new problems 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**.** Using the principle that you have just learned, resolve this contradiction.



Exercise—Special Delivery II

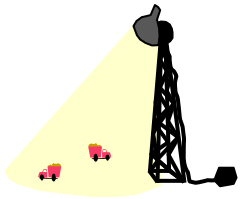


During war in a third world country, an effective means of gaining support from the local people is to give them much needed supplies such as medicine, food and clothing. In order to avoid anti-aircraft and small arms fire, the drop plane must fly high. If the package is dense and compact, it falls with 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 hoard the supplies to themselves.



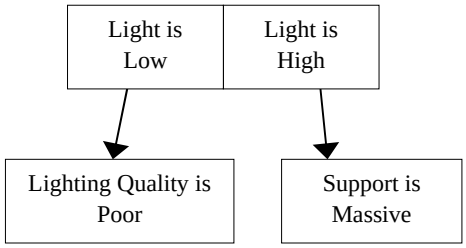
Dropping many packages gets more packages into the hands that need them, but high winds may disperse the drop if they are dropped separately. The Package Configuration must be COMPACT AND DISPERSED. Using the principle that you have just learned, resolve this contradiction.

Exercise—Construction Lights



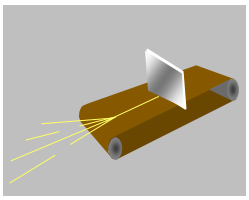
During large construction projects, it is desirable to light a work area the size of many football fields. It would be desirable to have one very large and high light.

But, doing this is prohibitive because of the large structure that would be required to support the light.

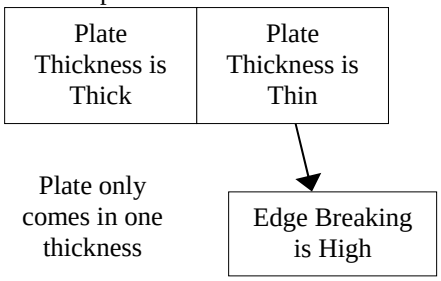


The construction light needs to be HIGH & LOW. Using the principle that you have just learned, resolve this contradiction.

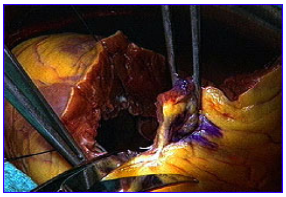
Exercise—A Slight Polishing



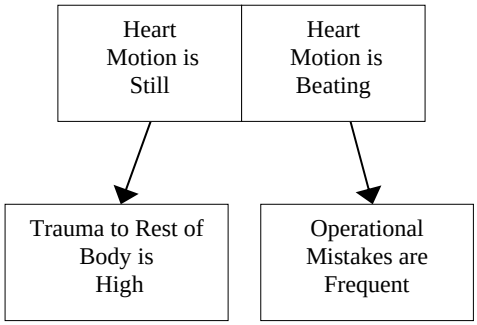
Your company polishes the edges of glass plates. Thousands of plates are polished each day. The edges of the glass plates are polished on a fast moving belt covered with abrasive materials. One day an order comes in for polishing glass plates which are only .010 inches thick. The first attempts to polish 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 THICK, but they only come THIN. Using the principle that you have just learned, resolve this contradiction.



Exercise—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**.** Using the principle that you have just learned, resolve this contradiction.



L2-Compensation

Without special recognition, the method of resolving contradictions by compensation is taught in some of Altshuller's earliest works[85]. Up to this point, we have only considered solving the contradiction by turning the knob to both settings. It is also possible to resolve the contradiction by setting the critical property to one setting only. Then we compensate for this property setting by turning another knob.

L2-Method

Step 1: Set a critical property to one setting which solves the main problem.

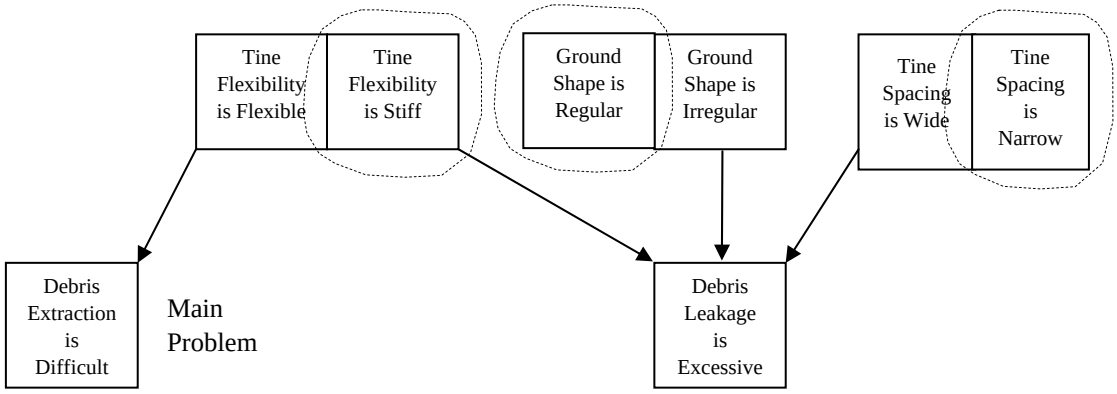
Step 2: Look for another knob which can be turned to compensate for the harmful effect created by step 1.

Example—Raking

Going back to the raking example at the first of the chapter, we can ask what we might do if debris extraction were the main problem with a flexible leaf rake. Let's assume that we have already formed the causal analysis shown below.

Step 1: Set a critical property to one setting which solves the main problem.

The main problem is debris extraction with the leaf rake. This is because the tines are flexible. We can solve this problem by making the tines stiff. Unfortunately, this causes a variety of problems. (We will only focus on one of these by assuming that the other main function of the rake is debris collection but not on lawns).



85 An Example of Compensation can be found on page 34 of The Innovation Algorithm by G.S. Altshuller, Technical Innovation center. First Edition 1999. What is described is a diving mask that distorts the vision of the diver due to the change of index of refraction between the water and glass which have a refractive index around 1.5 and the air which has a refractive index around 1.0. (Think about the last time that you used diving goggles with a flat glass or plastic plate.) The refractive index is the parameter which drives the distortion which is the problem that needs to be overcome. A second parameter is found that compensates for the difference in refractive index and that is the curvature of the glass. The curvature of the glass can be used to compensate and even correct the vision of the diver which may have imperfect vision when not underwater. (Many divers try to wear their normal corrective glasses by wedging them into diving goggles. Unfortunately, this, alone, does not change the original distortion of the diving goggles.)

Step 2: Look for another knob which can be turned to compensate for the harmful effect created by step 1.

We have already noted that debris leakage is also a function of irregularly shaped ground and narrow tine spacing. We can compensate for the stiff tines by making the ground regular and the tine spacing narrow.

L2-Iterate on Solutions

You have probably discovered by now that there are many potential ways to resolve a contradiction and there are many potential solution paths to a problem. Each solution path will bring you to a point where you can visualize an architecture that brings you close to solving your problem. Unfortunately, this rarely occurs on the first pass. It is entirely possible that resolving a contradiction will cause other problems. You may recall the problem of measuring the dimensions of a flexible boot. One way to overcome this problem is to resolve the contradiction that the boot must be soft in order to perform its function and it must be hard in order to be accurately measured. One way to resolve this contradiction is to freeze it in liquid nitrogen. This does, in fact, resolve the immediate contradiction, but a new problem arises. The material is distorted by freezing. Note that is problem has nothing to do with the original contradiction. Now we have a new problem that may seem more difficult than the original problem.

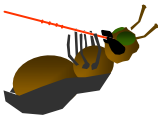
L2-Method—Continuing Evolution of Solutions

Rather than abandon the solution, we should continue with this solution path until we are satisfied with the solution. Each solution path may branch many times with the ensuing iterations. This is fine. It is not unusual to have a number of potential solutions. The intention is to continue evolving the solutions as long as it is practical before making a decision. It is not unusual to have several ideas to work on at the same time. In some ways, this creates a state of mind that is very healthy. Rather than focusing in on one idea and sending it to finishing school, you will greatly increase your chances of success by thinking in terms of solution sets. Further discussion on this topic can be found in the book concerned with implementing solutions.

Contradiction Exercises

These exercises are provided to give the reader experience solving contradictions. While there are known solutions for each of these, applying each of the methods allows for an element of the unknown.

Exercise—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 AND SMALL**.** Resolve this contradiction using any method.

Weevil Size is Large	Weevil Size is Small

Weevils only come small

Thermometer insertion is difficult or complex

Exercise—Traffic Light

The lights in a traffic light must eventually FAIL due to the action of the current on the filament and to vibration. The traffic light must NOT FAIL in order to not cause traffic delays or make the intersection more dangerous.

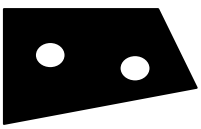
This is an example of an output contradiction. Most people would think of this as the Y in the function. Resolve this contradiction using any method.

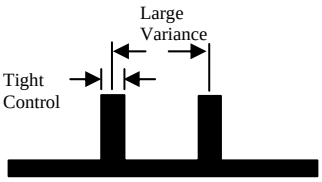
Traffic Light Operation Fails	Traffic Light Operation Doesn't Fail

All lights will eventually fail

Note that nothing gets worse

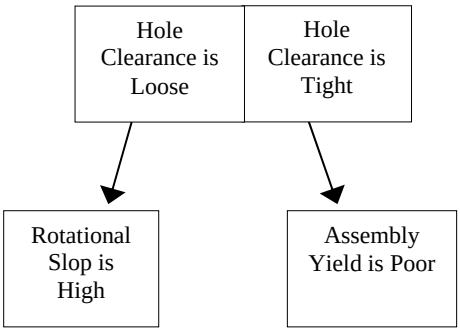
Exercise—A Post and an Outpost



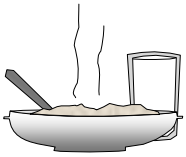


For years your company has produced an aircraft product which fits over two posts on your customer's aircraft. Both the position and the diameter of the posts were closely controlled. Unfortunately, a recent production change by the customer allows a large variance in the distance between the posts.

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 fit snuggly in the application, 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 Resolve this contradiction using any method.

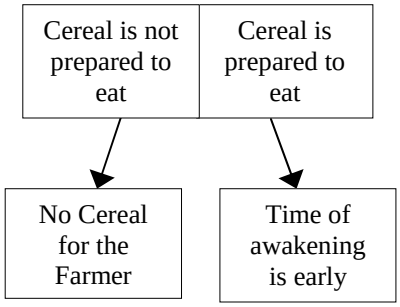


Exercise—The Farmer's Mush

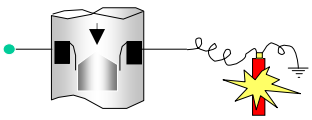


"I can't stand cold cereal anymore!" The farmer says. "Yes, but it takes a long time to make hot cereal the way that you like it! I'm not getting up any earlier to make it!" The farmer's wife complains.

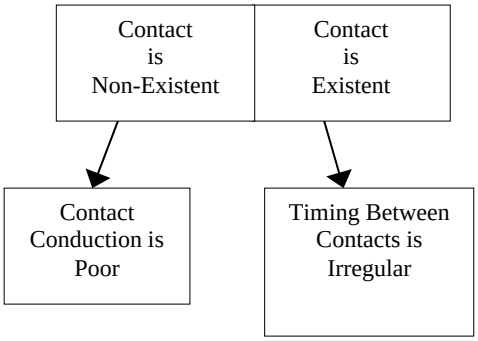
The cereal MUST BE PREPARED in order to nourish the farmer. It must NOT BE PREPARED in order to not fatigue the farmer's wife. Resolve this contradiction using any method.



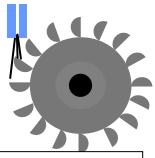
Exercise—Controlled Explosions



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 a tube with electrical contacts spaced at precise intervals. As the conductive weight passes each set of contacts, continuity is established across the contacts 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 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. Resolve this contradiction using any method.

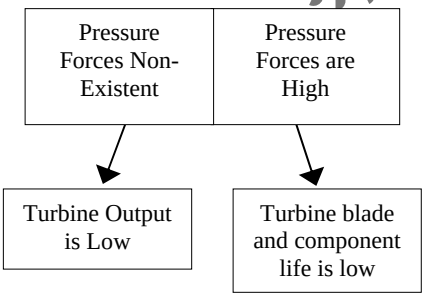


Exercise—Vibrating Water Wheel

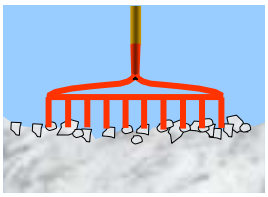


Consider an aluminum water wheel. Inlet flow strikes the blades after accelerating in the nozzle, transferring energy and momentum to the blade and wheel. During energy transfer the blade is bent slightly and released causing it to vibrate.

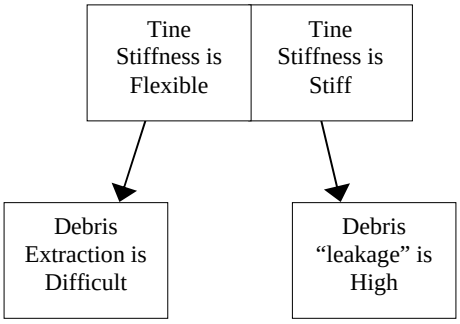
The resulting alternating stresses decrease the life of the turbine blades. If the pressure forces were eliminated, so would the vibration. (Assume a constant speed). The Pressure Forces should be HIGH & ABSENT**.** Resolve this contradiction using any method.



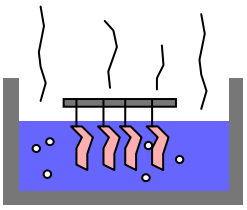
Exercise—Two Tining Rake



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**.** Resolve this contradiction using any method.

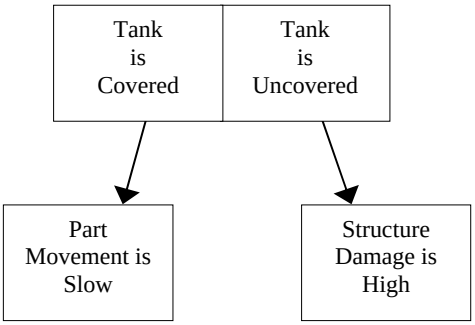


Exercise—The Cover That Wasn't

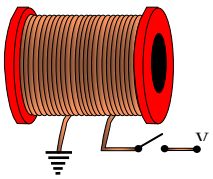


In large plating operations, the plating tanks give off large amounts of corrosive gases. Over the course of time, these gases damage the plating facility and everything in it. Covering the tanks with non-corrosive covers would greatly reduce the evolution of gases, but a cover slows down production.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

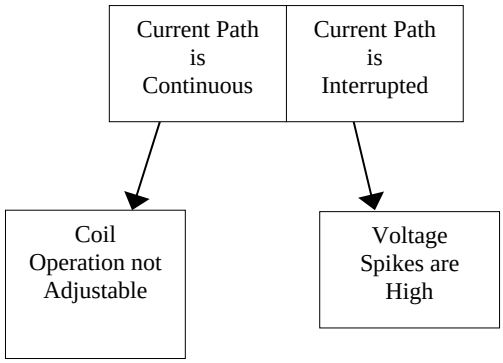
Plating Tank Needs to be COVERED & UNCOVERED**.** Resolve this contradiction using any method.



Exercise—I Just Can't Stop

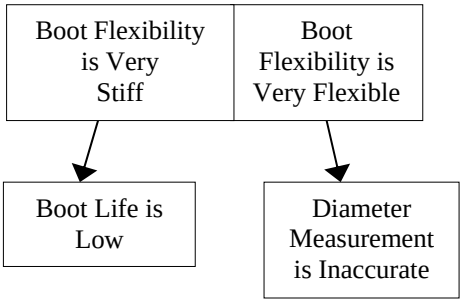


Electromagnetic coils are used for many applications which require the generation of force. Magnetic fields generated by the coil and the spool upon which the wire is wound interact with plungers also made of magnetic materials. Usually, the flow of current to the coil is initiated by throwing a switch 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. The current path needs to be CONTINUOUS AND INTERRUPTED. Resolve this contradiction using any method.



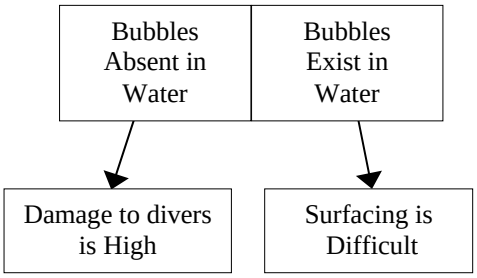
Exercise—Too Flexible

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. Resolve the Resolve this contradiction using any method.

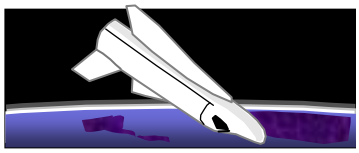


Exercise—Soft Water

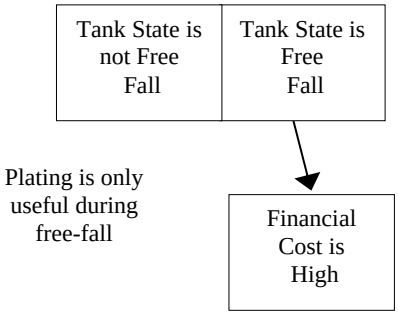
The addition of bubbles to diving pools is a good way to keep diving injuries to a minimum. This is especially true when diving from great heights. Unfortunately, the diver is no longer buoyant in the water and finds it difficult to surface after a dive. The Bubbles need to be EXISTENT AND ABSENT. Resolve this contradiction using any method.



Exercise—Free-Fall Plating

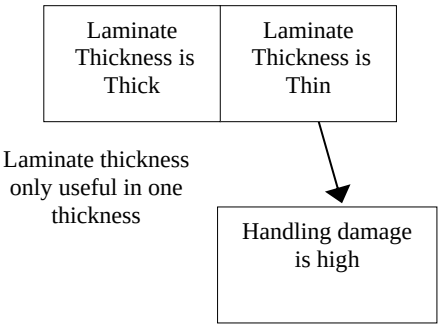


Crystals grown in a micro-gravity environment have unusual properties. Such an environment is created by objects in free-fall. A space craft in orbit about the earth achieves this same effect by being in a constant free fall state. Plating in such a free-fall state might also have unusual properties. 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. Resolve this contradiction using any method.



Exercise—Metallic Film

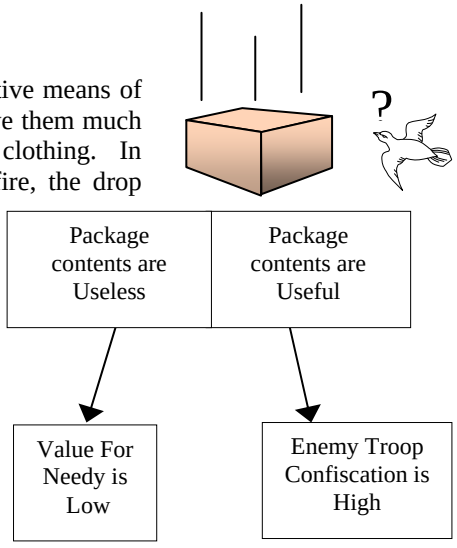
In the production of metallic laminates, Thick metallic films are produced by successively rolling the metal between rollers until it reaches the desired thickness. The resulting film is rolled up into large rolls which are easily manipulated. When making ultra thin films for laminates, new problems 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. Resolve this contradiction using any method.



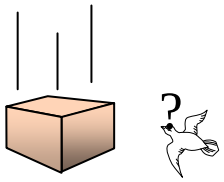
Exercise—Special Delivery

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 hoard the supplies to themselves.

They quickly discover that the contents are useful and look for them. The Package Contents must be USEFUL AND USELESS Resolve this contradiction using any method.



Exercise—Special Delivery II



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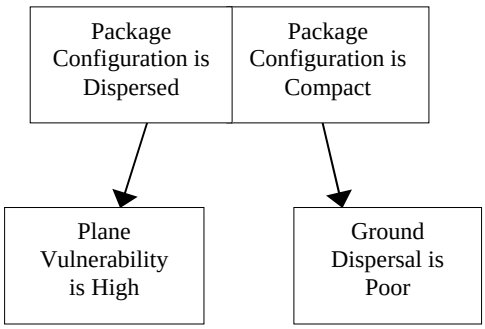
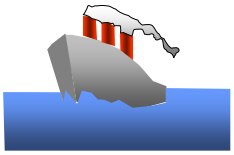
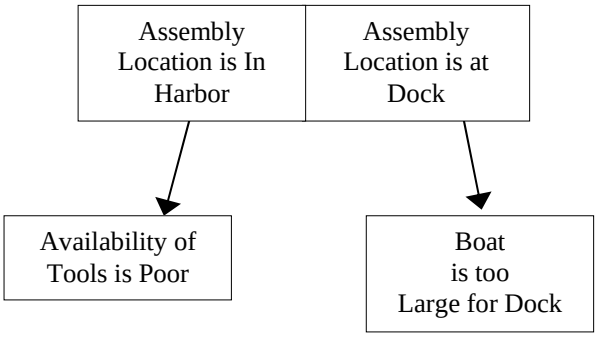


Dropping many packages gets more packages into the hands that need them, but high winds may disperse the drop if they are dropped separately. The Package Configuration must be COMPACT AND DISPERSED. Resolve this contradiction using any method.

Exercise—Super Yacht

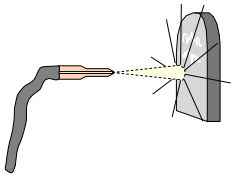


A small ship building company considers a contract to build a super yacht. The yacht is so big that only a third will fit into their dock. "We will need to build this in the open harbor." A frustrated engineer says. "We can't do that; we need the availability of lifts and tools."

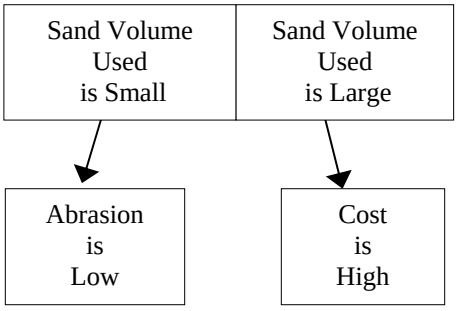


The Building Location: It should be IN THE HARBOR & AT THE DOCK. Resolve this contradiction using any method.

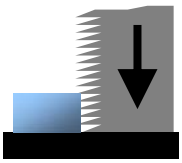
Exercise—Eternal Sand



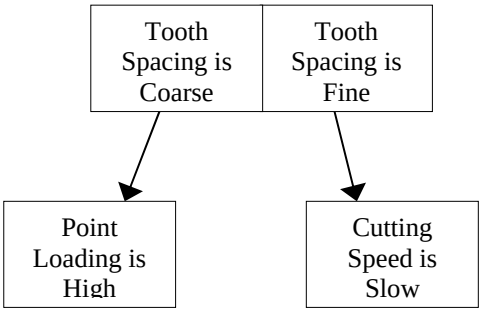
Inscriptions on grave stones are made by sandblasting the polished stone through a rubber mask. The mask is attached to the stone by adhesive and later peeled off. The sand is ejected through a nozzle at high velocity in a pneumatic stream. The sand can be reused for a time, but must eventually be replenished 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 the sand which is used must be LARGE AND SMALL. Resolve this contradiction using any method.



Exercise—Take Smaller Bites



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.

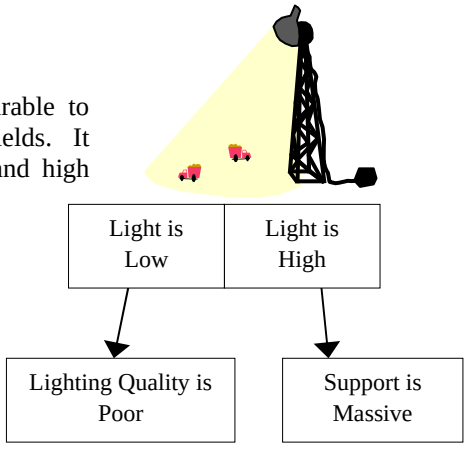


Exercise—Construction Lights

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.

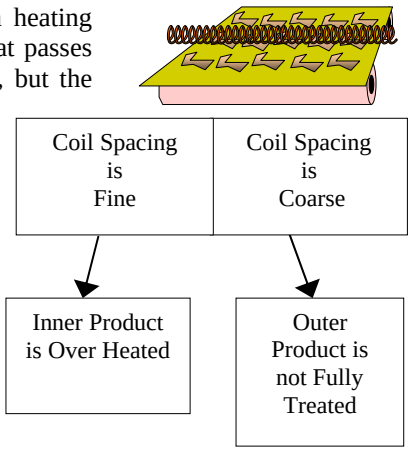
But, doing this is prohibitive because of the large structure that would be required to support the light.

The construction light needs to be HIGH & LOW. Resolve this contradiction using any method.

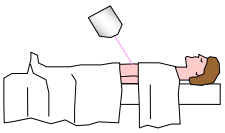


Exercise—Blistering Coils

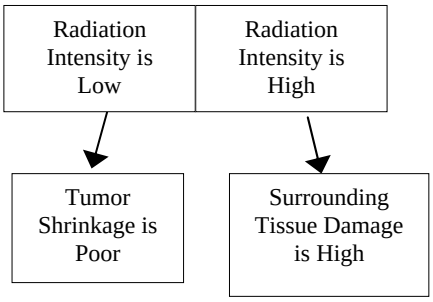
Product on an assembly line must pass under a heating coil in order to be fully treated. The product that passes under the center part of the coil is fully treated, but the product that passes under the coil at the edge of the conveyor belt is not fully treated. If the coil spacing was finer, the outer product could be fully treated. However, the product at the center of the belt is over-heated. The Coil Spacing should be FINE & COARSE. Resolve this contradiction using any method.



Exercise—Radiation Treatment



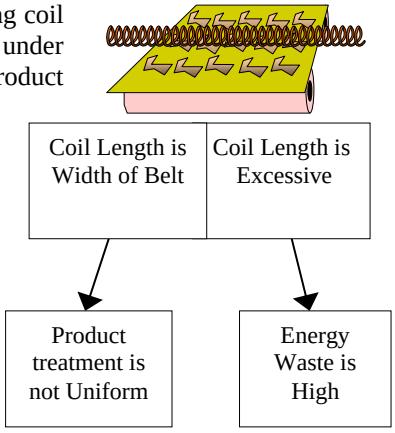
High levels of radiation can damage the structure of cells and cause them to cease functioning. This is useful in the treatment of tumors. A beam of high energy radiation is focused on the tumor. After the procedure, the tumor shrinks. Unfortunately, the tissue surrounding the tumor is also damaged by the high energy radiation. The Radiation Intensity needs to be HIGH AND LOW**.** Resolve this contradiction using any method.



Exercise—Blistering Coils II

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.

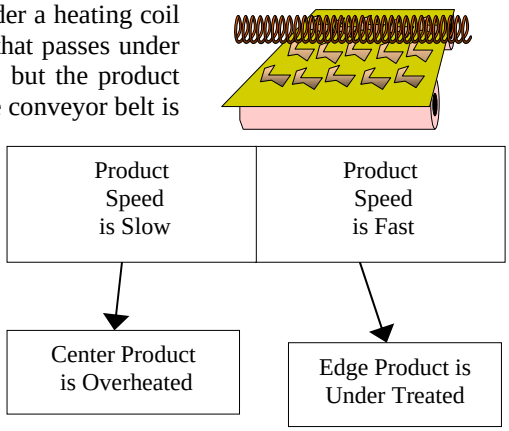
The Coil Length should be EXCESSIVE & THE WIDTH OF THE BELT. Resolve this contradiction using any method.



Exercise—Blistering Coils III

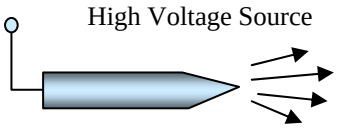
Product on an assembly line must pass under a heating coil in order to be fully treated. The product that passes under the center part of the coil is fully treated, but the product that passes under the coil at the edge of the conveyor belt is not fully treated. If the product speed were slower at the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

If the product is slowed down, the center pieces will be over heated. The belt speed should be SLOW & FAST**.** Resolve this contradiction using any method.



Exercise—Molecular Wind Pump

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.

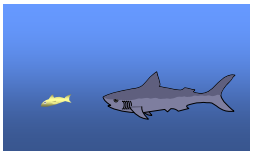


Local Gas Movement is Large	Local Gas Movement is Small

Only comes one way → Flow is Miniscule

The Local Gas Movement should be SMALL & LARGE. Resolve this contradiction using any method.

Exercise—Fish to the Rescue

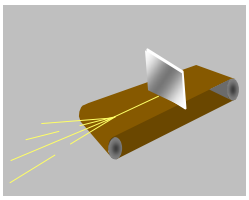


Like most large predators, a shark will follow its prey in close pursuit until the smaller prey exhausts its energy. Although the prey may be more nimble, it cannot outrun its larger foe forever. If the smaller fish could dodge and dart forever, it could easily outmaneuver the larger shark. The Fish should have INFINITE ENDURANCE in order to outrun the shark and NORMAL ENDURANCE because that is how small fish are. Resolve this contradiction using any method.

Endurance is Infinite	Endurance is Low

No Fish Come this way → Vulnerability is High

Exercise—A Slight Polishing



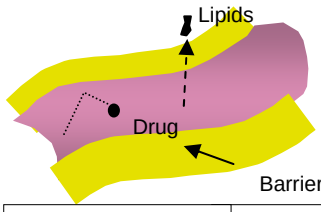
Your company polishes the edges of glass plates. Thousands of plates are polished each day. The edges of the glass plates are polished on a fast moving belt covered with abrasive materials. One day an order comes in for polishing glass plates which are only .010 inches thick. The first attempts to polish 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 THICK, but they only come THIN. Resolve this contradiction using any method.

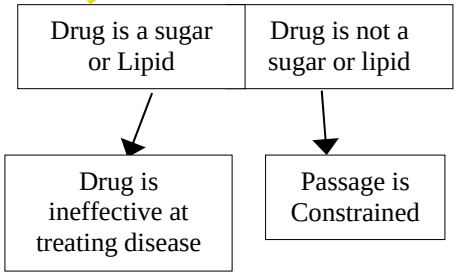
Plate Thickness is Thick	Plate Thickness is Thin

Plate only comes in one thickness → Edge Breaking is High

Exercise—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. Resolve this contradiction using any method.

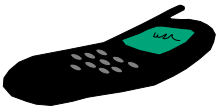


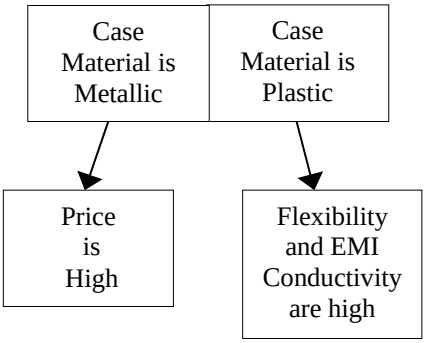


Exercise—A Limit to Cell Phones

Cell phone cases have become increasingly thinner. This reduces the weight and cost of raw materials. The traditional method of production has been injection molding. But, injection molding has reached several limits. The pressures required to inject into increasingly narrow passages is very high. Additionally, the cases are required to do more. They must be as rigid as metal and conductive like metal to reduce electromagnetic interference, yet they should be made from light moldable materials like plastic.

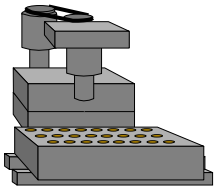
The cases should be METALLIC & PLASTIC. Resolve this contradiction using any method.

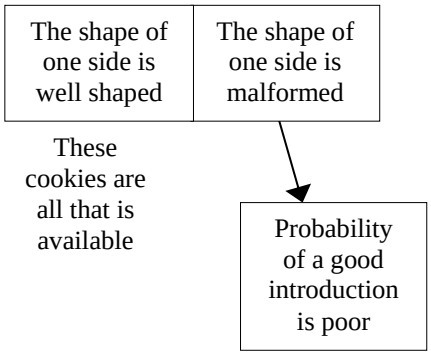




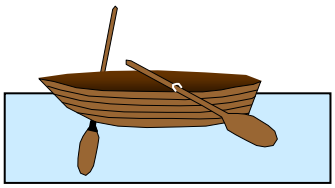
Exercise—Ugly Cookies

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 cookies should be MALFORMED & WELL SHAPED. Resolve this contradiction using any method.

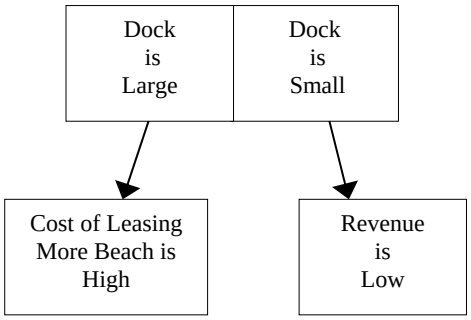




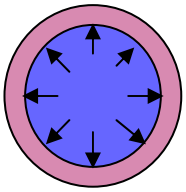
Exercise—What's Up Dock



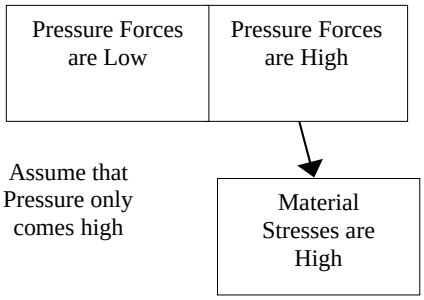
"We'll make a fortune" the small investor said. "When they build the houses around this lake, everyone will want a place to dock their boats and we got the last parcel on the lake". "Yes, but it is too small to store many boats" his wife complained. "And we are not allowed to build the dock out more 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. Resolve this contradiction using any method.



Exercise—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. Resolve this contradiction using any method.

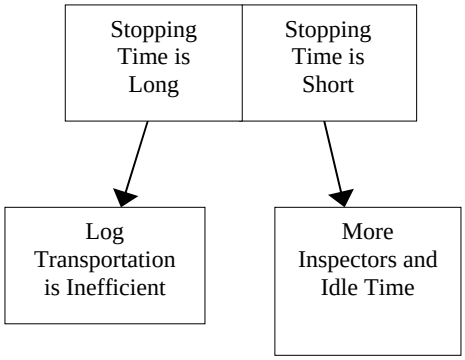


Exercise—Log Jam

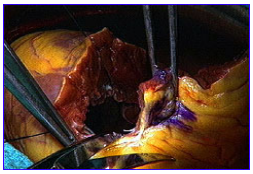
Every few hours, a train enters the depot with several cars full of logs. It is the job of the inspector to measure each log diameter. Unfortunately the train does not stay long. So far, the problem has been solved by hiring many inspectors.

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. Resolve this contradiction using any method..



Exercise—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**.** Resolve this contradiction using any method.