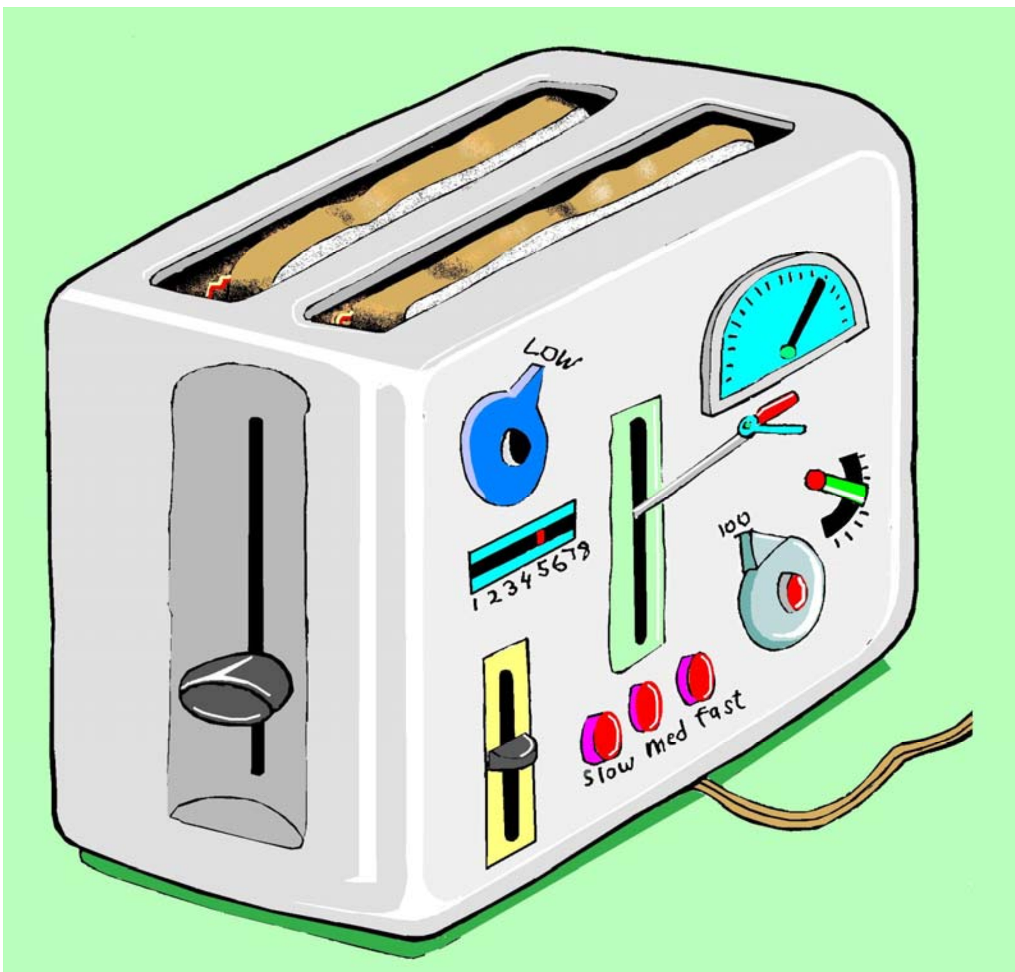
TRIZ POWER TOOLS

Skill # 8
Identifying and Mobilizing Function Resources

April 2011 Edition



Defining Parameters of Function Elements

TRIZ Power Tools

Skill #8 Identifying and Mobilizing Object Resources

April 2012 Edition

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TRIZ Power Tools by Collaborative Coauthors

60 Pages

Acknowledgements

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The Algorithm

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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)

This book constitutes a comprehensive list of object parameters (knobs). It is a restructuring and reinterpretation of the parts of the "Inventive Standards[1]" which deal with object parameters. Many of the standards give hints as to object and field parameters . The concept of knob may be objectionable to some, but is easily learned and so used in the text. The idea is that objects and fields have structure or architectural and functional features which can be varied. Once we know the structure, we can vary the measurable parameters. This is like turning knobs on a device. Apologies are made in advance if the concept of "knobs" trivializes object and field parameters.

Identifying object resources

The first use of this list of object parameters is to help determine what object parameters control the functions in question. It is human nature to forget important controlling parameters until we ask ourselves if specific ones apply. It is common that in using the Table of Knobs the problem solver will uncover several unanticipated ways to control functions.

Mobilizing Idle Knobs

During the causal analysis, you may have discovered parameters of the existing system that could have been used to control harmful or useful effects, but were not. These parameters may show up on the causal analysis diagram because they are a part of the equations. There is no escaping the fact that these parameters enter into the equation of friction, but from the viewpoint of human intent or potential usefulness, they remain idle.

For example, the friction between two surfaces might currently be controlled by the clamping force between the surfaces. Other parameters, such as the coefficient of friction, lubricants or surface texture determine the friction forces, but were not actively employed to control the friction.

There are various reasons that some knobs are not turned to control a situation. Some parameters are simply overlooked because they do not typically show up in formulas for friction. For example, we may have forgotten that the number of objects sliding past each other or temperature might have an effect on the outcome. The number of objects is usually not a parameter in formulas for friction.

Another reason that a parameter may be overlooked is because changing it to improve one outcome may harm another. For whatever reason, there are often parameters that could be used to provide a problem solution, but they remain idle. The intent of this step in the algorithm is to put these idle resources to work to resolve the problem.

1 The Inventive Standards can be found in a variety of texts including Yuri Salamatov, TRIZ: The Right Solution at the Right Time by INSYTEC pages 226-244

The Table of Knobs (Object Parameters) is a restructuring and reinterpretation of the parts of the "Solution Standards[2]" which deal with object and field parameters (knobs). The concept of knob may be objectionable to some, but is easily learned and so used in the text. The idea is that objects and fields have structure or architectural and functional features which can be varied. Once we know the structure, we can vary the measurable parameters. This is like turning knobs on a device. Apologies are made in advance if the concept of "knobs" trivializes object and field parameters.

2 "Standard Solutions" is a TRIZ tool which is not covered in TRIZ Power Tools except in its restructured form. Table of Standard Solutions can be found in a variety of texts including ________________________

L1-Identifying and Mobilizing Function Resources

Most of the time, an individual or team is capable of identifying the object parameters that control an interaction or how well a function is performed. However, it has been the experience of the author that many interactions are controlled by parameters that we may have forgotten. Here, we will consider many object, field and modification parameters to see if we have missed any.

How to change these parameters may also not be fully apparent. Many clever solutions are related to how the knobs are turned.

L1-Method

Step 1: Consider whether any of the following knobs controls the situation that you are analyzing: Existence, Number of objects, Location, Movement, Structure, Surface Properties, Bulk Properties, Direction, Field Structure, Adding or Superimposing Fields, Conductivity, Adjustability[3]*, Timing, Time Variation*

Step 2: Consider the following knobs that have not been turned (mobilized): Existence, Number of objects, Location, Movement, Structure, Surface Properties, Bulk Properties, Direction, Field Structure, Adding or Superimposing Fields, Conductivity, Adjustability[4]*, Timing, Time Variation*

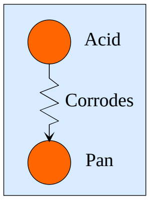
Step 3: Turn the knob to create solutions.

---

3 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.

4 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—Acid Bath



The acid in the pans is meant to test the corrosive properties of various metals. Unfortunately, it corrodes the pan that contains the acid and the cubes.

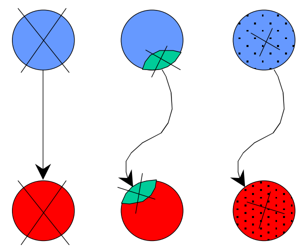
Step 1: Consider whether any of the following knobs controls the situation that you are analyzing: Existence, Number of objects, Location, Movement, Structure, Surface Properties, Bulk Properties, Direction, Field Structure, Adding or Superimposing Fields, Conductivity, Adjustability, Timing, Time Variation

New knobs were found: (1) Acid contact area. (2) Surface area of pan.

Step 3: Turn the knob to create solutions.

Reducing the contact area and/ or the surface area of the pan will decrease the amount of material that is corroded.

L2-(Existence) Existence



Existence of the tool or product is a controllable feature of the product. The existence of the product is not limited to the whole product, but can be extended to the existence of interaction zones and constituents of the objects involved.

Method—Identifying Resources

Step 1: Consider existence of the ***tool****, its* ***source*** *or its* ***path***

Step 2: Consider existence of the ***product****, its* ***source*** *or its* ***path***

Step 3: Consider existence of the interaction site on the tool or product.

Step 4: Consider the ***micro-constituents*** *that interact*

Existence is a measurable parameter of objects. It is often neglected when mobilizing resources. Consider that objects or their parts may not be required to exist. Contradictions having to do with existence are often solved by transparency[5].

Method—Mobilizing Resources

Step 1: Consider eliminating the tool

Step 2: Consider eliminating the Product

Step 3: Consider eliminating the source of the product

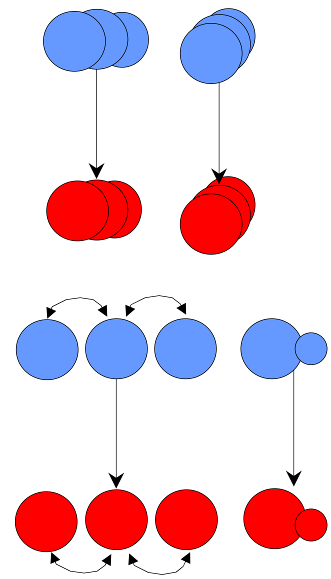
Step 4: Consider eliminating the path of the tool or product.

Step 4: Consider removing the existence of the interaction site on the tool or product.

Step 5: Consider removing the ***micro-constituents*** *that interact*

5 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.

L2-(Number of Objects) Number of Like Objects



When identifying object knobs, this is an object parameter that is often overlooked. Objects collected together have interesting properties. Simply collecting the objects together allows for interactions between objects. If the objects are similar, they have the ability to be used in different environments.

Method—Identifying Resources

*Do any of the following changes affect the outcome? (With each of these, new capabilities should emerge): --Number of tool objects--Number of product elements--**Orientation** of multiplied objects --Combining or interacting of multiplied objects --Variety of size or features of multiplied objects?*

System efficiency can be improved by moving from single elements to multiple elements. This progression can be from single to bi-systems to poly-systems.[6] The efficiency can be further improved by transitioning to bi and poly-systems that have interaction between the multiplied elements.[7] Efficiency can be further increased by using elements with "biased" properties. Each element is somewhat different from the others.

Method—Mobilizing Resources

*Step 1: Do any of the following changes affect the outcome? (With each of these, new capabilities should emerge):--Number of tool objects--Number of product elements--**Orientation** of multiplied objects --Combining or interacting of multiplied objects --Combinations of objects that come in natural groupings--Multiply the product--Multiply the tool--Combine multiple objects in different orientations. New capabilities should emerge.*

Step 2: Make the multiplied objects modify or interact with each other. New capabilities should emerge.

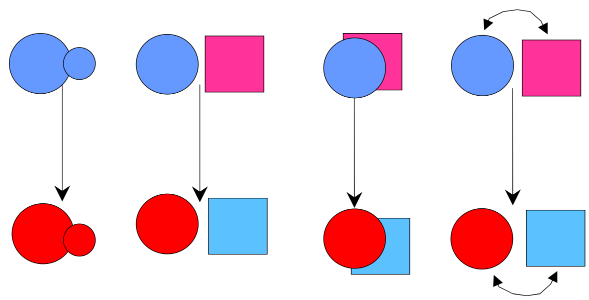
Step 3: Nest[8] or stack the objects

6 STANDARD 3-1-1. System efficiency at any stage of its evolution can be improved by combining the system with another system (or systems) to form a bi- or poly-system. Notes: For a simple formation of bi- and poly-systems, two and more components are combined. Components to be combined may be substances, fields, substance- field pairs and whole SFMs. Example: To process sides of thin glass plates, several plates are put together to prevent glass from breaking.

7 STANDARD 3-1-2. Efficiency of bi- and poly-systems can be improved by developing links between system elements. Notes: Links between elements of a bi- and poly-system may be made either more rigid or more dynamic. Example: To synchronize a process of lifting a very heavy part by three cranes, it is proposed to use a rigid triangle synchronizing the cranes moving parts.

8 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.

L2-(Number of Objects) Groupings or Combinations of Unlike Objects



Multiple physical phenomena can be used to deliver a function. This allows for the possibility that different types of objects can be involved in delivering a function. These combined objects constitute hybrid tools.

On the other end of the function, multiple object types can be served by the same function. The parameter in question can be influenced by the type and number of objects delivering the function or receiving the function.

Method—Identifying Resources

Step 1: Identify another effect/tool which performs the same function.

Step 2: What is the feature of the new tool which would extend the capability of the first tool?

Step 3: What different types of objects in the environment require the same function?

System efficiency is increased when dissimilar objects are combined in ways that complement each other.[9] This can begin with grouping biased objects and progresses to grouping together objects that are entirely different.

Method—Mobilizing Resources

Step 1: Identify another effect/tool which performs the same function.

Step 2: What is the feature of the new tool which would extend the capability of the first tool?

--Variety of size or features of multiplied objects?

***--Bias** some of the objects to handle different operating conditions*

Step 3: Identify the cheap tool which should deliver most of the function.

Step 4: Transfer the whole new tool or just the desirable feature of the new tool.

Step 5: Merge the tools. A new capability should emerge.

*Step6: Make the tools modify each other. **A new capability should emerge.***

---

9 STANDARD 3-1-3. Efficiency of bi- and poly-systems can be improved by increasing the difference between system components. The following line of evolution is recommended: similar components (pencils of the same color) –->components with biased characteristics (pencils of different colors) –->different components (set of drawing instruments) –->combinations of the "component + component with opposite function" (pencil with rubber)

L2-(Location) Location of Objects

An object parameter that is easily overlooked is the location of the object. The location of objects affects the operating environment. Many factors can be changed by simply changing the location of the objects.

Method—Identifying Resources

Step 1: Define the entire location envelope for the tool and product (What space can the tool and product be located in?)

Step 2: Move the tool about in higher dimensions[10]. Are the fields affected?

Step 3: Move the product about in higher dimensions. Are the fields affected?

Step 4: Where are the fields more concentrated?

Step 5: Where are the fields of interaction less concentrated?

Step 6: Would a completely different location affect the tool or product?

Method—Mobilizing Resources

Step 1: Define the entire location envelope for the tool and product (What space can the tool and product be located in?)

Step 2: Move the tool about in higher dimensions[11]. Are the fields affected?

Step 3: Move the product about in higher dimensions. Are the fields affected? Where are the fields more concentrated? Where are the fields of interaction less concentrated?

Step 4: Move the product and tool to environments that are conducive to their operation or where the environment is much better.

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10 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.

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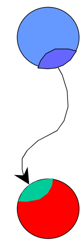
L2-(Location) Interaction Zone Location



An object parameter that is sometimes missed is the location of the interaction zone on either the tool or the product. The location of the interaction zone can change the substances and fields involved in the interaction.

Method—Identifying Resources

Step1: Locate the ***exact zone*** *of the modification on the tool and product.*

Step 2: Does changing the location affect the fields of the function?

Method—Mobilizing Resources

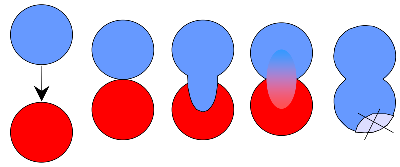
Step 1: Locate the ***exact zone*** *of the modification on the tool and product.*

Step 2: Does changing the location affect the fields of the function?

Step 3: Make the interaction zone a completely benign region on the tool and product or make it the most effective part of the tool or product.

Step 4: If the action degrades either the product or the tool, make sure that the location is not important.

L2-(Location) Relative Location



With this knob, we consider the full range of possibilities from complete separation to fully merging the tool and product. The relative location of the tool and product will almost certainly affect the fields of interaction.

Method—Identifying Resources

*Do the following parameters have an effect on the function?--Distance--Contact or separation--Location of contact--**Mixing** of tool and product--**Absorption** of tool into product--**Combining** the tool and product*

Method—Mobilizing Resources

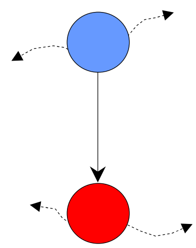
*Consider the following changes: Distance--Contact or separation--Location of contact--**Mixing** of tool and product--**Absorption** of tool into product--**Combining** the tool and product --Move the parts **far away** from each other--Try **different distances** from each other--**Nestle**[12] one into the other--**Mix** the tool and product--**Combine** the tool and product. Consolidate.*[13] *Look for new capabilities--**Combine with super-system**. Look for more consolidation, new capabilities and room for growth.*

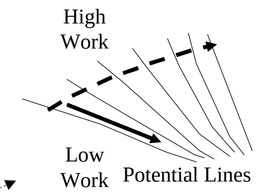
12 Inventive Principle #7—Nesting (Matrioshka): One object is placed inside another. That object is placed inside a third one. And so on. An object passes through a cavity in another object. Genrich Altshuller, The Innovation Algorithm page 287.

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.

L2-(Movement) Path

The paths that the tool and product move on will affect the interaction fields and cause them to change in time. What is the path in relation to potential field lines of a field. In order to perform lower work, it is necessary to move along lines of constant field potential. An example of this is moving objects horizontally rather than up and down to avoid moving against gravity. The lines of constant potential in the earth's gravitational field are arcs with constant radius from the earth's center. To us, this looks like horizontal movement. For an electrostatic field between two capacitor plates, the lines of constant potential (at the center) run nearly parallel to the plates.



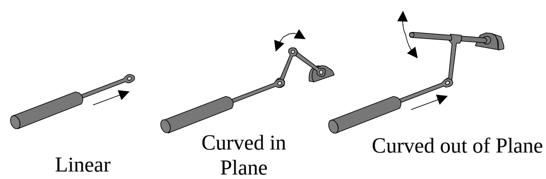


Method—Identifying Resources

Step 1: Consider how the interaction fields change as the tool and product move along their separate paths.

Step 2: Consider how the fields change with respect to field potential[14]

Line of Evolution



14 Inventive Principle #12—Equipotentiality: Change the condition of the work in such a way that it will not require lifting or lowering an object. Genrich Altshuller, The Innovation Algorithm page 287.

Method—Mobilizing Resources

Step 1: Consider CONSTANT POTENTIAL PATHS: Path in relation to potential field lines of a field.

Step 2: Move along lines of constant field potential

Step 3: Move directly through lines of constant field potential.

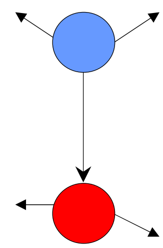
Step 4: Move in an entirely new dimension[15]*.*

Step 5: Movement around harmful objects or functions

Step 6: Rotation[16] *rather than linear paths*

L2-(Movement) Velocity Acceleration or Jerk

This knob considers the absolute and relative velocity, acceleration and jerk (the rate of change of acceleration. It turns out that humans are able to sense the change of acceleration and it can be quite uncomfortable if the jerk is high.)



Method—Identifying Resources

*Consider the following:--**Velocity** or relative velocity--**Stopping** the tool or product--Acceleration--Rate of change of the acceleration (jerk)*

Method—Mobilizing Resources

*Consider the following changes:--**Velocity** or relative velocity --**Stopping** the tool or product--Existence of acceleration--Rate of change of the acceleration (jerk) --**Stop** the tool or product--Try **extremely high or low** rates of acceleration.*

15 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.

16 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.

L2-(Structure) Structure of Interaction Zone

Efficiency of systems increase when the interaction zones are structured to compliment the fields which are used to perform the functions.[17]

Method—Identifying Resources

Step 1: Locate the ***exact zone*** *of the modification on the tool and product.*

Step 2: Does changing the structure change the efficiency of the interactions?

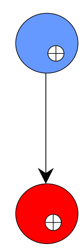
Method—Mobilizing Resources

Step 1: Make the interaction zone a completely benign region on the tool and product.

Step 2: Change the structure of the interaction zone to compliment or augment the fields that are being used.

L2-(Structure) Symmetry

Symmetry refers to how half of an object appears to be a reflection of the other half. This reflection can be made around a variety of axis or planes. As long as the reflection is exact about any plane, the object is said to be symmetric. Symmetric objects can generate symmetric fields of interaction. Objects tend to evolve towards un-symmetric structures which are usually more difficult to manufacture than symmetric objects.



Method—Identifying Resources

Step 1: Consider parameters or knobs which have already been identified. Are they symmetrically located?

Step 2: Consider ***symmetry*** *or* ***asymmetry***[18] *of the tool and product*

Method—Mobilizing Resources

Step 1: Consider parameters or knobs which have already been identified. Are they symmetrically located?

Step 2: Consider ***symmetry*** *or* ***asymmetry***[19] *of the tool and product*

Step 3: Change symmetry to ***another axis***

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17 STANDARD 2-2-6. Efficiency of a SFM can be improved by transition from substances that are uniform or have a disordered structure to substances that are non-uniform or have a predefined spatial-temporal structure (permanent or variable). Notes: In particular, if an intensive effect of a field is required in certain places of a system (points, lines), then substances that produce the required field are introduced in these spots beforehand. Example: To make a porous material with oriented spatial structure threads are inserted into the soft material beforehand. After the material solidifies these threads are burned out.

18 Inventive Principle #4—Asymmetry: Replace symmetrical form(s) with asymmetrical form(s). If an object is already asymmetrical, increase its degree of asymmetry. Genrich Altshuller, The Innovation Algorithm page 287.

19 Inventive Principle #4—Asymmetry: Replace symmetrical form(s) with asymmetrical form(s). If an object is already asymmetrical, increase its degree of asymmetry. Genrich Altshuller, The Innovation Algorithm page 287.

Step 4: Make the tool or product ***unsymmetrical***

Step 5: Make symmetrical

L2-(Structure) Dimension

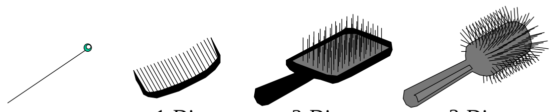
Systems which produce useful functions tend to evolve to higher dimensions. Structures which produce harmful functions tend to evolve to lower dimensions. Lower dimensional structures tend to have more minimum fields. An example of moving to a higher dimension is a plan.

Method—Identifying Resources

Does the dimension affect the interaction fields?

Efficiency of useful functions is increased by moving to higher dimensions[20]. Harm done by harmful functions is decreased by decreasing the dimension of the harming interface.

Line of Evolution



Method—Mobilizing Resources

Consider changing the structure dimension[21] to the next higher dimension for useful effects and to lower dimensions for harmful effects.

20 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.

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L2-(Structure) Nesting—Nestling—Through

Unless the main function of the system requires a high volume in order to perform well, this can be accomplished by nesting [22]objects, nestling them together or making one go through the other.

Method—Identifying Resources

Are objects nested or through each other? If not, these resources are not yet mobilized.

Method—Mobilizing Resources

Step 1: Consider putting objects inside each other to change the volume requirements

Step 2: Make one object go through another

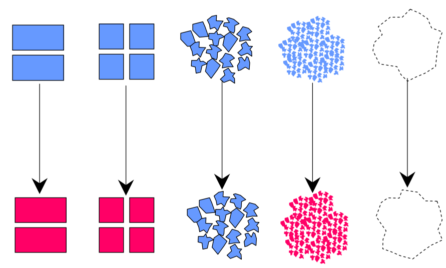
Step 3: Nest an object completely inside another

Step 4: Allow one object to invade the space of another by nestling in to its volume.

Nested
sink trap

L2-(Structure) Degree of Segmentation

Increasing the degree of segmentation[23] can increase the efficiency of a system. Degree of segmentation can have a large influence on the interaction fields. Systems tend to increase segmentation for useful functions.



Method—Identifying Resources

Step 1: Would increasing the number of ***interaction sites*** *improve the function?*

Step 2: Can the sites be ***independent?***

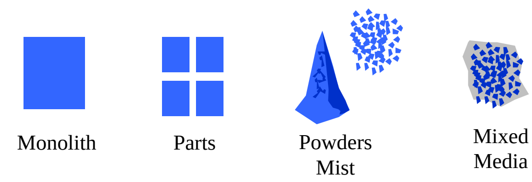
Step 3: Consider the effect that the following would have size, shape and aspect ratio if the objects were segmented.:

22 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.

23 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.

The efficiency of systems generally increases with segmentation of the elements. Methods for creating particles are provided in the standard solutions.[24]

Line of Evolution



Method—Mobilizing Resources

*Step 1: Would increasing the number of **interaction sites** improve the function? Can the sites be **independent?***

Step 2: Consider the affect that the following would have on the segmented pieces:

*--Dividing into **multiple copies** of the original objects--Size--Shape--Aspect Ratio*

*Step 3: Make the sites **independent***

*Step 4: Break the original piece into **sections** that can be easily dismantled and assembled.*

*Step 5: Make **multiple copies** of the original objects. Reduce in size. Combine or make interact*

Step 6: Change the shape of the segmented pieces

Step 7: Change to a powder or aerosol

Methods of segmenting:

--Decompose: *Grains—Dust—Molecules—Atoms—Ions—Sub Atomic Particles*

--Combine: *Sub Atomic Particles—Ions—Atoms—Molecules—Dust—Grains*

--Solidify a liquid *or its constituents into particles*

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24 STANDARD 5-5-1. If substance particles (e. g. ions) are required to solve a problem and they are not available according to the problem conditions, the required particles can be obtained by decomposing a substance of a higher structural level (e.g. molecules).

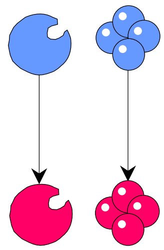
STANDARD 5-5-2. If substance particles (e.g. molecules) are required to solve a problem and they cannot be produced by decomposing a substance of a higher structural level, the required particles can be obtained by combining particles of a lower structural level (e.g. ions).

STANDARD 5-5-3. If a substance of a higher structural level has to be decomposed, the easiest way is to decompose the nearest higher element. When combining particles of a lower structural level, the easiest way is to combine the nearest lower elements.

L2-(Structure) Voids, Capillary Structures, Foam

Voids [25] capillary structures[26] [27] and foam [28] [29] [30] can have an effect on interactions between objects. It should be noted that the difference between voids and foam is one of ratio between gas and substance. Foam has very little substance and voids have little gas. Capillary structures are somewhere between and can be very structured.

Method—Identifying Resources



Step 1: Consider the effect of voids in the structure of the tool and the product.

Step 2: Consider the effect of porosity or capillary structures in the tool or the product

Step 3: Consider the effect of fluids in conjunction with capillary or porous structures

Step 4: Consider the effect of either the tool or product being composed of foam or introducing foam between them.

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25 STANDARD 5-1-1-1. If it is necessary to introduce a substance in the system, and it is not allowed, a "void" can be used instead of the substance. Notes: A "void" is usually gaseous substance, like air, or empty space formed in a solid object. In some cases a "void" may be formed by other substances, such as liquids (foam) or loose bodies.

26 STANDARD 2-2-3. Efficiency of a SFM can be improved by transition from a solid object to a capillary porous one. The transition is performed as: solid object —> object with one cavity —> object with multiple cavities (perforated) —> capillary porous object —> capillary porous object with a predefined porous structure. Notes: Transition to a capillary porous object enables a liquid substance to be placed in the pores and use physical effects. Example: A bunch of capillaries apply liquid glue more accurately on a surface to be glued than a single large-sized tube.

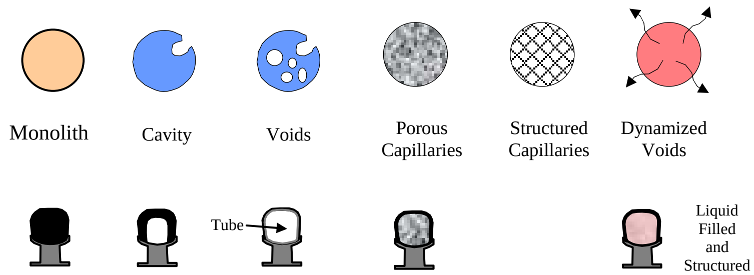
27 Inventive Principle #31—Porous Material: Make an object porous, or use supplementary porous elements (inserts, covers, etc.). If an object is already porous, fill poured in advance with some substance. Genrich Altshuller, The Innovation Algorithm page 289.

28 STANDARD 1-2-1. If useful and harmful effects appear between two substances in a SFM and there is no need to maintain a direct contact between the substances, the problem is solved by introducing a third substance between them. Notes: The third substance can also be obtained from the present substances by exposure to the existing fields. In particular, the substance to be introduced can be bubbles, foam, etc. Example: To compact walls of a borehole, gases produced during explosion are used. However, the gases also may cause cracks in the borehole's walls. It is proposed to cover the walls by plasticine that transmits pressure but prevents the walls from crack formation.

29 STANDARD 1-2-2. If there are a useful and a harmful effects between two substances, and there is no need to maintain direct contact between the substances, and it is forbidden or inconvenient to use foreign substances, the problem can be solved by introducing a third substance between the two, which is a modification of the first or the second substances. Note: The third substance can be obtained from the existing substances by exposure to the present fields. In particular, the substance to be introduced can be bubbles, foam, etc. Besides, a modification of the substance may bring about a change in the law of its movement: movable-fixed parts, etc. Example: A hydrodynamic foil's surface might be destroyed by a cavitation produced by the friction between the foil and the water when moving at a high speed. It is proposed to refrigerate the surface of the foil. Surrounding water will freeze and form an ice layer on the foil.

30 STANDARD 5-1-4. If it is necessary to introduce a large quantity of a substance, but this is not allowed, a "void" in the form of inflatable structures or foam should be used as the substance. Note: Introduction of foam or inflatable structures resolves a contradiction 'much substance - little substance'

Line of Evolution



Tire Example

Method—Mobilizing Resources

Step 1: Consider the affect of the following changes to the tool or product: --Voids --Porosity--Structured capillaries--Fluids in voids or capillary structures

Step 2: Place specially shaped voids in the tool or product (honeycomb, spherical, random)

Step 3: Use open or closed celled porous materials

Step 4: Consider using: --Sintered powders--Dried or fired clays--Porcelain--Sand--Loose Powders--Pumice

Step 5: Make the tool or product from structured capillary materials such as:

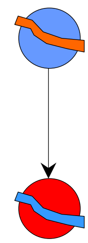
--Fabrics--Fiber batting--Fiber bundles (thread, string, rope…)--Screen or layers of screens--Capillary tubes or tube bundles

Step 6: Fill the porous material with special fluids or allow fluids to move through the porous material.

Step 7: Replace the tool or product with a foam

Step 8: Put foam between the tool and the product

L2-(Structure) Thickness/Length/Aspect Ratio



The thickness or the length of an object can have a strong effect on interacting fields. In general, objects trend toward smaller lengths and thicknesses as they evolve which makes a better use of resources. When taken together, the length to width ratio gives an aspect ratio. Any one of these three measures of an object may dominate as the controlling factor.

Method—Identifying Resources

Does the thickness of the tool or the product affect the function?

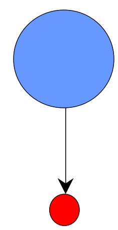
Method—Mobilizing Resources

Step 1: Does the thickness of the tool or the product affect the function?

Step 2: Replace solid constructions with flexible membranes

Step 3: Isolate objects with thin films[31]

L2-(Structure) Volume



Objects may start with large volumes because the strength of interacting fields may be a strong function of the size. However, they trend toward smaller volumes [32] [33] to conserve resources unless their main function is to transport, in which case, the trend is toward greater volumes.

Method—Identifying Resources

Consider the volume of the tool or product

Method—Mobilizing Resources

Step 1: Does the volume of the tool or the product affect the function?

Step 2: Consider changing the volume of the tool or product. Consider extreme changes in volume.

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31 Inventive Principle #30—Flexible Membranes or Thin Films: Replace customary constructions with flexible membranes or thin film. Isolate an object from its outside environment with flexible membranes or thin films. Genrich Altshuller, The Innovation Algorithm page 289.

32 Inventive Principle #35—Transformation of Properties: Change the physical state of the system. Change the concentration or density. Change the degree of flexibility. Change the temperature or volume. Genrich Altshuller, The Innovation Algorithm page 289

33 This comes from what is sometimes called the STC operator which stands for size, time and cost. When using this concept, the problem solver considers the possibility that the there is no limit to each of these variables and to consider the problem at the extremes of each. In this case, we consider the size or volume of the tool or product only Page 112 of The Innovation Algorithm, Genrich Altshuller.

L2-(Structure) Curvature

The use of spherical structures is a very important tool in TRIZ. Curved structures[34] have special properties. They allow for the precise rotation of objects relative to each other. They also allow for the concentration or dispersion of fields in unique ways. While the constant curvature of objects is very common, non constant curvatures, such as parabolas and ellipses and hyperbolas have unique characteristics.

Method—Identifying Resources

Does the curvature of the tool or product affect the outcome?

Method—Mobilizing Resources

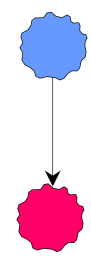
Step 1: Does the curvature of the tool or product affect the outcome?

Step 2: Change from linear shapes to curved shapes

Step 3: Use rollers or balls

Step 4: Change from linear to rotary motion

L2-(Surface) Surface Structure



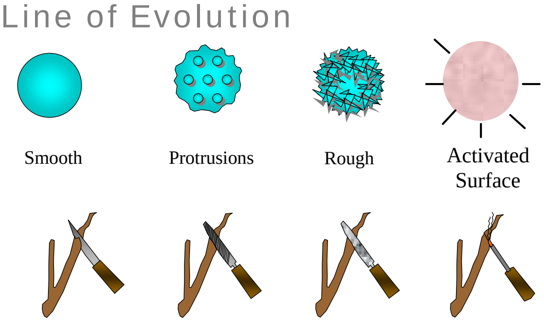
Many functions are controlled by the surface structure[35] of objects. Surface shapes can be rough or smooth. They can also have a fine structure. Surface shapes can have a strong effect on reflection, transmission and dispersion of electromagnetic fields. Many other properties of objects can be changed at the surface in ways that have a strong effect on interaction fields. The table on the next page shows how other properties can effect various fields.

Method—Identifying Resources

Step 1: Identify the primary fields of interaction

Step 2: Reference the chart on the following page to identify what surface properties might have an effect on the fields of interaction.

Line of Evolution



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34 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.

35 The source of this object property is The line of evolution was presented in Invention Machine TM Software.

Method—Mobilizing Resources

Step 1: How does the surface shape affect the fields of interaction?

Step 2: Make the surface ***smooth*** *if it is not already*

Step 3: Make ridges, protrusions or cavities in the surface of the tool or product (Random or structured)

Step 4: Make the surface of the tool or product ***rough*** *(random or structured)*

Step 5: Use a finer and finer surface roughness

Elastic Force Internal & External
Creep Coefficient-Strength-Elasticity-Toughness-Ductility

Gravity
Density

Friction
Protrusions-Roughness-Matter State-Friction Couple-Slipperiness

Adhesive
Adhesiveness-Matter State-Cohesiveness

Centrifugal Force

Inertia of Bodies (Note Direction)

Coriolis Force

Buoyant force

Hydrostatic Pressure
Surface State

Jet Pressure

Surface Tension
Bulk Properties-State-Wetted Circumference-Temperature

Odor & Taste
Chemical Composition-Surface State

Diffusion
Surface Porosity
Surface State

Osmosis
Surface Molecular Structure
Surface State

Chemical Fields
Chemical Reactivity-Surface State-Concentration

Sound

Vibrations & Oscillations

Ultrasound
Surface State

Waves

Corona Discharge
Surface Protrusions-Roughness-Surface State

Current
Continuity-Surface State-Conductivity

Eddie Currents (Internal and skin)
Continuity-Surface State-Conductivity

Particle Beams
State-Chemical Reactivity-Surface Molecular Weight

Surface Property Knobs which Affect these Fields

Thermal Heating or Cooling
Surface Protrusions or Roughness-Surface State

Thermal Shocks
Surface Protrusions or Roughness-

Nuclear Forces
Nuclear Particle Type

Electrostatic Field
Protrusions
Roughness

Magnetic Field

Electromagnetic (Voltage)
Continuity
Conductivity

Information

Radio Waves
Reflectivity--State
- Absorbtivity
-Emissivity

Micro-waves
Reflectivity--State
-Absorbtivity
-Emissivity

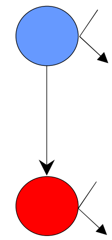
Infrared
Reflectivity--State
--Absorbtivity
-Emissivity

Visible Light
Reflectivity--State
-
-Emissivity

Ultra-violet
Reflectivity--Emissivity--State
--
Fluorescence

X-Ray
Atomic Weight

L2-(Surface) Surface Properties



Fields of interaction are modified and controlled surface properties other than surface structure. The table on the previous page gives suggestions as to surface properties that can modify fields of interaction.

Method—Identifying Resources

Step 1: Identify the primary fields of interaction

Step 2: Reference the chart on the previous page to identify what surface properties might have an effect on the fields of interaction.

Method—Mobilizing Resources

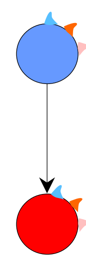
Step 1: Identify the fields which deliver the modification.

*Step 2: Consult the **Table of Surface Properties** to see which ones modify the fields of the function*

Step 3: Greatly increase the surface properties.

Step 4: Change to new materials or coatings if necessary

L2-(Surface) Surface Substances



Substances can exist on surfaces which modify the fields of interaction. Such substances can be put there for useful purposes or they can be contaminants. Over the course of time, it is almost a certainty the some type of contaminant will find its way to the surfaces of the product or tool.

Method—Identifying Resources

Can contaminants (solids, liquids or gases) find a way to the surface? (Internal or external paths)

Method—Mobilizing Resources

Step 1: Can contaminants (solids, liquids or gases) find a way to the surface? (Internal or external paths)

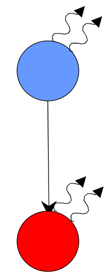
Step 2: Greatly decrease the surface contaminants until the surface is ultra-clean

Step 3: Greatly increase the contaminants

Step 4: Add a lubricant to the surface

Step 5: Condense a liquid onto the surface

L2-(Bulk) State of Matter



Most substances exist in multiple physical states, even if one of the states is barely perceptible. Because of this, it is possible that the different states of matter will react differently with the fields of interaction. These controlling factors are even stronger when multiple states of matter exist. Look at every tool or product as being composed of at least two states of matter and consider whether less dominant state might be having an effect on the interactions.

Method—Identifying Resources

Consider how the following changes of the physical state[36] [37] of the tool or product might affect the interaction or fields:

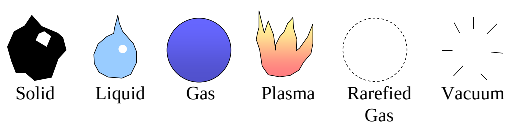
State of the tool

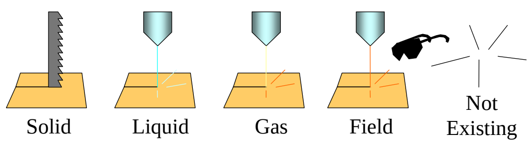
State of the Product

State of the Environment

Note that state of matter controls most fields

Line of Evolution





Method—Mobilizing Resources

Step 1: Consider how the following affect the interaction or fields: --State of the tool--State of the Product--State of the Environment--Note that state of matter controls most fields

Step 2: Change the State of the tool

Step 3: Change the State of the Product

Step 4: Change the State of the Environment. (Note that state of matter controls most fields)

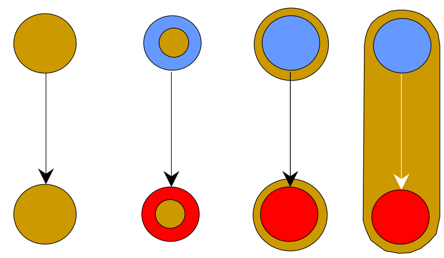
36 Inventive Principle #35—Transformation of Properties: Change the physical state of the system. Change the concentration or density. Change the degree of flexibility. Change the temperature or volume. Genrich Altshuller, The Innovation Algorithm page 289

37 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.

L2-(Bulk) Bulk Properties of Substance

Substances of the product and the tool have many native bulk properties[38] Generally, we would like the substances to have a strong effect on the useful interaction fields and a weak effect on the harmful fields. Below is a table of bulk properties. Each property reflects its typical reaction to interacting fields.

Substances of the product and the tool have many native bulk properties[39] [40] [41]. These properties can have strong effects on the interaction fields. In general, it is important that the bulk substances interact strongly with useful fields and weakly with harmful fields. Below is a table of bulk properties. Each property reflects its typical reaction to interacting fields.



Method—Identifying Resources

Step 1: Identify the current fields throughout the tool or product.

Step 2: What materials are affected by these fields?

Step 3: What are their bulk properties(Properties spread throughout the volume?)

Step 4: Do the bulk properties change these fields?

Step 5: Do the bulk properties have an effect on the functions being performed?

38 STANDARD 3-2-1. Efficiency of a system at any stage of its evolution can be improved by transition from a macro-level to a micro-level: the system or its part is replaced by a substance capable of delivering the required function when interacting with a field. Notes: There is a multitude of micro-level states of a substance (domains, crystal lattice, molecules, ions, domains, atoms, fundamental particles, fields, etc.). Therefore, various options of transition to a micro-level and various options of transition from one micro-level to another, lower one, should be considered when solving a problem. Example: Instead of a micro-screw, a microscopic table can be positioned by fixing it on a metal rod that is subjected to a thermal field. The rod expands and contracts relatively the value of the temperature due to the effect of thermal expansion.

39 STANDARD 3-2-1. Efficiency of a system at any stage of its evolution can be improved by transition from a macro-level to a micro-level: the system or its part is replaced by a substance capable of delivering the required function when interacting with a field. Notes: There is a multitude of micro-level states of a substance (domains, crystal lattice, molecules, ions, domains, atoms, fundamental particles, fields, etc.). Therefore, various options of transition to a micro-level and various options of transition from one micro-level to another, lower one, should be considered when solving a problem. Example: Instead of a micro-screw, a microscopic table can be positioned by fixing it on a metal rod that is subjected to a thermal field. The rod expands and contracts relatively the value of the temperature due to the effect of thermal expansion.

40 STANDARD 1-1-2. If there is a SFM which is not easy to change as required, and the conditions do not contain any limitations on the introduction of additives to given substances, the problem is to be solved by a transition (permanent or temporary) to an internal complex SFM, introducing additives in the present substances enhancing controllability or imparting the required properties to the SFM. Example: To detect very small drops of liquid (S2) in a liquid (S1), a luminescent substance is added to the liquid (S2) in advance.

41 STANDARD 1-1-3. If there is a SFM which is not easy to change as required, and the conditions contain limitations on the introduction of additives into the existing substances, the problem can be solved by a transition (permanent or temporary) to an external complex SFM, attaching to one of these substances an external substance which improves controllability or brings the required properties to the SFM. Example: To detect a leakage of gases (S1) from a pipe (S2), an outer surface of the pipe is covered with a substance (S3)

Introduce a substance into the environment of the tool or product which allows the ideal properties for control.[42]

Method—Mobilizing Resources

Step 1: Identify the current fields throughout the tool or product

Step 2: What materials are affected by these fields? What are their bulk properties (Properties spread throughout the volume?)

Step 3: Change the product or tool to be composed of a substance with the ideal bulk properties.

Step 4: Introduce a substance to the product or tool which has the ideal properties for control.[43]

Example of Bulk Properties

- Creep Coefficient
- Strength
- Elasticity
- Toughness
- Ductility
- Physical State
- Density
- Temperature
- Viscosity
- Coefficient of restitution
- Gas Constant
- Gamma
- Cohesiveness
- Chemical Composition
- Molecular Weight
- Ionization Potential
- Molecular size
- Ease of Ionization
- Rarefaction
- Conductivity
- Trans Conductance
- Thermal Conductivity
- Coefficient of Thermal Expansion
- Thermal Capacity
- Dielectric Constant
- Magnetic Permeability
- Magnetic Hysteresis
- Curie Point
- Permeability
- Transparency
- Image Splitting Properties

Step 5: Attach a substance to the product or tool which has the ideal properties for control.[44]

Step 6: Introduce a substance into the environment of the tool or product which allows the ideal properties for control.[45]

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42 STANDARD 1-1-4. If there is a SFM that is not easy to change as required, and the conditions contain limitations on the introduction or attachment of substances, the problem has to be solved by synthesizing a SFM using external environment as the substance.

43 STANDARD 1-1-2. If there is a SFM which is not easy to change as required, and the conditions do not contain any limitations on the introduction of additives to given substances, the problem is to be solved by a transition (permanent or temporary) to an internal complex SFM, introducing additives in the present substances enhancing controllability or imparting the required properties to the SFM. Example: To detect very small drops of liquid (S2) in a liquid (S1), a luminescent substance is added to the liquid (S2) in advance.

44 STANDARD 1-1-3. If there is a SFM which is not easy to change as required, and the conditions contain limitations on the introduction of additives into the existing substances, the problem can be solved by a transition (permanent or temporary) to an external complex SFM, attaching to one of these substances an external substance which improves controllability or brings the required properties to the SFM. Example: To detect a leakage of gases (S1) from a pipe (S2), an outer surface of the pipe is covered with a substance (S3)

45 STANDARD 1-1-4. If there is a SFM that is not easy to change as required, and the conditions contain limitations on the introduction or attachment of substances, the problem has to be solved by synthesizing a SFM using external environment as the substance.

Step 7: Change the bulk properties by chemically transforming, decomposing, and combining existing materials or by heat treatment.[46]

Step 8: Further enhance by adding a field.

Step 9: If the addition of substances is not allowed, a number of ways are provided in the Solution Standards to add these substances. [47]

Step 10: Change the bulk properties by chemically transforming, decomposing, and combining existing materials or by heat treatment.[48]

Cheap Substances

- Grocery store products
- Powders
- Foam
- Void
- Loose Bodies
- Waste or transformed waste
- Garbage
- Water, Steam or Hydrates
- Air and its

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46 STANDARD 1-1-5. If the external environment does not contain ready substances required to synthesize a SFM, these substances can be obtained by replacing the external environment with another one, or by decomposing the environment, or by introducing additives into the environment. Example: To improve a coefficient of sliding effect, a liquid lubricant is aerated.

47 STANDARD 5-1-1-1. If it is necessary to introduce a substance in the system, and it is not allowed, a "void" can be used instead of the substance. Notes: A "void" is usually gaseous substance, like air, or empty space formed in a solid object. In some cases a "void" may be formed by other substances, such as liquids (foam) or loose bodies.

STANDARD 5-1-1-2. If it is necessary to introduce a substance in the system, and it is not allowed, a field can be introduced instead of the substance.

STANDARD 5-1-1-3. If it is necessary to introduce a substance in the system, and it is not allowed. an external additive can be used instead of an internal one.

STANDARD 5-1-1-4. If it is necessary to introduce a substance in the system, and it is not allowed, a very active additive can be introduced in very small quantities.

STANDARD 5-1-1-5. If it is necessary to introduce a substance in the system, and it is not allowed, an additive can be introduced in very small quantities, and concentrated in certain parts of the object.

STANDARD 5-1-1-6. If it is necessary to introduce a substance in the system, and it is not allowed, the substance can be introduced temporarily and then removed.

STANDARD 5-1-1-7. If it is necessary to introduce a substance in the system, and it is not allowed, a copy of the object can be used instead of the object itself, where introduction of substances is allowed.

STANDARD 5-1-1-8. If it is necessary to introduce a substance in the system, and it is not allowed by the system's operating conditions, the substance can be introduced in a form of a chemical compound which can be later decomposed.

STANDARD 5-1-1-9. If it is necessary to introduce a substance in the system, and it is not allowed, the substance can be produced by decomposing the external environment or the object itself, for instance, by electrolysis, or by changing the aggregate state of a part of the object or external environment.

STANDARD 5-1-2. If a system is not easy to change as required, and the conditions do not allow to replace the component acting as an instrument or introduce additives, the artifact has to be used instead of the instrument, dividing the artifact into parts interacting with each other.

STANDARD 5-1-3. After the substance introduced in the system has fulfilled its function, it should either disappear or become indistinguishable from the substance that was in the system or in the external environment before. Note: The substance that has been introduced may disappear due to chemical reactions or change of phase.

STANDARD 5-1-4. If it is necessary to introduce a large quantity of a substance, but this is not allowed, a "void" in the form of inflatable structures or foam should be used as the substance. Note: Introduction of foam or inflatable structures resolves a contradiction 'much substance - little substance'.

48 STANDARD 1-1-5. If the external environment does not contain ready substances required to synthesize a SFM, these substances can be obtained by replacing the external environment with another one, or by decomposing the environment, or by introducing additives into the environment. Example: To improve a coefficient of sliding effect, a liquid lubricant is aerated.

Elastic Force Internal & External
Creep Coeff-Strength-Elasticity-Toughness-Ductility-Physical

Gravity
Density-State

Friction
Temperature-Viscosity-State

Adhesive
Temperature-State of Mater

Centrifugal Force
Density

Inertia of Bodies (Note Direction)
Density-State-Elasticity Coeff. of Restitution

Coriolis Force
Density

Buoyant Force
Density-State

Hydrostatic Pressure
Gas Constant-State-Gamma-Temperature

Jet Pressure
Density-State

Surface Tension
Cohesiveness-State

Odor & Taste
Chemical Composition-State

Diffusion
Molecular Weight-State

Osmosis
Molecular Size-Ionization Potential-State

Chemical Fields
Chemical Composition-Concentration-State

Sound
Coeff. of Restitution-Viscosity-Density-State

Vibrations & Oscillations
Coeff. of Restitution-Viscosity-Density-State

Ultrasound
Coeff. of Restitution-

Waves
Coeff. of Restitution-Viscosity-Density-State

Corona Discharge
Ease of Ionization-Rarefaction-State

Current
Conductivity-State-Trans-conductance

Eddie Currents (Internal and skin)
Conductivity-State-Trans-conductance

Particle Beams
Molecular Weight

Bulk Property Knobs which Affect these Fields

Thermal Heating or Cooling
Thermal Conductivity-Coeff. Thermal

Thermal Shocks
Thermal Conductivity-Coeff. Thermal

Nuclear Forces
Atomic Weight-Density Temperature

Electrostatic Field
Dielectric Constant

Magnetic Field
Magnetic Permeability-Magnetic Hysteresis-Curie Point

Electromagnetic (Voltage)
Permeability--Conductivity Dielectric Constant

Information

Radio Waves
Transparency-State-Image Splitting Refractive index

Micro-waves
Transparency-State-Image Splitting Refractive index

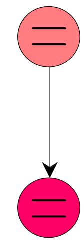
Infrared
Transparency-State-Image Splitting Refractive index

Visible Light
Transparency-State-Image Splitting Refractive index

Ultra-violet
Transparency-State-Image Splitting Refractive index

X-Ray
Molecular Weight

L2-(Bulk) Match or Mismatch of Properties



When substances must touch each other, a matching of properties is often necessary to avoid harm. For example, having two substances clamped together with different thermal expansion coefficients can lead to high stresses or high levels of friction. The tool and product should match the properties that matter the most. Not every property is required to match. For instance, clamping two substances with different densities may be fine so long as the thermal coefficients match under conditions of large temperature swings. Examples of properties that are often considered are: Thermal expansion[49], Thermal Conductivity, Electrical Conductivity, Modulus of Elasticity

Method—Identifying Resources

Step 1: Are the tool and product alike?

Step 2: Do the bulk properties match each other?

Step 3: For the given situation, consider the properties that must match in the tool and product.

Method—Mobilizing Resources

Step 1: Are the tool and product alike? Do the bulk properties match each other? Consider the following and how well matched the tool and product are:

--Thermal expansion

--Thermal Conductivity

--Electrical Conductivity

--Modulus of Elasticity

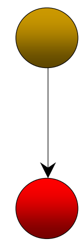
Step 2: Match or mismatch tool and product properties, especially if they are in contact or must move or expand together

Step 3: Make the product and tool from the same materials if possible

49 Inventive Principle #37—Thermal Expansion: Use expansion or contraction of material by changing its temperature. Use various materials with different coefficients of thermal expansion. Genrich Altshuller, The Innovation Algorithm page 289.

L2-(Bulk) Gradients of Components

The gradient of any property is its rate of change with respect to distance. High gradients change from one value to another over a very short distance. In this case, we are considering the gradient of substance components. An additive to a substance can have a high gradient and thus, the properties vary across the object. This is sometimes important in the control of fields and is similar to the concept of asymmetry of structures in controlling fields.



Method—Identifying Resources

Step 1: Consider the bulk constituents. Can they be made non-uniform[50]*?*

Step 2: How would a material gradient affect the internal fields?

Method—Mobilizing Resources

Step 1: Consider the bulk constituents. Can they be made non-uniform[51]*?*

Step 2: How would a material gradient affect the internal fields?

Step 3: Allow a gradation or mixture gradient[52] *of material constituents*

Step 4: Allow a sharp gradation of material constituents

Step 5: Add a new material and allow the gradient to vary

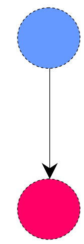
---

50 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.

51 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.

52 Inventive Principle #35—Transformation of Properties: Change the physical state of the system. Change the concentration or density. Change the degree of flexibility. Change the temperature or volume. Genrich Altshuller, The Innovation Algorithm page 289

L2-(Bulk) Chemical Activity



The chemical activity is a reference to how chemically active the tool is to the product under a given condition. This has greatest emphasis when the main useful functions are involved in a chemical reaction between the tool and the product. The chemical reactivity can be boosted by thermal fields or electrical currents.

Method—Identifying Resources

Consider how chemically reactive the Product is to the Tool. [53]

Method—Mobilizing Resources

Step 1: Consider how chemically reactive the Product is to the Tool

Step 2: Increase Chemical Activity

Step 3: Change to very active chemical substances:

--Use progressively activated oxygen[54].

--Ambient Air

--Oxygenated Air

--Pure Oxygen

--Ionized Oxygen

--Ozone

--Singlet Oxygen

Step 4: Change the tool or product to an inert substance[55]

Step 5: Introduce inert gases[56]

Step 6: Introduce or mix in inert substances[57]

Step 7: Use a vacuum

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53 Inventive Principle #38—Accelerated Oxidation: Make transition from one level of oxidation to the next higher level : Ambient air to oxygenated; Oxygenated to oxygen. Oxygen to ionized oxygen. Ionized oxygen to ozoned oxygen. Ozoned oxygen to ozone. Ozone to singlet oxygen. Genrich Altshuller, The Innovation Algorithm page 289.

54 Inventive Principle #38—Accelerated Oxidation: Make transition from one level of oxidation to the next higher level : Ambient air to oxygenated; Oxygenated to oxygen. Oxygen to ionized oxygen. Ionized oxygen to ozoned oxygen. Ozoned oxygen to ozone. Ozone to singlet oxygen. Genrich Altshuller, The Innovation Algorithm page 289.

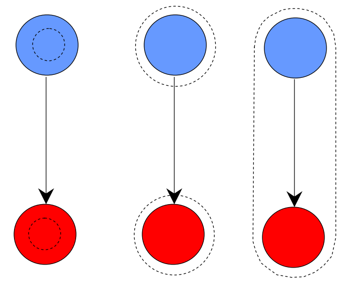
55 Inventive Principle #39—Inert Environment: Replace a normal environment with an inert one. Introduce a neutral substance or additives into an object. Carry out the process in a vacuum. Genrich Altshuller, The Innovation Algorithm page 289.

56 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.

57 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.

L2-(Field) Adding Fields

There are a variety of reasons to add fields[58]. Whenever it is necessary to introduce a field, it should be done in a way that requires the least use of resources. The Solution Standards shown in the references below, give a variety of ways to introduce fields without increasing system complexity.[59]



Method—Mobilizing Resources

Step 1: Identify substances and constructions which react strongly to the existing fields or fields which would react strongly to the existing substances.

Step 2: Identify other fields in the environment.

*Step 3: Consider **assisting fields** or **counter fields** that could be superimposed **into**, **onto** or **in the environment** of the objects?*

*Step 4: Consult the table of Storage of Fields for consideration of **residual fields.***

Step 5: Introduce a field into the system that performs the required action.[60]

Step 6: Superimpose a counter field

Step 7: Superimpose an assisting field[61]

Step 8: Superimpose a new field type

Step 9: Pre-stress the parts

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58 Inventive Principle #35—Transformation of Properties: Change the physical state of the system. Change the concentration or density. Change the degree of flexibility. Change the temperature or volume. Genrich Altshuller, The Innovation Algorithm page 289

59 STANDARD 5-2-1. If a field has to be introduced in a SFM, one should use first of all the present fields for whom the media are those substances that form the system or its part. Note: The use of substances and fields which already present in the system improves the system's ideality: number of functions performed by the system increases without increasing the number of used components.

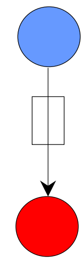
STANDARD 5-2-2. If a field has to be introduced in a SFM and it is not possible to use the fields which already present in the system, one should use the fields of the external environment. Note: The use of external environment fields (gravitation, thermal field, pressure...) improves the system's ideality: the number of functions performed by the system increases without increasing the number of used components.

STANDARD 5-2-3. If a field has to be introduced in a SFM but it is impossible to use the fields which already present in the system or in the external environment, one should use the fields for whom the substances present in the system or external environment can act as media or sources. Notes: In particular, if there are ferromagnetic substances in a system and they are used for mechanical purposes, it is possible to use their magnetic properties in order to obtain additional effects: improve interactions between components, obtain information on the state of the system, etc.

60 STANDARD 1-1-1. If there is an object which is not easy to change as required, and the conditions do not contain any limitations on the introduction of substances and fields, the problem is to be solved by synthesizing a S F M: the object is subjected to the action of a physical field which produces the necessary change in the object. Example: To remove air (S1) from a powdered substance, the substance (S2) is subjected to centrifugal forces (F).

61 STANDARD 2-1-2. If it is necessary to improve the efficiency of SFM, and replacement of SFM elements is not allowed, the problem can be solved by the synthesis of a dual SFM through introducing a second field which is easy to control. Example: It is proposed to increase control over a melted metal by rotating the metal in a centrifuge.

L2-(Field) Conductivity of Medium



The conductance[62] of the medium in which the fields must operate can control the affect of the function. The medium refers to the substance that contains the tool or product whether that be a solid, liquid or gas or even a vacuum. The conductivity of the medium can have a strong impact on the fields and their distribution in space. For instance, electromagnetic fields would be strongly influenced by electrically conductive materials in the vicinity.

Method—Identifying Resources

Step 1: What medium surrounds or is between the tool and product?

Step 2: Draw field potential lines and gradients

Step 3: How does the conductivity of the medium affect the interaction?

Method—Mobilizing Resources

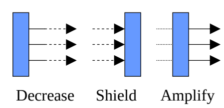
Step 1: Draw field potential lines and gradients

Step 2: How does the conductivity of the medium affect the interaction?

Step 3: What medium is between the tool and product?

Step 4: Is the conductivity of the medium adjustable?

Step 5: Should a different medium be used?



Step 6: Change the conductivity of the medium by using concentrated additives

Step 7: Change the gradient of conductivity

Step 8: Change to a different medium with higher or lower conductance

Step 9: Shorten the flow path

Step 10: Decrease flow transformations

Step 11: Change the number of turns

Step 12: Increase or decrease the field intensity from the tool

Step 13: Use an intermediate substance to shield, amplify or decrease the field

Step 14: Change the conductivity of the mediator

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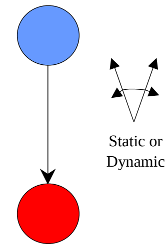
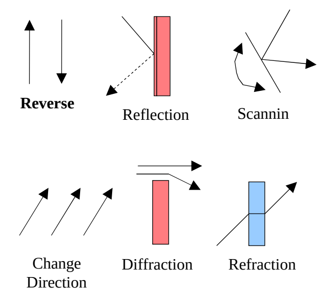
62 The concept of conductance was first introduced to the author by Invention Machine software graphics which showed how fields could be modulated by the medium that was placed between the tool and the product to decrease or amplify the effect of the field.

L2-(Field) Field Direction



Field direction[63] refers to the direction that actions will take when influenced by a field. If one knows the field gradient, then the field direction is perpendicular to the field gradient lines. The direction of a magnetic field between two infinite plates emanates perpendicular to the two parallel surfaces and is related to the charge of the plates (assuming constant charge distribution). The field direction has a direct effect on the function of the tool on the product.

Method—Identifying Resources



Step 1: Identify the field gradients and potential lines

Step 2: Identify the field direction as being perpendicular or orthogonal to the field gradient lines.

Step 3: Is the field direction important?

Step 4: What would happen if the fields were reversed[64]?

Step 5: Identify whether the field direction is important to the function at hand.

Step 6: Does varying the field direction in time affect the function?

Method—Mobilizing Resources

Step 1: Reverse the fields?

Step 2: Change to the ideal field direction.

Step 3: Identify the field gradient and potential

Step 4: Does varying the field direction affect the function? Vary the field direction

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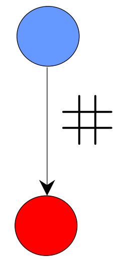
63 The concept of changing the field direction was first introduced to the author by Invention Machine software graphics which showed how fields direction could be changed by the graphics shown.

64 Inventive Principle #13—Do It in Reverse: Instead of the direct action dictated by a problem, implement an opposite action (i.e., cooling instead of heating). Make the movable part of an object, or outside environment, stationary and stationary part moveable. Turn an object upside-down. Genrich Altshuller, The Innovation Algorithm page 287.

L2-(Field) Field Gradient or Concentration



Field gradient refers to how rapidly a field changes at a point in space. High field gradients mean that the field strength changes rapidly at that point. The efficiency or harm of functions is often related to the uniformity of fields or the structure of the fields. [65] [66]

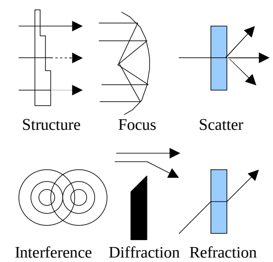
Method—Identifying Resources

Step 1: Draw the field gradients and field potential lines as they currently exist. Consider the following:--Concentration of the field--Rate of change of field gradient--Coherence of field--Interference of field--Field Scatter

System efficiency can often be improved by moving from uniform fields to fields with structure. [67]

Method—Mobilizing Resources

Step 1: Draw the field gradients and field potential lines as they currently exist. Consider the following:--Concentration of the field--Rate of change of field gradient--Coherence of field--Interference of field--Field Scatter



Step 2: Move to higher dimensions[68].

Step 3: Change the dimension of the affected area of the product

Step 4: Use heat to change the refractive index

Step 5: Sharply change the field gradient to eliminate harmful functions

Step 6: Make the Field ***Coherent***

---

65 STANDARD 2-2-5. Efficiency of SFM can be improved by transition from a uniform field or fields with a disordered structure to non-uniform fields or fields with a definite spatial- temporal structure (permanent or variable). Notes: If a certain spatial structure is to be imparted to a substance object, the process can be conducted in a field having a structure that matches the required structure of the substance object. Example: To mix two magnetic powders, a layer of the first powder is put in the layer of the second powder and the non-uniform magnetic field is applied.

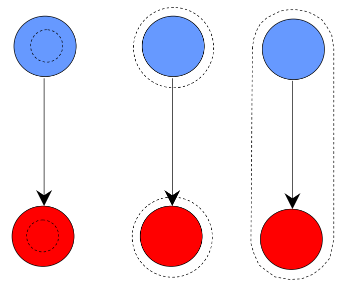
66 Inventive Principle #3—Local Quality: Transition from homogeneous to heterogeneous structure of an object or outside environment (action). Different parts of an object should carry out different functions. Each part of an object should be placed under conditions that are most favorable for its operation.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

67 The various methods for changing the field gradients was first introduced to the author by Invention Machine software graphics which showed how fields gradients could be changed by the graphics shown.

68 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.

L2-(Field) Field Location

Field location refers to the existence and location of fields in the system and their effect on the functions being performed. Fields which exist in the system can contribute to harm or to good. For instance, the presence of heat during friction can cause chemical reactions to occur in rubbing components or even other attached components. If we were studying the chemical interaction between the tool and the object, then we would necessarily be interested in the thermal fields generated by the friction. Considering the location of the fields adds to our understanding of what is happening. The fields can be on the inside of objects, on their surface or in the surrounding medium. It is important to understand where these field exist and the level of the fields in each location. The concept of being aware of field location[69] [70] comes from TRIZ standards.



Method—Mobilizing Resources

Step 1: Identify substances and constructions which react strongly to the existing fields or that aid or harm the existing interaction

Step 2: Identify fields which would react strongly to the existing substances.

Step 3: Indentify where the fields reside. Do they reside within; on the surface of; or in the environment of the tool or product?

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69 Inventive Principle #35—Transformation of Properties: Change the physical state of the system. Change the concentration or density. Change the degree of flexibility. Change the temperature or volume. Genrich Altshuller, The Innovation Algorithm page 289

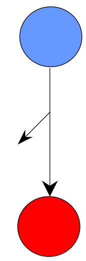
70 STANDARD 5-2-1. If a field has to be introduced in a SFM, one should use first of all the present fields for whom the media are those substances that form the system or its part. Note: The use of substances and fields which already present in the system improves the system's ideality: number of functions performed by the system increases without increasing the number of used components.

STANDARD 5-2-2. If a field has to be introduced in a SFM and it is not possible to use the fields which already present in the system, one should use the fields of the external environment. Note: The use of external environment fields (gravitation, thermal field, pressure...) improves the system's ideality: the number of functions performed by the system increases without increasing the number of used components.

STANDARD 5-2-3. If a field has to be introduced in a SFM but it is impossible to use the fields which already present in the system or in the external environment, one should use the fields for whom the substances present in the system or external environment can act as media or sources. Notes: In particular, if there are ferromagnetic substances in a system and they are used for mechanical purposes, it is possible to use their magnetic properties in order to obtain additional effects: improve interactions between components, obtain information on the state of the system, etc.

L2-(Field) Variety or Separation of Field Components

Many fields come as combinations of different field regimes. For instance sunlight is a continuation of frequencies which can be separated into different frequencies. Some field components may be harmful or less useful. It is also possible that more regimes can be helpful.



Method—Identifying Resources

Step 1: Can the field be broken into various components by direction, Frequency or Variety of Fundamental Fields?

Step 2: Identify the truly useful components

Step 3: What properties of the product or tool affect the variety of field components?--Transmission of frequency--Absorption of frequency--Reflection of frequency--Anisotropy of Medium--Resonance properties of medium

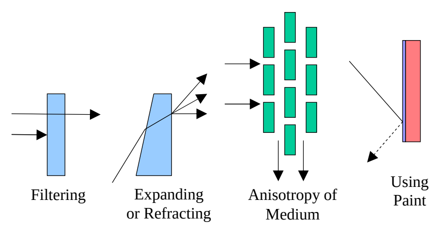
Various parts can be operating in different directions. It is possible to separate[71] out the different field components by the methods shown.

Method—Mobilizing Resources

Step 1: Can the field be broken into various components by direction, Frequency or Variety of Fundamental Fields?

Step 2: Identify the truly useful components

Step 3: What properties of the product or tool affect the variety of field components?--Transmission of frequency--Absorption of frequency--Reflection of frequency--Anisotropy of Medium--Resonance properties of medium



Step 4: Break the field into various components: --Variety of field directions--Frequency--Variety of Fundamental Fields

Step 5: Separate out the ***useful components***

Step 6: Use a different Color: Filter field or reflect only certain frequencies

Step 7: Change the receptivity of the product to certain field components

Step 8: Search the ***Table of Effects*** *for ways to separate field components*

Step 9: Move to a higher dimension[72] to enhance the filter.

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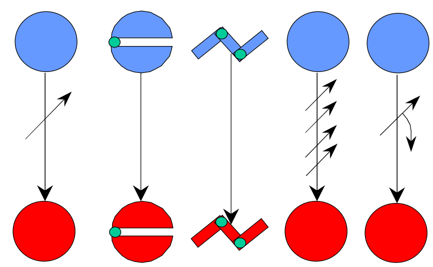
71 The concept of separating field components was first introduced to the author by Invention Machine software graphics which are similar to those shown.

72 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.

L2-(Adjustability) Adjustability

The efficiency of systems is generally increased by increasing the degrees of freedom[73] and ultimately the flexibility. [74] Adjustability first comes from the increase in degrees of freedom. This can occur by adding a joint or making an object flexible. It can come from increasing the number of variables that are varied in order to control a final result.

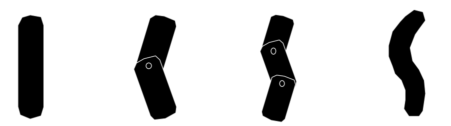


Method—Identifying Resources

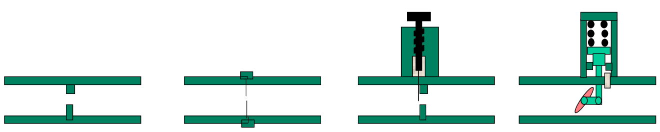
Step 1: Are important control parameters adjustable?

Step 2 Which of the features of the tool, product or field can be made adjustable[75]?

Line of Evolution



Line of Evolution Adjustable Features

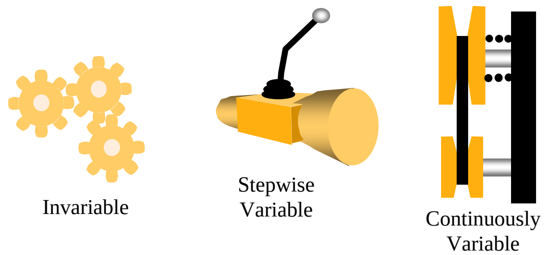


73 Inventive Principle #15—Dynamicity: Characteristics of an object or outside environment, must be altered to provide optimal performance at each stage of an operation. If an object is immobile, make it mobile. Make it interchangeable. Divide an object into elements capable of changing their position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

74 STANDARD 2-2-4. Efficiency of a SFM can be improved by increasing the degree of dynamics of SFM, i.e. by transition to a more flexible, rapidly changing structure of the system. Notes: Making a substance dynamic starts with dividing it into two joint-coupled parts and continues along the following line: One joint —> many joints —> flexible object. A field can be made more dynamic by transition from a permanent field (or of the field together with a substance) to a pulsed field. Example: A door made of hinged segments -> "Accordion" door ->.

75 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.

Line of Evolution for Continuity of Adjustment



Method—Mobilizing Resources

Step 1: Which of the features of the tool, product or field can be made adjustable?

Step 2: Make adjustable to adapt to each stage of operation.[76]

Step 3: Make self-adjusting according to operating conditions. Immobile objects become mobile.

Step 4: Place ***joints*** *in the tool or product. Increase the number of joints*

Step 6: If a parameter is already adjustable, ***increase*** *the degrees of freedom.*

Step 7: Make ***several*** *controlling parameters adjustable*

Step 8: Make an existing or new parameter ***continuously adjustable.***

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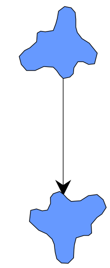
76 STANDARD 2-1-1.

Efficiency of SFM can be improved by transforming one of the parts of the SFM into an independently controllable SFM, thus forming a chain SFM. Example: A tractor with movable center of gravity to work on steep slopes.

L2-(Adjustability) Flexibility



Everything is flexible[77] . Look at the system as a collection of springs, masses and dampers that go in every direction, sort of like bed springs. Materials are flexible in all directions, however the structure of an object will make it more flexible in some directions. The flexibility of the tool or product can affect the adjustability of the interaction or make the system more robust. Remember that the state of matter affects the flexibility of materials.

Method—Identifying Resources

Step 1: Consider the flexibility of the tool and how it affects the fields relating to the problem..

Step 2: Consider the flexibility of the product and how it affects the fields relating to the problem.

Step 3: Consider the direction of flexibility and how it affects the fields relating to the problem.

Step 4: Consider how the state of matter affects the flexibility.

Method—Mobilizing Resources

***Step 1: Everything** is flexible. Look at the system as a collection of springs, masses and dampers.*

*Step 2: Consider the flexibility of the **tool**.*

*Step 3: Consider the flexibility of the **product**.*

*Step 4: Consider the **direction** of flexibility*

Step 5: Consider the state of matter

*Step 6: Change the flexibility of the **tool**.*

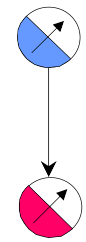
*Step 7: Change the flexibility of the **product**.*

*Step 8: Change the **direction** of flexibility.*

*Step 9: Make very flexible by transforming to a **liquid or gas**.*

77 Inventive Principle #35—Transformation of Properties: Change the physical state of the system. Change the concentration or density. Change the degree of flexibility. Change the temperature or volume. Genrich Altshuller, The Innovation Algorithm page 289

L2-(Adjustability) Operation Near Critical Point



For many physical phenomena, there are critical points[78] which cause an abrupt change of properties when they are crossed. For example, when the temperature of water reaches the boiling point, large amounts of vapor are generated. Many of the properties of water vapor and water are different. We can think of the boiling point of water as a critical point. When interactions occur near critical points, more effect occurs for smaller changes in inputs. Thus, efficiency of system operation can be increased by operating near critical points.

Phase Transitions[79] are another example of critical points. To the right is a non-exhaustive table of critical points for various physical phenomena. One can often construe a critical point for nearly every physical phenomenon.

Method—Identifying Resources

*Step 1: Does the feature have a **natural critical condition** or threshold, such as boiling point or Curie temperature?*

*Step 2: Can a critical condition or threshold **be created** for a feature which does not normally have one, such as a bi-stable condition?*

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

Human Critical Points
Temperature threshold;
Pressure threshold
Auditory threshold
Olfactory threshold
Personal space violation
Speed threshold
Altitude threshold
Visual thresholds
Startling point
Discomfort (perception that something is out of place)
Equilibrium threshold

*Step 3: If the function is useful, **operation near the critical condition** can trigger large results.*

*Step 4: If the function is harmful, operating **far away** from the critical point reduces the effect.*

Method—Mobilizing Resources

*Step 1: Does the feature have a **natural critical condition** or threshold, such as boiling point or Curie temperature?*

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78 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.

STANDARD 5-4-2. If it is necessary to obtain a strong effect at the system's output, given a weak effect at the input, the transformer substance is placed to a condition close to critical. The energy is stored in the substance, and the input signal acts as a "trigger".

79 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.

Step 2: Can a critical condition or threshold ***be created*** *for a feature which does not normally have one, such as a bi-stable condition?*

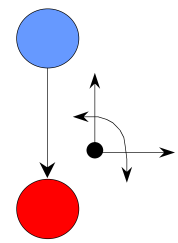
Step 3: If the function is useful, ***operation near the critical condition*** *can trigger large results.*

Step 4: If the function is harmful, operating ***far away*** *from the critical point reduces the effect. This can be used to switch off the harmful field*[80]*.*

Step 5: Operate near or far from the critical condition

L2-(Direction) Direction of Action

This is not to be confused with the direction of fields. The direction of action is the direction of the resulting interaction between the tool and the product. For instance, if the product moves, it is the direction of movement.



Method—Identifying Resources

Step 1: Identify current direction of action.

Step 2: Does the direction of action have an effect on the function?

Method—Mobilizing Resources

Step 1: Identify current direction of Action

Step 2: Reverse *the direction of action*[81]

Step 3: Change from linear to rotary motion.

Step 4: Change from rotary to linear motion.

Step 5: Go 90 degrees to the current direction

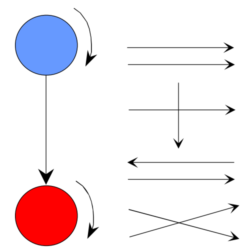
---

80 STANDARD 1-2-5. If it is necessary to decompose a SFM with a magnetic field, the problem is solved by using physical effects, which are capable of “switching off” ferromagnetic properties of substances, e.g. by demagnetizing during an impact or during heating above Curie point. Notes: The magnetic field may appear at the right moment if a system of magnets compensating the effect of each other's field is used. When one of the magnets is demagnetized, a magnetic field arises in the system. Example: During welding, it is difficult to insert a ferromagnetic powder in the welding zone: an electromagnetic field of a welding current makes the particles move away from the welding zone. It is proposed to heat the powders above the Curie point to make them non-magnetic.

81 Inventive Principle #13—Do It in Reverse: Instead of the direct action dictated by a problem, implement an opposite action (i.e., cooling instead of heating). Make the movable part of an object, or outside environment, stationary and stationary part moveable. Turn an object upside-down. Genrich Altshuller, The Innovation Algorithm page 287.

L2-(Direction) Relative Orientation

The relative orientation is how the product and tool "face" each other. To the right of the diagram is shown a non-exhaustive variety of orientations. Do they both face the same or opposite directions? Are they crosswise of each other? The relative orientation is another way of looking at the orientation of the fields of action.



Method—Identifying Resources

Step 1: Try different rotational[82] orientations, relative to each other.

Step 2: Consider differences between linear and rotary motion.

Method—Mobilizing Resources

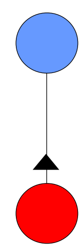
Step 1: Try different rotational orientations[83], relative to each other.

Step 2: Consider differences between linear and rotary motion.

Step 3: Change the orientation of the tool to the product

L2-(Direction) Reversal of Relative Action

Reversal of action[84]refers to doing the opposite action rather than the action that is being performed. We could say that instead of pushing we pull, but it needs to be thought of as more than this. What we are saying is that if an action is performed, it is performed relative to something. That something changes instead. Instead of the mechanic moving to get under the car, the car is lifted relative to the mechanic. A collar is heated to expand it to go over a rod. Now the rod is cooled so that the collar can fit over it.



Method—Identifying Resources

Step 1: What is the action performed relative to?

Step 2: What constitutes the reverse of the current action?

Method—Mobilizing Resources

Step 1: What constitutes the reverse of the current action?

---

82 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.

83 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.

84 Inventive Principle #13—Do It in Reverse: Instead of the direct action dictated by a problem, implement an opposite action (i.e., cooling instead of heating). Make the movable part of an object, or outside environment, stationary and stationary part moveable. Turn an object upside-down. Genrich Altshuller, The Innovation Algorithm page 287.

Step 2: What is the action performed relative to?

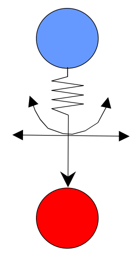
Step 3: Change the relative action

Step 4: Perform the reverse action

Step 5: Place parts upside down or backward

Step 6: Make moving parts stationary

L2-(Direction) Movement Relative to Field Gradients



When objects move, they not only move relative to other objects, but they also move relative to fields and field gradients. Gravity is a field gradient. The closer we get to the earth, the greater its pull. When we move relative to field gradients, we do work which is usually a burden on the system. Moving up or down in a gravity field requires work which is proportional to the distance moved. Fortunately, this is reversible since gravity is a field that conserves energy. No matter how we move in the field, it always retains the same direction, making the energy flow reversible. Since it takes work to move across field gradients, it is often possible to move along field gradients and avoid performing work. For instance, if motion can be done in such a way that neither moves up or down, then the work performed against gravity is not required. An example of this is the movement of heavy objects on wheels or rotated on their center of gravity. Acceleration of the mass, either rotationally or horizontally requires energy, but no energy is required to move it up or down. The same is true of many other field types that are conserving. Some field types are not conserving. For instance, fields which change with a change of direction of motion. Friction is a notorious example of this. Energy lost by friction is difficult to recover for this reason. The question that we are asking with this tool is: are we moving along gradient lines or against them which requires energy input.

Method—Identifying Resources

Step 1: Draw the field lines and the equipotential lines[85]

Step 2: Does either object move or rotate[86] *through a field gradient?*

Step 3: What direction do they move relative to the gradient?

Method—Mobilizing Resources

Step 1: Draw the field lines and the equipotential lines[87]

Step 2: Does either object move or rotate through a field gradient?

Step 3: What direction do they move relative to the gradient?

Step 4: Make objects move ***along*** *equipotential lines*

---

85 Inventive Principle #12—Equipotentiality: Change the condition of the work in such a way that it will not require lifting or lowering an object. Genrich Altshuller, The Innovation Algorithm page 287.

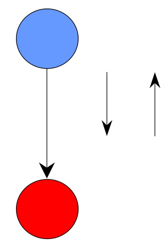
86 Inventive Principle #14—Spheroidality: Replace linear parts with curved parts, flat surfaces with spherical surfaces, and cube shapes with ball shapes. Use rollers, balls, spirals. Replace linear motion with rotational motion ; utilize centrifugal force. Genrich Altshuller, The Innovation Algorithm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

87 Inventive Principle #12—Equipotentiality: Change the condition of the work in such a way that it will not require lifting or lowering an object. Genrich Altshuller, The Innovation Algorithm page 287.

Step 5: If either object already moves along equipotential lines, ***changing the field slightly*** *can make the function adjustable. How can the fields be changed?*

Step 6: Avoid lifting.

L2-(Timing) Continuity of Operation



Efficiency of a function is a function of the percentage of time that the function is performed[88]. If the attribute that is being examined has to do with efficiency of operation or the overall value of the function performed, then this feature of timing will have a controlling effect.

Method—Identifying Resources

Step 1: Does the Tool Follow a Path?

Step 2: Does the Tool perform the function on the entire path, both coming and going?

Step 3: Is the function at full load (always operating)?

Step 4: Have dummy runs and downtimes been eliminated?

Method—Mobilizing Resources

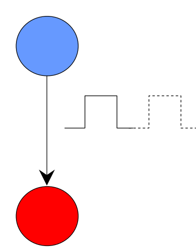
Step 1: If the tool follows a path, make the Tool perform the function on the entire path, both coming and going?

Step 2: If the function is not at full capacity, find a way to ensure that it is operating all the time. Eliminate the downtimes.

Step 3: Eliminate all dummy runs and downtimes.

Step 4: Make the tool perform the function on the entire path.

L2-(Timing) Different Time



Sometimes the only difference between a harmful function and a useful function is when it is performed. If the conditions under which a function occurs can change with time, then so can the variables that control the outcome.

Method—Identifying Resources

Step 1: Process Map the changing conditions over time.

Step 2: Does the requirement for the function vary over time?

Step 3: If the process is continuous, can it be changed to

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88 Inventive Principle #20—Continuity of Useful Action: Carry out an action without a break. All parts of the objects should constantly operated at full capacity. Remove idle and intermediate motion. Replace "back-and-forth" motion with a rotating one. Genrich Altshuller, The Innovation Algorithm page 288

periodic action[89]*?*

Step 4: Could other tools help out at another time?

Step 5: If the modification is performed as a step in a process, can the sequence be varied?

Method—Mobilizing Resources

Step 1: Periodically perform the function[90]*.*

Step 2: Process Map the changing conditions over time.

Step 3: Does the requirement for the function vary over time?

Step 4: Could other tools help out at another time?

Step 5: If the modification is performed as a step in a process, can the sequence be varied?

Step 6: Change the Sequence

Step 7: Change the time

Step 8: Perform during transportation or while queued or waiting

Step 9: Temporarily turn the function off

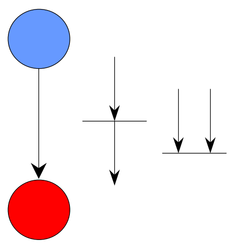
Step 10: Introduce a temporary blocking. (Should be taken away by resources only)

Step 11: Make the product temporarily insensitive

Step 12: Temporarily move the product away

L2-(Timing) Partial Modification

Functions are shorthand for processes. Any function can be separated into parts. The efficiency of a function may be controlled by when the parts of a function are performed. It is possible to perform part[91] of a function at one time and the rest at other times. It is also possible to perform parts of the function at the same time or in parallel.



Method—Identifying Resources

Step 1: Can the modification be broken into two (or more) ***stages****?*

Step 2: Can the operation be broken into ***parallel*** *processes?*

89 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.

90 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.

91 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.

Method—Mobilizing Resources

Step 1: Can the modification be broken into two (or more) ***stages****?*

Step 2: Can the operation be broken into ***parallel*** *processes?*

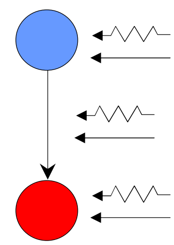
Step 3: Separate the modification into two or more serial ***stages***

Step 4: Separate the operation into ***parallel*** *stages*

Step 5: Perform setup at the same time as the operation.

Step 6: Implies use of a previously placed tool

L2-(Timing) Addition or Subtraction of Other Functions



With a function diagram of the system, it is possible to see all of the functions that other objects perform, both inside and outside the system. If an object performs a function in the system, it is sometimes possible to have that object perform a similar function on other system objects. It is also possible to decouple functions (both useful and harmful).

Method—Identifying Resources

Step 1: Identify other functions performed on the tool, product and field.

Step 2: Does uncoupling these other functions affect the interaction?

Step 3: Would coupling other functions such as vibration affect the outcome?

Method—Mobilizing Resources

Step 1: Identify other functions performed on the tool, product and field.

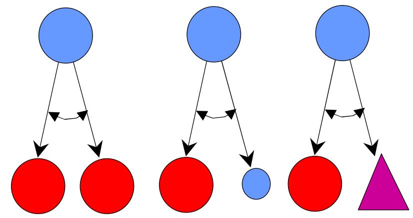
Step 2: Does uncoupling these other functions affect the interaction?

Step 3: Would coupling other functions such as vibration affect the outcome?

Step 4: Couple or uncouple other functions such as vibration.

L2-(Timing) Uninterrupted Operation

Systems are more efficient when operations are performed continuously[92]. This may require that a tool in the system be capable of handling biased products or even different products that require the function. This is particularly true for systems that manufacture goods.



Method—Identifying Resources

Step 1: Are all parts of the system at full load?

Step 2: Have dummy runs and downtimes been eliminated?

Method—Mobilizing Resources

Step 1: Are all parts of the system at full load?

Step 2: Have dummy runs and downtimes been eliminated?

Step 3: What else in the system requires the same modification?

Step 4: Is it possible to change functions between objects?

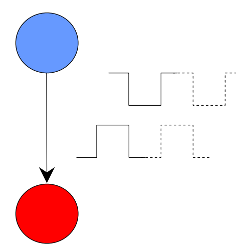
Step 5: Move to uninterrupted operation

Step 6: Make the tool operate on other similar products

Step 7: Modify the tool to operate on diverse products

L2-(Timing) Incompatible Operations

Efficiency is increased when one incompatible operation is performed during the pauses of the other.[93] [94]



Method—Identifying Resources

Step 1: Identify incompatible operations

Step 2: Identify their timing relative to each other. Is the timing necessary?

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92 Inventive Principle #20—Continuity of Useful Action: Carry out an action without a break. All parts of the objects should constantly operated at full capacity. Remove idle and intermediate motion. Replace "back-and-forth" motion with a rotating one. Genrich Altshuller, The Innovation Algorithm page 288.

93 STANDARD 2-3-3. If we are given two incompatible actions, e.g. changing and measuring, one action should be performed during the pauses of another one. In general, pauses in one action should be filled with another useful action.

Example: To provide accuracy of contact welding, measurements are conducted during the pauses between the pulses of an electrical current.

94 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.

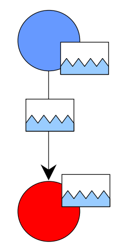
Method—Mobilizing Resources

Step 1: Identify incompatible operations

Step 2: Identify pauses in each operation

Step 3: Identify how one operation might be employed in pauses of the other.

L2-(Timing) Storage of Action or Field



Many actions are "stored" or at least delayed in their delivery. As stated, the timing of actions has much to do with how harmful or useful they are. An action can be harmful because it is delayed or not. Here we consider what storage or delay action currently exists. In particular, it is possible that actions are already being stored in field storage elements of the system, or they are slowly building up due to oscillations of the function.

Method—Identifying Resources

Step 1: Identify the main fields of the function.

Step 2: Consult the next page for ways to store this field

Step 3: Is this field stored, even for an instant in the tool, product or in space? (Is there a lag between field generation and application?)

Step 4: Is there energy storage in oscillations?

Method—Mobilizing Resources

Step 1: Identify the main fields of the function.

Step 2: Does storage improve the function?

Step 3 Consult the next page for ways to store this field

Step 4 Is this field stored, even for an instant in the tool, product or in space? (Is there a lag between field generation and application?)

Step 5: Is there energy storage in oscillations? Consider storing in oscillations.

Step 6: Can storage be a mediator between the tool and product?

Step 7: Store the field in the lag between field generation and application

Elastic Force Internal & External
Springs
Elastic Media
State

Gravity
Height of Objects
Weight or Density

Friction

Adhesive

Centrifugal Force
Momentum

Inertia of Bodies (Note Direction)
Momentum

Coriolis Force
Momentum

Buoyant Force
Average Density of Buoyant Object

Hydrostatic Pressure
Pressure Vessel

Jet Pressure
Fluid
Momentum

Surface Tension
Surface Tension
Area

Odor & Taste
Container

Diffusion
Pressure
Vessel

Osmosis
Container

Chemical Fields
Explosives
Chemical Potential

Sound
Oscillation Chamber--Distance of Travel--Resonance of Objects

Vibrations & Oscillations
Oscillation Chamber--Distance of Travel--Resonance of Objects

Ultrasound
Oscillation Chamber--Distance of Travel--Resonance of Objects

Waves
Oscillation Chamber--Distance of Travel--Resonance of Objects

Corona Discharge
Low Field
Vacuum

Current
Inductance
Super-conducting media

Eddie Currents (Internal and skin)
Inductance
Super-conducting media

Particle Beams
Low Field
Vacuum

Storage Property Knobs which Affect these Fields

Thermal Heating or Cooling
Thermal Mass
Thermal Capacity--State

Thermal Shocks
Thermal Mass of Two Objects
Expansion-
Thermal Capacity--State

Nuclear Forces
Radio-active Materials

Electrostatic Field
Capacitance-- Piezo Electric Materials

Magnetic Field
Permanent Magnet

Electromagnetic (Voltage)
Separation Space

Information
Data Fields

Radio Waves
Separation Space
Oscillating Circuits

Micro-waves
Separation Space
Oscillating Circuits

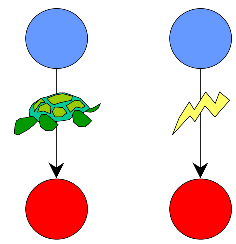
Infrared
Separation Space
Hot Objects

Visible Light
Separation Space
Hot Objects
Fluorescence

Ultra-violet
Separation Space
Hot Objects
Fluorescence

X-Ray
Separation Space
Radio-

L2-(Time Variation) Speed



The speed at which an action is performed can have a strong impact on many sub-steps to the action. Since all interactions and functions are processes and functions are shorthand for processes, there may be several steps that occur when an action is performed. Performing an action very rapidly may preclude other actions from occurring at the same time. Performing it very slowly may allow for other actions to be performed during the action time or, at least, performed more completely.

Method—Identifying Resources

Step 1: Story board or process map the process.

Step 2: What actions can be performed more completely if the action is performed more slowly?

Step 3: What actions can be excluded if the function is performed more rapidly. If the modification were performed more rapidly[95], would other harmful functions be precluded?

Step 4: How are the fields changed by performing the modification at different speeds?

Method—Mobilizing Resources

Step 1: How are the fields changed by performing the modification at different speeds?

Step 2: If the modification were performed more rapidly, would other harmful functions be precluded?

Step 3: Slow the function way down (hours, days, weeks, months, years)[96]

Step 4: Perform the modification very rapidly[97] to preclude harmful or hazardous functions.

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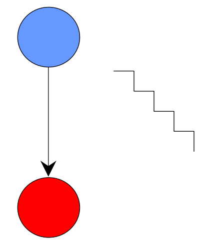
95 Inventive Principle #21—Rushing Through: Perform harmful and hazardous operations at a very high speed. Genrich Altshuller, The Innovation Algorithm page 288.

96 This comes from what is sometimes called the STC operator which stands for size, time and cost. When using this concept, the problem solver considers the possibility that the there is no limit to each of these variables and to consider the problem at the extremes of each. In this case, we may consider that we have all the time in the world and that the function is performed quite slowly or we have no time and the function must be performed very quickly. Page 112 of The Innovation Algorithm, Genrich Altshuller.

97 Inventive Principle #21—Rushing Through: Perform harmful and hazardous operations at a very high speed. Genrich Altshuller, The Innovation Algorithm page 288.

L2-(Time Variation) Discrete or Continuous



When it is difficult to perform a useful function at all, the ability to perform it may be a function of continuity. Generally, functions move from discrete instances to continuous operation. In order to create a function, it may be necessary to go through the discrete[98] stage first in order to perform it at all.

Method—Identifying Resources

Step 1: Is it not possible to perform a function continuously? Is existence of the function controlled by whether it is discrete or continuous?

Step 2: Can the Tool be ***Multiplied or segmented***[99] *into separate pieces?*

Step 3: Can each piece move into action in discrete steps or into fixed positions or amplitudes.

Step 4: If the action is discrete, can it be made ***continuous?***

Method—Mobilizing Resources

Step 1: If the action is continuous, is there any advantage to make it discrete?

Step 2: Can the Tool be Multiplied or segmented into separate pieces.

Step 3: Can each piece moves into action in discrete steps or into fixed positions or amplitudes.

Step 4: If the action is discrete, can it be made continuous?

Step 5: Continuous actions move to discrete actions

Step 6: Multiply or segment the tool into separate pieces.

Step 7: Each piece moves into action in discrete steps or into fixed positions or amplitudes.

Step 8: Discrete actions move to continuous actions

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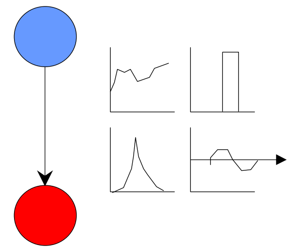
98 This method is an adaptation of STANDARD 4-1-3. If a problem involves detection or measurement, and the problem cannot be changed to eliminate the need for measurement, and it is impossible to use copies or pictures, it is proposed to transform this problem into a problem of successive detection of changes. Notes: Any measurement is conducted with a certain degree of accuracy. Therefore, even if the problem deals with continuous measurement, one can always single out a simple act of measurement that involves two successive detections. This makes the problem much simpler. Example: To measure a temperature, it is possible to use a material that changes its color depending on the current value of the temperature. Alternatively, several materials can be used to indicate different temperatures.. In this case, we are considering the more general case of useful functions and performing them in discrete steps.

99 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.

L2-(Time Variation) Time Variance or Pulse

The outcome of a function may be controlled by the variation in timing or the shape[100] of the application of fields. Functions become more efficient when the fields become more controllable and can vary as the conditions vary.



Method—Identifying Resources

Step 1: How is the interaction affected if you could continuously vary the action in time?

Step 2: If it can be continuously varied, consider pulsing the action.

Method—Mobilizing Resources

Step 1: How is the interaction affected if you could continuously vary the action in time?

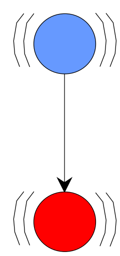
Step 2: Shape the curve

Step 3: Square pulse the action

Step 4: Shape the pulse.

Step 5: Make the pulse travel.

L2-(Time Variation) Pulsation or Oscillation



All matter and many fields oscillate. The oscillations may be very small and sometimes nearly undetectable. Assume that the objects of study are oscillating. Actions can be stored or amplified by oscillating the action, the object or the tool. Here we consider whether oscillations are taking place and what controls these oscillations.

Method—Identifying Resources

Step 1: What oscillations[101] [102] are already occurring in the tool, product, action (modification) or fields? Look for small oscillations or oscillations within the bulk matter itself.

*Step 2: Is the interaction affected by pulsing or oscillating the **tool, product or field**?*

Step 3: Is a feature or an attached object of the tool or product being oscillated?

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100 STANDARD 2-2-4. Efficiency of a SFM can be improved by increasing the degree of dynamics of SFM, i.e. by transition to a more flexible, rapidly changing structure of the system. Notes: Making a substance dynamic starts with dividing it into two joint-coupled parts and continues along the following line: One joint --> many joints --> flexible object. A field can be made more dynamic by transition from a permanent field (or of the field together with a substance) to a pulsed field. Example: A door made of hinged segments -> "Accordion" door ->.

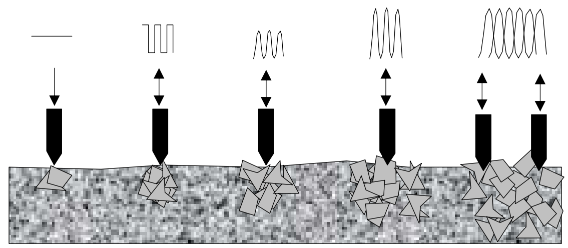
101 Inventive Principle #18—Mechanical Vibration: Utilize oscillation. If oscillation exists, increase its frequency to ultrasonic. Use the frequency of resonance. Replace mechanical vibrations with Piezo-vibrations. Use ultrasonic vibrations in conjunction with an electromagnetic field. Genrich Altshuller, The Innovation Algorithm page 288.

102 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.

Step 4: How do the natural frequencies of the tool and product affect the interaction?

System efficiency is improved by matching the oscillation of fields to the natural frequency of objects being acted upon.[103] [104] [105] Efficiency can also be improved by matching or mismatching the frequency of the fields that are being used.[106]

Line of Evolution



Method—Mobilizing Resources

Step 1: Is the interaction affected by pulsing or oscillating the ***tool, product or field****?*

Step 2: Can a feature or knob of the tool, product or field be oscillated?

Step 3: How do the natural frequencies of the tool and product affect the interaction? Increase or decrease the frequency.

Step 4: Pulsate or oscillate the tool, product, field or product receptivity.

Step 5: Make the tool, product or field resonate

Step 6: Create standing waves

Step 7: Cancel oscillations in the tool, product or field

Step 8: Mismatch the product natural frequency with the tool driving frequency

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103 STANDARD 2-3-1. Efficiency of a SFM can be improved by matching (or mismatching) the frequency of acting field with the natural frequency of a product (or tool). Example: 1. The rhythm of massage is synchronized with a pulse of a patient. 2. In arc welding, the frequency of magnetic field is equal to the natural frequency of a melting electrode.

104 Inventive Principle #18—Mechanical Vibration: Utilize oscillation. If oscillation exists, increase its frequency to ultrasonic. Use the frequency of resonance. Replace mechanical vibrations with Piezo-vibrations. Use ultrasonic vibrations in conjunction with an electromagnetic field. Genrich Altshuller, The Innovation Algorithm page 288.

105 The graphics shown are similar to Invention Machine software graphics which are used to describe oscillations..

106 STANDARD 2-3-2. Efficiency of a complex SFM can be improved by matching (or mismatching) frequencies of the fields being used.

Example: To coat a part with a material, the material is applied as a powder. To provide a high degree of regularity, the frequencies of pulses of an electrical current and pulses of magnetic field are made equal.