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The Systematic Innovation e-zine is a monthly, subscription only, publication. Each month will feature articles and features aimed at advancing the state of the art in TRIZ and related problem solving methodologies.

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Readers' comments and inputs are always welcome.
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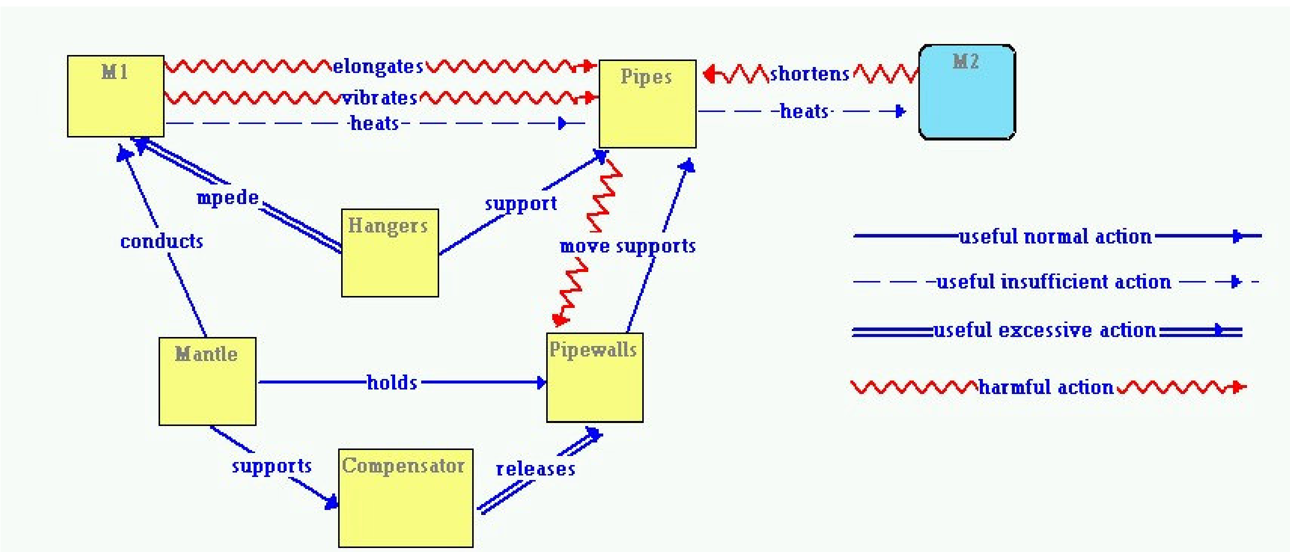
Functional Hierarchies

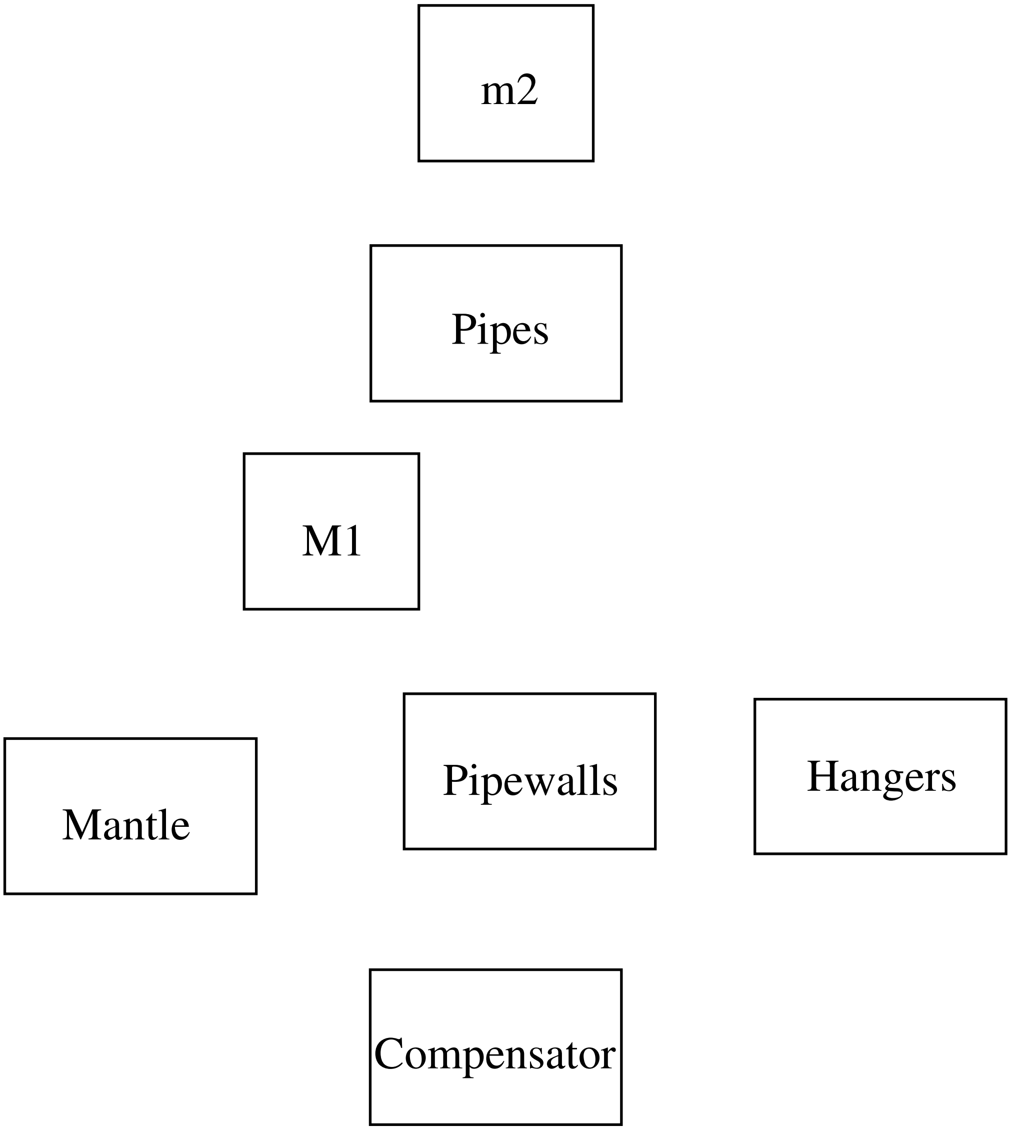
Anyone who is just beginning to explore function analysis either on paper or through CreaTRIZ may be interested in using some of the unused evolutionary potential in the method to enhance what they do with it.

Our simple thought is that instead of placing components at random on the page/screen, there are advantages in arranging things in such a way that they communicate more useful information with little if any extra effort, and quite possibly offer even greater structure to the way in which the function analysis process is conducted.

A 'normal' function analysis picture might look something like the one shown below (this is in fact one of the pictures we use on our two day CreaTRIZ course). The picture has been constructed using the usual sequence of 1) define components, 2) define the positive functional relationships existing between each component pair, and, 3) define the negative functional relationships.



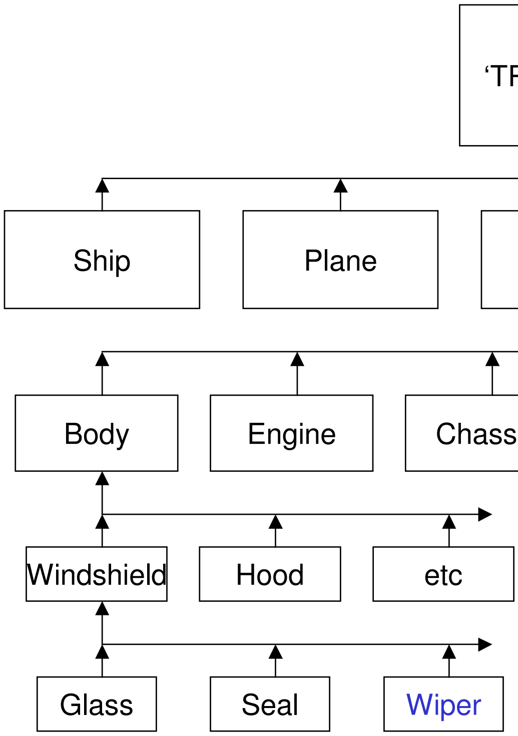
A revised function analysis illustrating exactly the same information is reproduced below. The only difference between this picture and the previous one is that this new analysis has been conducted after taking into account the idea of functional hierarchy.



The revised analysis encourages the user to think more carefully about the functionality of a system. It begins this process by asking what with Main Useful Function (MUF) is. In the case of this heat exchanger example, the MUF is ‘pipes heat M2’. This becomes the startpoint for the functional hierarchy – every other function contained in the system existing to serve this one. At the next level down, for example, it is clear that the MUF requires ‘M1 heats pipes’ to be performed, and likewise (in the current system), the hangers are required to support the pipes.

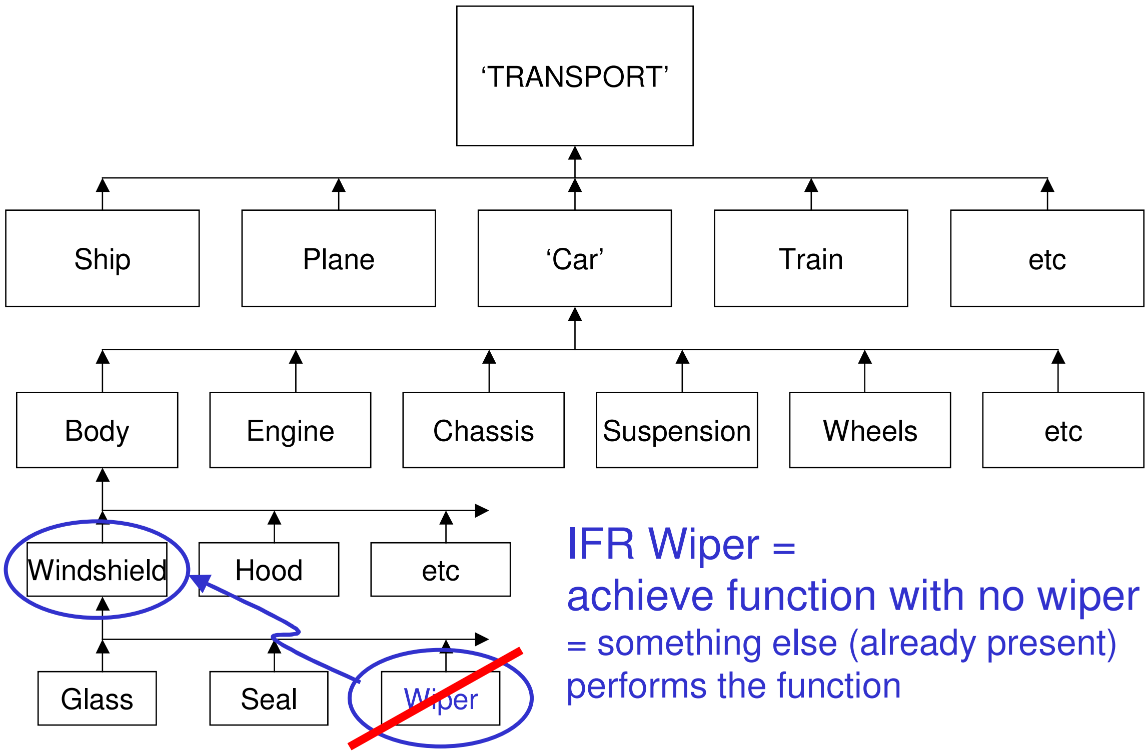
The completed hierarchical function analysis is useful from several perspectives: At a first most basic level, it has provided more structure to the way the analysis has been conducted, and will consequently offer ease of reading benefits because fewer lines will intersect one another. At a more important level, the functional hierarchy presents a likely sequence for trimming of components from the system – those at the bottom end of the hierarchy being much more likely to be ‘trimmable’ than those at the top.

A useful image to compare with here is the one we often use when thinking about Ideality and the way in which systems evolve. Windscreen wipers are a good example of this sort of hierarchy in action – see figure.

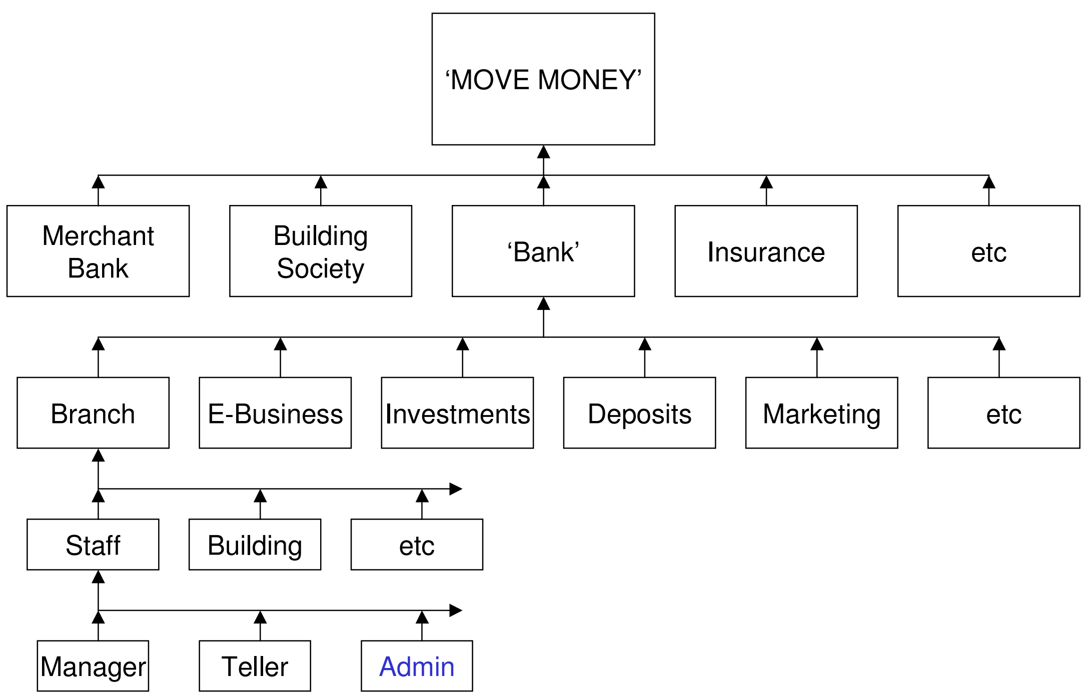


Ideality tells us that if the Ideal Final Result windscreen wiper is 'clean windscreens without any wipers', then the most likely way to achieve that IFR will come by having something else already in the system performing the function. In the terms of the hierarchy, it is most likely that such a 'something' will reside somewhere higher up the hierarchical tree.

As shown in the figure below, a very useful image to then keep in mind is that things lower down a hierarchy will gradually disappear as things higher up the tree are designed to take over the useful functions of the trimmed items. Thus, to take the example a little further, any replacement to the windscreen wiper is likely to exist only so long as the component 'windscreen' exists – at some stage, evolutionary pressures from the market willing, this too will disappear to in turn have its useful function performed by something higher up the 'car' component hierarchy.



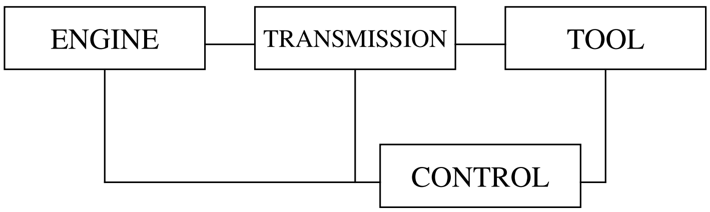
The same process of components being trimmed from the bottom of the hierarchy is also highly relevant to images of function analysis pictures drawn for business systems like the one cartooned for 'banks' below.

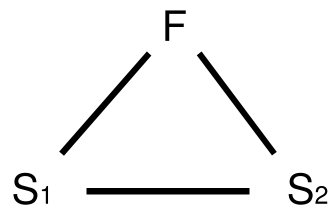


Conclusion – incorporating the idea of functional hierarchy into your function analysis diagrams allows you to structure your thinking better, and gives you a picture that communicates more information for little or no extra effort.

System Completeness versus System Viability

We've had a few questions now regarding possible connections between the TRIZ Law of System Completeness and the concept of the S-Field as a test of a 'viable system'. The two are illustrated side-by-side in the figure below.





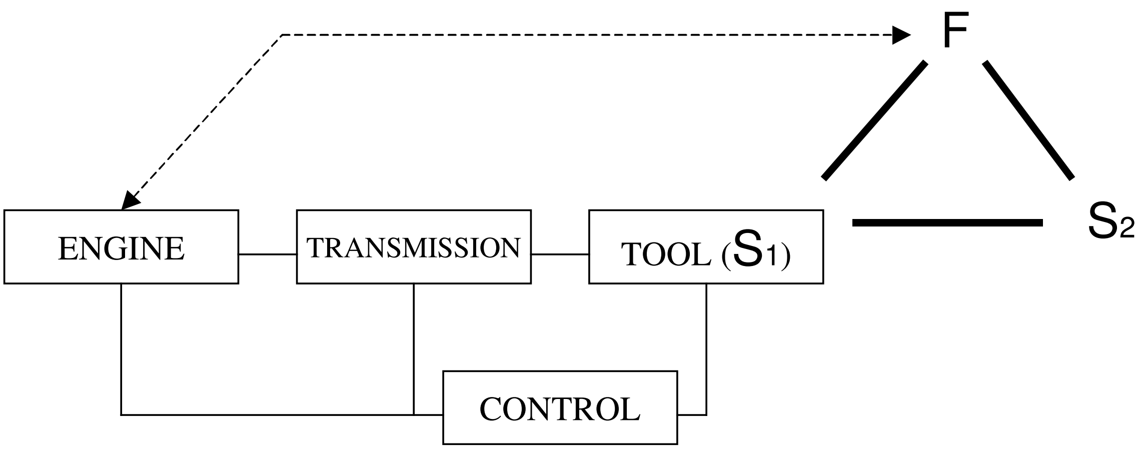
The Law of System Completeness in its classic form dictates that a system requires the four essential components engine, transmission, tool and control system before it is able to perform a function. The S-Field model similarly suggests that it is only possible for a system to perform a function if it contains two substances and a field.

The latter of the two tests is generally speaking the more useful (the idea of engine-transmission-tool-control being largely self-evident in most Western engineering education systems), although both have their uses.

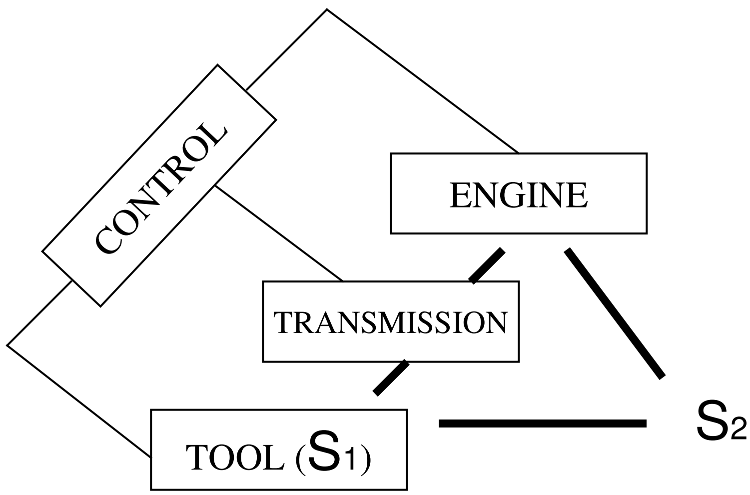
By way of example of both, the function 'clean teeth' will only be satisfactorily be delivered, in the Law of System Completeness case, when there is a toothbrush (tool), handle (transmission), hand (engine) and control (brain/tongue/mirror). The equivalent S-Field viability test suggests that the function will be delivered when we have our two substances (brush and teeth in this case) and that there is a field acting – in this case a mechanical field causing the brush to move relative to the tooth.

The example hopefully suggests a commonality between the two tests, but there is perhaps a doubt that if either is right, then the other can't be – e.g. where is S2 in the system completeness test, where is the control element in the S-Field test.

The answer to these doubts comes by beginning the process of integrating the two tests as shown in the next figure:



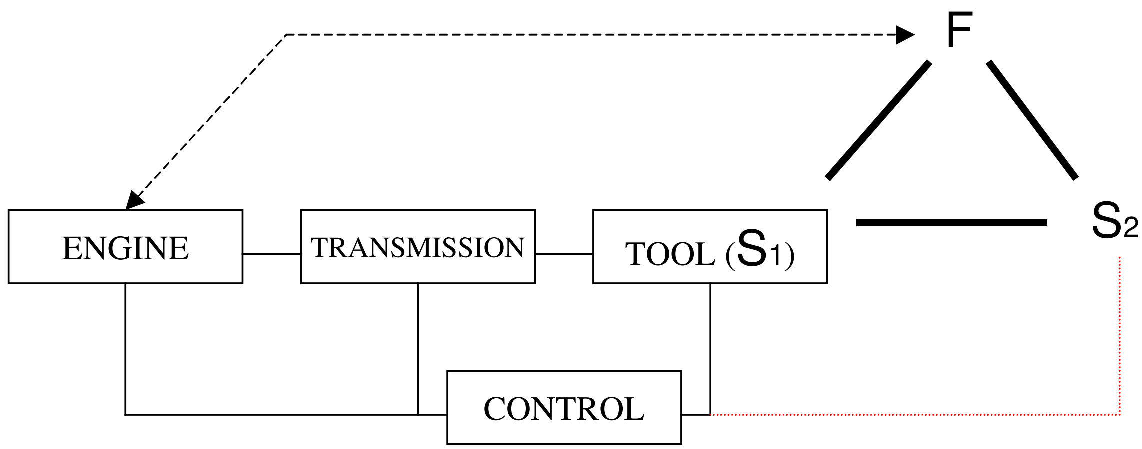
This picture highlights the tool and S1 as the common link between the two tests; the two things are in fact the same. There is a similar link between the engine and the field required to make the function happening. A good way to then think about the system is:



The net effect of this combination is that the Law of System Completeness is only strictly speaking correct if S2 – 'the object' or 'interface' is present. This is consistent with the extension to the Law of System Completeness described in our TRIZ Journal article from last year.

In certain situations, it is more helpful to think of the 'engine' and 'field' in separate terms rather than to try and combine them as above. Thus the previous image is the one we recommend you keep in mind when thinking about the two system viability tests.

The 'control' element is interesting also with regard to the way it gets us to think about its relationship with S2:



Returning to the cleaning teeth example, it should be evident that while it is perfectly possible to deliver the function without any connection between the teeth (S2) and the control system – most teeth cleaning systems exhibit precisely this disconnection such that we don't know other than by visual or tactile examination after the event whether we have clean teeth or not – a far more effective solution emerges when the object (S2) is included in the control loop – as shown by the dotted red line. This line is in fact the 'feedback' line suggested by the controllability trend. Either way, this final picture should give us a useful image of what actually defines a viable and effective system.

TRIZ and Humour

When is a door not a door, and Principle 35.

One of our favourite Gary Larson cartoons is the one featuring two scientists doing a 'toxicological' experiment. One scientist is pouring various substances onto a duck's back while the second one is at a blackboard writing down the results, e.g. "Milk off a duck's back" tick, "Water off a duck's back" tick, “Honey off a duck’s back”, cross, "Acid off a duck's back" (heavily crossed out), etc. As usual with Gary Larson, there are several jokes contained within the detail of the cartoon (for example the likely unforgettable mental image of the ‘acid’ experiment). The over-riding joke however is a Principle 35, Parameter Changes one.

As usual also, Gary Larson puts a great new spin (or series of spins) on what is a very common trick in joke telling – getting the listener to think of one type of thing, and then replacing it with another thing at the punch-line. This application of Principle 35 is the basis of all pun jokes like the ‘when is a door not a door’ groaner above; the answer (probably for English speakers only - sorry!) ‘when it’s ajar’.

And just when you thought things couldn’t get any worse, the joke, apart from being truly bad, plays on the two possible meanings of a jar. Apart from illustrating Principle 35 in action, it also happens to describe the physical contradiction ‘door and not door’ being solved by separation on condition!

By way of redeeming things (slightly), one of the UK radio stations recently read out the jokes voted best from the different countries of the world. Unfortunately this was at 7am and so we missed a lot of them. What we can remember is that the French and German jokes were very unfunny (sorry friends!), and that the Belgian one went something along the lines that there were only three sorts of people in the world – those that could count and those that couldn’t.

Prizes for anyone working out what Principle is being used in this joke, and for telling us where the complete list of top voted national jokes can be found. (Hint: although you might think otherwise, the answer probably has nothing to do with your national parliament).

Best of The Rest

December was a particularly thin month in terms of new output on TRIZ and so we find ourselves unable to recommend anything. We hope that everyone has been using up all their good stuff for their TRIZCON 2002 papers – which had to be submitted by the end of December.

The best book we read over the Christmas break was a re-visit to Edward De Bono's 'I am Right; You Are Wrong' classic from 1980. We first came across this book before we were aware of TRIZ. It has been a truly fascinating experience re-reading the book now through 'TRIZ-eyes'. Dr De Bono presents a series of very solid arguments in favour of and-and thinking in place of our traditional contradiction-laden either-or mode of thinking.

Patent of the Month

Our patent of the month this month is US6,378,932 granted on 30 April to Daimler Chrysler in Stuttgart. As an experiment, we looked at all of the patents granted in the US on the same day (over 4400!) to see what else the examiners were granting. About 2000 of these patents seemed to be related to software in someway. Very depressing from the perspective of some of us who used to spend our lives writing what now looks like prior art for a new generation of software programmers. Thankfully, it is not possible to patent software outside the US yet. If anyone wants to see for themselves why patenting software is not such a good idea, check out some of the 30 April 2002 patents. Dreadful.

Our favourite worst patent of the month is the self-cleaning litter box for cats. Our interest was originally guided by the word 'self' and the fact that one of us owns cats that seem intent on filling up their litter trays at world record rates. Anyone that has read our article on 'self' patents will know that there are two kinds of 'self' patent; one in the TRIZ spirit of trying to achieve more with less, and the other which seeks to perform the desired function by complicating the system as much as possible. Check out US6,378,461 for an example of the latter. Foot pedals, hoods, pivoting ramps, this patent has it all. The method of removing offending items from the tray is also quite surreal. All in all, a very sad state of affairs.

Meanwhile, back to our recommendation, US6,378,932, 'motor vehicle with flow influencing devices to reduce air resistance'. We like the patent for several reasons; firstly because it uses the Level 3 invention strategy of taking a good solution from another industry – in this case aerospace *(" In an area in a different species, aircraft construction, it is known from U.S. Pat. No. 5,209,438 to provide oscillating movable disturbing elements in the wall boundary layer area of the flow around a wing in order to increase the lift of the wing"* – dated 1993!) – and adopts it to a new one. Secondly, we like the fact that the invention seeks to reduce drag by using an existing resource – air! And third we like the fact that it uses the rhythm co-ordination trend towards pulsed actions to increase the beneficial effect.

As a final thought, you may notice from the picture that the design is still rather more complex than it need be. We believe there is plenty of scope for taking this basic idea and taking it a lot further. Over to you automotive engineers out there.

(12) **United States Patent**
Fasel et al.

(10) **Patent No.: US 6,378,932 B1**
(45) **Date of Patent: Apr. 30, 2002**

(54) **MOTOR VEHICLE WITH FLOW-INFLUENCING DEVICES TO REDUCE AIR RESISTANCE**

(75) Inventors: **Hermann Fasel**, Tucson, AZ (US); **Albert Hack**, Graz (AT); **Ralf Rossmanith**, Oberstenfeld (DE); **Jörg Russow**, Grafenau (DE); **Volker Schwarz**, Altbach (DE); **Rainer Tiefenbacher**, Steinenbronn (DE)

(73) Assignee: **DaimlerChrysler AG**, Stuttgart (DE)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **09/531,493**

(22) Filed: **Mar. 20, 2000**

(30) **Foreign Application Priority Data**

Mar. 18, 1999 (DE) 199 12 140

(51) **Int. Cl.**[7] **B60J 9/00**
(52) **U.S. Cl.** **296/180.5**; 296/180.1; 180/903
(58) **Field of Search** 296/180.1, 180.2, 296/180.3, 180.5; 180/903

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Primary Examiner—Stephen T. Gordon
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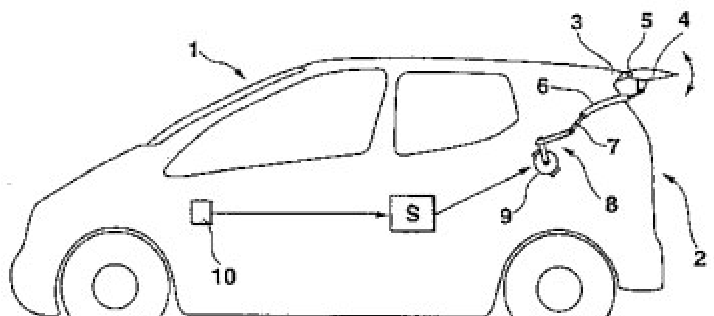
(57) **ABSTRACT**

A motor vehicle has an outer contour around which the headwind flows when driving has associated with it flow-influencing structure to reduce the air resistance of the motor vehicle is known. The flow-influencing structure are movably mounted in a vicinity of the outer contour and can be activated periodically with the aid of drive devices in order to introduce suitably time-dependent disturbances into the flow of the headwind in the vicinity of the flow-influencing structure.

1 Claim, 6 Drawing Sheets



Investments – Sonochemistry

Our recommendation this month concerns the use of ultrasound (a great field – potent effect, and easy to generate) to help speed (amongst other things) chemical reactions.

Here is some introductory text for those not familiar with sonochemistry (text is taken from http://www.scs.uiuc.edu/~suslick/britannica.html for anyone wanting to find out more):

"Ultrasound can produce temperatures as high as those on the surface of the Sun and pressures as great as those at the bottom of the ocean. In some cases, it can also increase chemical reactivities by nearly a millionfold.

"Ultrasound is simply sound pitched above human hearing. It has found many uses in many areas. At home, we use ultrasound for dog whistles, burglar alarms, and jewelry cleaners. In hospitals, doctors use ultrasound to remove kidney stones without surgery, to treat cartilage injuries (such as "tennis elbow"), and to image fetal development during pregnancy. In industry, ultrasound is important for emulsifying cosmetics and foods, welding plastics, cutting alloys, and large-scale cleaning. None of these applications, however, take advantage of the effects that ultrasound can have on chemical reactivity.

"The chemical applications of ultrasound, "sonochemistry", has become an exciting new field of research during the past decade. The history of sonochemistry, however, begins in the late 1800s. During field tests of the first high-speed torpedo boats in 1894, Sir John I. Thornycroft and Sydney W. Barnaby discovered severe vibrations from and rapid erosion of the ship's propeller. They observed the formation of large bubbles (or cavities) formed on the spinning propeller and postulated that the formation and collapse of these bubbles were the source of their problems. By increasing the propeller size and reducing its rate of rotation, they could minimize this difficulty of "cavitation". As ship speeds increased, however, this became a serious concern and the Royal Navy commissioned Lord Rayleigh to investigate. He confirmed that the effects were due to the enormous turbulence, heat, and pressure produced when cavitation bubbles imploded on the propeller surface. In the same work, he explained that cavitation was also the origin of teakettle noise!

"This phenomenon of cavitation occurs in liquids not only during turbulent flow but also under high-intensity ultrasonic irradiation. It is responsible for both propeller erosion and for the chemical consequences of ultrasound. Alfred L. Loomis noticed the first chemical effects of ultrasound in 1927, but the field of sonochemistry lay fallow for nearly 60 years. The renaissance of sonochemistry occurred in the 1980's, soon after the advent of inexpensive and reliable laboratory generators of high-intensity ultrasound.

"Scientists now know that the chemical effects of ultrasound are diverse and include substantial improvements in both stoichiometric and catalytic chemical reactions. In some cases, ultrasonic irradiation can increase reactivities by nearly a millionfold. The chemical effects of ultrasound fall into three areas: homogeneous sonochemistry of liquids, heterogeneous sonochemistry of liquid-liquid or liquid-solid systems, and sonocatalysis (which overlaps the first two). Because cavitation can take place only in liquids, chemical reactions do not generally occur during the ultrasonic irradiation of solids or solid-gas systems."