Contradiction Oriented Methods of Invention

A Brief Introduction to Some Fundamental Concepts Using the Example of the Double Invention of the Cordless Iron with Induction Ironing Board

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1) Introduction

1.1) The Double Invention of the Cordless Iron and Two Modes of Inventing

The cordless iron with induction ironing board was invented twice: in 1999 and in 1983. According to W. Brian Arthur (2007), the irons in question should be considered inventions in the sense of radical novelties, since they exploit a principle that had not yet been used for accomplishing this particular purpose.

Although both inventions can be seen as the same solution to one and the same problem, the ways in which they were discovered diverged greatly. In the case from 1999, the inventor was faced with a problem and solved it with an invention, while in the case from 1983, the inventor was consciously looking for a problem in order to solve it with an invention. In other words: In the first case an invention was made by solving a problem and in the second case a problem was solved because an inventor needed or wanted to make an invention.

The second case makes clear that inventions can, in some sense, be made on purpose. I will call this assumption the *method of invention thesis*. It is a stronger version of what I will call the *theory of invention thesis*, since the latter only holds that "invention has a logic – a systematic structure" (Arthur, 2007, 286). While the method of invention thesis works on the same assumption, it adds the further claim that the logic of invention can be pragmatically used as a means for developing radically novel inventions. Seen from this perspective, a theory of invention is only as good as the method of inventing that can be derived from it.

The double invention of the cordless iron gives us an occasion to take a closer look at the relation between both theses. While the cordless iron from 1999 was invented without an explicit method, the iron from 1983 was developed during a workshop where inventors were taught new methods on how to invent. The underlying theory of this method belongs to a tradition that I will later call *Contradiction Oriented Topical Heuristics* (COTHs). This tradition has its beginnings in Soviet Union of the late 1940s, when Genrich S. Altshuller introduced a Marxist-Leninist version of Hegelian dialectics into the field of engineering.

1.2) On the Essay's Structure

The overall goal of this essay is twofold. First, the relation between the two theses on inventing mentioned above will be discussed. Second, the reader will be introduced to the dialectical theories of invention that belong to the tradition of what I will later call *Contradiction Oriented Topical Heuristics* (COTHs). In this context, the specific difference that distinguishes the latter theories from the commonly held theories of invention based on the idea of combination will be explained.

In order to provide a point of comparison, I will take up Arthur's *The Structure of Invention* (2007), which can be seen as a paradigmatic attempt to explain the logic of invention from the perspective of combinatorics. According to this perspective, "invention is a process of linking some purpose or need with an effect that can be exploited to satisfy it" (Arthur, 2007, 275). The overall structure of the process of invention that is outlined by Arthur's theory will be explained alongside a short narration of the process undergone by Pierre Flécher when inventing the 1999 cordless iron (section 2.1). Based on this structure, which I will later call the SPI-scheme of invention, I will develop some criteria for judging the completeness of theories of invention (section 2.2). With the help of these criteria, I will show that Arthur's theory is itself incomplete to a certain extent. After that, I will outline the history of three versions of the COTHs: TRIZ, ProHEAL and WOIS (section 3). This outline will help the reader gain a better understanding of the COTHs. After shortly detailing the specifics of the COTHs and comparing these versions with one another against the SIP-scheme's criteria of completeness, I will discuss the path taken by the inventors of the cordless iron from 1983, which is reported in Linde and Hill (1993) (section 3.6). As this invention provides an example for the method of invention thesis, I will discuss the relation between both theses in light of the respective examples in section 4.

2) On Arthur's Structure of Invention

2.1) The Cordless Iron from 1999

On 4 February 1999, Pierre Flécher patented the cordless iron heated by an induction ironing board (Flécher, 1999). It was designed as the solution to the problem that the cord poses for the person ironing: it gets in the way. Flécher's radical solution lay in the complete elimination of the iron's cord. The ironing board is plugged into the outlet instead of the iron itself. With the help of induction coils built into the ironing board, the iron is then powered by induction. In this way, the cord no longer hinders the person using the iron. When asked how he came up with this invention, Flécher answered:

> "The task was given to me by my mother, who was annoyed by the inconvenient cord. There were charcoal-fired systems and preheated irons, it is true, but all that was quite cumbersome and without steam. So I thought: From a certain distance the energy must be transmitted via non-conductive materials. What are the physical solutions? Induction would be a solution for which the iron would be virtually predestined. At this time, my cousin had an induction

cooker. I put a towel under the pot and voilà: it was smooth!" (Flécher, personal communication, 24 November 2015, my translation)

Flécher's description fits perfectly with Arthur's definition of what inventing is: "invention is a process of linking some purpose or need with an effect that can be exploited to satisfy it" (Arthur, 2007, 275). Indeed, Flécher made use of the effect of induction in order to create an iron without a cord. Or put more explicitly in terms of Arthur's definition, the purpose or need was to create a cordless iron and for this purpose, Flécher exploited the effect of induction. It sounds surprisingly simple. Accordingly, when I asked him via email if he knew that the same cordless iron had already been invented in 1983, he thanked me for the tip and told me that he had indeed been surprised that nobody had found this simple solution before. In addition, he also expressed wonder at the fact that the invention had not yet been marketed (ibid.).

2.2) On a Deficiency of Arthur's *Structure of Invention* in Light of Flécher's 1999 Invention

Let us take a step back and look at the situation from some distance. According to Arthur (2007, 278), a particular need stands at the beginning of every invention. Some practitioners might be aware of this need and the problem it poses, but none of them can find an adequate solution because current technology is unable to solve the problem. Inventors, or *originators* as Arthur prefers to call them, nonetheless accept the challenge. They "may encounter the situation as a need to be fulfilled or a limitation to be overcome; but they quickly reduce it to a set of desiderata – a problem to be solved" (Arthur, 2007, 279).

In other words, the process of invention starts with a situation S that is encountered as a need or a limitation. Moreover, it has to be reduced to a problem P that is to be solved. As for the example of the cordless iron, the situation S that has to be reduced to a problem P to be solved is the experience that, when it comes to ironing, the cord is a hindrance. Consequently, someone may encounter this limitation as something to be overcome.

According to Flécher's description of how he came up with his invention, anything other than a cordless iron was out of the question. With regard to the reduction of S to P, the question thus arises as to where the precise formulation of the problem P came from. I asked Flécher whether his mother explicitly wanted to have a cordless iron or only a less impractical one. The distinction is significant: Being posed with the task of inventing a cordless iron is distinct from being posed with the more general task of simply inventing one where the cord doesn't get in the way. The formulation of the problem that Flécher ultimately solved might be called PF, while the formulation of a more general task might be called PF*. So when I asked, Flécher responded with the following:

> "I was asked to come up with an iron without cord, not heavy, and with adjustable temperature, thus not running with latent temperature like in grandma's time, and using steam in accordance with the current state of the art. An ironing board was needed in any case, but it was not to be heated itself." (Flécher, personal communication, 26 November 2015, my translation)

Indeed, if the question is how to build a cordless iron with all the features of a modern iron, the "search space" for finding feasible solutions shrinks significantly in comparison with those suggested by a similar question based on the formulation PF*. In the first case, using induction is more or less the only viable solution, simply because the question's formulation really doesn't leave one with many other choices. In contrast, the space of possible solutions for a more practical iron "where the cord simply didn't get in the way" is much wider. The possibility of creating a cordless iron by exploiting the effect of induction belongs to this set of possible solutions, it is true, but it is only one possibility among others.

This makes it clear that, according to Arthur's theory of invention, the transformation of S into PF was relevant for Flécher's invention. If the term inventing only referred to the process of linking a certain purpose or need with the effect required for its solution, it would indeed be surprising that this solution for the iron was only formulated in 1999. However, if the transformation of S into P is viewed as an integral aspect of the process of inventing, the process itself becomes more complex. When one considers this, the fact that nobody had come up with a cordless induction iron before 1999 becomes, in a sense, less surprising. [2]

Arthur (2007) does not offer a further specification as to how S can be reduced "to a set of desiderata" that make up the problem P to be solved. Rather, the focus of his analysis is set on finding the base principle – "the idea of some effect (or combination of effects)" (Arthur, 2007) – that allows one to meet the demands of the problem and find a solution for it. By neglecting to analyse the necessary transformation of S into P, Arthur is unable to provide an account of the nature of the problems to be solved. As a consequence, Arthur's theory cannot account for how situations S are to be reduced to problems P in order to be solved by an invention. The deficiency in

[2] From this perspective, it might be reasonable to modify the formulation of Arthur's definition slightly by saying that invention is a process of (i) articulating some purpose or need and (ii) linking it with an effect that can be exploited for its satisfaction. Put like this, the process itself can be divided into multiple parts; concerning the invention of the cordless iron, Flécher's mother can be seen as having fulfilled one of the key tasks.

question seems to be due to the fact that the theory is built on the general properties of technology and not on the general properties of the development of technology.

More precisely, from the very beginning, Arthur defines invention as the act of linking a purpose or a need with the effect required for its fulfillment. This, however, is a general feature of technology as such. Since every technology must once have been invented, these general features also apply to invention. However, invention does not concern technology alone. It concerns first and foremost the development of technology. For this reason, it can be stated that the proper subject of a theory of invention is the development of technology itself. Note that both subjects are not in contradiction with one another. Rather, the formulation of the second subject follows from a more concrete definition of what theories of invention are about.

As a consequence of what has been said so far, we can insist on a few criteria that every adequate theory of the logic of invention that is in keeping with Arthur's (2007) description of the process of inventing has to fulfill: The respective theory should be able to show how a situation S arises, how it is transformed into a problem P, and how this P is solved by an invention I. Let us call this scheme of the process of invention the SPI-scheme. Moreover, the method of invention thesis adds an extra demand. The theory should be able to explain the logical connections between the steps of the process of invention with such detail that it can be used as a guideline for how to come up with inventions.

As mentioned above, such guidelines led to the invention of the cordless iron from 1983. They belong to a larger tradition of theories of invention that I will later call COTHs. However, before I turn to the description of the process of invention that led to the 1983 iron, I would like to introduce the basic ideas of the COTHs and relate the three different approaches – TRIZ, ProHEAL and WOIS – to one another. For the purpose of comparison, I will relate these approaches to the SPI-scheme of invention outlined above.

3) On the Method of Invention Thesis

3.1) Introductory Remarks

The cordless iron invented in 1983 is discussed in the book *Inventing Successfully – Contradiction Oriented Innovation Strategy* by Hansjürgen Linde and Bernd Hill (1993, 14f.). According to the authors, the iron had been invented during a one-week workshop on the development of irons. The workshop took place in a hotel (Linde/Hill, 1993, 12) whose location is not further specified. As I will later argue, the authors did so to hide the fact that the hotel was in the GDR.

The overall goal of the book by Linde and Hill is to give an elaboration of the *Contradiction Oriented Innovation Strategy* (WOIS), which was designed to provide inventors and development engineers with an efficient method for inventing successfully. The cordless iron from 1983 is discussed in the first chapter as an example among others. The chapter outlines the method's general strategy before explaining the different steps and tools that make up the WOIS to the reader. In order to give a better understanding of this method of invention, I would like to briefly sketch the basic features of the class of theories of invention that the WOIS belongs to.

3.2) Contradiction Oriented Topical Heuristics (COTHs)

According to Linde and Hill's (1993) own classification of approaches to inventing, tools for fostering invention fall into two classes. In the first class, there are approaches designed for producing as many solution candidates as possible, which proceed either intuitively or systematically. A subclass of these systematic approaches is known in the philosophy of technology under the name *combinatorial heuristics* (see Hubig, 2006), which includes approaches like the morphological approach developed by Fritz Zwicky (1966).[3]

The second class of approaches to inventing are those that aim to make the demands placed on developmental tasks – or in terms of the SPI-scheme, the problems P – more restrictive. Gradually imposing stricter demands, so the theories go, will ultimately result in contradiction, because every technical system's capacity to meet particular demands is limited: in other words, every system's design only allows it to meet certain demands to a certain degree. Moreover, no technical system can ever achieve ideal effectiveness, which is defined as the quotient of advantage and expense, with as many advantages as possible and no expenses at all. Striving towards ideal effectiveness by gradually increasing the requirements that have to be met pushes the structure of every system to its inherent limits. When one reaches this limit, a contradiction between the various demands arises: it is impossible for the system at its current stage of development to meet them all at the same time, so that a compromise becomes necessary. In order to avoid compromising on some of the demands, a solution has to be found that transcends the current state of the art. In other words, an invention becomes the next logical step in the process.

The focus on unearthing and overcoming contradictions connects these approaches with the broader tradition of materialist dialectics as developed by Lenin, Engels and Marx, and their roots in Hegel's philosophy (Zobel, 2011). No doubt, their founder, Genrich S. Altshuller, developed these approaches in the Soviet Union in the late 1940s (Souchkov, 2008) by introducing materialist

[3] For a broader discussion of combinatorial heuristics in philosophy of technology see Müller (2001).

dialectics into the field of engineering. In order to explain the concept of *technical contradiction*, Altshuller borrowed an example from Engels' "History of the Rifle" (Marx/Engels, 1972). According to him, this work can be seen as "an analysis of the internal contradictions that determined the historical development of the rifle" (Altschuller, 1973, 81, my translation). Briefly stated, the contradiction that guided the development from the muzzleloader to the breechloader was a conflict between two parameters that needed to be improved upon: pinpoint accuracy and loading speed. Muzzle-loading rifles must be loaded from the front. The longer the barrel, the longer the loading process. Thus, in order to decrease the time needed for loading, the barrel must be shortened. However, the longer the barrel, the greater the accuracy. Hence, there is a contradiction between the two goals: increased accuracy and decreased loading time. By sticking to the muzzle-loading system, the best solution that can be found is a shaky compromise. This mutual dependency of parameters that prevents them from attaining a better state (the elimination of negative effects included) is a *technical contradiction*. It is a contradiction inherent to the system "Muzzleloader", which can be seen from the fact that the amelioration of both parameters leads to a contradictory demand: The length of the barrel must be long (for the sake of pinpoint accuracy) and the length of the barrel must be short (for the sake of shortening the loading time). This contradiction of the muzzle-loading system was finally eliminated by the shift to the breech-loading system. In this system, rifles are no longer loaded from the front but from behind. Hence, the barrel can be long without increasing loading times. The technical contradiction between pinpoint accuracy and loading speed disappears.

However, Altshuller did not think that understanding technical evolution was an end in itself. On the contrary, the underlying idea of his approach is that any knowledge about how technical systems evolve can be used for developing technical systems further. In other words, Altshuller was an adherent of the method of invention thesis. Guided by this idea, Altshuller worked on an *Algorithm of Inventive Problem Solving* (ARIZ) and its respective theory (TRIZ) in order to provide inventors with orientation during the process of invention by demanding that they strive towards ideal effectiveness and articulate the contradictions that come up along the way. This in turn narrows the search space of possible solutions, weeding out the weaker ones and preserving the stronger. This stands in stark contrast to *combinatorial heuristics*, which, as explained above, aims to increase the field of possible solutions.

In the philosophy of technology, approaches that are based on the general idea of search spaces can be called *topical heuristics*. Although such heuristics can be found as early as Stoic thought (Hubig, 2006), the orientation towards contradiction was first developed by Altshuller. Thus, I will call the approaches of the second class in Linde's and Hill's classificatory scheme *Contradiction Oriented Topical Heuristics* (COTHs).

In 1973 Altshuller's work first entered the GDR via translation (Altschuller, 1973; later also Altschuller/Seljuzki, 1983; Altschuller, 1984 and Altow 1986/1977). The theory helped give rise to the so-called inventor school movement (see for example DABEI, 1993; Rindfleisch/Thiel, 1994). It also underwent some transformations, the most significant of which was the so-called ProHEAL, the *Guidelines for Developing and Resolving Problems in Invention* (Rindfleisch and Thiel, 1986; 1988; 1989).

In 1993, TRIZ/ARIZ, ProHEAL and WOIS (i.e. the theory elaborated in Linde and Hill (1993)) made up the whole class of COTHs (at least in the perspective of Linde and Hill). In detailing the history of these theories and comparing them with one another, I will first focus on the crucial difference between TRIZ and ProHEAL before turning to WOIS and the iron from 1983. The difference between them is important for two reasons. First, when judged against the criteria developed in section 2.2, one can say that ProHEAL addresses a deficiency in Altshuller's TRIZ. Second, although Linde and Hill's WOIS inherited many of the theoretical developments that had been introduced by ProHEAL, the latter has more or less been completely forgotten. As I will later explain, Linde and Hill's strategy for making WOIS successful was partially responsible for the suppression of the sister theory.

3.3) On the Difference between ARIZ and ProHEAL – A Step Towards a More Complete Theory of Invention

The crucial difference between ProHEAL and ARIZ can be found in their respective starting points. According to the SPI-scheme of the process of invention outlined above, an inventor encounters a situation S that must be transformed into a well-defined problem P that is to be solved by an invention I. While Arthur's theory only explains how to go from P to I, the ARIZ begins with a situation S that is in some way given and that simply needs to be made into a task for inventors, i.e. transformed into a well-defined problem P. In contrast, the ProHEAL begins by analyzing the factors that gave rise to the situation S in the first place, only then moving towards an analysis of the ways it might later become a task for inventors, i.e. a well-defined problem P. Aside from the internal logical reasons for beginning the analysis of the process of invention with the origins of the situation S, the difference between ARIZ and ProHEAL can probably be best understood when one considers the different contexts in which the theories were developed.

TRIZ/ARIZ was developed as a tool for professional inventors in the USSR who had to solve problems on demand. In contrast, the GDR inventor school movement that shaped ProHEAL emerged out of the initiative of individuals working in state-owned industrial enterprises in the GDR (Rindfleisch/Thiel, 1994). These enterprises had to meet the demands set by a yearly economic plan. As is common knowledge, however, control economies lack the dynamic of market economies.[4]

In this context, the ProHEAL was designed as a means for turning ordinary engineers into inventors. Moreover, the authors of the ProHEAL wanted to empower people to autonomously determine what society needed and which problems needed to be overcome in order to ensure society's progress (private communication with Rainer Thiel).

Thus, in contrast to the different versions of Altshuller's ARIZ, ProHEAL includes an additional step that requires the inventor to begin by analysing social need before proceeding to formulate the inventive task that needs to be solved. Hans-Jochen Rindfleisch and Rainer Thiel were convinced that the final goal of invention should be the production of something useful for society as a whole. What this means for a particular technical system has to be determined for each particular case. Their method thus begins with a case specific analysis of social need. Adding new concepts to Altshuller's theory to account for this step, they developed a systematic method of analysing the demands a particular technical solution had to meet in order to fulfil a particular social need. For each particular invention, the inventor then has to translate these requirements into a set of parameters whose improvement reflects an improvement from the perspective of social need.

With the help of these concrete parameters, tasks for inventors can be intentionally created. The idea is quite simple: if all these parameters are increased theoretically or experimentally, contradictions arise which can be easily detected in a matrix of parameters (see Schollmeyer, 2016, Writing Sample). Consequently, the technical contradictions that emerge are not only conceived of as hurdles on a technical system's path towards its ideal form, as in the case of ARIZ. In ProHEAL, they take the form of hurdles to society's development, their eventual elimination implying the solution of societal problems.

The question as to what society needs and where this need comes from thus precedes the detection of the technical contradictions both temporally and logically. To make the comparison between the two systems clearer: in the last stage of ARIZ's development, Altshuller writes with a normative thrust that "an invention is the development of a technical system" (Altschuller, 1984, 32, my translation). ProHEAL might append this with the additional normative claim that an invention is the development of a technical system made for the sake of the development of society.

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[4] According to Roemer (1994), by the 1980s the ability of economies to innovate became much more important for the growth in economic welfare. "At this, the Soviet-type economies failed dismally, [...] because [...] without the competition that is provided by markets – both domestic and international – no business enterprise is forced to innovate, and without the motivation of competition, innovation, at least at the rate that market economies engender, does not occur" (ibid., 44).

In a sense, ProHEAL might be seen as a further step in the development of Altshuller's theory, because it analyses the process of invention not by explaining the passage from S to P and from P to I alone, but by starting with the origins of the situation S itself. It not only takes the history of a particular technical system and its further development into account, but also the history of social need and the development of society (see, for example, Rindfleisch/Thiel, 1988, 56). According to ProHEAL, technological development cannot be considered as an end in itself. It is worth noting that this position leads to a sort of technological determinism, which might be seen as a latent tendency of TRIZ.

Starting with the situation itself, however, has a further methodological implication: ProHEAL not only explains how inventors should analyse a situation, but also contains an explanation of how potential situations that yield problems to be solved by inventions can be intentionally produced. This means that invention can not only be planned (as in TRIZ), but also guided in a particular direction. The direction an invention takes depends on the way the need to be satisfied is formulated. Because of this shift in perspective, the theory of invention has to step out of the domain of technology and become a part of political and social science, which confirms Schmidt's (2007) claim that innovation should be characterized as an eminently political category. Moreover, the socio-economic system in which the theory of invention is carried out becomes relevant for the theory itself, which is readily apparent in the respective paths the ARIZ and the ProHEAL took after the collapse of the Eastern Bloc, an issue that I will take up in the next two sections (3.4 and 3.5).

3.4) ARIZ in a Market Economy

Contemporary versions of the ARIZ also contain a prior step in which potential situations that give rise to the problems to be solved by an invention are analysed. In essence, this step consists of a set of tools for market analysis. They became important when the TRIZ theory entered Western market economies after the collapse of the Eastern Bloc. That market analysis alone decides which situations can give rise to inventive problems implies that market demand is viewed as the *ultima ratio* for determining the path technological development takes. This is indeed true in modern market economies. An innovation is justified if and only if there is a potential demand on the market that it can fulfill in a legal manner.

In contrast, one of the intentions of the authors of ProHEAL was to make the criteria for calling something an innovation more rigorous. From their perspective, the simple fact that a potential market demand can be fulfilled by an invention does not make it innovative. Rather, they claimed, innovation ought to be determined from the perspective of society as a whole. If a novelty contradicts the general well-being of society by, for example, pushing society further into climate catastrophe, its status as an innovation could be contested (private communication with Rainer Thiel). Thus, let us take a look at ProHEAL's history after 1989.

3.5) WOIS as ProHEAL in a Market Economy

When the Berlin Wall fell, TRIZ was still completely unknown in West Germany. Dietmar Zobel, one of the leading figures of the GDR inventor school movement, published the first book on TRIZ and systematic invention in German after Reunification (Zobel, 1991). Since then the situation has changed significantly. Currently 23 people – among them at least ten are university professors – are working on a set of guidelines outlining the method and concepts of TRIZ for the Association of German Engineers (VDI) (VDI, 2015).

A similar set of guidelines was published about 30 years earlier in the former GDR by the VDI's sister organization, the KDT, the Chamber of Technics: namely, the ProHEAL system developed by Rindfleisch and Thiel (1986; 1988; 1989). In 1990, that is, 25 years before the VDI set up its own TRIZ guidelines, Thiel offered this material to the VDI. However, according to him, it was turned down without having been examined, as the VDI considered it useless in a market economy (private communication with Rainer Thiel). This might be a relevant detail for getting an understanding of the problems that the COTHs and their proponents, like Linde and Hill, had to face in Germany after Reunification.

Thiel met Rindfleisch in 1979, with whom he developed the ideas of the ProHEAL. In 1984, he met Hansjürgen Linde (1942 – 2011). He motivated Linde to write a dissertation on contradiction oriented problem solving, i.e. on TRIZ and ProHEAL, and became the third supervisor on his dissertation committee. Linde defended his doctoral thesis in 1988 at the Technical University of Dresden (Linde, 1988). After German Reunification he worked for BMW until he became professor at the University for Applied Technology in Coburg (a West German city) in 1991. There he successfully introduced his *Contradiction Oriented Innovation Strategy* (WOIS) at the institutional level. Its method is nearly identical to Rindfleisch and Thiel's ProHEAL.

Further research must be conducted to thoroughly conceptualize the differences between WOIS and ProHEAL. One difference, however, is obvious. That difference is in the methods' respective first steps, which are oriented towards determining the problem that is to be solved. Because of Germany's market economic system, the WOIS's first step (in contrast to Linde (1988)) is more oriented towards market analysis than the ProHEAL's analysis of social need.

In contrast to Rindfleisch and Thiel, Linde tried to hide his own origins and those of his theory. He introduced himself as “Linde from BMW” and recommended his friends do the same (private communication with Dietmar Zobel). The content of the WOIS’ official founding text, namely Linde/Hill (1993), is nearly identical with Linde’s 1987 dissertation (Linde, 1988). However, in the version from 1993, everything that might have connected Linde and Hill with the GDR was cut out. Only a close look at the bibliography reveals that most of the cited materials were published in East German cities. The oldest publication by Linde himself that is cited, however, is from 1991 and was published in Coburg. In contrast to Linde’s dissertation (1988), there are no references at all to the patents that serve as examples in the book from 1993. Most of them are patents that belonged to Linde and his team from the engineering office in Gotha (an East German city) where Linde worked until 1989. A case in point is the workshop from 1983, where the cordless iron was invented 16 years before the same idea was patented by Pierre Flécher.

3.6) The Cordless Iron from 1983

As mentioned above, the invention of the cordless iron is discussed in the first chapter of Linde and Hill’s (1993) book on the so-called *Contradiction Oriented Innovation Strategy* (WOIS).[5] The chapter’s overall function is to familiarize the reader with the basic concepts of WOIS. Within this chapter, the cordless iron exemplifies how a situation in which a need is articulated can be transformed into a well-defined task for inventors. The underlying idea is that well-defined tasks for inventors will guide the inventor towards the problem’s solution by giving orientation in terms of both (i) the direction of the system’s development, which helps articulate a purpose, and (ii) the choice of the appropriate means required for its realization.

The discussion of Flécher’s iron above has already familiarized us with the situation that must be translated into a problem to be solved by the invention – when it comes to ironing, the iron’s cord gets in the way. According to Linde and Hill, this problem was given to the inventors by the staff of the hotel where the workshop took place. More precisely, the engineers were asked whether the cord of the iron could be laid down differently so that it would stop getting in the way. Whereas the problem posed to Flécher by his mother in 1999 made it fairly apparent that the solution would be a cordless iron powered by induction, the way the hotel staff posed the problem to the East German inventors makes this solution less obvious; it is imaginable, for instance, that they could have invented a cord somehow designed to always stay off the board.

[5] The reader will recall that Linde didn’t meet Rindfleisch and Thiel at this time. However, he was already working with TRIZ. Thus, this example serves as a demonstration of the method of invention thesis in form of the COTHs in general.

However, one of Linde and Hill's first pieces of advice for successful invention is that "[t]o solve a problem means to break away from the problem" (Linde/Hill, 1993, 11).[6] In other words, the inventor should be aware that it is rarely the case that the first formulation of the problem that is to be solved is the best formulation of the problem. Here the concept of ideality comes into play: at least in principle, the further development of a technical system goes hand in hand with an increase of its ideality. In other words, undesirable effects go down and desirable effects go up. By applying this so-called "law of technical development", the team came up with the following idea: "The best iron's cord is the cord that no longer exists but that nonetheless fulfills its function" (Linde/Hill, 1993, 14). In short, the problem could clearly only be solved by a cordless iron.

According to Linde and Hill (1993), the team was guided by two further "laws of technical development" that helped them come up with a more precise formulation of the problem at hand. One of them was the so-called "law of building super-systems". The law states that if a system's effectiveness has been exhaustively optimized, its effectiveness can only be further improved if the original system is integrated into a super-system. If it is successfully integrated, the original system stops existing for itself. Guided by this "law", the team thought that the iron should be combined with another system that is also required for ironing. The winner was the ironing board. The team thus decided to fix the cord to the board and not to the iron, and concluded that the iron would somehow have to be heated through the board. But how?

Here another "law of technical evolution" came into play, a law the authors call a "law of tendency", namely, the so-called "law of an increasing amount of substance-field-systems". Understanding what this means requires some further explanation, as the concept of "substance-field-systems" is TRIZ specific and was first developed by Altshuller and his colleagues. The term itself refers to abstract models. These models are designed to help the inventor represent technical systems as abstractly as possible. According to Linde and Hill, the two categories "substance" (S) and "field" (F) represent two different ways in which matter (as a philosophical category that is opposed to consciousness) appears. In addition, different types of effects and interactions between substances and fields can be represented by different types of arrows, whereby effects and interactions can be carriers of both energy and information. A so-called minimum system consists of two interacting substances and a field.

So much for the concept of substance-field-systems. According to the law of tendency in question, the development of technical systems is directed towards an increase in the number of substance-field-systems. That is, elaborated technical systems based on mechanical principles are gradually replaced by fields, which are more effective. Given this law of tendency, one can ask

[6] In German the postulate is catchier since the expressions "to break away from something" and "to solve something" are constructed out of the same verb, i.e. "lösen": "Ein Problem lösen heißt, sich von dem Problem lösen."

whether the overall effectiveness of the technical system at hand might not be increased if the system was transferred into a substance-field-system (Linde/Hill, 1993, 75).

The ideas suggested by this law brought the breakthrough. The transfer of energy from the ironing board to the iron had to be brought about by an adequate field. By searching in the catalogue of physical effects, which is a fundamental part of all COTHs, the team found the principle needed for an adequate solution: induction. Based on that, the team invented the same iron as Flécher did 16 years later.

4) On the Relation Between the Theory of Invention Thesis and the Method of Invention Thesis

In comparison with Flécher's description of the way he invented the cordless iron, the report about the iron from 1983 is much more detailed. At the same time both reports reflect the order of Arthur's SPI-scheme during the process of invention. In both cases, the need to be tackled became apparent to people who use irons, namely to Flécher's mother on the one hand and to the hotel staff on the other. The problematic situations S were then translated into well-defined problems for the inventors. In the case of the invention from 1999, Flécher's mother did this job herself by asking her son for the solution of a problem that needed no further articulation. In contrast, the inventors who invented the cordless iron in 1983 had to transform the badly defined problem into a well-defined problem. They did this by proceeding in accordance to the rules that can be derived from the theory of invention underlying the COTHs in general and the WOIS in particular.

This process itself fell into several steps. Moreover, it yielded a formulation of the problem that was not only just as well-defined as the problem raised by Flécher's mother, but that itself contained hints for finding the solution, as it forced the inventors to look up the required physical effects in the catalogues found in the COTHs' guidelines for inventors. With regard to the SPI-scheme, the guidelines for the passage from S to P led the team step by step through the transition from P to I, which in turn led them to the principle needed to solve the problem. In other words, the fully understood problem is almost the solution itself.

Again, this is not in contradiction with Arthur's theory, according to which "principles are arrived at, they are never invented from nothing. They are appropriated from or suggested by that which already exists, be it other devices or methods or theory or phenomena" (Arthur, 2007, 280). However, Arthur's theory is not detailed enough to be turned into a prescriptive method for inventing. For this reason, the steps that lead to the solution of the problem at hand remain unclear.

This is reflected in the continuation of the citation above: “This process of mental appropriation and half-conscious suggestion”, Arthur writes, “lies at the creative heart of invention” (ibid.).

The potential point of contention between proponents of the theory of invention thesis and proponents of the method of invention thesis revolves around what this “creative heart of invention” is. The method of invention thesis implies that a theory of invention can gain a sufficient understanding of what Arthur calls “the creative heart of invention” by developing a method of inventing. In contrast, the theory of invention thesis is not committed to this claim.

5) Conclusion

To sum up, the method of invention thesis states that it is possible to develop a method for guiding inventors during the process of invention out of the SPI-scheme of the inventive process. The more one understands the epistemic practices involved in this process of inventive problem solving, the more useful the method that can be derived from the respective theory becomes. From this perspective, invention is only mysterious as long as these practices remain implicit: the more they are worked out, the clearer the inventive process becomes. Thus, while every method of invention requires an adequate theory of invention, not every theory of invention yields a method of how to invent successfully.

In order to judge the completeness of theories of invention, I have referred to the SPI-scheme of invention that underlies Arthur’s theory. While Arthur (2007) is only concerned with understanding how well-defined problems are solved by inventions, the ARIZ begins a step earlier by explaining how the situations in which a need is articulated can be reduced to well-defined problems that have to be solved by an invention. Thanks to this shift in perspective, the epistemic practices involved in the passage from S to P as well as those relevant for the path from P to I can be explained in greater detail. The ProHEAL even starts a step earlier than the ARIZ by trying to understand how a situation S containing a need arises, which only then is to be reduced to a well-defined problem P for inventors that can be potentially solved by an invention I. This shift in perspective allows inventors to intentionally produce their own tasks or well-defined problems.

Today, the ProHEAL that was developed in the context of the GDR’s control economy has been more or less forgotten, but its descendant, WOIS, is well established in Germany’s market economy. WOIS’s proponents successfully promoted it by suppressing its origins in the GDR, most likely in order to navigate the hostile climate towards virtually everything East German after the fall of the Berlin Wall. It seems clear, however, that contemporary problems such as global warming demand that we return to asking questions about how urgent social needs arise that can only be satisfied by creative problem solving and how they are to be articulated so that we can effectively identify what is to be done. As shown above, these questions go to the heart of the relation between technology or technological progress on the one hand and political and social sciences on the other. Both WOIS and ProHEAL deal with this relation, but in different socio-economic contexts, which would make comparing them in a rigorous manner a fruitful project for further research.

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