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Patent circumvention strategy using TRIZ-based design-around approaches

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Abstract

This paper proposes guidelines for a systematic patent circumvention strategy utilizing innovation and TRIZ tools. It focuses on starting from a *landscape of patents and claims* of an existing patent to create solutions that circumvent this existing patent. Information gathered from various sources is used to create the *landscape of patents and claims*, and circumvention opportunities are categorized into three types of problems: *Unnecessary elements, Types of limitations* and *Potential disadvantages*. These types act as a starting point to guide the inventor through various recommended innovation and TRIZ tools in search to find new feasible and non-infringing solutions while taking infringement law into account. A case study is presented demonstrating the outlined strategy to circumvent a patent describing an incremental improvement of a Rzeppa constant velocity joint.

1. Introduction

Patent circumvention plays an important role in the product development industry. Patents contain a lot of information that can be used by inventors to fuel product innovation. Despite some of the negative associations patent circumvention has, it has to be clearly distinguished from patent infringement. Patent circumvention is a process with its guidelines built upon the rules of patent infringement law to assist the creation of new products that do not infringe the patent to be circumvented.

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TRIZ tools can be used to aid the process to systematically design around or circumvent patents. There are publications presenting TRIZ tools to assist with designing around patents [1-4]. They are tailored to the rules of patent infringement judgment, which are the major constraints of the design-around process. These publications follow the process shown in Figure 1. In general, the patent circumvention process consists of 4 steps, starting with the gathering of information in the (1) *information gathering process*, followed by the (2) *landscaping of patents and claims process* to get a clear overview of the patents and claims. Subsequently the (3) *applying the approaches of the design-around process*, which encompasses various TRIZ tools, is done to find new possible designed-around solutions. Finally (4) an *infringement analysis* is conducted to find out if the new solution infringes the original patent.

Publications that provide concrete guidelines to move from the *landscaping of patents and claim*s *process* to an actual solution by means of *applying the approaches of the design-around process* around are limited. The existing publications usually state TRIZ tools but do not state which one to use in a specific scenario.

For instance, Hung and Hsu [1] propose an integrated process for designing around existing patents using TRIZ. A design problem is identified and solving it is done by either trimming or applying the standard TRIZ process without differentiating between types of problems.

The method presented by Jiang et al. [2] focusses more on finding next generation product innovations, instead of designing around, by analyzing the core technology evolution trends and applying the contradiction matrix. Design-around solutions that are closer the current solution are less likely to be found with this method.

Liu et al. [3] recommend to formulate functional requirements from the patented product and they have the limited suggestion to design-around the patent by replacing, deleting, adding or combining function elements. The paper does not resort to any other TRIZ tools.

Figure 1. General patent circumvention process flowchart.

Lee [4] gives a comprehensive overview of the complete design process; however, it only lists the Contradiction-Matrix of TRIZ to solve the facing contradictory design-around question.

It can be seen that many publications apply TRIZ to solve certain design-around problems found in Steps 1 and 2, but a limited number of TRIZ tools is suggested. Moreover, little explanation and motivation for the choice of tools is given. The novelty of the presented paper is a solution to fill this gap and propose a series of advised and suggested TRIZ tools bases on a given patent claim landscape.

Steps 1, 2 and 4 of the patent circumvention process are briefly described in Chapter 2; the focus of this paper lies in the aforementioned third step, which is discussed in detail in Section 2.3. This patent circumvention research fits in the broader research scope of facilitating Intellectual Property (IP) protection in product development [5], as studied at the laboratory of Design, Production and Management at the University of Twente.

1.1. TRIZ

TRIZ is the Russian acronym for the Theory of Inventive Problem Solving developed by Genrich Altshuller and his colleagues [6-7]. One of its key strengths is to avoid mental inertia, also known as 'tunnel visioning', to find new innovative solutions using patterns of previously solved problems. This set of patterns was discovered by analyzing millions of patents. Due to its origin, TRIZ tools are applied in this paper.
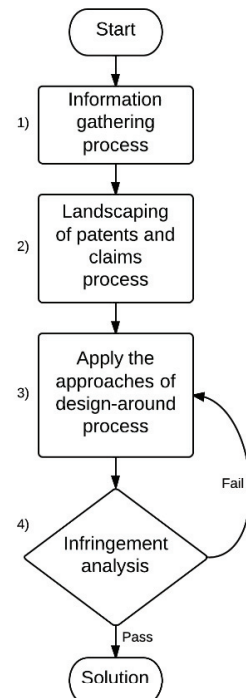
1.2. Infringement laws

To circumvent a patent successfully, a new solution (invention) should obey the laws that define patent infringement. There are two rules that are fundamental to the design-around process and judgment of infringement, namely the '*all elements rule*' and the '*doctrine of equivalents*' rule according to Bingxuan [8]. There are less used rules such as the '*doctrine of estoppels*' and '*doctrine of redundant specified*' rules. Their use is situational [8] and are therefore not described in this publication.

The *all elements rule* states that infringement may occur if the new invention contains all the elements that are constituted in a claim. If the elements correspond to those in the claims but are substantially different, judgment by the '*doctrine of equivalents*' rule comes in to play. This rule, also known as the 3-way test, states that new solutions infringe if (1) it performs substantially the same function (2) in substantially the same way (3) to yield substantially the same result.

Note that each country has its own legal system and has different patent laws. This research follows an internationally accepted trend; however, it is advised to investigate the local area where the new innovation will be patented to avoid infringement.

2. Design-around strategy

2.1. Information gathering process

Information is gathered about the product that is subject to be designed around. This process is crucial for the development of concepts and therefore a decent investment has to be made. TRIZ tools, general information sources, and patent search and analysis tools can assist the inventor in this process. There are however two actions that must be undertaken during this process step, namely a function analysis, and a patent search and analysis. These can be done either in parallel or in a random order.

This research proposes a function analysis of a (physical) product by conducting a TRIZ Function Analysis (FA) [9-10], as this gives comprehension of the functioning of the product and its interactions (e.g. positive, insufficient and harmful interactions). Other function analysis or function modeling (e.g. NIST [11] or IDEF0 [12]) focus more on a decomposition based on material, signal and energy flows rather than on interactions. The creation of the FA can be assisted by studying related literature and addressing external expert knowledge. Determining an Ideal Finalized Result (IFR) [9-10] can give insight into the highest degree of ideality of the product and gives good insight into the useful and negative effects of the product and cost.

The second required action is to search and analyze patents by means of manual or automated methods. Depending on the number of relevant patents a decision has to be made whether automated methods, e.g. software tools, should be used to create a clear overview of the patent landscape and to assist with the second process step of the general patent circumvention process: *landscaping of patents and claims process*. An example of an automated method is 'Wips' combined with 'PM Manager' [4]. This software can be used to create a technological effectiveness matrix to analyze selected patents' data. The manual patent search may utilize the use of the advanced search options in web based patent databases to find all relevant patents. Examples of the use of advanced search options are the use of keyword and classification searches.

2.2. Landscaping of patents and claims process

A landscape of patents and claims is created from the information gathered in Step 1. Information from patents and especially claims must be categorized into three potential types of problems, namely: '*Unnecessary elements*', '*Types of limitation*' and '*Potential disadvantage*' as determined by Nydegger and Richards [13]. These types of problems act as a starting point for the *applying the approaches of designing around process* step in the general process overview of Figure 1:

1: "*Unnecessary elements*" are elements of the product that can be removed without losing product functionality. Each element of the product used in the FA and claims should be judged if it can potentially be removed without

losing functionality. If deemed so, it must be considered as a candidate to be categorized as an unnecessary element. Often, the previous state of the art is mentioned in a patent outside the list of claims. Elements from this previous state of the art can be listed and treated as an *unnecessary element*. Removing an unnecessary element results in avoiding the '*all elements rule'* of patent infringement, making the new design less likely to infringe.

2: "*Types of limitation"* or bottlenecks are often shortcomings in the current product to be designed around. These limitations are often the insufficient functions from the FA. Patents are often a solution to reduce or overcome a certain limitation and describe these outside the list of claims. For example, in the patent chapter 'Problem to be solved by innovation'. The solution presented in the patent cannot always be extracted from interpreting the claims, as they often only describe the physical state of the invention. Therefore, expert knowledge and literature must be addressed to find types of limitations that are not mentioned in patents and their claims. Another way to find types of limitations is by using the IFR and its goal for an optimal result. Achieving this goal will be limited by certain claims and these claims can be categorized as such.

To illustrate this type of problem an example of a *type of limitation* is given. For instance, a certain part of a product cannot hold a mass above a certain limit due to dimensional limitations. Possible solutions around these *types of limitations* will easily infringe the current patent due to not being able to circumvent the '*doctrine of equivalents'* rule with ease. For instance, optimizing a certain limitation without changing it notably does not change anything 'substantially different' and thus infringes the original patent. For that reason extra care has to be taken when designing around *types of limitations*. Only making the part thicker or from a different material will solve the problem but is not substantially different. Using a different mechanical field such as magnetism to overcome the dimensional limitations and hold the mass will yield the same result and in a substantially different way and therefore is a valid non-infringing design.

3: "*Potential disadvantages"* are often harmful interactions or side effects that can be distilled from the FA, patents and their claims. The IFR has no disadvantages. So each claim that is a possible disadvantage must be categorized as a *potential disadvantage.*

For instance, friction between two objects creates heat which can cause failures. Reducing or removing these interactions can lead to a new design. Similar to the optimization of *types of limitations*, the new design has to obey the '*doctrine of equivalents'* rule for it to not infringe upon the original patent.

2.3. Applying the approaches of design-around process

From each of the three types of problems categorized in the previous section, advised TRIZ tools to aid the design-around process are shown in the flowchart in Figure 2 and are elaborated in this section.

From the '*unnecessary elements'* category there are two best possible ways to find a new design. The first consists of trimming the '*unnecessary elements'* in the FA to reduce the number of components while preserving the products' functionality (also known as 'Functional idealization' [10, p.56]). If a function cannot be delivered by another component with the known scientific principles, the database of effects can be utilized to find new ways of delivering the function by the component [9]. Software such as "TechOptimizer" [14] can be used to aid this process. As mentioned before, this step should be done for every component listed in the FA if deemed necessary. This is one of the most promising and effective TRIZ tool and, if time permits, should be considered to be applied to every component.

The second solution path that can be taken is to go back one step in the state of the art of the original patented product and the *unnecessary element* in question, and then take a new step in the evolution to reinvent the next step of the function but now in a significant different way (the previous state of art can often be extracted from the related patent). This process takes more time but it can sprout a completely new solution branch for the product. Tools such as Multi-Screen Analysis (MSA), 'S-curve and functional evolution analysis' and Value Conflict Mapping (VCM) [9-10] are advised tools to define this new next step in evolution. The MSA is the fastest and simplest method, and should be considered first. If the results are insufficient, the S-curve analysis and function evolution analysis should be considered. This takes more time, but guides the process of finding the next step in the evolution better than the MSA. Performing VCM shows contradictions that can be used to find the new next step in evolution.

Problems and contradictions found by these tools that are not focused on the function that is to be replaced by the *unnecessary element* can be solved independently at the expense of falling outside of the *landscape of patents and*

claims created in the second step of the general patent circumvention process. To check for possible infringements, a complete new patent search and analysis has to be conducted, since in that case the *landscape of patents and claims* only describes relevant patents and not completely different ones. Staying close to the goal of finding the next new step in the evolution of the specific function of the *unnecessary element* and not the product completely is recommended.

The knowledge gained from the application of these methods can be used to generate an evolutionary radar plot (as an optional step). The evolutionary radar will present possible areas in which the product could evolve. Such as the areas of system merging, segmentation or (a) symmetry. The radar plot acts as a starting point for developing new solutions that deliver the same function of the original patented design resulting in a novel designed-around product which does not infringe the original patent.

Both categories of '*types of limitations*' and '*potential disadvantages*' can be further explored by performing an Root Contradiction Analysis (RCA+) [15] or creating Substance-field (Su-field) models. Conducting an RCA+ analysis to the main problem that prevents or hinders the IFR can provide clarification about the situation of the product and provide insight for new contradictions to solve.

The RCA+ can assist in finding a more suitable contradiction to solve that is causing the particular *type of limitation* or *potential disadvantage*. If a contradiction is found, possible solutions can be found via the contradiction matrix and by applying the 40 inventive principles for the technical contradictions. Alternatively, ARIZ [9-10] can be performed for the physical contradictions, if the required TRIZ expertise is present in the design group.

Su-field models give an abstract view of the system interactions. The 76 inventive standards can be applied to the Su-field models of the patent to facilitate the discovery of significantly novel promising solutions.

2.1. Feasibility and infringement analysis

The fourth and final step of the general patent circumvention process is the infringement analysis. Each solution that is obtained should be evaluated for its feasibility. If deemed feasible, an infringement analysis should be conducted to determine whether or not the new solution infringes the original patent.
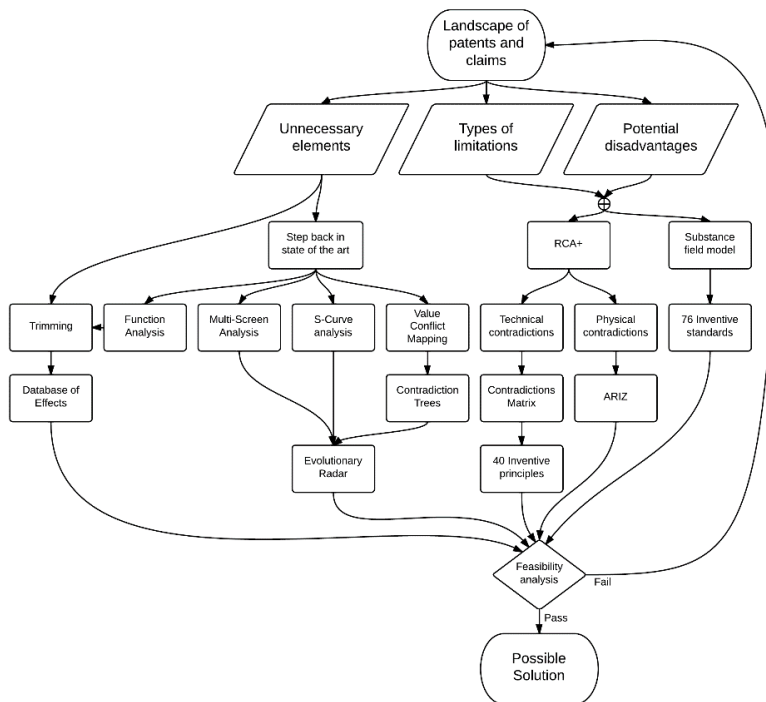

Figure 2. Applying the approaches of design-around process flowchart.

3. Case study: Constant Velocity Joint.

The presented patent circumvention strategy of this research is also applied in an industrial case study. The goal of the case study is to invent a new Constant Velocity joint (CV-joint) (shown in Figure 3), commonly known as a Rzeppa joint. This joint, together with a tripod CV-joint, is used in the front axis drive shafts in the automotive market including but not limited to cars and trucks. CV-joints are specifically designed to transfer torque at an equal angular speed under a variable angle. The Rzeppa CV-joints are placed between the front wheels and the shaft as shown in Figure 4; while the tripod CV-joints are placed between the transmission and the shaft. Rzeppa CV-joints have to be able to operate under large angles up to around 52 degrees since they are connected to the front wheel where large operation angles occur.
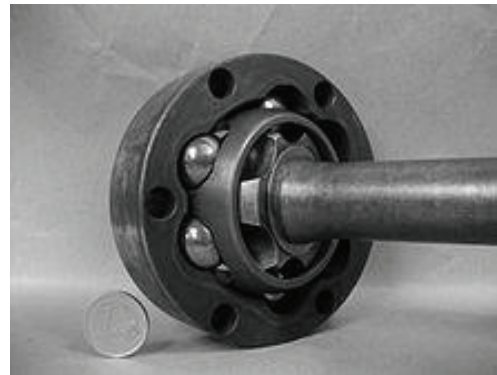

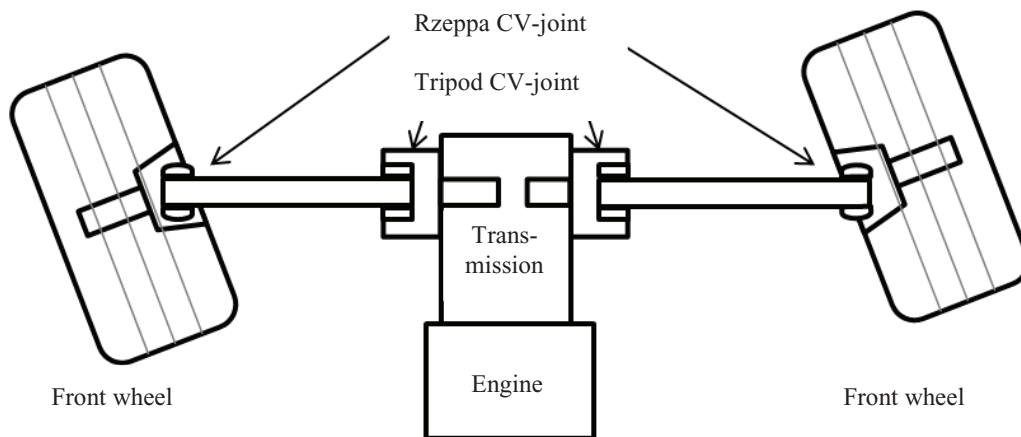Figure 3. Rzeppa constant velocity joint.

Figure 4. Schematic overview of the transmission of power from the engine to the front wheels through drive shafts with multiple Constant Velocity joints.

The original design (and patent) of the Rzeppa CV-joint is over 20 years old and so patent protection has expired. Therefore the original design can be manufactured without infringement; however, small incremental improvements to the patent are vastly patented by competitors and form an obstacle to produce a competing new design. To be able to compete, these small incremental improvements have to be taken into account in a new design to stay competitive in terms of performance, durability, reliability, etc. To reduce cost the patent circumvention strategy proposed in this paper is applied to avoid the necessity of licensing technology from competitors.

3.1. Information gathering process

During Step 1 of the circumvention process, a FA is made using the real physical product. A handbook was addressed to learn more about the working principle of the joint and mechanical engineers with expert knowledge about joints were added to the design group.

A manual patent analysis was conducted online due to the short project duration of the case study. A classification search revealed that all related patents are listed in a certain International Patent Classification (IPC) number:

F16D3/224. Using the keywords "(RZEPPA AND JOINT) OR (CONSTANT AND VELOCITY AND JOINT) OR (CV AND JOINT) OR CVJ" and a publication date after 1994 (patents before this date are not valid anymore) gave many relevant results. These results showed all types of incremental improvements to the CV-joint. All relevant patents were stored for use in the next step of the circumvention strategy.

3.2. Landscaping of patents and claims process

From the results from the information gathering process all relevant patents were manually inspected and categorized by product part and interaction, patent number, source, potential types of problems, a short description and preferred action. A segment of this table is shown in Table 1. In the first column the type of problem according to Section 2.2 is listed. The final column lists the preferred follow-up action based on the type of problem (Section 2.3). The other columns list the respective part, patent number and information source. Also, a short description is added to the entry.

Table 1. Partial result of the *landscaping of patents and claims* process for Rzeppa constant velocity joints.

Type of problem	Part / Interaction	Patent	Source	Description	Preferred action
Type of Limitation	Shaft - innerrace	US8128504B2	Chapter: Problems to be solved by invention	Backlash between shaft and inner race	RCA+
Type of Limitation	Shaft - innerrace	EP2119929A1	Chapter: Problems to be solved by invention	Backlash between shaft and inner race	RCA+
Unnecessary Element	Stopper ring – shaft - innerrace	EP2119929A1	Chapter: Problems to be solved by invention	Prevents dislocation/backlash	Take step back in state of the art
Potential disadvantage	Shaft - innerrace	EP2119929A1	Chapter: Problems to be solved by invention	Backlash generates noise and decrease fatigue	Su-field modeling
Unnecessary Element	Projections formed on the outer diameter surface of the shaft	EP2119929A1	Claim 4	Transfer force from ball bearings to outer shaft	Trimming

3.3. Applying the approaches of the design-around process

From the landscape shown in Table 1 it can be seen that two different patents both have the same *type of limitation:* "Backlash between shaft and inner race" (Rows 1 and 2). The IFR for this negative effect that was formulated by the design team read: "The shaft and inner race that produce backlash eliminates the backlash all by itself without adding anything new to the shaft and inner race." An RCA+ was conducted to find the root contradiction to be solved that will lead to a new solution to the *type of limitation*. A simplified RCA+ diagram is shown in Figure 5. Solutions were sought focusing on the CV-joint itself, therefore
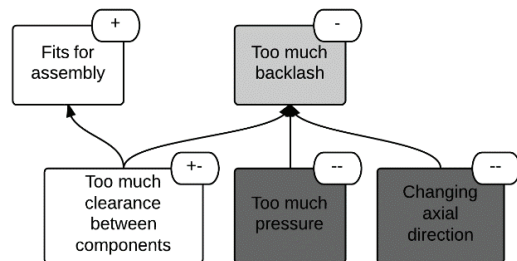

Figure 5. Simplified Root Contradiction Analysis (RCA+) to overcome backlash between the shaft and inner race.

changing the pressure and axial direction fall outside the scope (i.e. --sign). The contradiction "Too much clearance between components" has been chosen to find solutions for by applying the 40 inventive principles.

The inventive principle #2 "taking away" made the design team think about removing the hole within the inner race and (friction) weld the shaft to the inner race directly. The solution and the original design are shown in Figure 6. This solution completely removes the need for clearance between the shaft and inner race since now a fixed connection is used. Thus achieving the formulated IFR, as the shaft and inner race remove the backlash without adding anything new to the shaft and inner race).

3.4. Feasibility and infringement analysis

Friction welding is a process that can achieve high performances in the areas of the weld strength and the alignment of the center of axis of both the inner race and shaft. However, a disadvantage of the fixed connection is that it makes (dis)assembly more difficult or maybe even impossible for certain types of Rzeppa CV-joints. Hence, this solution is feasible for applications that can cope with this additional design rule.

The way this solution performs its function is in a substantially different way than the original circumvented patent; thus it successfully avoids infringement by the '*doctrine of equivalents*' rule and is a patentable new design.
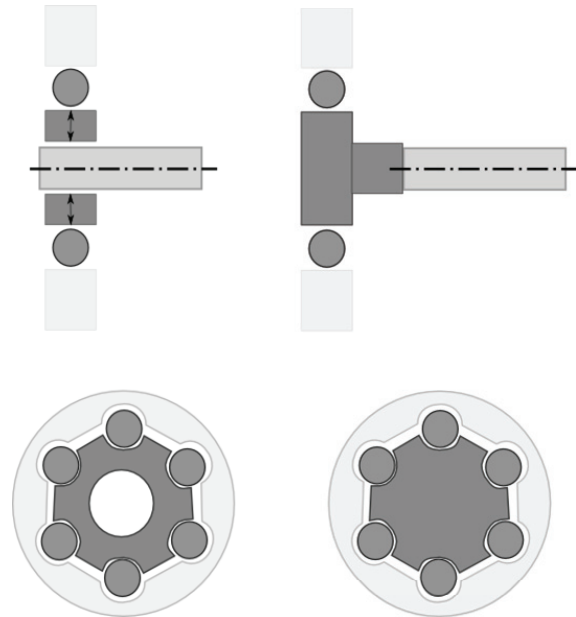

Figure 6. Schematic overview of original patent (left) and friction welded solution (right).

4. Summary

This paper introduces a systematic approach to circumvent existing patents utilizing TRIZ tools with a focus on creating directive guidelines to find new solutions. This is achieved by creating a *landscaping of patents and claims* in which circumvention opportunities are categorized according to three types of problems: *Unnecessary elements, Type of limitation* and *Potential disadvantages*. The *application of design-around approaches* recommends specific tools based on these three types of problems. For *Unnecessary elements*: Trimming, Database of Effects, Function Analysis, Taking a step back in evolution, MSA, S-curve analysis, VCM, Contradiction trees/matrix and the Evolutionary radar are recommended. For both the *Types of limitations* and *Potential disadvantages* the tools RCA+, 40 inventive principles, ARIZ, Su-field modeling and the 76 inventive standards are recommended.

An industrial case study demonstrated the presented strategy by circumventing a patent of an incremental improvement of a Rzeppa constant velocity joint successfully.

Future research can focus on adding more suitable TRIZ tools to the strategy. For instance, Function Orientated Search (FOS) [16] could be implemented in the strategy to find and effectively use appropriate existing techniques for certain design problems.

Acknowledgments

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