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CONSIDERATION OF DIVERGENT THINKING IN DESIGN PROCESS

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ABSTRACT
This research concerns with the possible support system, which effectively aids to come across creative concept for designers and to make them product. Process of design thinking is, broadly speaking, divided into divergent process and convergent process. In the divergent thinking process, the possibility of getting new ideas is high, but usually the existing concepts block against it. We tried to have theoretical framework for the method to make us free from stereotypes. The author focused into the relationship between 'Utility' which is directly related to the operation that enables the function of design object and 'Configuration' which is related to the space structure of components of design object. Then, we established a method for facilitating divergent thinking by tentatively making a denial expression of the extracted utility. Through the denial expression of the utility, we found it possible to get creative concepts, by widening the scope of images, and to reconstruct the new product concepts. The author also have examined the effectiveness of this theory. Finally, the author developed two different type of products for real market by using this method.

Keywords: Design Method,Utility,Configuration

1 INTRODUCTION
As opposed to the conventional theory of mass production, market differentiation has progressed through the process of diversification and individuation in Japan, and this tendency has become more and more pronounced [1]. Therefore, there have been increasing an interest in and demand for a "tool for developing new creative concepts". Search into modeling and ease of use in design alone cannot sufficiently meet the needs of the times. With the fast evolving technological progress and innovation, concept design has come to exert much more influence on hardware design than ever before. More specifically, it has become increasingly necessary to involve a concept into design process. In industrial design, emphasis is still placed on the formalization of given concepts and designs. Under the present circumstances, however, the above-described invisible design, or the conceptualize part, is expected to serve as a key factor in the process of designing. In his "General Design Theory", Yoshikawa explains that it is possible to image artifacts not found in real life by introducing a category that does not actually exist in this world [2]. In other words, a new concept may be created by introducing an unexisting category of concept. This study develops a theory on the basis of Yoshikawa's theory. Breaking away from stereotype ideas in the process of designing seems important for idea conception. We will discuss below the possibility of a support system that is effective for designers to generate creative concepts and make them commercially available. The author defined the relationship between the function level directly related to the operation of a design object and the space structure of the components of design object concerned which can be linked to the operation, as "Utility". Then, we established a divergent search space by tentatively making a denial expression of the extracted Utility. This paper examines the effectiveness of the method through case studies. Mobile phones and paper stands have been chosen as cases. Mobile phones belong to a product family for which the number and range of users are expanding, and of which there are diversified needs. Mobile phones are being developed rapidly into multifunctional products and they may be classified into plural functional product families of which a relatively large number of users have demand, whereas paper stands are products of simple function and belong to a product family of simple

function. We will discuss matters relating to get rid of the conventional concept resulting from denial expression and will look into method difference through these two cases of products.

2 RELATIONSHIP BETWEEN REQUIRED FUNCTION AND ATTRIBUTE CONCEPT OF COMPONENTS OF DESIGN OBJECT

In general design theory, an client writes specifications, and a designer reads them. The result of reading forms a required concept in the designer and is translated into a solution concept, the result of which is extracted in the form of a drawing . This required concept may be regarded as a required function, and the solution concept as an attribute concept of substance. In general design theory, the process of converting the required concept into the solution concept is generally considered, with both concepts being perceived as set, and defined as a mapping between the sets (See Fig.1) [3]. Here, the function level directly related to the "operation" needed for the required function to work will be referred as "Utility." There are hierarchical levels from highly abstract concepts of the design object to the level of part arrangement which can be linked to the operation. The most concrete level of the space structure of components directly related to the operation is called "Configuration." Configuration is defined as "parts or partial elements as plural constitutional elements that relate their respective positions and produce the optimal shape, form, and aspect in accordance with any specific purpose." We will describe this study according to the same interruption and definition. Note that the state where correspondence between utility and configuration is established by stereotype ideas or as a model is called "Normative." (See Fig. 2) According to A. Osborn, Confrontational expression was the basic principle of association[4]. He said, "The more associations one gets by thinking confrontationaly, the more drafts one can get consciously or unconsciously."

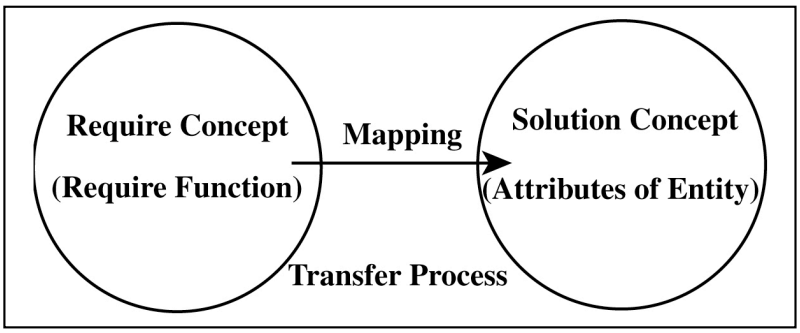

Figure 1. The process of converting the required concept into the solution concept

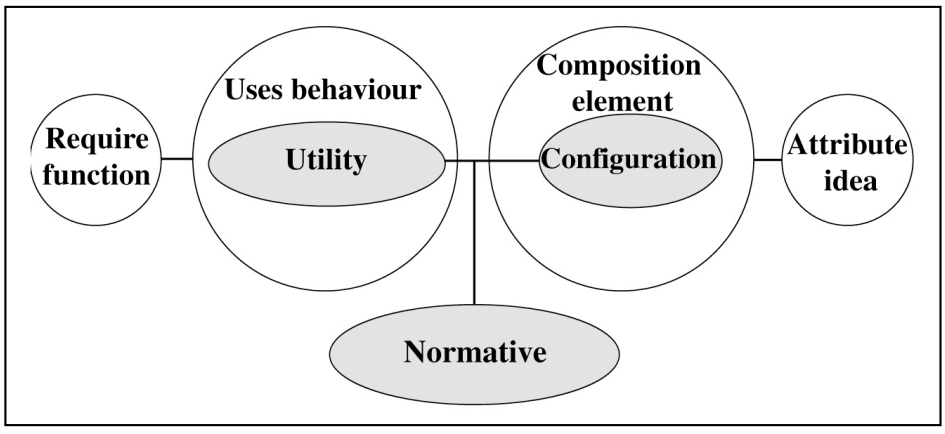

Figure 2. Relationship between utility and configuration

Jean Comelly from GE illumination machine division was doing Research & Development for new illuminations to think that light could shine not from above but from below. As a result of this, she got the novel idea of illuminations for dining tables. The confrontational expression of this example was that light shined upwardly from below. As Fig.3 shows, Confrontational expression is a part of Denial Expression. If Confrontational expression of A is B, B is a part of Denial Expression.Comparison is to be made between it and Yamada's opinion of the Denial Opposition. Fig.4 is the logic quadrilateral which is set to show the Confrontational relation. A and B is opposite confrontation. A and C is contradictory confrontation. B and D is contradictory confrontation. D is a part of A and C is a part of B. C and D is secondary opposition. Fig.5 is Fig.4's logic quadrilateral into which sentences are put. "Tony is big." and "Tony is small." is opposite confrontation . "Tony is big." and "Tony is not big." is contradictory confrontation . "Tony is big." includes "Tony is not small." . "Tony is small." Includes "Tony is not big." [5]. Denial expression of utility level has only diagonal relation in association with confrontation relationship in the logic quadrilateral. Human being acts do not show situations and do not have any intermediate. Relationship between utility expression and configuration of normative product can be shown by the denial expression.The denial expression of utility might generate ideas which is impossible to make into products. On the other hand, truly creative and innovative products are prone to be generated from ideas which seems strange compared with current products.We used to scoop up gel type paste out of a package, but now it is natural to use stick type paste. Brand new creativity comes from outside any stereotypes. If producers have any stereotypes, creative concepts can't be proposed. Fancy ideas which are impossible to realize must be eliminated not to increase meaningless expressions.This can't be avoided by the use of denial expressions in the abstract thinking.

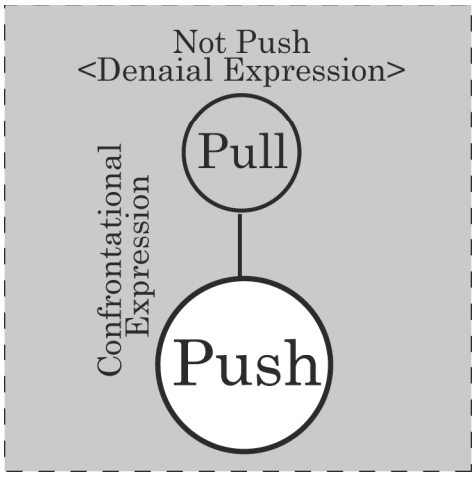

Figure.3. Relationship between Confronational Expression and Denial Expression

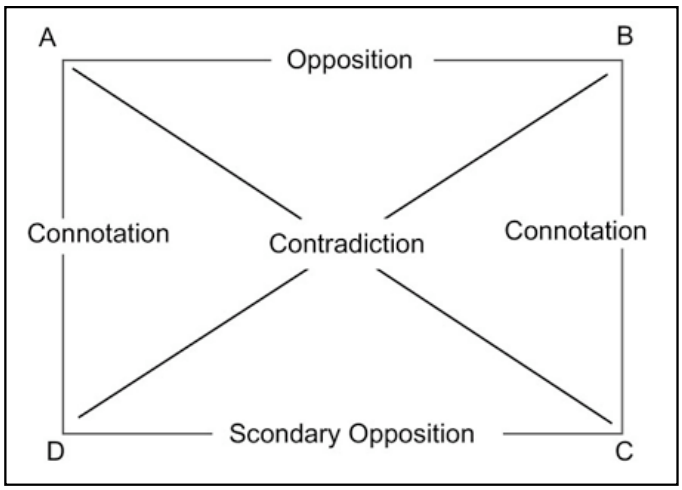

Figure 4.Logic Quadrangle and the Confrontation

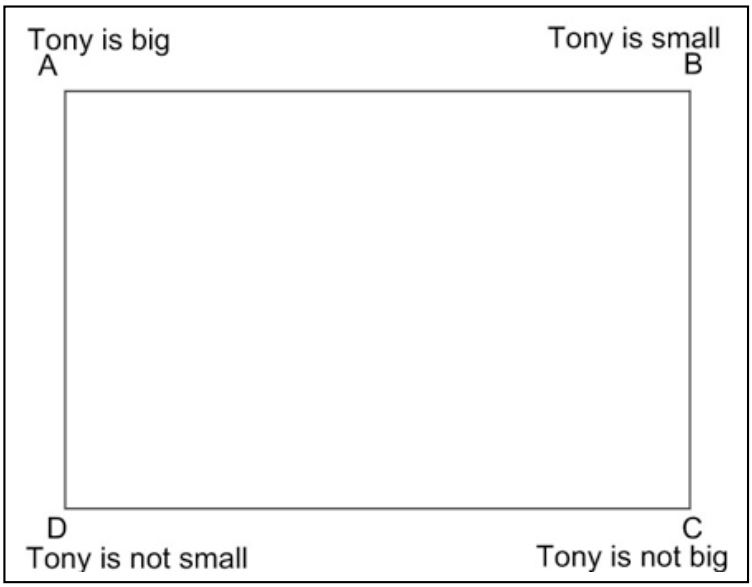

Figure 5. Logic Quadrangle and the Confrontation

3 CONSIDERATION OF MOBILE PHONES AS CASE EXAMPLES

3.1 Consideration at utility levels

In consideration of normative relationship of the Utility of mobile phones (relationship based on stereotype ideas), it is considered that mobile phones involve acts of watching the display (black and white display and color display), pushing buttons, hearing voice from the receiver, and speaking to the speaker. The normative utility can be organized into four acts of "Hearing," "Watching," "Pushing," and "Speaking."(See Fig.6)

3.2 Concept generation by logic operation

Yoshikawa said that it is possible to form an imaginary subject as a concept . That is to say that abstraction concepts are capable of making some classification categories with respect to the same object group. When some categories are formed, a real world can be indicated through intersection of the categories. When there exists only three types of substances, for instance, there can be four types objects if two types of classification views are introduced. In this way, what does not exist in the real world can be theoretically pointed to by an abstract concept. Developing this idea into a method of industrial design, a category does not exist in the real world may effectively be used in forming a new concept and defining the search space concerned by negatively expressed concept of existing knowledge. Four quadrant concept spaces are generated when axes of two normative utilities and its denial expressions are combined in orthogonal coordinates as shown in the figure. The second quadrant represents a space where words of normative utility overlap each other, which is an existing act of using that generates no new idea. The first and third quadrants represent spaces where words of normative utility and denial expression overlap each other and serve as a clue of new utility conception while maintaining the existing utility. The fourth quadrant represents a space where the two words of denial expression overlap each other and serves as a search space, where a new utility not found in the existing required function, may be created.(See Fig.7&Fig.8) When one ventures to consider an idea belonging to this space, one can hit upon an idea generated at the utility level which has got rid of the stereotype ideas. In the case of the mobile phone as shown in Fig.9, for instance, an idea of "Writing a telephone number instead of pushing the same" is generated on the supposition of an act of "Writing the telephone number" resulting from the denial expression of "Pushing the

telephone number buttons." Thus, a combination of axes of normative utility and denial expression allows four-concept groups to be generated and a new utility conception to be created.

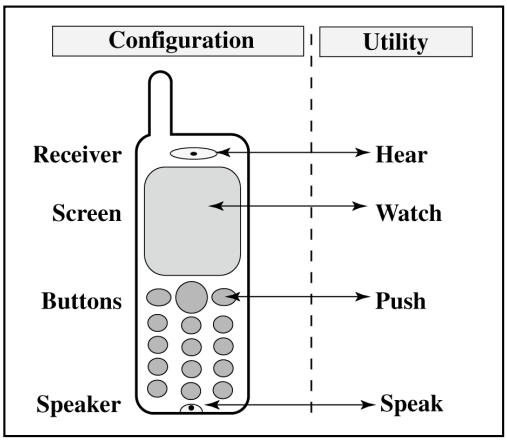

Figure 6. Mobile phone's utility and configuration

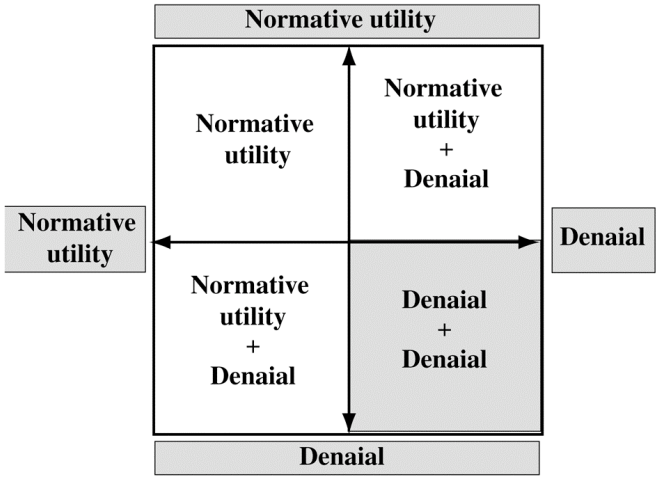

Figure 7 .Classification categories in utility

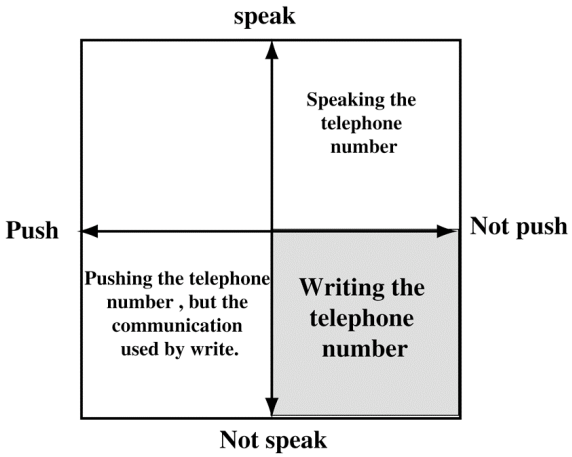

Figure.8 .Example of classification categories

Figure 9. Concept model from Denial Expression

3.3 CASES OF CONSIDERATION AT A CONFIGURATION LEVEL

From the configuration level, we will consider a case of expression, namely, "to tell the destination telephone number or the like to the instrument and then continue communication without interruption", which is achieved by denial expression at a utility level. At the configuration level, the above-mentioned expression was considered in conjunction with the spatial arrangement of the instrument as a whole, and as a clue to determine which parts attention should be paid to and what kind of spatial arrange would be possible. The technique of, "The instrument recognizes human voices and transcribes the voice information" has been already developed and applied to personal computers. Also, along with its advanced technique, a mobile phone adopts the developed form of "to tell a destination name or the like to the instrument, and the instrument recognizes it to make a call automatically". However, such acts of handling a handset with one hand, telling the destination name to a speaker, and pushing a send button after confirming the destination name on a display are the same as conventional mobile phones. Moreover, the same applies to the configuration as the spatial arrangement of a constituent. Then, in the utility of "to tell the destination telephone number or the like to the instrument and then continue communication without interruption" is set a constraint for make ideas more concrete as the configuration, which is not found in the conventional mobile phones. By setting a constraint, thinking acts as an on-target divergent process in the limited space. In addition, by setting users in a constraint, diverged idea can be evaluated and converged [6].

Here, in order to promote a divergence of ideas, the following constraints are set in consideration of places to be used:

(1) Communication is made with a handset being attached on an ear instead of handling the same.
(2) Tell the destination name to a object and then continue communication without interruption.
(3) An object includes a receiving function and a transmitting function.
(4) Users are those engaging in driving and machine-operation, and are female office workers requiring a hands-free type mobile phone.
(5) Weight should be 50 g or less.

3.4 Convergent process for design solution

In Fig. 11, an interior constituent of the product as the illustrated in Fig. 10 is considered, and it is an image example where a "water droplet" image is enhanced as mentioned above. Fig. 12 illustrates an image example, which is drawn in a real manner so as to make the form visually advanced as a product. Fig. 13 illustrates a form of a product nearing completion for confirmation, which is drawn by the use of 3 dimensional CAD and keeps an image of Fig. 11 and accepts all the constraints. Fig. 14 illustrates a rendering object in which a configuration is designed, subjected to modeling, and decomposed. Thus, the concept of "to tell the telephone number or the like to the instrument and then continue communication without interruption" achieved by denial expression at a utility level can be changed to a product by bringing an embodiment image and usage image at a configuration level into actual shape and by increasing constraints gradually at some convergent process.

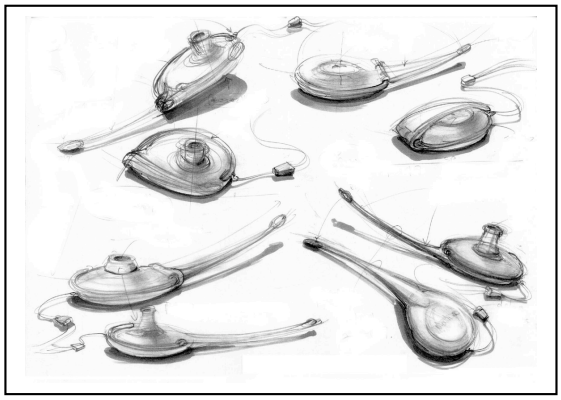

Figure.10 Example of design sketches

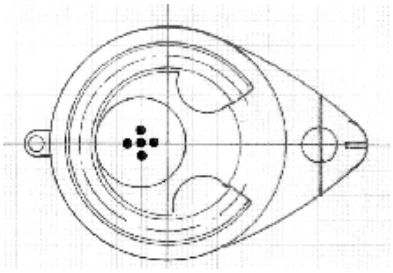

Figure 11 Water droplet image

Figure 12 Advanced sketch

Figure 13 3 dimensional CAD

Figure 14 Product

4. CONSIDERATION OF PAPER STANDS AS CASE EXAMPLES

4.1. Denial expression of utility levels

This example considers paper stands having a simple function. A paper stand is mainly used on a desk and an object thereof is "to clip a sheet of paper to a product and make it stand". Fig. 15 illustrates major paper stands commercially available in the market. For the purpose of confirming the normative relationship of a paper stand, the one illustrated in the lower right in Fig. 15 was given to the 68 students.

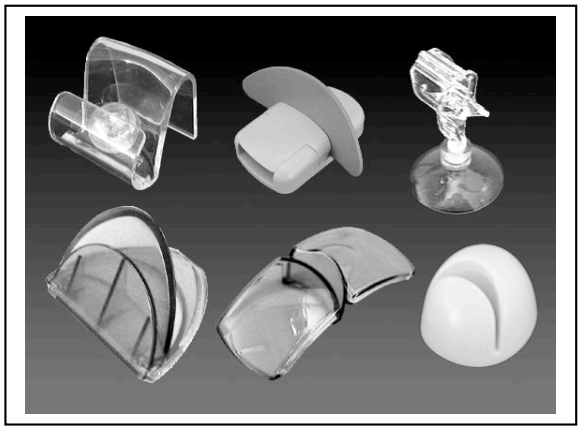

Figure 15.Major paper stands in the market

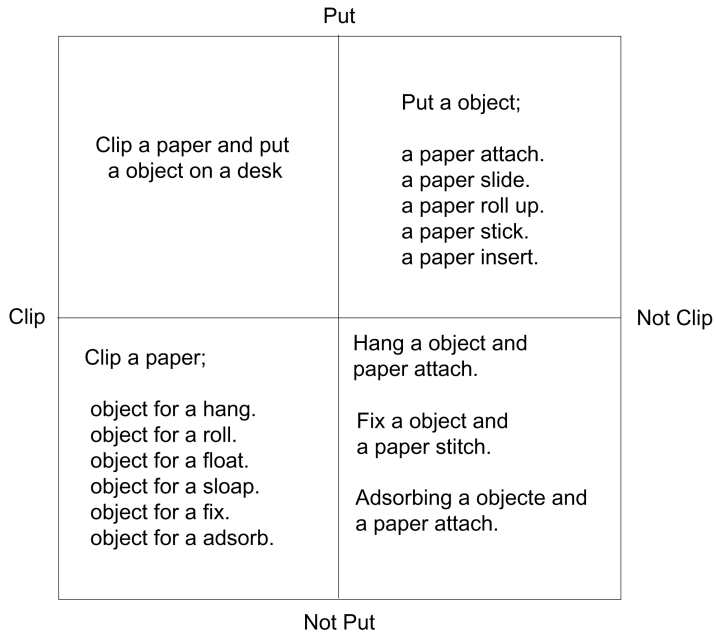

Figure 16.Generated four concept groups

They were required to think about use application of the paper stand without any information. As a result, 64 out of 68 students answered that "it was to clip a paper and make it stand on a desk," and the normative relationship was "to clip a paper" and "to put an object on a desk" . According to the denial expression of the normative relationship, it can be translated into "not to clip a paper" and "not to put a product on a desk". Fig. 16 illustrates the example where there are generated four concept groups, and a search for a novel idea is attempted.

4.2. Consideration at configuration levels

4.2.1. Idea variations

As an example of ideas, the theme of "adsorbing a substance" obtained in the first and the fourth quadrants in the figure was to be materialized. Almost no constraints are imposed if an object has a function as an adhesive disk for adsorption. It is characterized that a product having a simple function has less constraints as compared with a mobile phone having multiple functions. In order to keep the function of "clipping a paper and making it stand," for instance, such a constraint making a slit in a object almost vertically is resided. Fig.17 (a) to (e) illustrate examples in which constraints at a function level are considered and idea variations at the function level are accomplished. Supposing the major paper stands in the market, it is normative at the configuration level that "a single slit is present in the upper surface". Fig.17(a) to (e) illustrate variations other than the normative configuration where the number of slits and arrangement variations are focused.

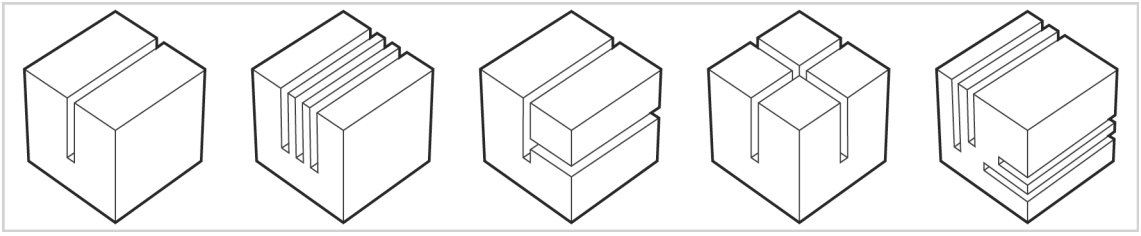

Figure 17.Idea variations of configuration level

4.2.2. Development of ideas

As one of idea variations, an idea for making one slit in the upper surface and the side surface in Fig.17 (c) is considered. With the idea of making a slit in the side surface, such concepts as "Capability of installing the object on a wall " and "Capability of clipping a paper to the object with it being installed on a wall" are developed. The concept is made based on the denial expression of "Putting". Fig. 18 illustrates a configuration example formed abstractly. Fig. 17 is a prototype formed by imposing design constraints on the form in Fig. 18. However, this is formed without any constraints for the molding at a time of mass production. In consideration of the constraints, there is developed the end product illustrated in Fig. 20. Fig. 21 illustrates the main functions of the product in Fig. 20.

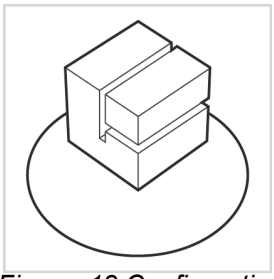

Figure 18.Configuration example

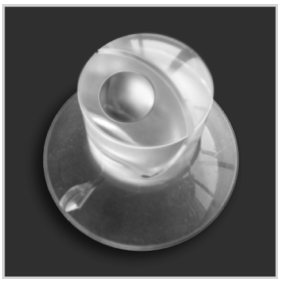

Figure 19. A prototype

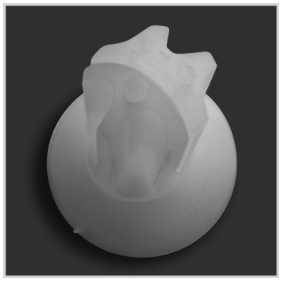

Figure 20.A product

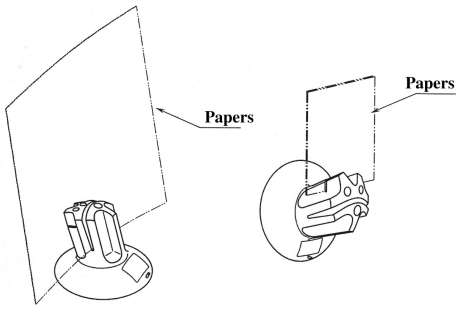

Figure 21.Maine function of the product.

CONCLUSION

In this research, we considered the case of the mobile phone having multiple functions and the paper stand having a simple function, tried to take away stereotype ideas by the method of denial expression in which theoretical backgrounds were described. Then, generation of a new concept and commercialization of the product were attempted. In the case of the mobile phone, normative utility was divided into four categories where ideas were generated based on denial expression. The resulting idea concept of "Telling the destination number or the like to an instrument and then continuing communication without interruption" was settled in morphological expression at a configuration level with some constraints being imposed.

In the case of products having multiple functions, since a searching space for idea increases in proportion to the amount of the normative relationship, the key is that what diffused idea is to be extracted and developed to a configuration level. In particular, such an information technique device as a mobile phone gives large influence on a society, and required concept of it is changed on a daily basis. Therefore, when the concept generated by the polarized expression is settled as a concrete idea, it is needed to know a social background, user's demand, and a development of a new technique, which are the indication of the future. At this moment, mobile phones have been advanced to the third generation and provided with a built-in camera, which tend to be a new normative. In addition, a

motion picture is expected as a mainstream of an image on a display. With this tendency, development of ideas is to be broadened; therefore, the method for handling it must be considered. At the process of the configuration level, the quality of an idea is different in accordance with a constrained content, and so a proper constraint for keeping the quality of an idea is needed. Hereafter, we will discuss if denial expression is effective as a support method for the high-quality idea.

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