國立勤益科技大學

研發科技與資訊管理研究所

碩士學位論文

身障人士室內行動輔具創新研究

A conceptual design for helping the disabled people transporting in the house

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中　華　民　國　一　〇　一　年　六　月

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中　華　民　國　一　〇　一　年　六　月

Abstract

Nowadays, the life of disabled people have been becoming more easily and comfortably thanks to the support of modern science and technology products. There were many devices that were produced to serve for a number of needs of disabled people such as walking around and living activities. In daily life, the issues of moving up and down using staircases have always been big difficulties for these people. The aim of this thesis is to study the patents which were invented to resolve these problems or demands. By employing the research tools including TRIZ and patent map, it is possible to propose an innovative idea which has more impact and improved or advanced properties in order to satisfy the demands of disabled people.

Keywords：Disabled people, Elevating lift, Stair climbing, Triz, Patent map

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Chapter 1 Introduction

According to UN Nations Convention on Rights of Persons with Disabilities 2007, about 650 million disabled people are living around the globe. In European region, there are more than 45 million with disabilities. The old people (from 65 year olds) among the worldwide population will be likely grown from 550 million to 973 millions in the period from 2000 to 2030 (Jukka etc., 2010). This only accounts for the increase countries in Europe, North America, Asia, and Latin America and the Caribbean.

All aspects in life of disabled people have many difficulties, and they want to integrate into the community, our mission is to create favorable conditions and in accordance with the specific disability groups residents. Most disabled people live with family in the apartment or common home, which was designed and built for healthy people. Hence, these houses are completely inconsistent with the daily life of these special population groups. Today, many countries around the world have designed and constructed more suitable houses for the old and disabled people. In these types of apartments, they are equipped with furniture and special equipments, thanks to them that the old and disabled people can self-service. In the design and construction of housing for disabled people that use wheelchairs, in addition to paying attention to the size, store, location, height where electrical appliances, cleaning ..., designers and investors are specially interest in "vehicles in the house", namely the support equipment for disabled people moving in the house and up and down stairs. Actually there are many manufacturers pay attention to this problem. Usually they use wheelchair, elevating lift, stairs or steep tilt (side entrance for disabled people). It is time we should study a new transportation which is more advantage and innovative for disabled people up and down stairs to help them actively in daily activities.

1.1 Purposes and limitations of the research

The purposes of this thesis are to develop a creative method concerning the existent patents about supporting disabled people in moving up and down stair then propose an innovative ideal to help them solve this problem. To satisfy the demands for equipment support of disabled people in the travel and climbing stairs in the house, the main purpose of this study is to create an innovative invention that can help disabled people to easily and conveniently traveling and climbing stairs in the house. This supporting equipment needs met certain requirements such as safety and easy use. Also users can manually manipulate all the steps with the product without the help of others. For disabled people, being able to satisfy their own travel and living independently in their house is extremely significant. Through this new invention that can bring comfort and confidence in life for them. In this research, designed products target at the disabled and those who have difficulty in traveling. The focus of the study is to address the inconvenience of the move in their houses, especially up and down stairs.

1.2 Methods of the research

With the development of Innovation Technology, there are a lot of smart and preeminent approaches are created and used extensively for research, analyze and invent the new modern product and technologies that contribute to the lives of people. In this study, TRIZ and Patent map are two methods that will be used in order to propose an innovative invention.

Patent map is a useful tool for us to learn about the inventions, products related to the support for the movement of disabled people in the past. Thereby, we can collect and analyze and improve the most appropriate and effective functions and techniques use for the purpose of the new design. Also the patent research helps us to understand more about disabled people and issues in their travel. Patent's information help us to gain more experiences about the advantages and disadvantages of old products so that it makes the new design become more completely.

TRIZ is always an excellent method for improving and inventing new ideas, new products. In this thesis, the TRIZ tools will be used to improve the function, technique that we have analyzed in the processes of patent map. Through the analysis of substance-field diagram and find out the weaknesses of the product, we can identify the problems and find out relevant engineering parameters. Engineering parameter matrix table is used to analyze and find out the inventive principle. And these inventive principles will lead the way to satisfy the requirements and complete the invention.

1.3 Procedure of the research

The procedure of this research is shown in figure 1.

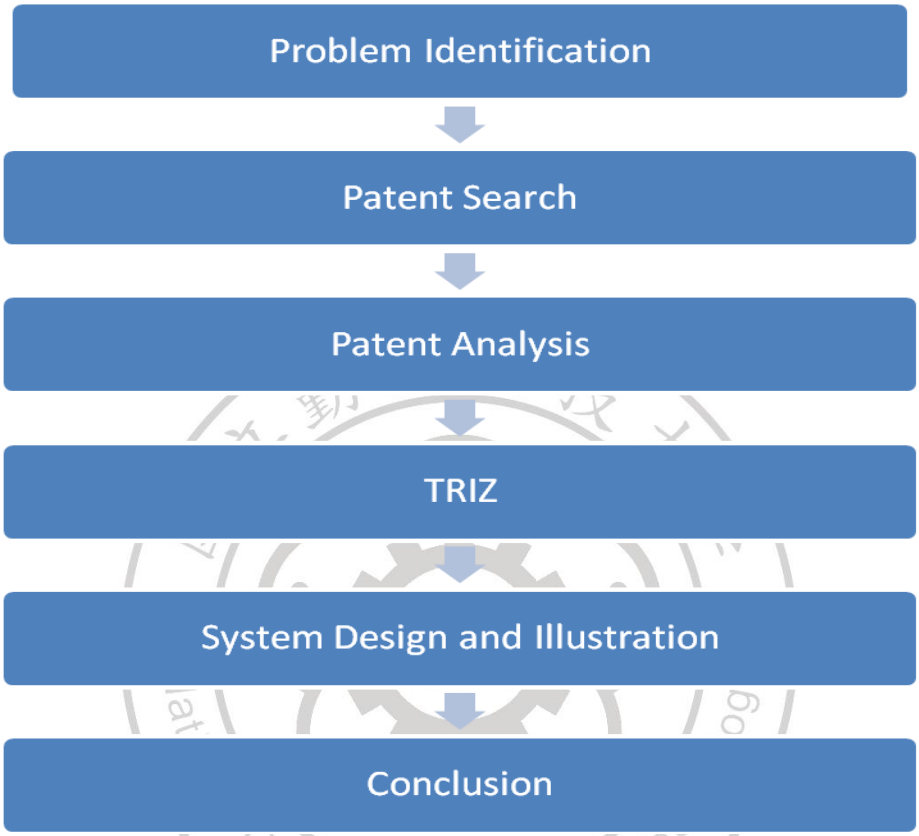


Figure 1: Research procedure

In the first step, we identify the problem to figure out the research coverage, its goals as well as the requirements needed from which we have an obvious direction with rational approaches to fulfill the thesis. Step 2 is patent searching, in this section, we find and collect patents that related to the disabled and support tools for travel up and down their stairs. This is important preparation for analyzing in future research. In step 3, we analyze the patents that are found to have the materials needed for the improvement of the invention. Step 4 is the key step for the analysis, data processing and new products design. Step 5 is the result of the whole process, in this section, the innovative design will be analyzed and Illustrated detail. The final step of the treatment course, the final stage of the procedure is to evaluate, conclude and offer new directions for the research and development for the future products.

1.4 Structure of thesis

The structure of this thesis is as follows. Chapter 1 presents a brief introduction, motivation, purposes, methods, limitation and the procedure of the thesis. Some of the existing works and methods related to the thesis topic are shortly discussed in the literature review in section 2. As the main part of the paper, chapter 3 describes the procedure and the research methods to create an improved elevator shift system for helping disabled people. Chapter 4 presents a case study as a result of the above sections. This chapter will analyze and demonstrate the new innovative design. Some discussions and estimations about the conceptual design are presented in chapter 5. This section closes the paper with conclusion and some further improvement in the future.

Chapter 2 Literature Review

As defined by the UK Disability Discrimination Act, a person with a physical or mental damage who has difficulties or inability in performing normal activities in their daily life is considered as a disabled one. About 8% of the world population which is equivalent to about 500 million is disabled people (UNESCAP, 2000). It is an expectation that these disable people should also have an equal human right as non-disabled people such as travelling for having a pleasant time and relaxing.

There are four kinds of disabled people that are hearing disability, sight disability, physical disability and intelligence deficiency. Physical disabilities are usually people who do not have an inability to move freely and to carry out convention activities in an appropriate time and level (Yuksel Ozturk, Ali Yayli, Mehmet Yesiltas, 2008).

The demands for travelling and walking of disabled people are really necessary. They face up to many difficulties in normal life, e.g., moving from one room to another, from indoor to outdoor, and especially in moving up and down using staircases. They expect and seek for aid products which can help them to overcome these difficulties (transporting in house and moving up and down using staircases).

2.1 An overview about the assisting equipment for the disabled people

Nowadays, with the rapid development of science and technology, inventors have been introduced many useful tools and products to help disabled people so that they can move and walk more easily and comfortably, especially in moving up and down using staircases. These products are really rich and diversified, and suitable for many kinds of disabled people, and becoming more perfect.

To support the travel of elderly and disabled people, powered wheelchairs have been developed. Although they have many functions and advantages, there still has some limitations leading to a number of troubles for users. Some intelligent wheelchairs have been introduced by adding navigational assistance functions to the normal ones. With these intelligent wheelchairs, the problems of avoiding obstacles or docking at tables can be resolved. However, one of the drawbacks of the intelligent wheelchairs is that the adaption of the assistance to specific users is

not possible because the assistance rules are hard-coded (Dirk Vanhooydonck, Eric Demeester, etc., 2010)

The design of a wheelchair has to take both functionally and economically aspects into account. A wheelchair constitutes from a number of the sub-systems and controls the communications among them (see figure 2). It needs to use high speed CPUs to handle the computational complexities arising from control algorithms and needs ordered by users. It must also satisfy a high level of reliability and robustness, with certain flexibility allowing different operation modes (P. Martı´n, M. Mazo, I. Ferna´ndez etc., 1999)

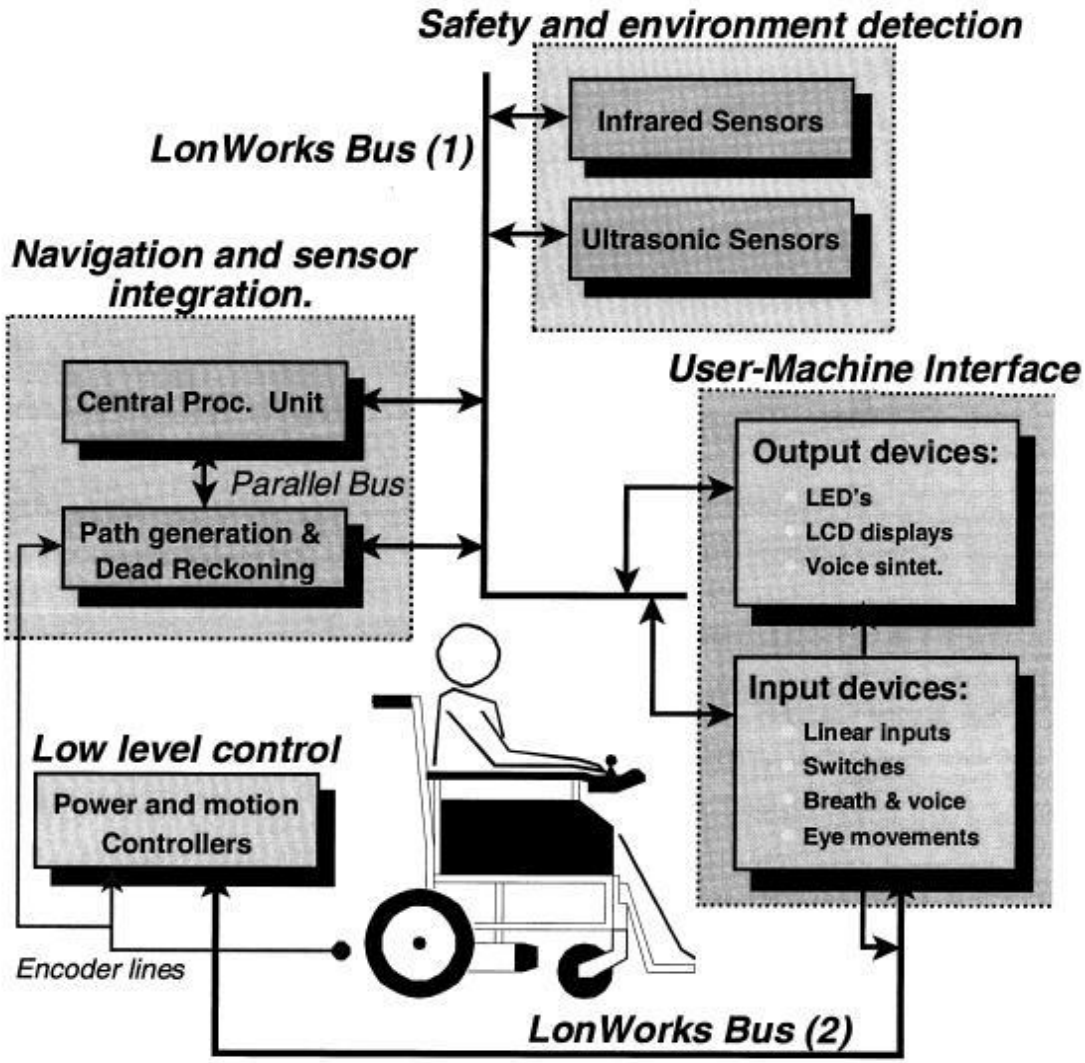


Figure 2: A wheelchair prototype

An indoor use system that helps for restricted mobility people to move from one room to another and do normal daily actions has invented by Kramer et al. (2009) The system contains a personal mobility device equipped with transfer drivers which link with a transfer system to transport between elevations (see figure 3).

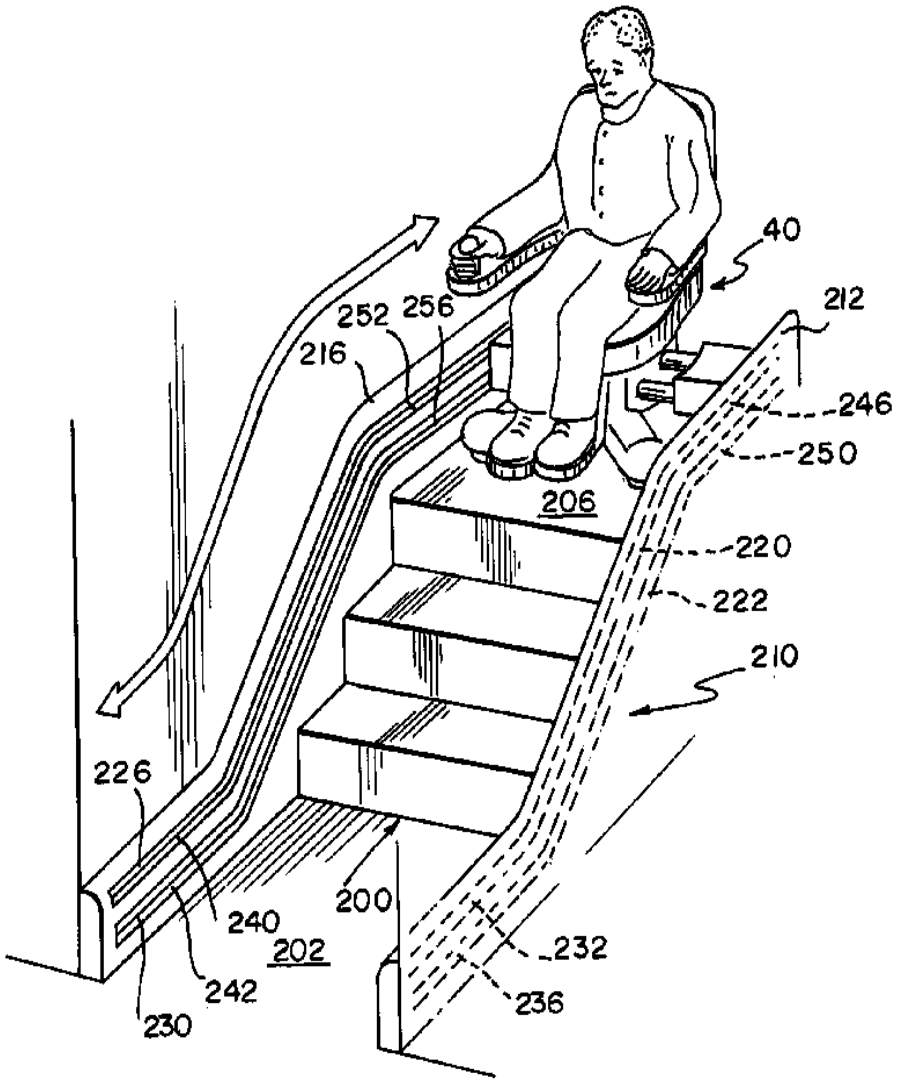


Figure 3 Home care equipment system (US patent 7537069 B2)

A bicycle seat invented by Schrader (2005) was described (see Figure 4). It is supported by a tubular V-shaped configuration with an offset seat post. This walking device provides padded leg cradle supports, padded handles and adjusting handle grip bars. The main elements of this device are the seat and the stabilization foot.

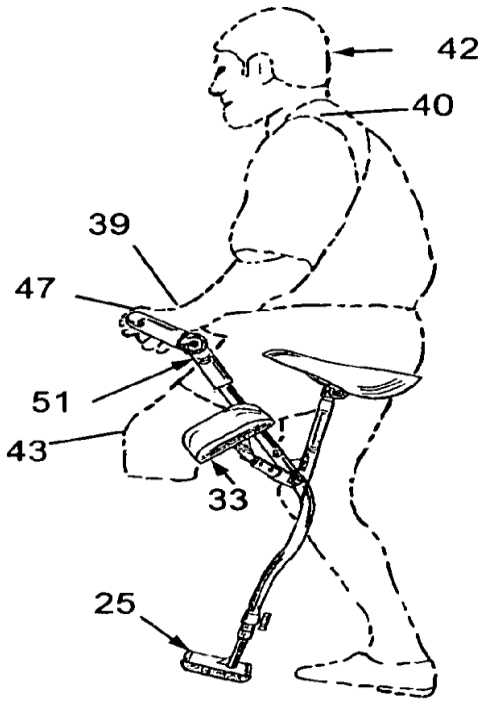


Figure 4: Ergonomically designed walker (US patent 6959716 B1)

The seat locates on a fixed top post and its position can be suitably adjusted. The latter is under the injured limb making a good balance for the injured user which helps the movements becoming easier and smoother.

Preferably, the automated wheelchair is capable of moving over a variety of contact surface types, including: a set of stairs with uniform rise to run ratio, a set of stairs with non-uniform rise to run ratio, a set of straight stair, a set of curved stairs, over a curb or over rough terrain.

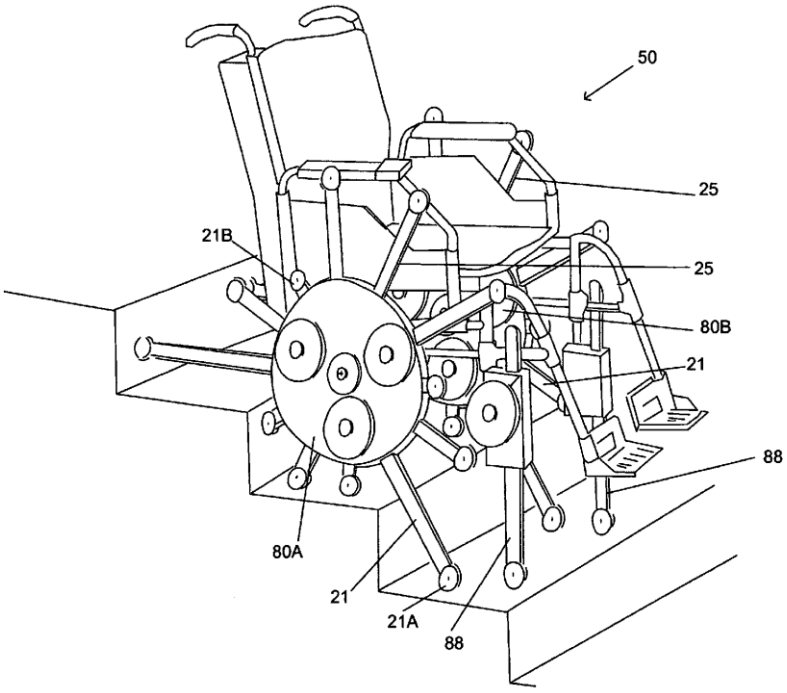


Figure 5: Automated wheelchair (US patent 7503567 B2)

An automated wheelchair for moving over contact surfaces has been invented by Thomas T. Frankie (2009). The wheelchair comprises of an operator chair, a controlled computer that processes the operation inputs, an operator input device, and two wheels for propelling the wheelchair (see Figure 5). A number of contact surface types for which the wheelchair can be used are: stairs with uniform or non-uniform rise to run ratio, straight stair, curved stairs, over a curb or over rough terrain.

Together with the useful support of new scientific equipments, the life of disabled people have been significantly improved and become more comfortably in everyday activities. The users of such equipments no longer have difficulties in moving between places, particularly in moving up and down using staircase. The about mentioned inventions and research had have a great contribution in the development of supporting equipments that help and bring about a better life for disabled people.

2.2 Introduction of TRIZ

The Russian Theory of Inventive Problem Solving (TRIZ) was originally proposed by (Altshuller, 1999). This approach settles technical issues and provides innovative produce framework by using a knowledge basis constructed from the analyses of about 2.5 million patents, essentially on mechanical design. TRIZ includes three basic instruments:

The first instrument is 'the system conflict resolution principles', which includes 40 principles to effectively settle the clash of the customer request. The second one is 'effect', which is a knowledge database network including physical, chemical and geometrical effects and issues resolving rules, and the third one is 'substance-field model' for modeling a technological issue in the form of 'two materials' and for starting answers which make the above interaction change in the desired way (Te-Sheng Li a, Hsing-Hsin Huang, 2009).

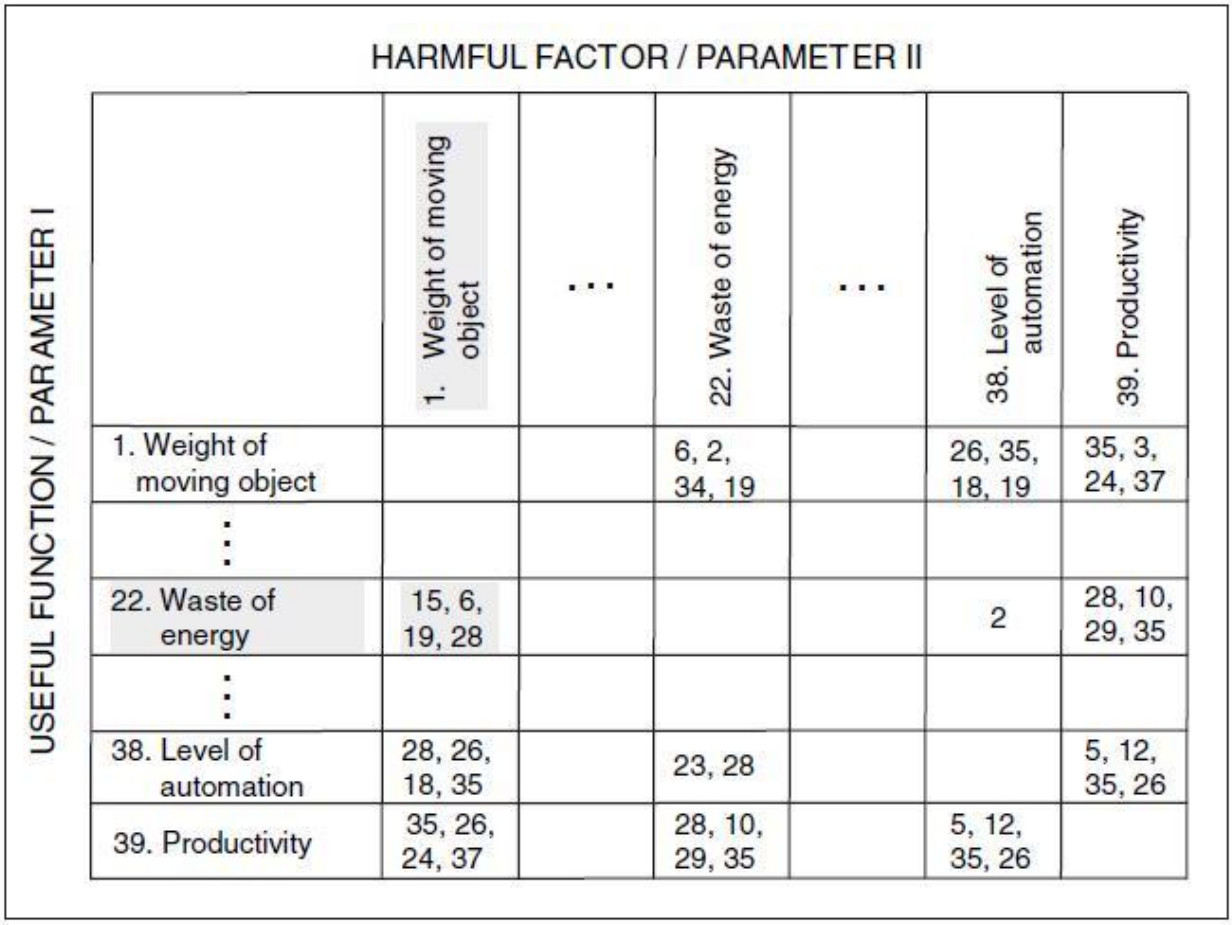
The most general tool which is put into practice is the matrix that includes the contradictions and 40 principles. The contradiction, we can understand that a worsening engineering parameter and an improving parameter (IP) concurrently exist.

There are 39 engineering parameters consisting of the weight of object, the size of object, the force of object, etc. The matrix is a 39_39 matrix, which consists of the zero to four most capable principles for resolving design issue relating to the 1482 most general contradiction types. In order to use TRIZ in the innovative design issue resolving, first, the design engineer has to find out the correlative contradictions of his/her issue at hand. After that, the design engineer accords the meaning of each contradiction with two suitable parameters from 39 engineering parameters in the matrix (Domb, 1997).

The specific issues can be analyzed by using contradiction thinking. After that, it's very useful to change the specific issue into an abstract issue. With this aim, the contradiction matrix can be put into practice. The contradiction matrix includes 39 rows and 39 columns. Rows and columns deputize for parameters of technical network, which can be modified in different ways, such as volume, mass, energy supply of user amicableness of a network. The rows of the matrix consist of desired functions of a network and the columns consist of harmful elements of a network.

In order to use the contradiction matrix, we have to resolve the issues proceeding in three steps. First of all, the desired function is modified into one (or more) parameters of the contradiction matrix's rows. Second, the harmful element is modified into one (or more)

parameters of the contradiction matrix's columns. Afterwards, the specific issue has been entrusted to one of 39x39-39=1.482 abstract issues. At last, up to four of forty inventive principles, which are suggested to overcome the technical contradiction and determined by the selected row and column of the contradiction matrix, will be found in the cross-field (see figure 6).



HARMFUL FACTOR / PARAMETER II

USEFUL FUNCTION / PARAMETER I

	1. Weight of moving object	...	22. Waste of energy	...	38. Level of automation	39. Productivity
1. Weight of moving object			6, 2, 34, 19		26, 35, 18, 19	35, 3, 24, 37
⋮						
22. Waste of energy	15, 6, 19, 28				2	28, 10, 29, 35
⋮						
38. Level of automation	28, 26, 18, 35		23, 28			5, 12, 35, 26
39. Productivity	35, 26, 24, 37		28, 10, 29, 35		5, 12, 35, 26	

Figure 6: Selecting inventive principles by applying the contradiction matrix (Martin G. Moehrle, 2005)

The so-called inventive-principle is an important conclusion of Altshuller's total patent analysis. A large number of inventions were relied on a small number of principles, which is intuitively used by the inventors. Additionally, the contradiction matrix mentioned above was expanded, which allows the linking of abstract issues with abstract resolutions – in the event the

inventive principles.

The inventive principles provide a different measure abstraction, and a variety of them are split into two to five sub-principles. . The problem-solver can put them into practice by looking over them and using his intuition for the best corresponding principle, or he can utilize the contradiction matrix to lead him to inventive principles, which had been put into practice in similar abstract issues. The table of 40 inventive principles is shown below:

Table 1: 40 inventive principles (Source: Ideation International, 1999**)**

1. Segmentation	21. Rushing through
2. Extraction	22. Convert harm into benefit
3. Local conditions	23. Feedback
4. Asymmetry	24. Mediator
5. Consolidation	25. Self-service
6. Universality	26. Copying
7. Nesting	27. Disposable object
8. Anti-weight	28. Replacement of a mechanical system
9. Prior counteraction	29. Pneumatic or hydraulic construction
10. Prior action	30. Flexible 'shells' or thin films
11. Cushion in advance	31. Porous material
12. Equipotentiality	32. Change the color
13. Inversion	33. Homogeneity
14. Spheroidality	34. Rejecting or regenerating parts
15. Dynamicity	35. Transforming the physical/chemical state
16. Partial or excessive action	36. Phase transition
17. Shift to a new dimension	37. Thermal expansion
18. Mechanical vibration	38. Strengthen oxidation
19. Periodic action	39. Inert environment
20. Continuity of useful action	40. Composite materials

By analyzing the patents around the world, TRIZ investigators have found that in the past, different areas distinctly used restricted rules, and some rules were usually used, which could be extensively used in so many areas. Even though these principles reference the aspects of physical, chemical, and other principles of engineering areas, they are still appropriate to inventions in other different areas. Consequently, the 40 inventive principles Altshuller concluded that can be powerfully inspire people for invention, which is also called inventors' ideal "inventive plant".

Furthermore, these principles are playing a great part in using technical contradiction matrix to resolve technical contradiction issues, the list of 40 inventive principles, which are extensively used in aspects of trade, sociology, architecture, nourishment, microelectronics, etc.

TRIZ has been used with other quality technique technologies, importantly contributed to mature produces and accomplish innovative theories, modified traditional technical renovation way which hinged on skill and inspiration into the current way, as said by technical evolution rule, and also turn into hot research emphasis in international technical renovation and quality engineering areas. Therefore, many super-companies has started to put TRIZ into practice for produces renovation, and through years, in Sony, Motorola, HP, Samsung, there has been higher than 30 percent profit originated by innovative plans. In America, TRIZ investigators have found that there will be much more investments come back in case the application of TRIZ theory is used in trade or administration areas besides in technology (Jing Zhang, Jie Shang, 2010).

TRIZ theory is called attention that can compromise the framework for resolving issues and the useful methodical definition in characteristic of business, management and human resources by Darrell Mann (2004). TRIZ tools and techniques are able to get special and systematic advanced technique, associating with other management problems and resolving technique that can directly operation in non-technical fields, or by made a little alteration. Darrell Mann regularly talks about the 40 technical principles can also be used in business, definitely there are so many problems can be present that are required to be solved, for example business confliction matrix, non-technical definition (Darrell Mann, 1999). Boris Zlotin (2001) figure out that in TRIZ theory, first, most communal methods in development system Altshuller make known, can be used in non-technical fields, and finally these can become the common concept of evolution model, second, analytic tools and psychological elements can directly operation in non-technical fields, or making a little amendment, third, though current tools come from technical information, taking-out course point to some inventive theory still can be applied usually, like converting, dividing, changing bad into good, power, self-service and so forth, meanwhile others can also be changed into application in different fields (Boris Zlotin, 2001)

Recently TRIZ theory has been widely used in more and more non-engineering fields, including trade, sociology, quality supervision, education, service operational management, finance, marketing, architecture, food technology, software developing, micro-electronics, chemical industry, and so on, and comparative explanation to advanced principles in other fields have been made by many researchers (Xinjun Zhao, Mingxi Hou, Ai Li, 2005).

2.3 Introduction to Patent map

According to The world Intellectual Property Organization (WIPO, 2003), the documents that are patented contain most of the inventions of the world (90-95%) but 80% among them are not shared with other professional articles (Liu & Shyu, 1997). In these patents, a lot of technical information could be found. Those cover practical and particular technological issues as well as technical reports and trends of companies about technology. The tendency of technological development is also included in the patents like others concerned (Chen, Liu and Tseng, 2000). In term of researching about technical creation and improvement, the patents become very helpful reference (Park et al, 2005). The information in patents could be very complex and hard to understand when it comes to deeply analysis. Therefore, the patent map is used as a visual technique to simplify the documents (WIPO, 2003). Once the analysis is taken properly, the technological details and involvement as well as business movement will be revealed to support industrial solutions and investment decision making (Campbell, 1983, Jung, 2003). The patents' roles become more and more important in industry and other involved fields in term of new products and technologies. So far, the patents act as protection method legally for inventions especially concentrated technological sectors (Bader, 2008). In business service sector, the value of the companies depend on intellectual property they process which under patents' protection (Hanel, 2006). Therefore, more and more service companies use patents for their creation in services (Bader, 2008). Protecting inventions in business and technology is very popular in US and Japan.

As a useful source for technical information, the patents are used to support R&D management because in technical and business issues, they present as being helpful for technical and commercial feasibility (Kuznets, 1962). Although some of patents developed with commercial purposes related, the development of technology is still the most significant aim that they are enhanced (Ashton and Sen, 1988). However, the relation between companies' success and patents' power cannot be denied (Lerner, 1994, Ernst, 2001, Shane, 2001). According to Ernst (1995, 2001), the good strategy in patent will bring more achievement to the companies than others who are inactive in this area and even in biotechnology sector (Austin, 1993). That is the reason why the patents should be analyzed and researched about. Fortunately, the databases for patents are easy to get access in most of the countries (Daim et al., 2006) with variable available information (Park et al., 2005) Despite the fact that only the patents with high value

help the effectiveness of companies (Lerner, 1994, Shane, 2001), all patents have the same value in development of technology and significance in tendency analyzing.

A patent document holds dozens of articles to be analyzed, which can be gathered into two groups. The first one involves structured article, which are unified in semantics and communicated at across patents (such as patent number, filling date, delivered date), while the other includes formless articles, which means that they are texts of tenors such as invention's portrayals. The visualization conclusion is called patent graph in case an analysis of patent documents is relied on the form data, and patent map if it is relied on the formless data, but the universal patent map scan is concerned with both of circumstances (Liu, 2003).

Even if different forms of patent maps have been progressed, most conservative people usually utilize information extracted from the bibliographic areas of patent document to accommodate with simple statistical conclusions. For example, according to the Japanese Patent Office, higher than 50 types of expressions and higher than 200 maps have been produced and provided for several technological areas (Japan Institute of Invention and Innovation (JIII) (2002).

Patent map is developed through three main steps: patent collection, patent analysis and patent mapping (see figure 7) as illustrated below:

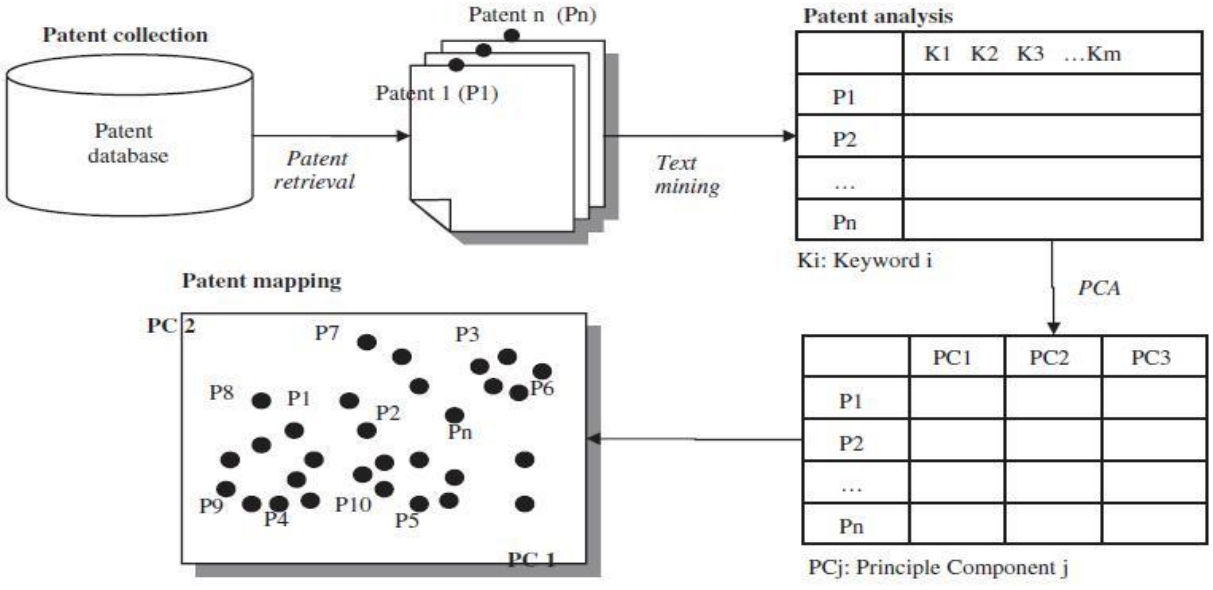


Figure 7: Process of patent map development (Sungjoo Lee, ByungunYoon, Yongtae Park, 2009)

1. Patent collection: The first assignment is gathering patent documents in the concrete technology area to be analyzed. Current progresses and diffusion of internet-based abstract services permit easy access to patent databases in electronic shape. Patent documents gathered at this period are formless data, in that they are manifested purely in text format
2. Patent analysis: The next assignment is conversing formless the text document into form data. A characteristic patent analysis screenplay embraces assignment identification, seeking, division, abstracting, clustering, positive thinking and clarification (Tseng etal.,2007a,b). Exactly, each patent will embrace keywords that we can use to signify its technological features. The keywords incidence in the whole documents can be utilized as an important proxy measure. After that, only the keywords with high importance will be chosen as the first applicant and go through experts' testing. After the testing, the remaining keywords will become a final theme of analysis.
3. Patent mapping: Once the keyword vector is accomplished, documents are mapped to a rectangular planar surface to create the patent map. Whereas there is no categorical process to find out the optimal number of factors, the factors that can clarify the variance of general variables are utilized in a enterprise practice and frequently three or four may be satisfactory to clarify the majority of total sample variance. (Sungjoo Lee, ByungunYoon, YongtaePark, 2009).

Patent maps are classified according to concrete aims: the technical patent map, the administration patent map and the assertion patent map (Yoon et al., 2002). The technical map is utilized to comprehend essence technology. Assertion patent maps are helpful in order to monitor patent clashes. Particularly, technical patent maps are special functional in uncovering patent vacuums through uncharted patent data on the map. Patent vacuums help practitioners construct future strategy through classifying important possible technology. As a result, the principle component analysis (PCA) and the self-organizing map (SOM) are illustrative techniques that discover patents in a patent map.(Changho Son, Yongyoon Suh, Jeonghwan Jeon, Yongtae Park, 2011).

Chapter 3 Patent-driven Product innovative method

In this chapter, the research methods will be implemented step by step based on a research procedure to satisfy the requirements. For the purpose of setting out a renovation to help disabled people transporting in the house, two leading methods which are used are TRIZ and patent map. With the search and analyzing of relevant patent combinationed with TRIZ method, we can find feasible ways to present an improved idea of invention.

3.1 Procedure of the inventive way for new products

In this research, we propose an inventive way for developing new products to support disabled people. The procedure includes patent mapping, patents comparison, substance-field analysis drawing, weak points finding of the patents and TRIZ method to give conceptual or improved invention, as shown in figure 8.

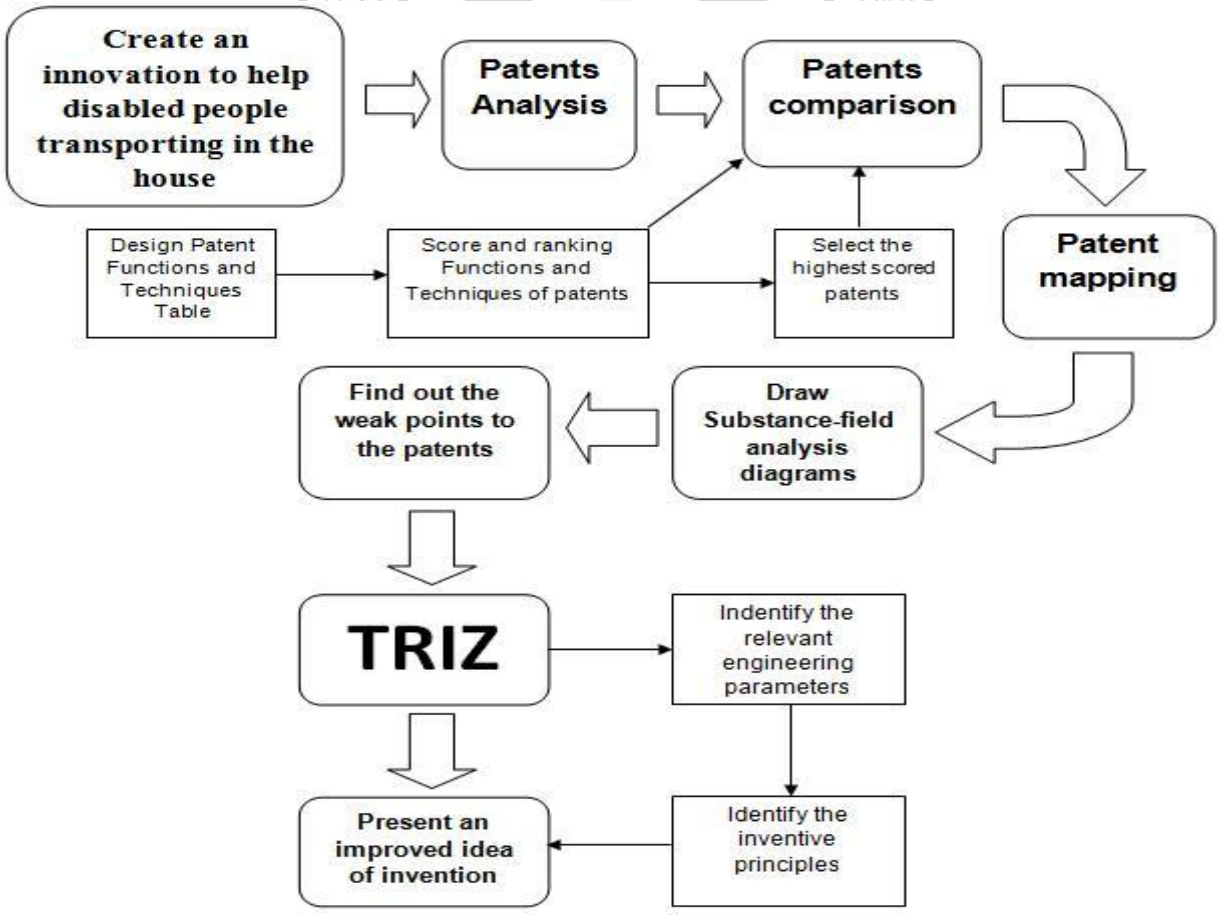


Figure 8: Procedure of the inventive way for new products

The research procedure is divided into 7 stages aim at finding a new invention for supporting disabled people to transport in the house. The first step of the research procedure is to find and analyze patents related to the problems of the disabled people's movement. This step helps us to have an overview of the capabilities and techniques used in the previous patents and their contributions, advantages and disadvantages. Since then we select the patents with suitable functions and techniques for further works. In the next step, we set up a table to analyze and compare the functions and techniques of the selected patents. Through the discussion and evaluation in certain criteria, some patents are chosen for our further operations. In the third step, we draw the patent map based on the functions and techniques of these patents in order to prepare for the fourth step: to draw substance field analysis diagram. Through the analyzing of the substance-field diagrams in the following steps, we can find out the weak points and limitations of the patents which they can seek to improve for more preeminent products. In the sixth step, TRIZ method is used as an effective tool to improve the weaknesses of the old system and find a more innovative system. By means of identifying the relevant engineering parameters and setting parameter engineering contradiction matrix table, we find the inventive principles which satisfy the functional requirements (that can satisfy the functional requirements). The last step of the procedure is to apply the inventive principles in order to design a new system that satisfies the requirements of the disabled people. The case study for the research process will be demonstrated and described in chapter 4.

3.2. Patents search and analysis

The first step in this research is to search for the patents that are related to the topic of helping the disable people transporting in the house. In the patent search, we only focus on US patents. The problem to solve here is about disable people transporting up and down stairs. The keywords to search patent are: "elevating lift, stair-lift, wheelchair, stair elevating, disable people, stair climbing" with the Boolean operation.

Through the patents available on http://www.us-patent-search.com/ we found out many patents related to the equipments for disabled people that can move up and down stairs easily. Table 2 shows the number of patents that were searched by using different keywords.

Among those patents, we analyze and select sixteen patents with qualified functions and techniques that are useful for research. The qualifications for selected patents are:

Table 2: Table of patent search

Keywords	The number of patents
Elevating lift	24,800
Stair-lift	3,150
Wheelchair	31,400
Stair elevating	1,190
Disabled people	8,860
Stair climbing	4,460

1. Equipments specialized to support disabled people:

The functions of those equipments are to serve disabled people move up and down stairs easily without any external support. Nowadays, those equipments have been applied in many fields such as, family homes, hospitals, schools and public areas, etc. After a period of time, they have proved to help the disable people in daily routine and to fit in the society.

2. The safety of equipments:

Since the users are the disabled people, the safety of equipments is considered as the first priority in the design steps. Those patents are mostly making the components to carry the weight of disabled people, as well as supporting bars supporting frames to avoid any unexpected accident due to failures.

3. The design for adaption to the working environment

Working environment is a fatal factor that influences the effectiveness of a product. The working environments for all the disabled people are various as counted: public areas, resident's houses, indoor or outdoor, etc. The essential needs of a product are its life cycle and the convenience of installation and the functions which can fit for most of the ones who use it.

4. The convenience of a patent:

The equipments should provide the flexibility of their uses at all times even at all places with a great convenience to the disabled people. Moreover, patents with a less space occupation and an ease for storage under various use circumstances are better.

Table 3: Table of 16 patents

Number	Patent title	Patent number	Inventors	Effective date
1	Ergonomically designed walker	United States patent, No. 6,959,716 B1	Joseph Francis Schradder	Nov 1,(2005)
2	Automated wheelchair	United States patent, No. US 7,503,567 B2	Thomas T. Frankie	Mar 17, (2009)
3	Stair-lift device	United States patent, No. US 7,225,899 B2	Gordon Molnar, Peter Shaw	Jun 5, (2007)
4	Step walker	United States patent, No. 4,253,287	Kenneth R. Overmoe	March 3, (1981)
5	Portable stair-lift	United States patent, No. 5,193,650	George W. Kent	March 16, (1993)
6	Stair climbing wheelchair	United States patent, No. 5,577,567	Johnson et al	Nov. 26, (1996)
7	Chair lift for stairs	United States patent, No. US 6,360,833 B1	Joseph R. Valencia	Mar.26, (2002)
8	Stair walker	United States patent, No. US 6,453,921 B1	Brian Mitchell Rost	Sep.24, (2002)
9	Battery powered stair-climbing wheelchair	United States patent, No. US 6,484,829 B1	Kenneth Ray Cox	Nov.26, (2002)
10	Collapsible chair	United States patent, No. US 6,561,524 B1	Henry Medina	May 13, (2003)
11	Stair chair	United States patent, No. US 6,648,343 B2	Christopher B. Way, Clifford E. Lambarth, Joshua C. Colvin	Nov. 18, (2003)
12	Stair chair with an adjustable glide track resistance and braking device	United States patent, No. US 7,520,347 B2	Chambliss et al	Apr.21, (2009)

13	Stair climbing aid	United States patent, No. US 7,950,498 B2	Yang et al.	May 31, (2011)
14	Wheelchair for stairs and obstacle	United States patent, No. US2010/0096194 A1	Lazo Starcevic	Apr.22, (2010)
15	Chair for stair elevating lift	United States patent, No. US D489,859 S	Keiichi Yamada	May 11, (2004)
16	Stair-climbing wheelchair carrier with crawlers	United States patent, No. 4,898,256	Max Lehner	Feb.6, (1990)

We considered these sixteen patents to do the functions-techniques table for scoring and ranking. In this table, analysis items include functions, techniques, score, average score and ranking. The function and technique columns describe the function and its relevant technique of the patents, and the score evaluation is performed by brain-storming. In this process, a group of experts such as salesmens, designers, manufacturers, etc were formed to evaluate the patents. The result is the table of patents scoring and ranking which is represented as in table 4. The score is set from one to ten and each function is scored based on the convenience and helpfulness to users. One point presents to strongly inconvenience and uselessness. Ten points presents to strongly convenience and usefulness. The score from one point to ten points with the level of convenience and usefulness increases proportionally. The technique is the way to indicate how to bring the features to the reality. There are many factors to consider that a technique is a good or bad one. One point presents to strongly poor logic, expensive or complication. Ten points present to a technique that holds strongly logic, simplicity or acceptable price. From one point to ten points, the magnitude of the logic, simplicity and the price rises proportionally. After giving the scores for the functions to their techniques as in column Score in table 4. In case we have patents with many functions and techniques, so that in order to have an accurate judge to them, we need to overview scores in Score column. The average score will be our score to a patent that give us an easy way to find out the comparison between the patents with precision. By the average scores, we make ranks for patents. The first place is for the highest score. And it goes down with lower scores. By doing so, we complete the table of functions and techniques compared among the patents. Otherwise we understand more about the strength and weakness of the patents.

Table 4: Table of patents comparison and scoring

	Functions	Techniques	Scores	Average Score	Ranking
US6959716 B1	- Help to rise from a seated position (7/10)	- Hands on seat and handle the grip bars (7/10)	7	7	7
	- Help to climb and go down stair (6/10)	- One hand holds on to rear of seat, one hand grips the bar with walker frame (7/10)	6.5		
	- Help to walk (7/10)	- Straddle the walker frame (7/10)	7		
	- Help to stand and give user the use of his hand to do various tasks (8/10)	- Straddle the walker frame (7/10)	7.5		
US7225899 B2	- The stair-lift can lift or lower at least one person on a rail on a stair way (9/10) <u>Function 1</u>	- Carriage has a track engaging drive and a motor to power the drive. The power drive cause the carriage to move along the rail (9/10) <u>Technique 1</u>	9	9	1*

US4253287	**- Aid person with walking disabilities of difficulties to move up and down stair (6/10)**	**- Holding the walking bar and moving easily along the guide slots (5/10)**	**5.5**	**5.5**	**16**
US5193650	**- Transporting individuals up and down inclined stairway (8.5/10)**	**- Portable stair-lift provides an adjustable seat that can rotate (7.5/10)**	**8**	**8**	**6**
		- Manual switches control the conveyor to move up and down along the stairway (7.5/10)	**8**		
US557 7567	**- Aiding individuals move up and down stair, over surface are disclosed (9/10) <u>Function 3</u>**	**- Each wheelchair wheel has extendable and retractable spokes. Those spokes are controlled by computer monitor (8/10) <u>Technique 2</u>**	**8.5**	**8.5**	**3***
		- The control computer sends control signals to each spokes in response to operator inputs and contacts position data	**8.5**		

		regenerated by the contact sensor devices (8/10) **<u>Technique 3</u>**			
US6360833 B1	**- Help disabled person to be effortlessly lifted up a flight of stairs while in a sitting position (7/10)**	**- A light weight metal chair frame mounted to a pair of metal slidable sled rails (7/10)**	**7**	**6.875**	**12**
		- A set of wheels mounted to the base of rails, a calf retaining sling mounted below chair frame (7/10)	**7**		
		- An electric winch mechanism that have a pulling cable located near the center line of chair frame (7/10)	**7**		
		- Chair frame also has a manual pull trap attached to a top cross rail (6/10)	**6.5**		

US6453921 B1	**- Aiding ambulatory persons in ascending and descending stairs ramps and other uneven walk able surfaces (7/10)**	**- A pair of hand – controlled levers used separately or together to adjust the front legs (6.5/10)**	**6.75**	**7**	**7**
		-The rear legs are adjusted for the user's height once only by suitable adjustable fastening (7/10)	**7**		
		-The sides of frame can be readily folded for storage or for carrying (7.5/10)	**7.25**		
US6484829 B1	**- A self-propelled battery-powered wheelchair replaces an ordinary wheelchair and improve access to homes (9/10) <u>Function 4</u>**	**- Moveable skids are mounted on four corners to ensure stability (8/10) <u>Technique 7</u>**	**8.5**	**8.5**	**3***
		- Motion and control are provided by electric motors, sensors, a computer and drive inputs (8/10) <u>Technique 8</u>	**8.5**		

	- Stair climbing, slope climbing, and reclining with minimal driver skill and strength (9/10) <u>Function 5</u>	**- Spiders wheels engage to propel and stabilize the chair during climbing stairs (8/10) <u>Technique 9</u>**	**8.5**		
US6561524 B1	**- Transporting people up and down stairs (7/10)**	**- Uniquely designed gripping bars used to help carrying chair upstairs (6/10)**	**6.5**	**6.75**	**13**
		- A set of wheels that is located to help stabilized chair (7/10)	**7**		
		- An improved locking mechanism is on the chair to lock seating assembly and rail assemblies (7/10)	**7**		
		- A harness system to hold a person on the chair (6/10)	**6.5**		
US6648343 B2	**- Transporting individuals up and down stairs (7/10)**	**- A back wheel rotably supported on each bracket for rotation about a**	**6.75**	**7**	**7**

		common axis of rotation (6.5/10)			
		- A least two mounts are provided at a lower end of the frame to pivotally connect one of the brackets to main frame for movement about second pivot axis (7.5/10)	**7.25**		
		- The rail assembly and seat assembly are configured to pivot their respective pivot axes independent of movement (7/10)	**7**		
US7503567 B2	**- Help people who haven't full physical function to move and displace on variety surface, included flat, stair form, and rough road (9/10) <u>Function 2</u>**	**- The two wheels are multi-spoke system at both sides of the chair. The spokes which have the pneumatic wheel at their ends, according to the analyzing results of the**	**8.5**	**8.75**	**2***

		pressure sensors installed in the pneumatic wheel, can automatically converse between retracted and deployed form to be fit and moving at any surface but keep the main chair in balance form (8/10) **<u>Technique 4</u>**			
		- People who use it can control all functions of the chair through the computer controller (9/10) **<u>Technique 5</u>**	**9**		
US7520347 B2	**- Transporting a person up and down a flight of stairs and over a surface is disclosed (7/10)**	**- The glide track assembly is pivotally connected to main frame for pivotal movement between open and close positions (6.5/10)**	**6.75**	**7**	**7**
		- The glide track assembly has at least one endless glide	**7.25**		

		track. The stair-chair provide an adjustable glide track resistance and braking (7.5/10)			
US7950498 B2	**- Aiding ambulatory person up and down stair (7/10)**	**- The control mechanism is disposed on the assist member to be controlled by user (6/10)**	**6.5**	**6.5**	**15**
		- The positioning assemblies are disposed at both sides of assist member (6/10)	**6.5**		
		- Each positioning assembly is provided with an engaging portion to engage respective positioning portion of slide rail (6/10)	**6.5**		

US 2010/0096194 A1	**- Aiding a person for up and down stair, and run over a surface which is not smooth (6.5/10)**	**- Internal motor serving as a battery charger, a drive wheel-belt safety running the wheelchair (6/10)**	**6.25**	**6.583**	**14**
		- A foldable front wheel-pulley belt pendulum supports and protects the wheels and also help the wheels can move more flexible (7/10)	**6.75**		
		- A seat moving assembly to shift the centre of gravity enabling user can move comfortably (7/10)	**6.75**		
US D489859 S	**- The chair can lift up and down the rail on stairway (8/10) <u>Function 6</u>**	**- An electrical device controls the chair to slide on the rail (8.5/10) <u>Technique 6</u>**	**8.25**	**8.25**	**5***
US4898256	**- The system is used especially for climbing stair, comprises an**	**- The adapter mounted on the wheelchair is connected to crawler unit through**	**7**	**7**	**7**

	undercarriage having power-driven tracks and an adapter to securing the wheelchair in a rearward tilted traveling position (7/10)	**lifting (7/10)**			
		- The adapter made from a male coupling member for mating engagement with a complementary female coupling member (7/10)	**7**		

After analyzing and scoring the patents, we select the five patents (with mark * in table 2) which are the ones with highest scores: US7225899 B2, US7503567 B2, US5577567, US6484829 B1, US D489859 S.

3.3 Patent map (Functions-Techniques Matrix)

From the chosen five patents as listed in the section above, we proceed to the next step to analyze and draw the patent map. This table is a useful tool to connect the functions and techniques of every patent in order to fulfill the requirements. As we consider which technique best satisfies the function requirements in the patents. Then we have chances to find out new techniques that have not been used or to improve some existent techniques for better uses. Otherwise, we can also find out some weak points of the techniques or function through analyzing the patent map. This step is the preparation for drawing the substance-field analysis diagrams in the subsequence step.

Table 5: Patent map for the top 5 highest scored patents

	Function 1	Function 2	Function 3	Function 4	Function 5	Function 6
Technique 1	**US7225899 B2**					
Technique 2			**US5577567**			
Technique 3			**US5577567**			
Technique 4		**US7503567 B2**				
Technique 5		**US7503567 B2**				
Technique 6						**US D489859 S**
Technique 7				**US6484829 B1**		
Technique 8				**US6484829 B1**		
Technique 9					**US6484829 B1**	

The result of the patent mapping is shown in Table 5. This is obtained by executing the following stages: patent search, patent reading, patent analyzing, and table drawing that describe the lists of all the functions and skills used in the considered patents.

3.4 Substance-field analysis for the top 5 highest scored patents

To further find the weak points of the patents, the diagrams of substance-field analysis for the five selected patents are drawn in figure 9 to figure 13. The dashed lines in the figures show the unsatisfied function or the weakness of each patent.

1. Stair-lift device (US 7225899 B2)

A chair is equipped with a carrier and this carrier can slip on a rail. The rail is mounted on a stairway. There is a motor which supports the carrier to slip on the rail (see figure 9). In this figure, two weak points are found out. The first one is that the rail way bases on the staircase. This design creates the restriction in space saving use of the stair. The second weakness is that the chair is fixed to the local load (carrier) in the system, which makes the system becomes inflexible, consume area and is difficult for the users when they have to try his/her self or ask other people to help them sit on chair when the system used.

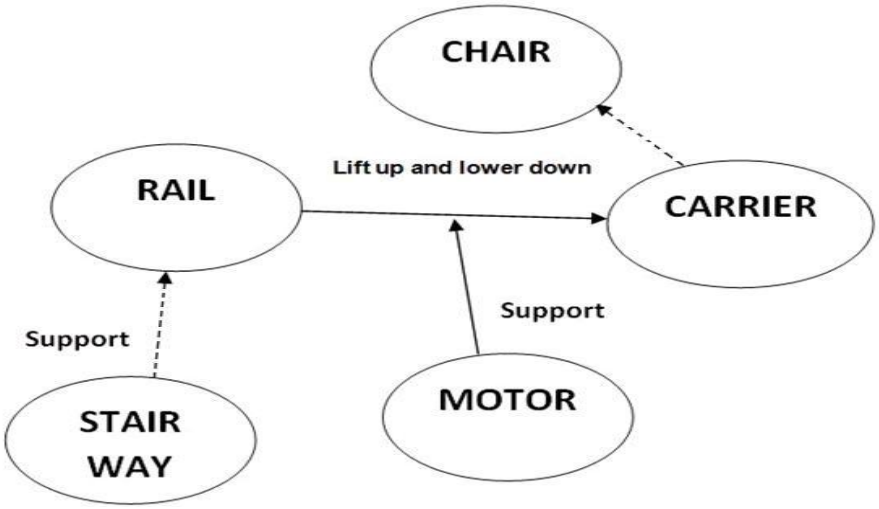


Figure 9: Substance-field analysis diagram for stair-lift device (US 7225899 B2)

2. Automated wheelchair (US7503567 B2)

A multi spoke system is supported from a pressure sensor and the pneumatic wheels and it will control the wheelchair to move up and down stairway (see figure 10). The weak point in this patent is that the multi spoke system (wheel spokes system) does not provide a high safety. It has a poor balance and stabilization ability, especially when scrolling up and down stairs, it can cause anxiety (not safe or inconvenience) to users. Also, the spokes (wheel spokes) are not really reliably designed and can be easily broken or damaged.

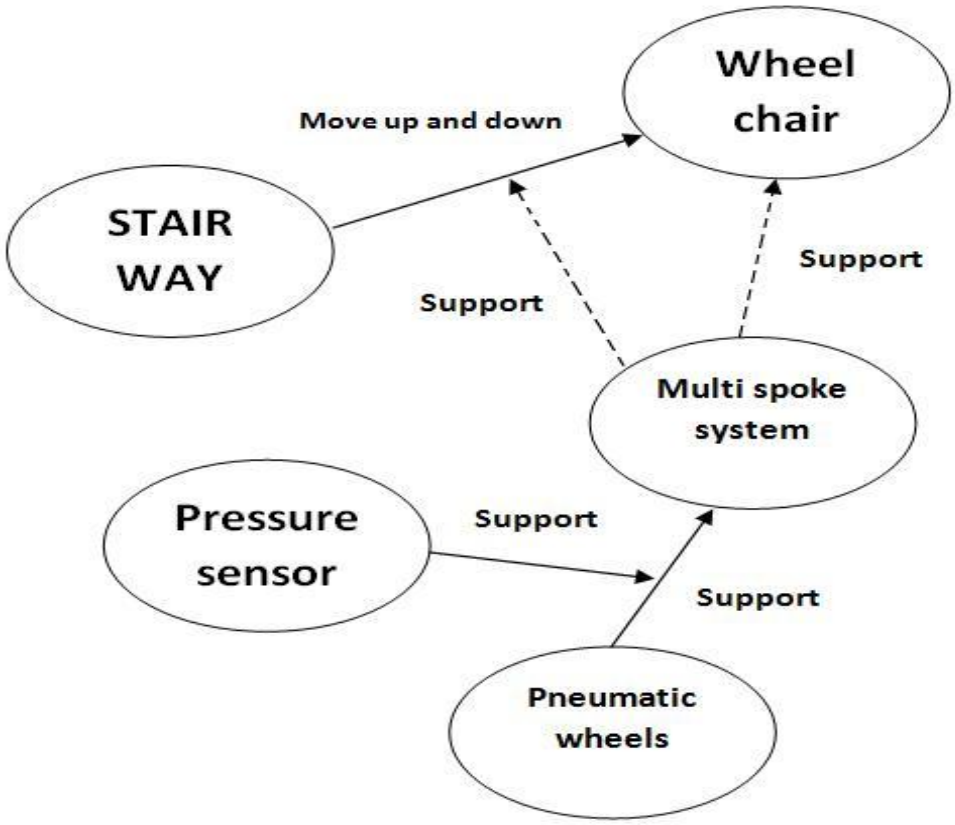


Figure 10: Substance-field analysis diagram for automated wheelchair (US7503567 B2)

3. Battery powered stair-climbing wheelchair (US6484829 B1)

In this system, moveable skids are mounted on four corners to guarantee the balance of the wheelchair. The computer system controls the motor and acts to the spider wheel. The wheelchair operates to move it up and down using staircase (see figure 11). There are few drawbacks found in this patent. With the spider wheel system, this design is the key to help the wheelchair to move up and down stairs. However, this system is complicatedly designed and costs more. Besides, this design also leads to the weight of the wheelchair to be increased significantly, thereby affects the flexibility of the product.

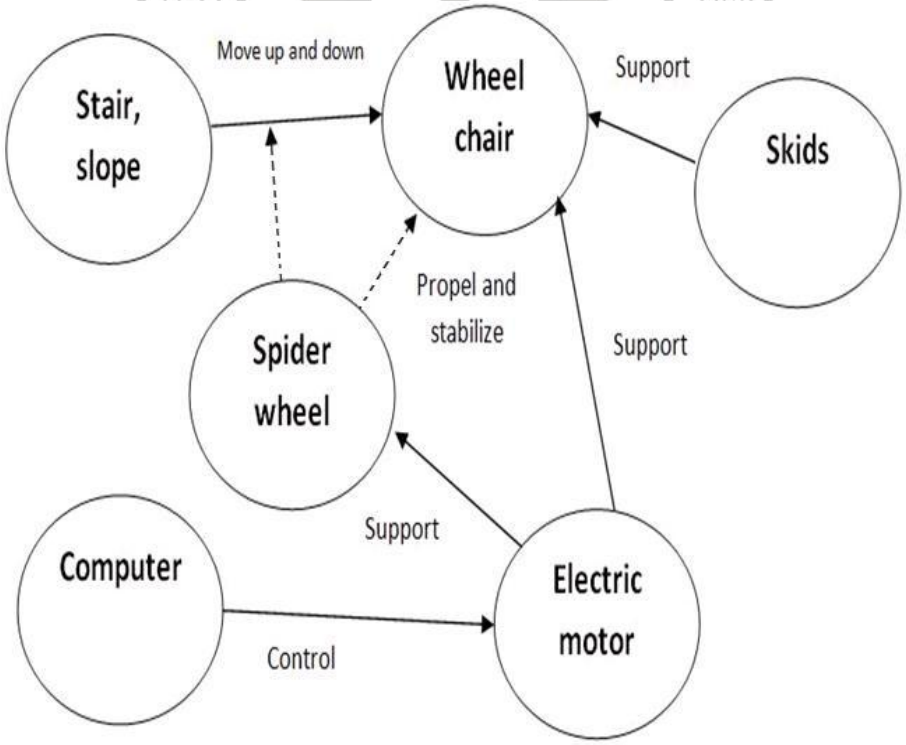


Figure 11: Substance-field analysis diagram for battery powered stair-climbing wheelchair (US6484829 B1)

4. Stair climbing wheelchair (US5577567)

Sensor device sends measured signals to the computer in which it analyzes the signal and issues a control commands to the spokes to move the wheel which makes the wheelchair going up and down on staircase (see figure 12). In this system, the moving method of the wheelchair is closer to a tank. With this design there will have the same weaknesses like Stair-climbing wheelchair Battery powered (in figure 11) which is a complex design, high cost, bulky and large weight. Therefore, this design is not an optimal choice for disabled people to transport in house.

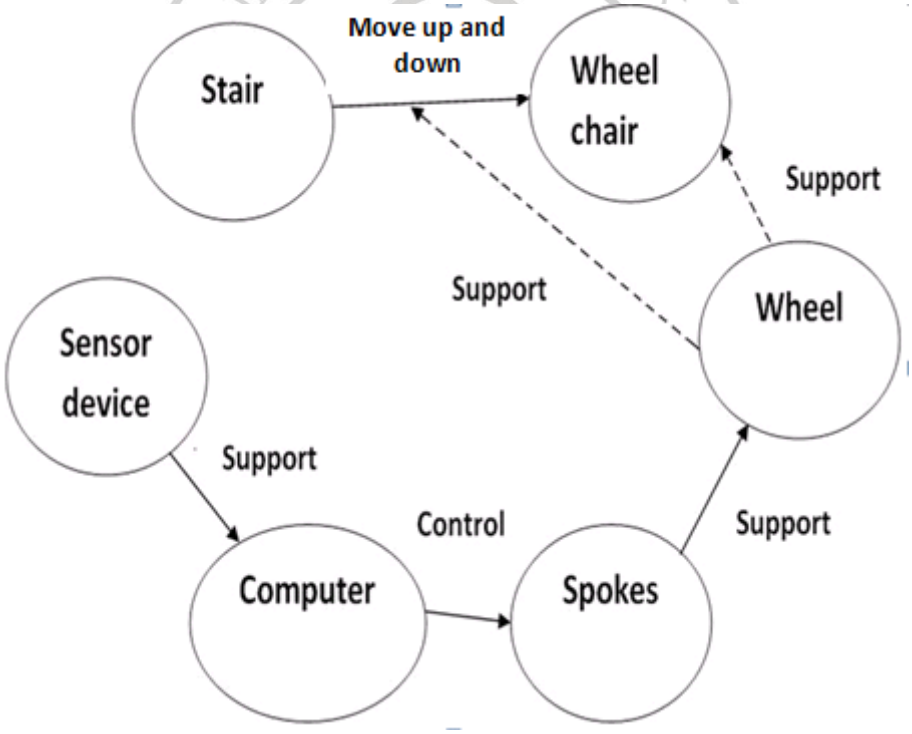


Figure 12: Substance-field analysis diagram for stair-climbing wheel chair (US5577567)

5. Chair for stair elevating lift (US D489859 S)

A chair is linked to an elevating lift which is shifted on a rail installed on the staircase. An electrical device will gives an action and controls the elevating lift system to operate (see figure 13). This design has the operation method similar to Stair-lift device in the figure 9. The weakness of this design is also located in the consuming area of stairs. However, the flexibility reduces when the chair is attached to the elevating-lift, which also affects the comfort (convenience) of disabled people when using the system.

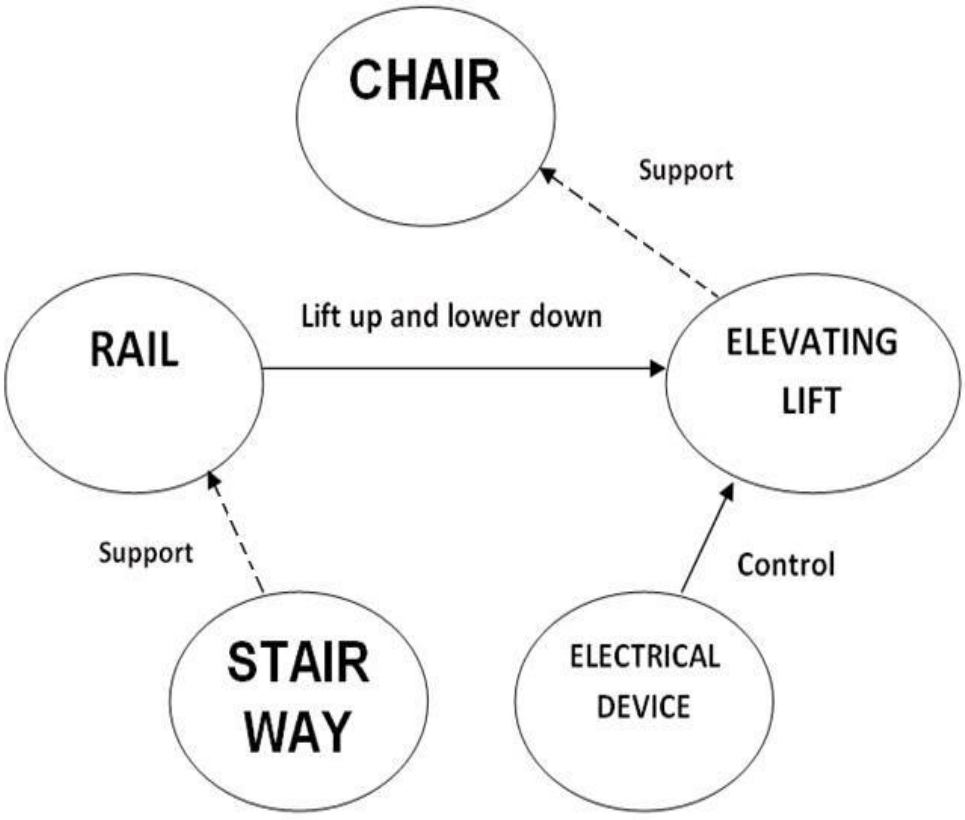


Figure 13: Substance-field analysis diagram for chair for stair-elevating lift (US D489859 S)

After drawing and analyzing the substance-field diagrams, the following weak points have been found.

1. Space saving: The products are too large and it is hard to move in a small space or climb on some small stair. In patent US7225899 B2 and US D489859 S, the rail will take a half space of the stair.

2. Safety: The wheelchair in patent US7503567 B2, US6484829 B1 and US5577567 are not very safe for users when using it to move up or down the stair. Users can be scared or fallen down from the chair.

3. Convenience for users: If the products in patent US7225899 B2 and US D489859 S are used, some disabled people will get difficulties when they get on the chair without helping from other people.

By considering these weak points, patent US7225899 B2 (see in figure 14) is selected as the best candidate so that it can be improved for a better product. TRIZ will be the method used to create an innovative idea for improving this product.

3.5 Engineering parameters and inventive principles identification for designing an improved idea of invention.

According to the weak points that have been realized in the previous section, we indentify the relevant engineering parameters and draw the parameters matrix table in order to find out the inventive principles as shown in table 6.

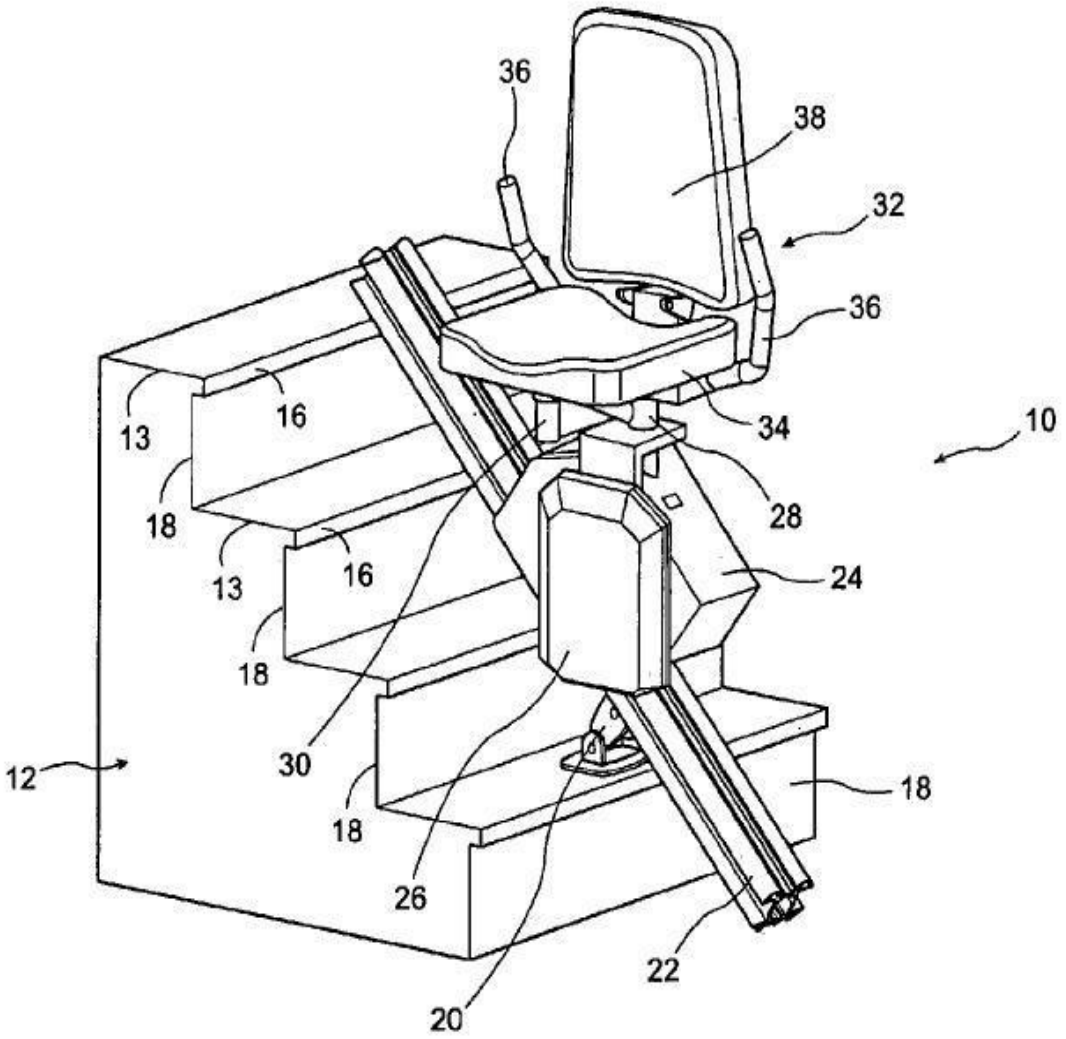


Figure 14: Stair-lift device (Patent US 7225899 B2)

The contradiction matrix table consults seven inventive principles that can propose a superior to patent US7225899 B2 (Stair-lift device). These principles are given below.

- Principle 1 (Segmentation)
- Principle 10 (Prior action)
- Principle 13 (The other way round)

- Principle 14 (Curvature)
- Principle 15 (Dynamic)
- Principle 17 (Another dimension)
- Principle 35 (Parameter changes)

Table 6: Table of contradictory parameters

	Length of moving object	Length of stationary object	Area of moving object	Area of stationary object	Volume of moving object	Volume of stationary object	Shape
Length of moving object	**X**	**-**	**15, 17, 4**	**-**	**7, 17, 4, 35**	**-**	**1, 8, 10, 29**
Length of stationary object	**-**	**X**	**-**	**17, 7, 10, 40**	**-**	**35, 8, 2, 14**	**13, 14, 15, 17**
Area of moving object	**14, 15, 8, 4**	**-**	**X**	**-**	**7, 14, 17, 4**		**5, 34, 29, 4**
Area of stationary object	**-**	**26, 7, 9, 39**	**-**	**X**	**-**		
Volume of moving object	**1, 7, 4, 35**	**-**	**1, 7, 4, 17**	**-**	**X**	**-**	**1, 15, 29, 4**

Volume of stationary object	**19, 14**	**35, 8, 2, 14**	**-**		**-**	**X**	**7, 2, 35**
Shape	**29, 34, 5, 4**	**13, 14, 7, 10**	**5, 34, 4, 10**		**14, 4, 15, 22**	**7, 2, 35**	**x**

Chapter 4: Structural design for the innovative wheelchair system

4.1 Illustration to the innovative wheelchair elevating system

Based on the analysis of engineering parameters and inventive principles in chapter 3, a new wheelchair lifting (elevating) system with more preeminent properties was designed as shown in figure 15. The innovative system solves the disadvantages in the patents which were analyzed before such as the problem of area saving, safety and easy to use. This system lifts the wheelchair moving up and down the stair according to the sliding principle of the wheelchair on a rail. Such system allows the users to perform all moving activities by themselves in an easy and comfortable way. For this new design, the chair in the old system was replaced by the wheelchair which provides better flexibilities (i.e., none affected) for the users. The wheelchair can be assembled in the system and detached from the system after the cycle of moving up and down the stair is finished.

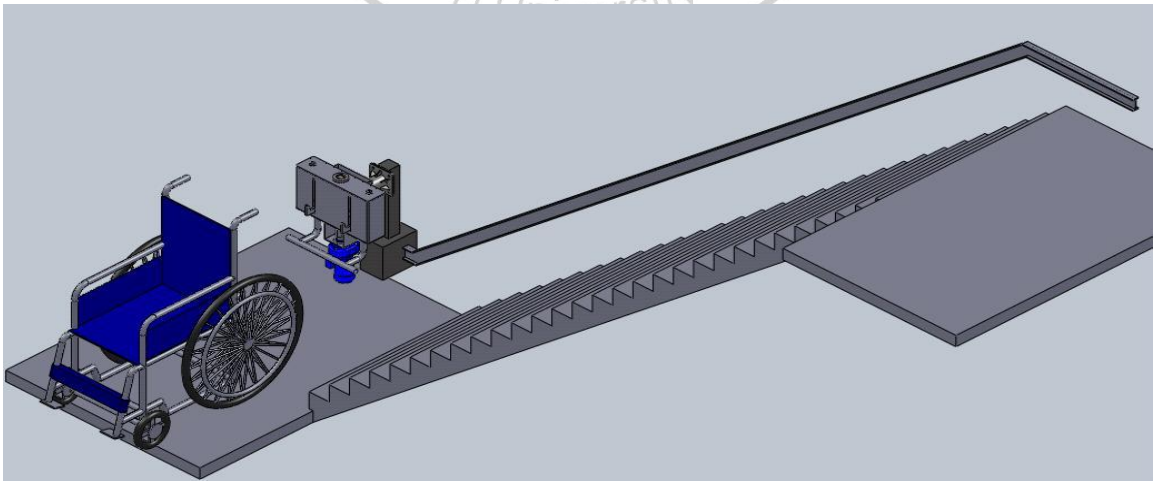


Figure 15: An overview of innovative wheelchair elevating system

4.1.1 Introduction of Sub-assemblies and components

The system has five sub-assemblies and twelve components with different functions. Each component has its own task and also support for other sub-assemblies and components. The most complicated sub-assembly is the loading machine. It includes eight components and has three main functions. The subs-assemblies and components of the system are shown in figure 16.

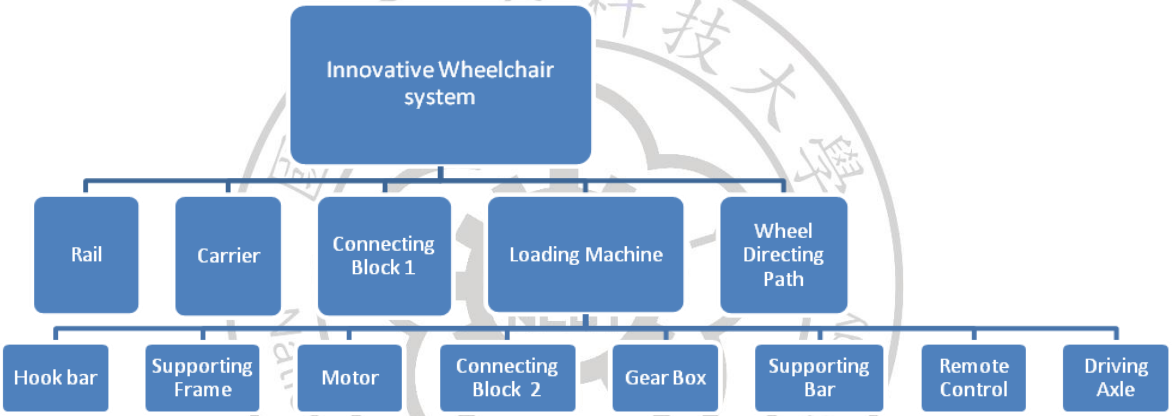


Figure 16: Sub-assemblies and components of the system

The moving parts of the system are the carrier, connecting block 1 and loading-machine. These parts are connected together by connecting block 1. They slide on the rail and drag the wheelchair to move up and down the staircase. The moving parts are shown in figure 17.

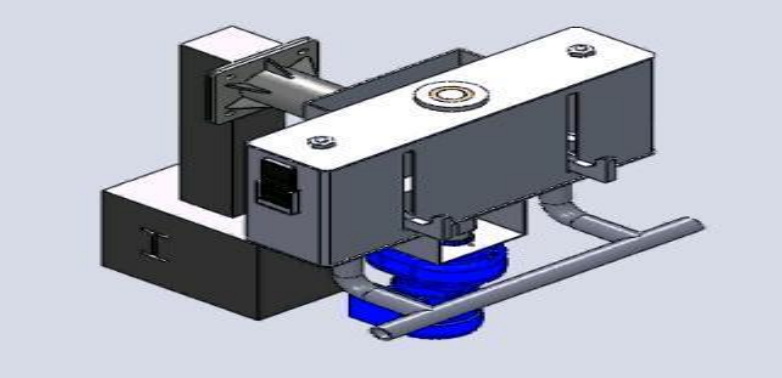


Figure 17: Carrier connected to loading-machine

Table 7 includes all components of the system which is made for the illustration of the new design. The total 12 parts of the system are shown in figure 18-20.

Table 7: Components in the system

1. Hook bar	7. Connecting block 1
2. Supporting frame	8. Supporting bar
3. Motor	9. Remote control
4. Connecting block 2	10. Driving axle
5. Gearbox	11. Rail
6. Carrier	12. Wheel directing path

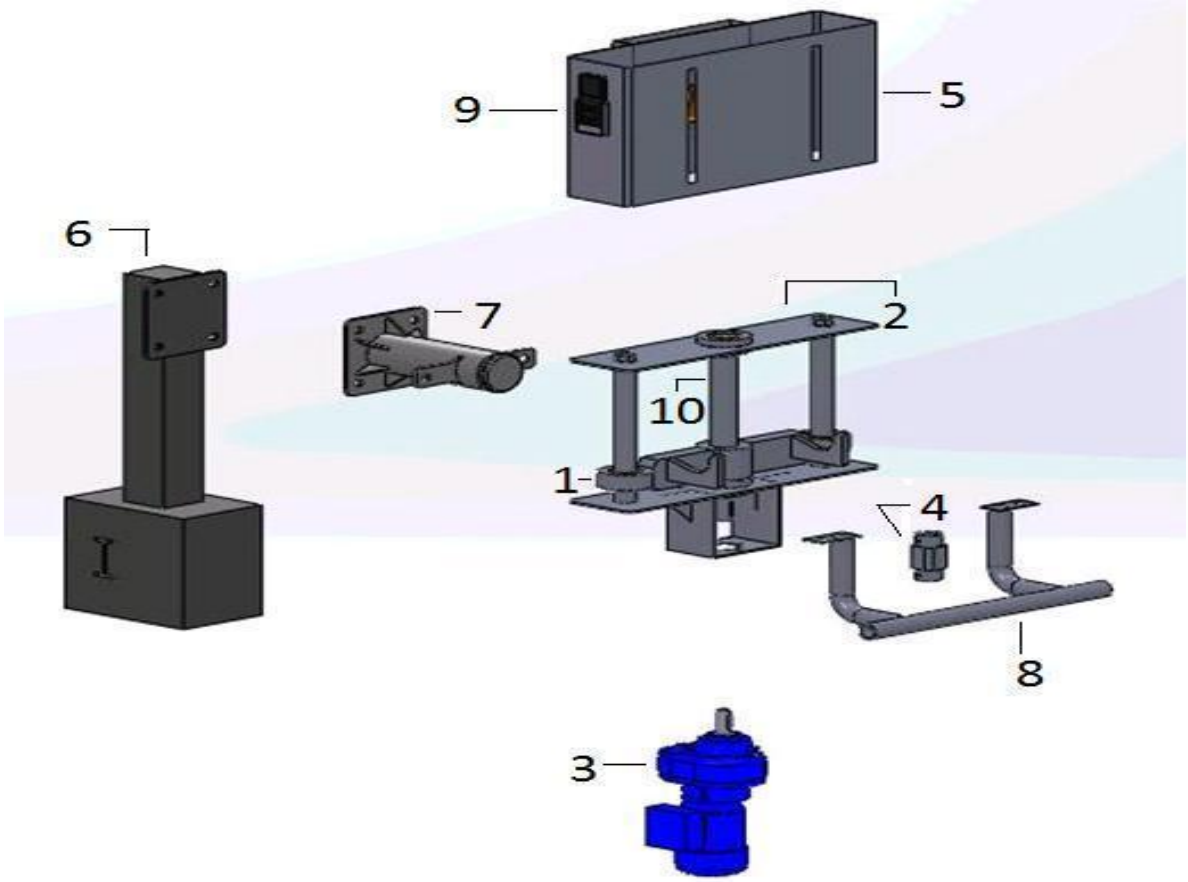


Figure 18: Components inside the system

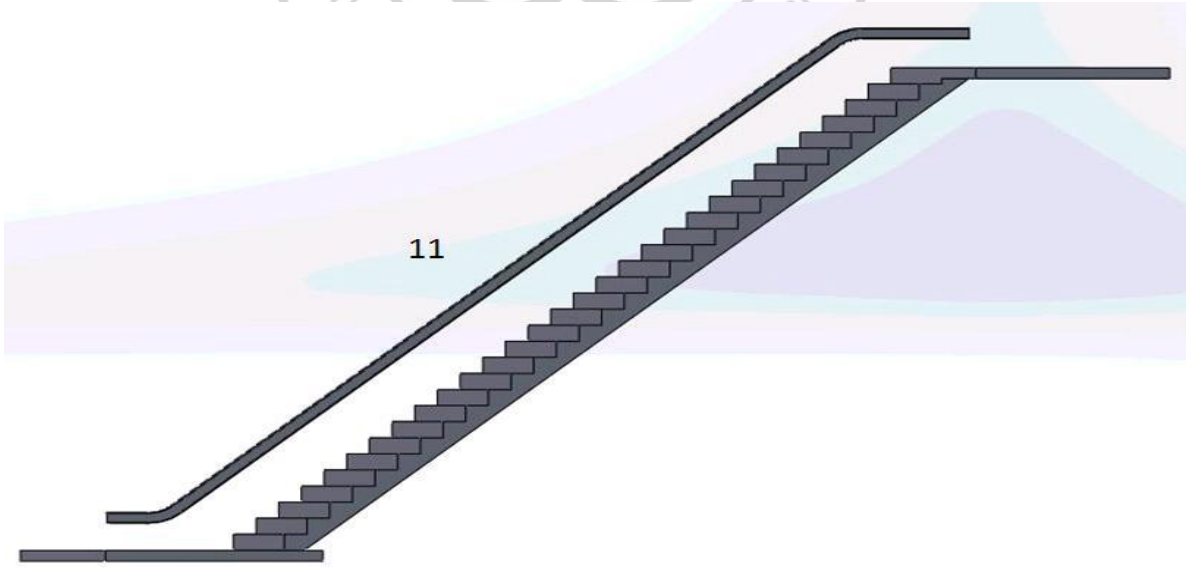


Figure 19: Rail and staircase

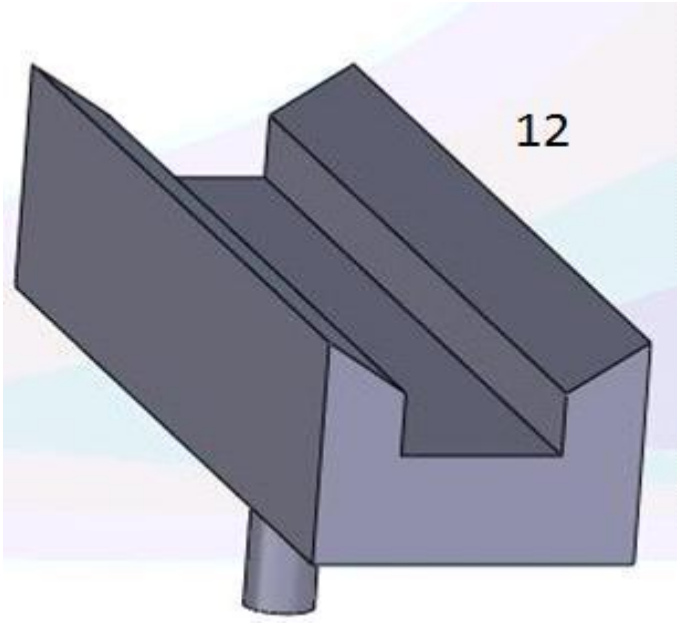


Figure 20: Wheel directing path

4.1.2 Sub-assemblies' functions and descriptions table

The five sub-assemblies' functions and their related components are analyzed in table 8.

Table 8: Sub-assemblies' functions and descriptions

Sub-Assemblies	Main function	Related Component	Task description
Rail	Way leading for the carrier	Rail	The rail is mounted on the wall and parallels to the stairway. This sub-assembly plays the role as a way for the carrier to slide on it.
Carrier	Carrying	Carrier	The carrier is the main motor of the system. It connects to the loading machine and wheelchair. It can slide on the rail and drag on those two up and down stair.
Connecting block 1	Connecting	Connecting block 1	The task of this part is to connect the carrier with the loading machine.

Loading machine	Load/Unload Wheelchair	Hook bar	The hook bar is a bar with two hooks and three nuts. It can hook the cross bar of the wheelchair to lift up or lower it down according to the operation of the system.
		Supporting frame	This component is the main frame of the loading machine.
		Driving axle	The driving axle locates inside the supporting frame. It makes the hook bar raise to up and lower down.
		Supporting bar	This bar is under the loading machine and it supports for the wheelchair to have a balance angle during the

			operation.
		Motor	The motor affects the driving axle raise up and lower down the hook bar.
		Connecting block 2	This component connects the motor with the driving axle inside the supporting frame
	Connecting	Connecting block 1	This block connects the carrier with the loading machine
		Supporting bar	When loading hooks the wheelchair up, this bar give the lower of wheelchair a position to press on so it can keep balance after connecting.
		Hook bar	The hook bar is the main part of the loading-machine that connects with the

			wheelchair.
	Stabilizing	Gearbox	The Gearbox is designed with a balance adjustor. This part has a ball-bearing can rotate and two block tracks can keep the wheelchair stable during the operation.
		Supporting bar	The main function of the supporting bar is to locate the wheelchair into a balance position.
Wheel directing path	Way leading for the wheelchair	Wheel directing path	This sub-assembly plays a role as a direction to help the wheelchair easily move to the right position of the system.

Each component of every sub-assembly is analyzed in detail for their specialities and to figure out how they help with the related functions. The analysis table gives us a

more general view about the functions and operations of each sub-assembly with their components as well as their contributions to the system.

4.2 Analyzing of inventive principles to the functions

In chapter 3, through analyzing the engineering parameters contradictions matrix table, we identified seven inventive principles that can solve the weak points of the old system and develop a better system with more preeminent and innovative functions. Each inventive principle can apply and satisfy different function requiments of the system. Table 9 describes the appications and efffects of each principle on different function requirements.

Table 9: Inventive principles and related function requirements

	Flexibility	Safety	Balance	Space saving	Convenience	Stabilization
Principle 1 Segmentation	●			●	●	
Principle 10 Prior Action		●	●			●
Principle 13 The other way round	●				●	
Principle 14 Curvature	●	●	●			●
Principle 15 Dynamics	●			●	●	
Principle 17	●			●		

Another Dimension						
Principle 35 Parameter Changes	●	●			●	

Principle 1: Segmentation

We divided the system into independent parts and they can support each other in an optimal way. Hence, this structure can increase the flexibility of the new system. In this system, we have four main parts: wheelchair, carrier, gearbox and rail. The wheelchair can be connected or released from the gearbox for using operation which also increases the convenience for users. Besides, the rail is designed to mount on the wall and parallel to the stair. Therefore, it will also save the space for the stair as indicated in figure 21.

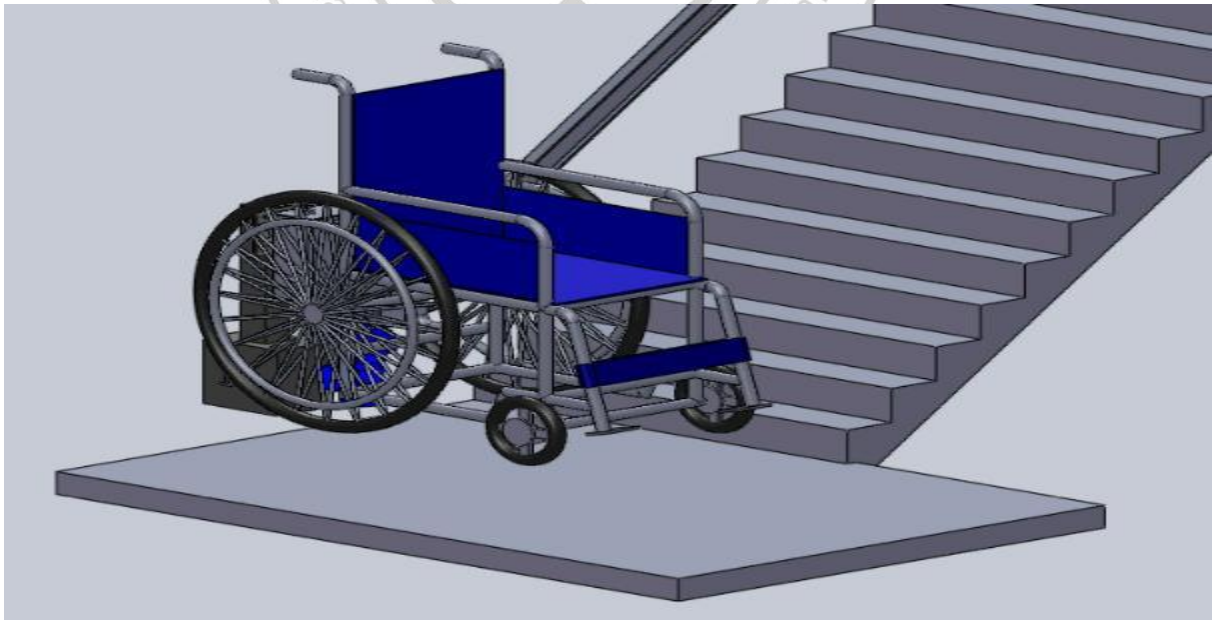


Figure 21: Loaded wheelchair before lifting up

Principle 10: Prior action

Preparative step is always important for a system and its process. In this innovation, directing axle is designed in order to make the wheelchair easier to move to the connection point of the system. Preferences of the wheel directing path helps the user to easily control the wheelchair by her/him self into an exact position which is linked with the gearbox. Besides, the hook-system and supporting bar can combine together to assure a stable and safe status.Thus, the wheelchair will be lifted and ready for the moving upward or downward process. Figure 22 shows the positions of the wheelchair, hook bar and supporting bar before the combination.

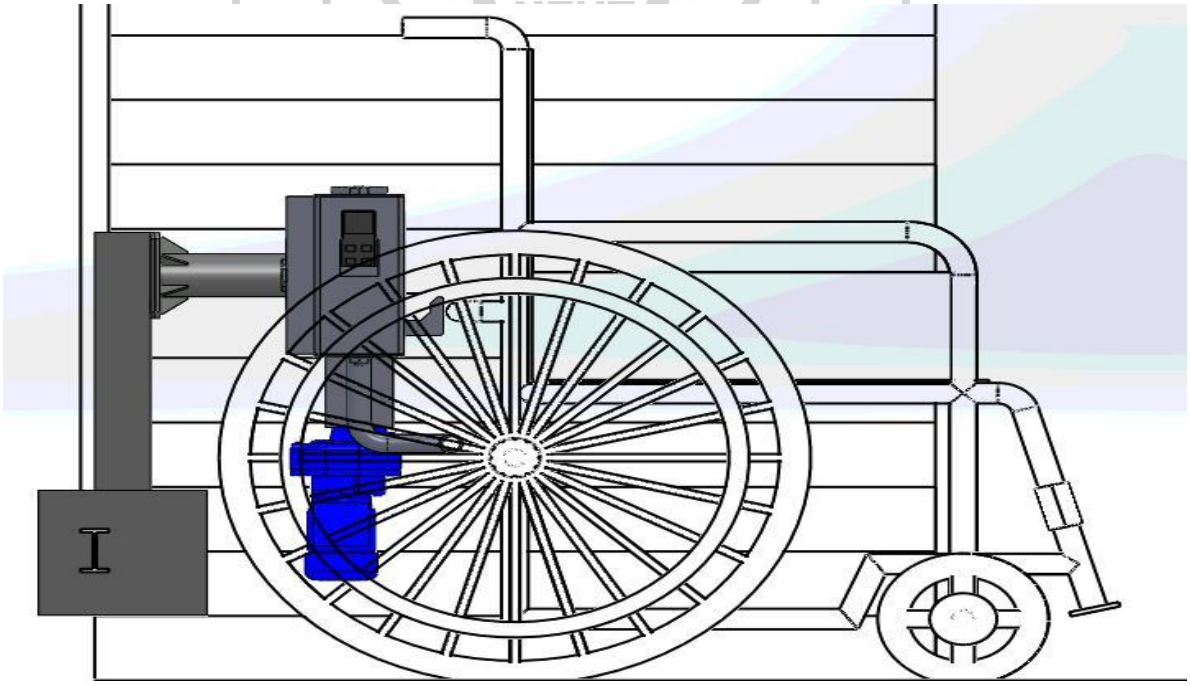


Figure 22: Wheelchair and hook position

Principle 13: The other way round

Instead of making the chair which to fixed to the system (just like the old system), the wheelchair can be mobilized, connected to or separated from the system. With the functions of hooking system and lifting system, the Gearbox creates the flexibility for the system and the convenience for the user. Figure 23 describes that the wheelchair moves out from the loading-machine after the operation.

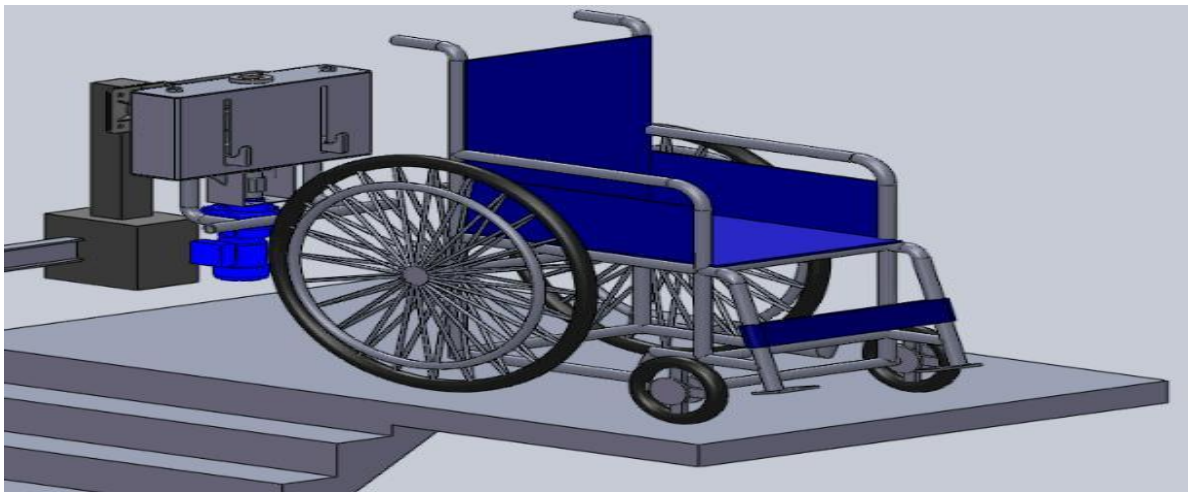


Figure 23: Wheelchair moves out after operation

Principle 14: Curvature

The rail is designed with a curved shape in order to serve the process, which makes the leaning angle compared to the vertical line becomes flexible. This can serve the movement of the carrier which is attached to the rail and makes it run easily and quite stably as shown in figure 24.

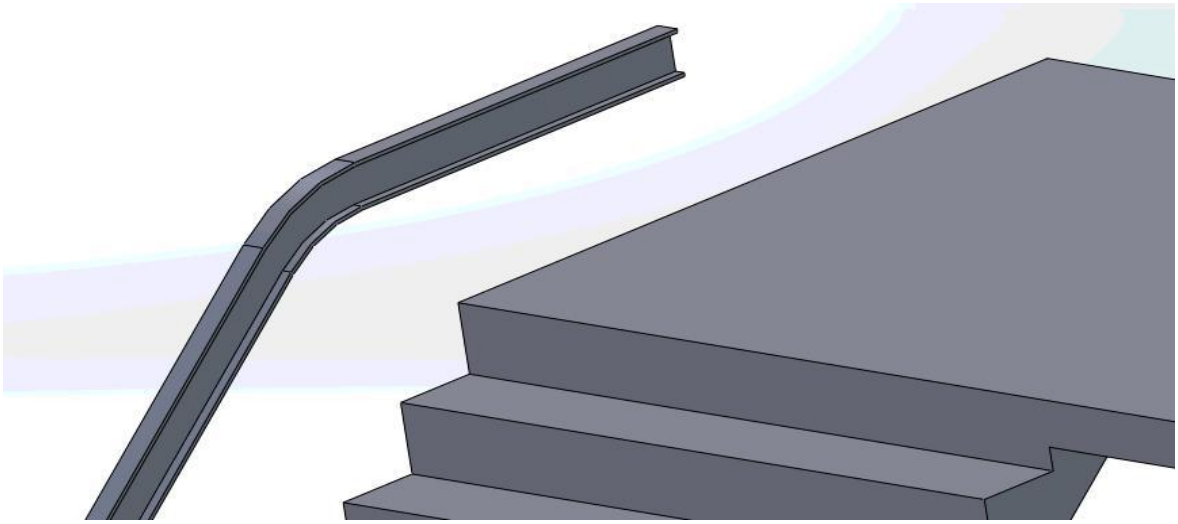


Figure 24: Curve of the rail

On the other hand, the balance adjustor is designed for rotated movement with two ball-bearings and two blocking tracks. The ball-bearing is designed on the gearbox which can be rotated and blocked in two directions. Its objective is keeping the wheelchair to rotate stabily at the angle of 90 degrees according to the floor during the process of moving up and down stairs. When the wheelchair has just moved upward, two wings of the connecting block 2 is located at the positions A and B. During the moving process of the wheelchair according to the leaning direction of the stair, the ball-bearing will be rotated and two wings of the connecting block 1 is moved and stayed at the positions C and D (see figure 25). The magnitude of AC and BD corresponds to the leaning angle of the stair. When moving to the ending position, two wings of the connecting block 2 are returned back to the positions of A and B. See in figure 23.

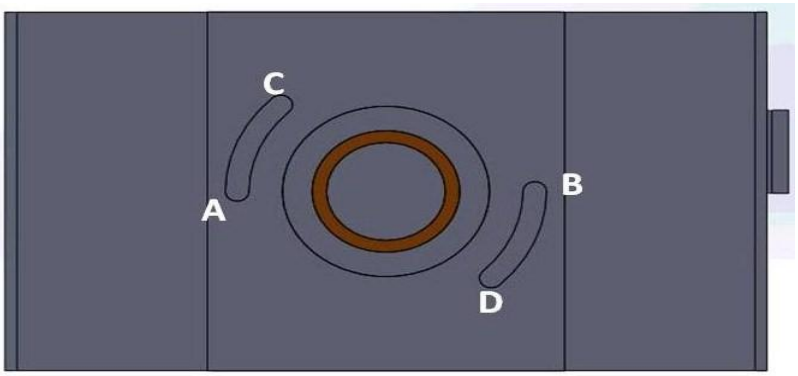


Figure 25: Balance adjustor with ball-bearing and 2 block tracks

From the design, we can understand that the curved and rotated movements have been improved with a high flexibility, balance, and stability for the user.

Principle 15: Dynamics

As the principle says “If your object is immobile, make it movable”, we change the wheelchair from an immobile chair into a free moving object. The system divides objects into parts that capable of moving relatively each other. This method can increase the degree of free motion and make environment dynamically change in accordence with the required conditions at each stage of operation. The rail will not be installed upon the stair anymore. Instead of that, the rail will be installed on the wall which means that the improvement for the using space of staircase is provided as shown in figure 26. On the other hand, the self control to the wheelchair system makes the user feel more comfortable. These changes remarkably increase the flexibility for the new system.

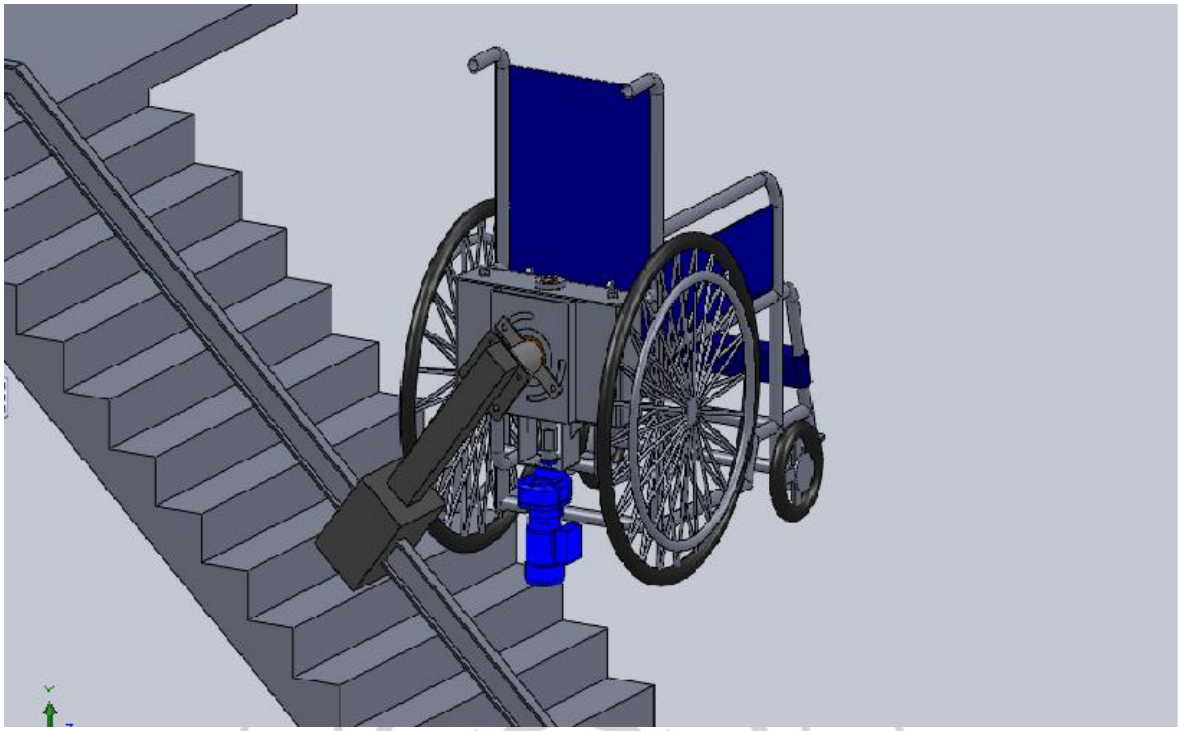


Figure 26: Wheelchair slides on the rail

Principle 17: Another dimension

We make the motion of the old system that it starts from the staircase and move to the wall and slide parallely along the stair. This leaves the free space for the stair so others people can walk freely. Parts of the system such as carrier, gearbox and wheelchair are installed reasonably which makes the system optimally save the space of the staircase.

Principle 35: Parameter changes

With this principle, we consider all the engineering parameters and flexibilities of the system. Many objects become more flexible such as wheelchair, rail, gearbox with

supporting of balance adjustor and hooking system. With these changes, a new design with preeminent properties has been made.

4.3 Patent analysis for innovative wheelchair elevating system

To further analyze the patents and have a comparison of techniques and functions between the old and the new system, we will do two steps. The first step is to draw substance-field analysis diagram for the innovative wheelchair system. The second step is to design a patent map that describes the innovative functions and techniques of the new system.

4.3.1 Draw substance-field analysis for innovative wheelchair elevating system

In this step, we draw five substance-field analysis diagrams in total. The first four diagrams are used to analyze four innovative functions and improvements in the new system. The fifth diagram briefly describes the whole operation of system by including the relationships among all the parts in the new system with functions. These figures will help to analyze the weak points of function requirements and solutions for them. The weaknesses, improvements and engineering relations are shown in figures 27- 30.

Figure 27 is constructed to analyze the space saving function between the two systems. For the old system, the rail is attached to the ground and so is the system. According to that circumstance, the space that is consumed by the system is quite large and leaves less space for other people to walk through the stair. The new system with

the rail installed upon the wall, the system becomes slimmer horizontally. Therefore, the space - consumption becomes less and gives more convenience and comfortable to other people.

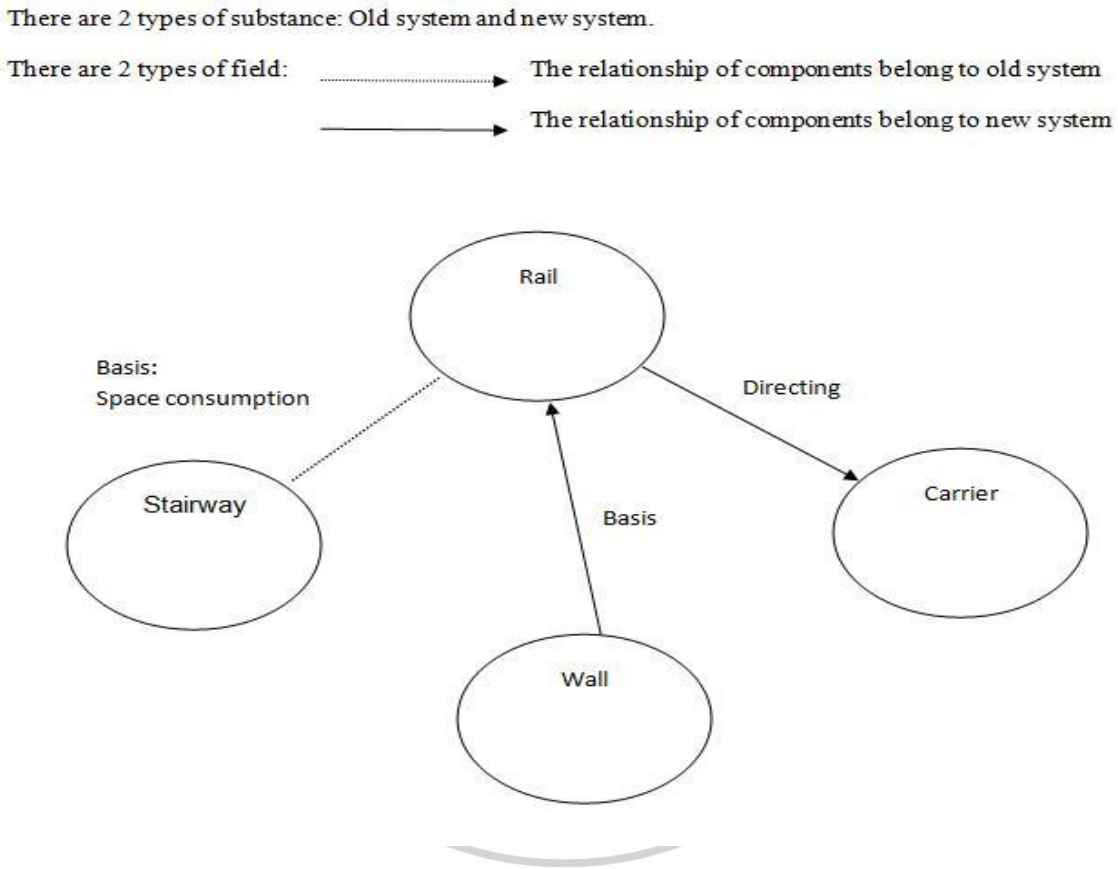


Figure 27: Substance field analysis diagram for space saving function

The flexibility of convenience improvements of the new system will be explained with the diagram in figure 28. In this figure, we divide the substance field analysis diagram into two parts, the left part belongs to the old system and the right part belongs to the new one. Thus, we can have a clear comparison between the two systems.

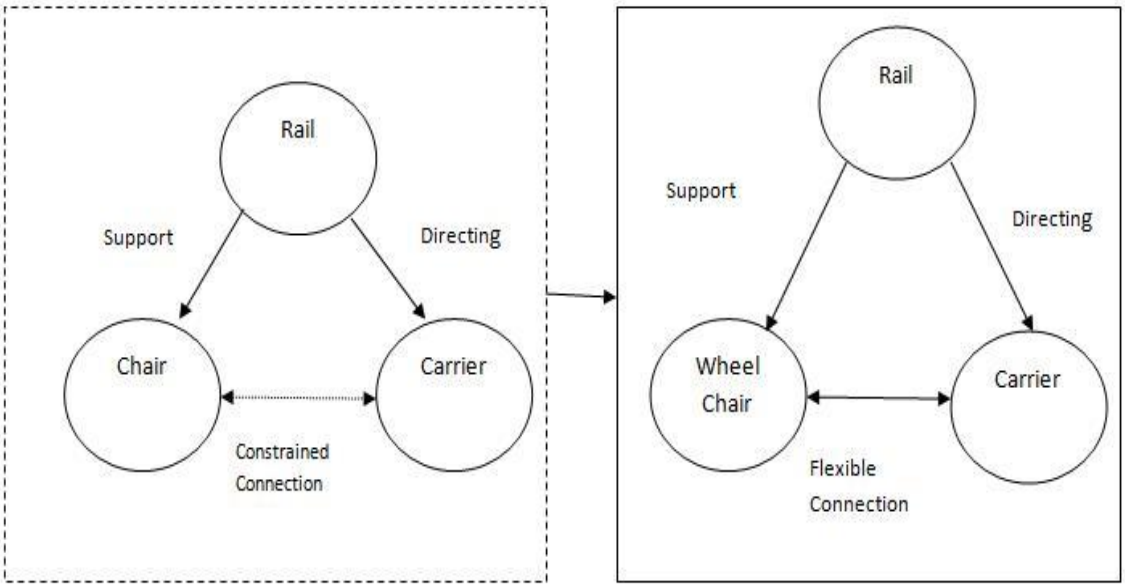


Figure 28: Substance field analysis diagram for object changes

As we know, the rail is the direction maker for the carrier as well as the wheelchair. The left figure with dashed boundary shows the relationships in the old system and the right figure shows the relationships in the new system.

The new system required the disabled people move from his/her wheelchair and gets up to the chair of the system in order to use the system. The user as well needs to move from the chair to get back to the wheelchair when they are at the destination. Many times, the disabled need helping hand to take back their wheelchair when they at destination. This issue causes a highly inconvenience to the user because the connection between the carrier and the chair is constrained.

That annoying issue has gone with the new system. The loading machine consists of hook bar, connecting block 2 and supporting bar which will hold the stability of the wheelchair. By loading machine, the carrier connects to the wheelchair with flexibility.

Therefore, all the users must do is moving his/her wheelchair to the hook bar and the supporting bar. The both hook-bar and supporting-bar will connect smoothly to the wheelchair when user is relaxing on the wheelchair. This innovative change has solved the annoying and inconvenient issue of the old system and offer more relax for the users once they use the system.

The following diagram analyzes the stabilization function of the system (see in figure 29).

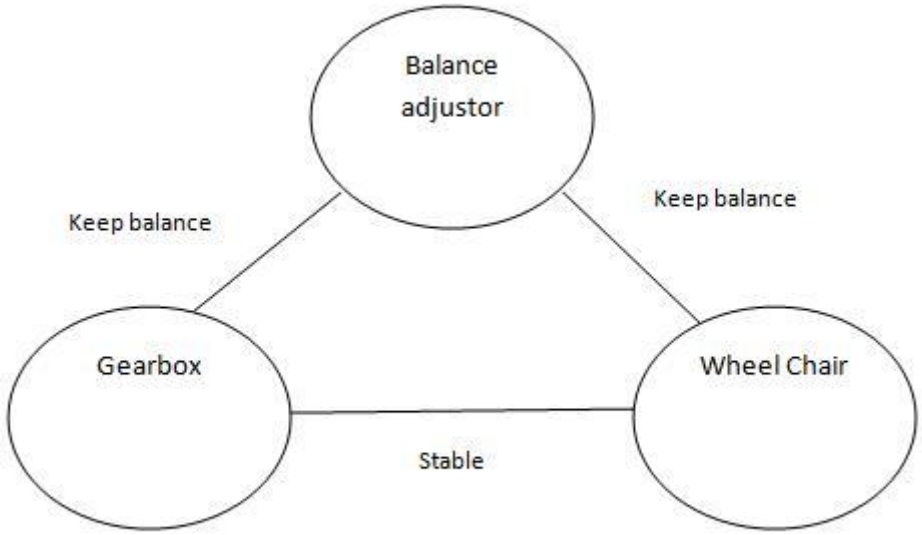


Figure 29: Substance field analysis diagram for stabilization function

When people think about making the wheelchair in order to connect directly to the system, they will get problem from the stability of the wheelchair due to the sensitivity of the disabled people. They cannot be harmed if they use the system.

Therefore, the question is "How to make the wheelchair becomes more stable and safer?" The balance adjustor is the answer. On the Gearbox, there are ball bearings and two blocking tracks. It will keep the balance for the wheelchair which enables those components to remain the angle of the wheelchair by 90 degrees vertically, and as a result the wheelchair will not be rotated.

The fourth diagram in figure 30 describes the relationships and effects of the hook system and the supporting bar on the wheelchair and gearbox.

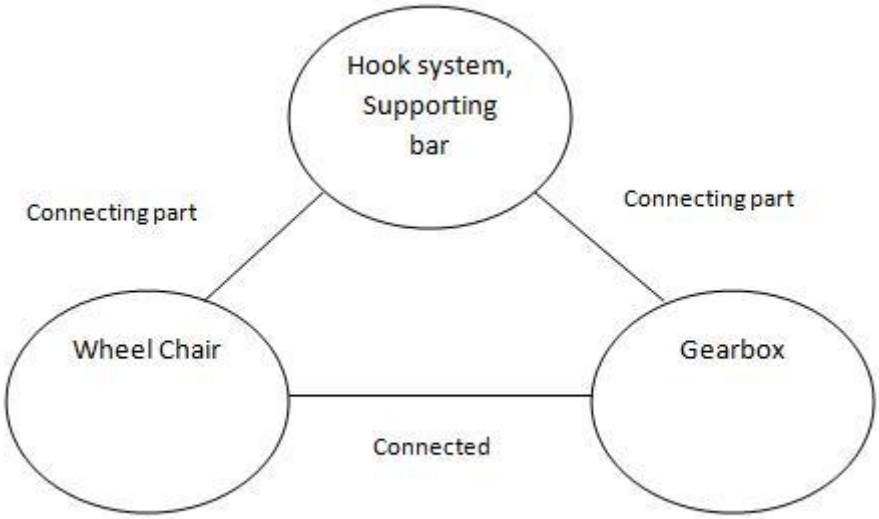


Figure 30: Substance field analysis diagram for connecting function

Those components are the connecting parts to both the wheelchair and the Gearbox. Through the hook system and supporting bar the wheelchair and the loading machine are connected indirectly. The hook system will hook the bar that located behind

the wheelchair. At the same time, the supporting bar will support the wheelchair from below during the wheel chair is lifted up. Therefore, it will not be rolled to the front. It keeps the user safe. It also makes the idea of connecting the wheelchair directly to the system comes to reality.

After all, we draw the final substance-field analysis diagram to analyze the whole operation of the system and innovative functions in figure 31.

(1) The wall is the support base for the rail. In the new system, instead of the rail located upon the stairway, the rail will be installed on the wall. The rail will make the path for the carrier lifting up and down the system.

(2) The power supply of the carrier in order to enable the carrier moving up and down - is the motor. The motor is not only the power supply for the carrier but also a component of the loading machine (1 of 8 components). In addition, the user can control the movement of the carrier by using the remote. The remote controller is put on a remote box in the rear of the Gearbox.

There are three types of substance: Components, technical systems and power.

There are three types of field with different symbols of lines:

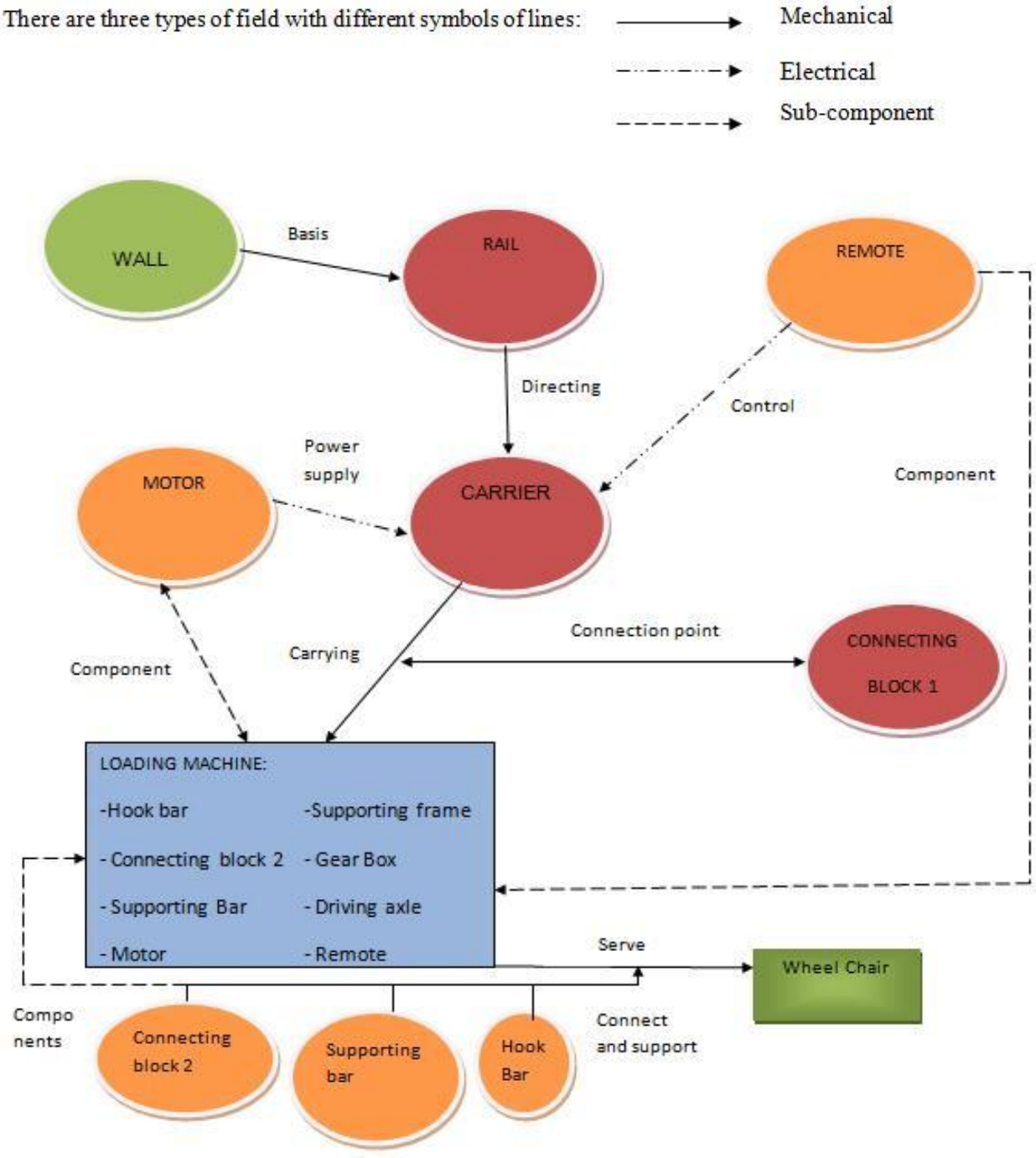


Figure 31: Substance field analysis diagram for the whole system

(3) The carrier can connect and carry the loading machine by means of the connecting block 2. This is the connection point between the carrier and loading machine. The loading machine gains the dynamic from the carrier will also can move up and down the stair. Components of loading machine are the connecting block 2, supporting bar and hook bar which will connect and support the wheelchair. Therefore the loading machine can serve the wheelchair in the purpose of lifting the wheelchair up and down the stairs.

4.3.2 Patent-mapping for the innovative wheelchair-elevating system

Through analyzing substance-field diagrams with new functions and the improvements of the limitations of the old system, we make the patent map to coordinate and integrate the innovative functions and techniques in wheelchair elevating system (see in table 10).

Table 10: Patent map for the innovative wheelchair-elevating system

	Functions	Techniques
Innovative wheelchair-elevating system	Flexibility: It can be easily assembled in and detached from the system during its operation. (3)	This system includes a carrier connected to a gearbox which can be slipped up and down on a rail. The gearbox has a hook part in order to seize and to release the wheelchair after the operation cycle is executed.

	Lifting and lowering the wheelchair (2), (3)	Once the wheelchair has been seized by the hook part which is located in the gearbox, the wheelchair is lifted up to a suitable height so that it can be ready for sliding on the rail. This step is done by the support of the motor placed inside the gearbox. When the process is finished, this part is lowered to the point where the wheelchair reaches the floor and stops the operation.
	Safety: Balancing and stabilizing the wheelchair (3)	Together with the hook part, the system has a supporting member which is placed in the under part of the gearbox. The aim of this supporting bar is to help the lower part of the wheelchair to be pressed against the gearbox and thus leads to a balancing for the wheelchair when it is seized and

		lifted.
		A ball-bearing was designed on the gearbox which can be turning locked and blocked in two directions. This part consists of a ball-bearing turned in the middle and two block tracks that will help the wheelchair always stabilizes at an angle of 90 degrees according to the floor.
	Moving the wheelchair up and down stair (1), (2)	The moving and sliding of the carrier on the rail leads to the whole system is seized with the wheelchair and lifted up and down stair.
	Convenience: It helps the user can easily control the wheelchair and use the system by him/her self. (2)	The wheel rail way helps the user by her/him self can easily control the wheelchair into a correct position which is linked to the gearbox.
		The system has a remote control

		placed on the gearbox. This can be easily used.
	Space saving (1)	The rail was designed and fixed on the wall according to the direction of the stair which results in the saving of the using space of the stair.

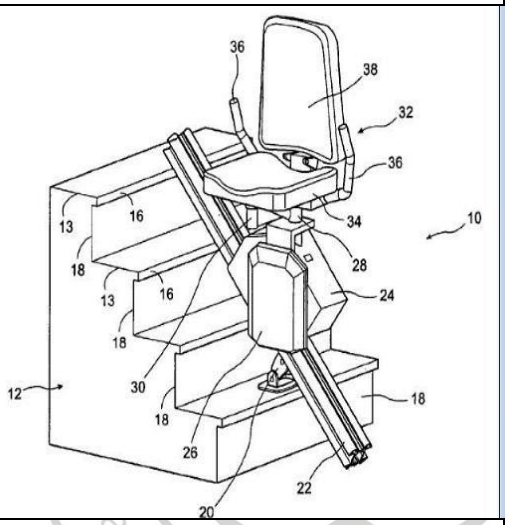
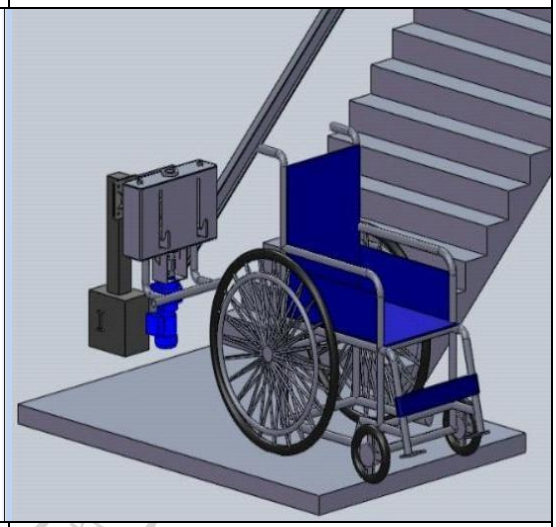
Every innovative function of the system can be satisfied by one or more techniques. One component can play many roles and affects different functions or techniques. Mechanical and electrical techniques together with components make close relations that can improve the functions for the system.

4.4 Evaluation of stair-lift device and innovative wheelchair elevating system.

From the selected patents, the stair-lift device (Patent number US 7225899B2), is a system designed to serve old people and disabled people in moving up and down stairs. This system is considered as one of the best device in aiding users in daily life. Innovative wheelchair elavting system has been designed based upon on the stair-lift device as well. Table 11 describes the comprarison between the stair-lift device (Patent number US 7225899B2) and the innovative wheelchair elevating

system.

Table 11: Table of comparison between the stair lift device (Patent number US 7225899B2) and the innovative wheelchair elevating system

Name of system	Stair-lift device (Patent number US 7225899B2)	Innovative wheelchair elevating system
Illustration of system		
Typical users	More convenience for old people who do not have a strong status to move up and down stair. There are still problems for disabled people when they want to sit and move from the chair as the system is used. They might need assistances from other people	Most users are disabled people. The system is designed specially to compatible to wheelchairs. All the disabled people need is stay remain on the wheelchair and operate the system.

Space saving	The rail is installed upon the stair. With this design, the system will need a lot of space to operate. It leads to high space - consumption and as well as inconvenience to other people who use stair by proper way.	Instead of installed upon the stair, the rail is installed upon the wall. This design will help the system save a lot of using space to the stair. The space consumption is reduced significantly and raises the convenience for other people to use the stair.
Flexibility	The chair is connected permanently to the carrier. It makes the system lack of flexibility. It might require complicated manipulations for users to get on the chair or the aid from other people.	The role of the chair is replaced by the wheelchair with mobilization. It is acquired the ability of connect and detach to the system before or after using. Disabled people can operate totally by themselves with easy. They just need to move the wheelchair to the connecting point by normal way and the system will automatically do the connecting and detaching when it get started.
	The shape of the rail and the slide of the system are designed as a trajectory of straight line. It leads	The rail is installed to the wall and it can be designed with many flexible shapes. This characteristic makes the

	the direction for the carrier to be a straight line. Therefore, it is difficult for the system to be applied to stair with more complicated shape such as curved stair.	system becomes suitable and simple to be applied to many kinds of stair such as curved stair.
Example of curved stair		
Safety	The chair is connected as a fixed part to the carrier. This leads to difficulties for users to get on or get off the chair during the operation of the system. Especially, if users do not have a good physically condition, they might get injure easily.	The design of system shows that there are supporting bars and balance adjustor that supports the wheelchair maintains a certain position and angle. During the moving, the wheelchair will be kept as 90 degree vertically and floating along with the carrier with stability.

	The chair is designed without foot-base for users. Beside, the two of handrails are small and short. They are not safe enough for users. The safety of the chair of this system is quite low for users.	During the process of connecting the wheelchair to carrier, users must move the wheelchair backward to the system. The view will be blocked due to backside. The wheel directing path will helps the users can easily determine the path for wheelchair. Hence, it guarantees the safety for connecting wheelchair to carrier process.
Convenience	The system in some points is without safety and flexibility to users especially if users are disabled people. Disabled people might need helps from others people to get on and get off the chair. They even are able to get injury.	The replacement of the chair by the wheelchair is innovative to system and useful to users. Users can manipulate when they are sitting on the wheelchair and control the wheelchair normally with simple and convenience.

With many improvements, the new system has increased the safety, the convenience and become more specialized.

Chapter 5: Conclusions

According to international organization, there are millions of people with disabilities in Europe, North America Asia and Latin America. Therefore, the demands of disabled people to integrate to community keep being higher than ever. Many engineers, researchers are moving on design equipments, systems in order to serve disabled people in activities of daily life such as moving up and down stairs, crossing roads, surfaces, etc. Those systems can help the disabled people to involved, contribute to society, reduces the burden for family and community, It truly is a good product satisfies the market's requirements and is a profitable invention.

The purpose of this thesis is presenting an innovative way to improve existing products that support the transportation of disabled people in various environments. The system mainly used by users who are disabled people and old people. Hence, its design must be qualified the safety, convenience and flexibility. The work is carried out by employing the approaches of TRIZ and patent map.

Patent map is a useful tool to describe and evaluate clearly properties as well as assessment of patents. By using this method, patents have provided valuable data and knowledge to current status of supporting devices for disabled people. Tables of matrix draw out by using patent map provide a general view of techniques and functions of current patents. Patent map can be considered as an important step before trying to analyze and generate ideas for improvements. TRIZ is an excellent method for improving and inventing new ideas, new products. In this thesis, the TRIZ's tools

analyzed US patents that can be found on the internet and many other sources. Through the analysis, sixteen patents have been selected as the most suitable devices to be researched, compared and potential to be improved. After analysis, we get contradiction matrix of techniques-functions and their efficiency of patents. Based on information that has been collected, TRIZ becomes a tool for generating new ideas for improvement.

The design of innovative wheelchair elevating system for disabled people creates improvements for strong points and annihilates weak points of the current patents. Beyond disabled people as mainly users, this system are also able to assist weak elderly people and injured people who lack of physical conditions and have difficulties in normal activities. For instant, athletes get injured during practice, competition or due to a traffic accident. In the case of recuperating patients in the process of recover, this system is able to be an incredibly useful assistant tool, brings comfort to those who get their physical abilities declined or eliminated. With new improvements, the system will operate safer and more comfortable and handful to helping the transportation of disabled people, typically move up and down stair. This system reduces space consumption, annihilates the need for external aiding, easy to be applied in a variety of environments. Last but not least, the system is significantly increased in safety, convenience, flexibility and simple in operating. This system surely helps disabled people feel more confident in life, more flexible in time. They are able to have certain contributions and decrease the burden for family as well as society.

On the other hand, we can present ideas to improve this design in the future. A

wheelchair can be replaced by a plat form or a cage that can connect to a loading-machine. The system then, beside the use of transporting people, can also be used as an elevator transporting goods and heavy family things like televisions, refrigerators, furniture, etc. Furthermore, materials, shape designs, color can be considered and improved in order to produce a better new system. Together with the developments of technology, we are able to highly hope that there will be many innovations as well as new systems will be developed upon this basic invention.

6. References

[1] Genrich Altshuller, 1999, The innovation algorithm, USA: Technical Innovation CentreInc.

[2] Ashton, W., Sen, R., 1988, Using patent information in technology business planning—II. Research Technology Management 32, 36–42.

[3] Austin, D., 1993, An event-study approach to measuring innovative output: the case of biotechnology. American Economic Review 83, 253–258.

[4] Bader, M., 2008, Managing intellectual property in the financial services industry sector: learning from Swiss Re. Technovation 28, 196–207.

[5] Brian Mitchell Rost, 2002, “Stair walker”, United States patent, No.US 6,453,921 B1.

[6] Campbell, R.S., 1983, Patent trends as a technological forecasting tool. World Patent Information 5 (3), 137–143.

[7] Chambliss et al., 2009, “Stair chair with an adjustable glide track resistance and braking device”, United States patent, No. US 7,520,347 B2.

[8] Chang ho Son, Yongyoon Suh, Jeonghwan Jeon, Yongtae Park, 2011, Development of a GTM-based patent map for identifying patent vacuums.

[9] Chen, J. L., Liu, S. J., & Tseng, C. H., 2000, Technological innovation and strategy adaptation in the product life cycle. Technology Management: Strategies and Application, 5 (3), 183–202.

[10] Daim, T., Rueda, G., Martin, H., Gerdsri, P., 2006, Forecasting emerging technologies: use of bibliometrics and patent analysis. Technological Forecasting & Social Change 73, 981–1012.

[11] Darrell Mann, 2004, Comparing The Classical and New Contradiction Matrix-Part1-Zooming Out. The TRIZ Journal.

[12] Darrell Mann, Ellen DOMB, 1999, 40 Inventive (business) principles with examples. The TRIZ Journal.

[13] Dirk Van Hooydonck, Eric Demeester, Alexander Hüntemann, Johan Philips, Gerolf Vanacker, Hendrik Van Brussel , Marnix Nuttin, 2010, Adaptable navigational assistance for intelligent wheelchairs by means of an implicit personalized user model, Robotics and Autonomous Systems 58, 963-977.

[14] Domb, E., 1997, 40 inventive principles with examples. TRIZ Journal of 1997, July.

[15] Domb, E., 1997, The idea final result: tutorial. TRIZ Journal of 1997 February.

[16] Domb, E., 1997, Using the ideal final result to define the problem to be solved. TRIZ

Journal of 1997 February.

[17] Ernst, H., 2001, Patent applications and subsequent changes of performance: evidence from time-series cross-section analyses on the firm level. Research Policy 30, 143–157. 225–240.

[18] George W. Kent Jr., 1993, “Portable stair lift”, United States patent, No.5, 193,650.

[19] Gordon Molnar, Peter Shaw, 2007, “Stair lift device”, United States patent, No.US7, 225, 899 B2.

[20] Hanel, P., 2006. Intellectual property rights business management practices: a survey of literature. Technovation 26 (8), 895–931.

[21] Henry Medina, 2003, “Collapsible chair”, United States patent, No.US6, 561,524 B1.

[22] Ideation International, 1999, Innovation WorkBench, Version 2.6. Southfield, MI.

[23] Japan Institute of Invention and Innovation (JIII), 2002, Guide Book for Practical Use of Patent Map for Each Technology Field.

[24] Jing Zhang, Jie Shang, 2010, Research on Developing Environmental Protection Industry Based on TRIZ Theory.

[25] Johnson et al., 1996, “Stair climbing wheelchair”, United States patent, No.5, 577,567.

[26] Joseph Francis Schradder, 2005, “Ergonomically designed walker”, United States patent, No.6, 959,716 B1.

[27] Jukka Ojasalo, Heikki Seppälä, Niko Suomalainen, Rob Moonen, 2010. “Better technologies and services for smart Homes of disabled People: empirical findings from an explorative study among intellectually disabled,” 2nd International Conference on Software Technology and Engineering.

[28] Jung, S., 2003. Importance of using patent information. In: WIPO—Most Intermediate Training Course on Practical Intellectual Property Issues in Business. World Intellectual Property Organization (WIPO), Geneva, pp. 10–14.

[29] Keiichi Yamada, 2004, “Chair for stair elevating lift”, United States patent, No.US D489, 859 S.

[30] Kenneth R. Overmoe, 1981, “Step walker”, United States patent, No.4, 253, 287.

[31] Kenneth Ray Cox, 2002, “Battery powered stair-climbing wheelchair”, United States patent, No.US 6, 484, 829 B1.

[32] Kramer et al., 2009, “Home care equipment system”, United States patent, No.US 7, 537, 069 B2.

[33] Kuznets, S., 1962, Innovative activity: problems of definition and measurement. In: Nelson, R. (Ed.), The rate and direction of inventive activity. Princeton University Press, New Jersey.

[34] Lazo Starcevic, 2010, “Wheelchair for stairs and obstacle”, United States patent, No.US 2010/0096194 A1.

[35] Lerner, J., 1994, The importance of patent scope: an empirical analysis. RAND Journal of Economics 25, 319–332.

[36] Liu, S. J., & Shyu, J., 1997, Strategic planning for technology development with patent analysis. International Journal of Technology Management, 13(5/6), 661–680.

[37] Liu, S.J., 2003, A route to a strategic intelligence of industrial competitiveness. In: Proceedings of the First Asia-Pacific Conference on Patent Maps, 2003, pp.2–13.

[38] Martin G. Moehrl, 2005, What is TRIZ? From conceptual basics to a framework for research.

[39] Max Lehner, 1990, "Stair-climbing wheelchair carrier with crawlers", United States patent, No.4, 898,256.

[40] P. Martý´n, M. Mazo, I. Ferna´ndez, J.L. La´zaro, F.J. Rodrý´guez, A. Gardel, 1999, Multifunctional and autonomous, high performance architecture: application to a wheelchair for disabled people that integrates different control and guidance strategies, Microprocessors and Microsystems 23 1–6.

[41] Park, Y., Yoon, B., Lee, S., 2005, The idiosyncrasy and dynamism of technological innovation across industries: patent citation analysis. Technology in Society 27 (4), 471–485.

[42] Shane, S., 2001, Technological opportunities and new firm creation. Management Science 47, 205–220.

[43] Sung joo Leea, Byung unYoonb, Yong taeParkc, 2009, An approach to discovering new technology opportunities: keyword-based patent map approach technovation 29481–497.

[44] Te-Sheng Li, Hsing-Hsin Huang, 2009, Applying TRIZ and fuzzy AHP to develop innovative design for automated manufacturing systems, expert Systems with

applications 36, 8302–8312.

[45] Thomas T. Frankie, 2009, “Automated wheelchair”, United States patent, No.US7, 503, 567 B2.

[46] Tseng, Y., Lin, C., Lin, Y., 2007a, Text mining techniques for patent analysis. Information Processing and Management 43 (5), 1216 –1247.

[47] Tseng, Y., Wang, Y., Lin, Y., Lin, C., Juang, D., 2007b, Patent surrogate extraction and evaluation in the context of patent mapping. Journal of Information Science 33 (6), 718–736.

[48] UNESCAP, 2000, “Conditions to promote barrier-free tourism for people with disabilities and older persons,” Presentation at the national workshop on sustainable tourism development in China, Tianjin, China: Economic and Social Commission for Asia and the Pacific.

[49] Valencia, 2002, “Chair lift for stairs”, United States patent, No.US 6, 360, 833 B1.

[50] Way et al., 2003, “Stair chair”, United States patent, No.US 6, 648, 343 B2.

[51] WIPO, 2003, Patent map with exercises (related). WIPO-MOST inter- mediate training course on practical intellectual property issues in business, Theme 16.

[52] Xin jun Zhao, Ming xi Hou, Ai Li, 2005, Research on Production Technical Forecasting Supporting System Based on TRIZ. Control and Decision Science Annual Conference, 2005 (6): 124-131

[53] Yang et al., 2011, “Stair climbing aid”, United States patent, No.US 7, 950, 498 B2.

[54] Yoon, B., Yoon, C., & Park, Y, 2002, On the development and application of a self organizing feature map-based patent map. R&D Management, 32 (4), 291–300.

[55] Yuksel Ozturk, Ali Yayli, Mehmet Yesiltas, 2008, “Is the Turkish tourism industry ready for a disabled customer’s market? The views of hotel and travel agency managers,” tourism management, 29, 382–389.

[56] Zlotin Boris, Zusman Alla, 2001, TRIZ beyond technology: The theory and practice of applying TRIZ to non-technical areas. The TRIZ Journal.

Appendix 1: Sixteen reviewed patents

Number	Patent title	Patent number
1	Ergonomically designed walker	United States patent, No.6,959,716 B1
2	Stair-lift device	United States patent, No.US 7,225,899 B2
3	Automated wheelchair	United States patent, No.US 7,503,567 B2
4	Step walker	United States patent, No.4,253,287
5	Portable stair-lift	United States patent, No.5,193,650
6	Stair climbing wheelchair	United States patent, No.5,577,567
7	Chair lift for stairs	United States patent, No.US 6,360,833 B1
8	Stair walker	United States patent, No.US 6,453,921 B1
9	Battery powered stair-climbing wheelchair	United States patent, No.US 6,484,829 B1
10	Collapsible chair	United States patent, No.US 6,561,524 B1
11	Stair chair	United States patent, No.US 6,648,343 B2
12	Stair chair with an adjustable glide track resistance and braking device	United States patent, No.US 7,520,347 B2
13	Stair climbing aid	United States patent, No.US 7,950,498 B2

14	Wheelchair for stairs and obstacle	United States patent, No. US2010/0096194 A1
15	Chair for stair elevating lift	United States patent, No.US D489,859 S
16	Stair-climbing wheelchair carrier with crawlers	United States patent, No.4,898,256

Patent 1: Ergonomically designed walker

US006959716B1

(12) **United States Patent**
Schrader

(10) **Patent No.: US 6,959,716 B1**
(45) **Date of Patent: Nov. 1, 2005**

(54) **ERGONOMICALLY DESIGNED WALKER**

(76) Inventor: **Joseph Francis Schrader**, Campion Rd., New Hartford, NY (US) 13413

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

(21) Appl. No.: **09/699,328**

(22) Filed: **Oct. 30, 2000**

(51) **Int. Cl.**[7] **A45B 3/00**; A47C 1/00
(52) **U.S. Cl.** **135/66**; 135/67; 135/68; 482/75; 297/5; 297/183.1; 297/195.11
(58) **Field of Search** 135/65, 67, 68, 135/66; 297/4, 5, 183.1, 195.11; 482/75, 482/66; 602/26, 28, 29; 623/27, 28; 280/14.27; D21/413; D12/130, 133, 129

(56) **References Cited**

U.S. PATENT DOCUMENTS

2,778,370	A *	1/1957	Chamblee	135/68
2,915,760	A *	12/1959	Bair	623/27
3,254,659	A *	6/1966	Williams	135/69
3,272,210	A *	9/1966	Boruvka	135/69
4,141,375	A *	2/1979	Tykwinski	135/66
4,254,948	A *	3/1981	Jacobs	482/68
4,641,882	A *	2/1987	Young	297/183.1
5,178,595	A *	1/1993	MacGregor	482/75
5,300,016	A *	4/1994	Marlatt	602/16
5,411,313	A *	5/1995	Counihan et al.	297/118
5,524,658	A *	6/1996	Schrader	135/72
5,927,797	A *	7/1999	Ferguson	297/4
6,062,638	A *	5/2000	Ferguson	297/4
6,439,250	B1 *	8/2002	Balan	135/67
6,783,134	B2 *	8/2004	Geary	280/21.1
2003/0027689	A1 *	2/2003	Chien	482/23
2003/0222419	A1 *	12/2003	Geary	280/21.1
2004/0100044	A1 *	5/2004	Monike et al.	280/14.1

FOREIGN PATENT DOCUMENTS

DE	4034755	5/1992
FR	2611492	9/1988
RU	2012315	5/1994

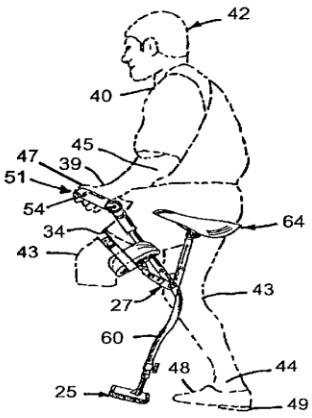
* cited by examiner

Primary Examiner—Robert Canfield
(74) *Attorney, Agent, or Firm*—Wall Marjama & Bilinski LLP

(57) **ABSTRACT**

A bicycle seat supported generally by a tubular V-shaped configuration with an offset seat post to allow for padded leg cradle supports, padded handles and adjusting handle grip bars. The bottom of the ergonomically designed offset walker frame has an adjustable rubber tip for height adjustment. The seat is on a fixed top post. The position can be adjusted up and down in height, forward and back and front to back. Using the handle grips the user can straddle the bicycle seat and rest the injured limb on the leg cradle supports without having to strap the injured limb to the walker frame. The walker frame has been ergonomically designed for balance. The tubular construction is comprised of a number of offsetting bends and spacers, which offset the leg cradle to the proper distance for comfort and balance. The padded handles are forward of the seat with rotating handle grip bars on the ends of the padded handles which gives the user more comfort and better control when using the walker frame making it possible to maintain better balance. The hands and wrists keep the frame in a vertical position and maintain control over the stabilization foot for better balance. The offset bends in the frame move the stabilization foot out of the way of the good leg and foot making for a less cumbersome and more comfortable natural stance. The stabilization foot is under the injured limb giving the injured user better balance, which improves comfort and makes for a simple easy to use walking device.

14 Claims, 4 Drawing Sheets



Patent 2: Stair-lift device

US007225899B2

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

(10) **Patent No.: US 7,225,899 B2**
(45) **Date of Patent: Jun. 5, 2007**

(54) **STAIR LIFT DEVICE**

(75) Inventors: **Gordon Molnar**, Toronto (CA); **Peter Shaw**, Richmond Hill (CA)

(73) Assignee: **Rutherford Independence Limited**, Concord, Ontario (CA)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 141 days.

(21) Appl. No.: **10/822,554**

(22) Filed: **Apr. 12, 2004**

(65) **Prior Publication Data**

US 2005/0224293 A1 Oct. 13, 2005

(51) **Int. Cl.**
B66B 9/08 (2006.01)

(52) **U.S. Cl.** **187/201**; 187/202; 187/271; 187/277; 187/300; 318/17; 414/550; 248/425; 297/183.9; 297/463.1

(58) **Field of Classification Search** 187/200, 187/216, 220, 276, 290, 302, 410; 104/300, 104/302

See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

2,507,887 A * 5/1950 Cheney 187/201
2,888,099 A * 5/1959 Hoffmann 187/202
3,830,379 A * 8/1974 Dechansreiter et al. 414/274
4,043,427 A 8/1977 Ackerman 187/201
4,913,264 A * 4/1990 Voves et al. 187/201
5,230,405 A * 7/1993 Bartelt 187/201
5,316,258 A * 5/1994 Gauger et al. 248/548
5,533,594 A 7/1996 Tremblay et al. 187/201
6,000,758 A * 12/1999 Schaffner et al. 297/344.17

FOREIGN PATENT DOCUMENTS

EP 1 197 465 A1 4/2002
EP 1 035 064 B1 7/2004
EP 1 125 882 B1 11/2004

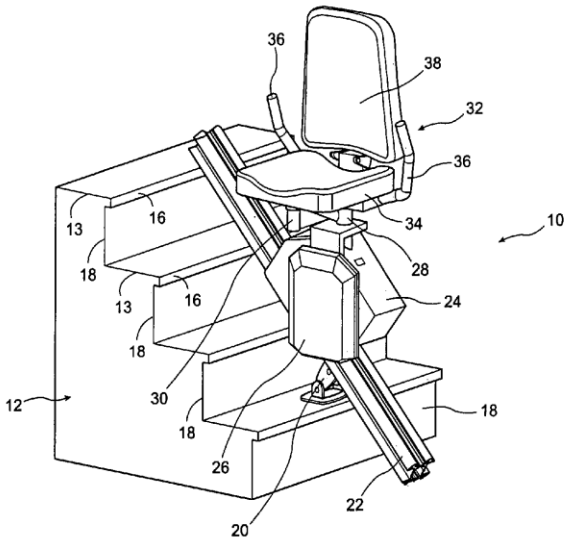
* cited by examiner

Primary Examiner—Gene O. Crawford
Assistant Examiner—Stefan Kruer
(74) *Attorney, Agent, or Firm*—Vidas, Arrett, Steinkrau

(57) **ABSTRACT**

A stair lift for lifting and lowering at least one person on a rail on a stairway. There is a carriage mountable to the rail, the carriage having a track engaging drive, and a motor to power the drive, the powered drive causing the carriage to move along the rail. There is a central support post mounted on the carriage and an offset arm connected to the seat support post. The offset arm is mounted to the carriage in one of a left side or a right side position. A seat is mounted on the offset arm, and a notched plate secures the seat in position on the offset arm in either the left side or right side position and permits the seat to swivel between a sideways facing position and an upward facing position to facilitate the person getting into and out of the seat.

42 Claims, 12 Drawing Sheets



Patent 3: Automated wheelchair

US007503567B2

(12) **United States Patent**
Frankie

(10) **Patent No.: US 7,503,567 B2**
(45) **Date of Patent: Mar. 17, 2009**

(54) **AUTOMATED WHEELCHAIR**

(76) Inventor: **Thomas T. Frankie**, 525 Torrey Point Rd., Del Mar, CA (US) 92014

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 105 days.

(21) Appl. No.: **11/787,620**

(22) Filed: **Apr. 16, 2007**

(65) **Prior Publication Data**

US 2008/0251300 A1 Oct. 16, 2008

(51) **Int. Cl.**
B62B 5/02 (2006.01)

(52) **U.S. Cl.** **280/5.2**; 180/8.2

(58) **Field of Classification Search** 280/5.2; 180/8.2

See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

4,061,199	A *	12/1977	Last	180/8.2
5,492,390	A *	2/1996	Kugelmann, Sr.	301/5.1
5,812,978	A *	9/1998	Nolan	704/275
5,839,795	A *	11/1998	Matsuda et al.	301/5.1
6,328,120	B1 *	12/2001	Haussler et al.	180/8.3
D540,503	S *	4/2007	Tsang	D34/28
7,380,618	B2 *	6/2008	Gunderson et al.	180/8.2
2004/0032119	A1 *	2/2004	Tran et al.	280/755
2005/0279540	A1 *	12/2005	Wisner et al.	180/65.1

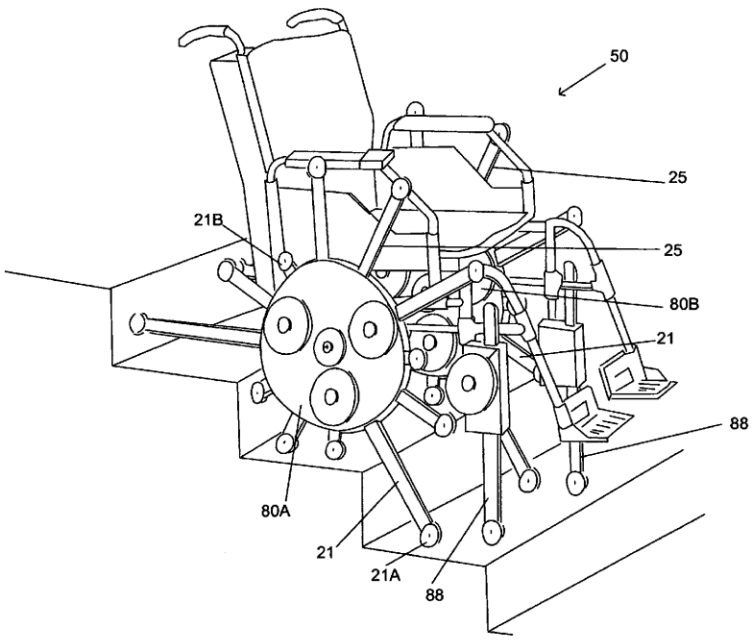
* cited by examiner

Primary Examiner—Paul N Dickson
Assistant Examiner—Tashiana Adams
(74) *Attorney, Agent, or Firm*—John R. Ross; John R. Ross, III

(57) **ABSTRACT**

An automated wheelchair for moving over a contact surface. The automated wheelchair includes an operator chair for seating the wheelchair operator, a control computer, an operator input device for transmitting operator inputs to the control computer, and two wheelchair wheels for propelling the wheelchair. Each wheelchair wheel includes extendable and retractable spokes. The extension and retraction of each spoke is controlled by a motor. At the ends of each spoke are contact sensor devices. The control computer is programmed to receive inputs transmitted from the contact sensor devices to record contact position data. The control computer generates and sends control signals to each spoke motor in response to the operator inputs and in response to the contact position data generated by the contact sensor devices.

21 Claims, 16 Drawing Sheets



Patent 4: Step Walker

United States Patent [19] [11] **4,253,287**

Overmoe [45] **Mar. 3, 1981**

[54] **STEP WALKER**

[76] Inventor: **Kenneth R. Overmoe,** 6644 Columbus Ave. South, Minneapolis, Minn. 55423

[21] Appl. No.: **52,757**

[22] Filed: **Jun. 28, 1979**

[51] **Int. Cl.**[3] **E04F 11/18**

[52] **U.S. Cl.** **52/184;** 135/65

[58] **Field of Search** 52/184; 182/3; 135/65, 135/67

[56] **References Cited**

U.S. PATENT DOCUMENTS

802,252	10/1905	Anderson	182/3
1,785,487	12/1930	McAvoy .	
2,576,556	11/1951	Babson .	
2,782,796	2/1957	Blue .	
3,421,529	1/1969	Vestal	135/67
3,591,874	7/1971	O'Kennedy	5/81

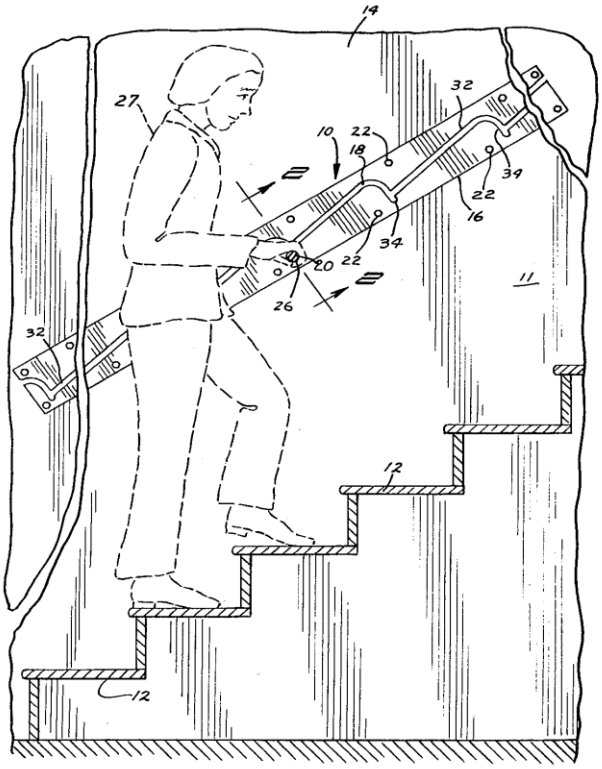
Primary Examiner—J. Karl Bell

Attorney, Agent, or Firm—Kinney, Lange, Braddock, Westman and Fairbairn

[57] **ABSTRACT**

A step walker for people with walking disabilities includes a pair of parallel, spaced-apart substantially flat, vertically faced guide railings fixedly positioned above either side of a stairway to lie in parallel relation to the stairway. Each railing is provided with a guide slot extending from top to bottom of the railing. These guide slots are defined by a plurality of ramp sections extending in direction up the stairway from a lower to an upper portion of the railing, and a plurality of ratchet tooth holding sections, one between each ramp section, the ratchet tooth holding sections extending in direction up the stairway from an upper portion to a lower portion of the railing. A walking bar slides in these guide slots to be brought to rest at the bottom end of each holding section so that the step walker user can support his weight on the bar while moving up or down from one step to the next. The user will then situate the walking bar in the bottom of the next adjacent holding section and use it as before to advance to the next step.

9 Claims, 5 Drawing Figures



Patent 5: Portable stair-lift

US005193650A

United States Patent [19]

Kent, Jr.

[11] **Patent Number: 5,193,650**

[45] **Date of Patent: Mar. 16, 1993**

[54] **PORTABLE STAIR LIFT**

[76] Inventor: **George W. Kent, Jr.**, 3522 Hampton Hwy., Yorktown, Va. 23693

[21] Appl. No.: **879,243**

[22] Filed: **May 6, 1992**

[51] **Int. Cl.**[5] **B66B 9/08**

[52] **U.S. Cl.** **187/12**; 198/322; 198/326; 198/835

[58] **Field of Search** 187/12; 198/321, 322, 198/326, 835; 414/921

[56] **References Cited**

U.S. PATENT DOCUMENTS

966,394	8/1910	Gavryloff	187/12
1,768,650	7/1930	Wood	187/12
1,838,204	12/1931	Wood	187/12
1,927,194	9/1933	Wood	187/12
1,933,131	10/1933	Wood	187/12
2,563,260	8/1951	Miller	187/12
3,422,947	1/1969	Kraft et al.	198/321
3,500,963	3/1970	Beutler	187/12
4,043,427	8/1977	Ackerman	187/12
4,564,086	6/1986	Kingston	187/12
5,125,481	6/1992	Shibata	187/12

Primary Examiner—Joseph E. Valenza

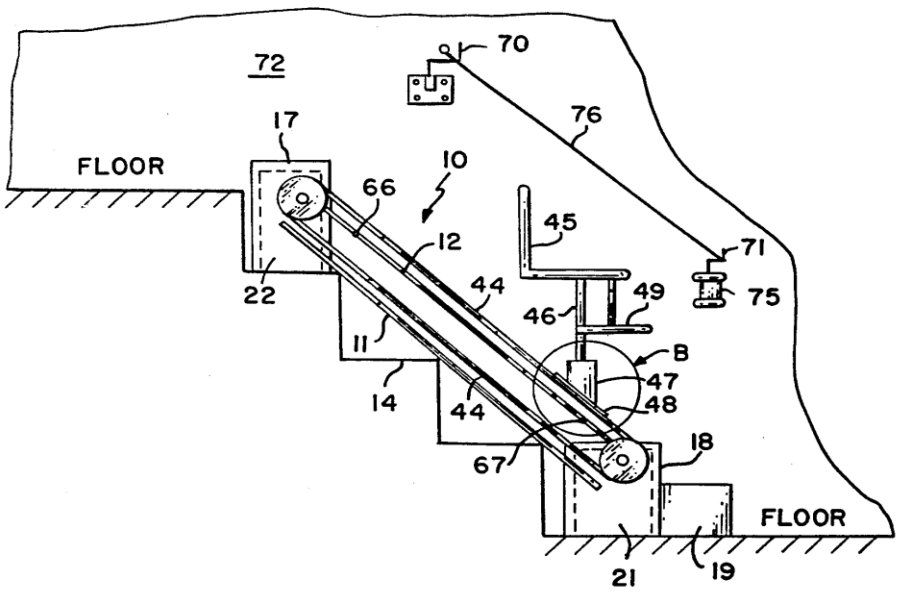
Assistant Examiner—Dean A. Reichard

Attorney, Agent, or Firm—Wallace J. Nelson

[57] **ABSTRACT**

A portable stair lift system, for assistance in traversing short or medium length stairways, employs a pair of spaced elongated solid metal plates extending the stairway length and supported by a pair of vertically extending end brackets attached to a block of wood at each end thereof. An axle extends through each pair of end brackets and each axle supports a roller transversely disposed at the metal plate ends. At least one of these rollers is provided with a sprocket wheel secured to the axle between split roller segments. A reversible drive gear motor, drive chain connected to the sprocket wheel, drives the roller. A heavy duty conveyor belt is positioned about the pair of rollers. A passenger support system (either a chair seat or step segments) is secured to and movable with the conveyor belt. Manual switch means for controlling motor operation and direction are provided and actuatable by the passenger at any point along the stairway. Automatic cut-off switches stop the stair lift at either end of the inclined stairway. In a modified embodiment, (FIG. 9) dual drive chains are provided for use with long stairways.

12 Claims, 4 Drawing Sheets



Patent 6: Stair climbing wheelchair

US005577567A

United States Patent [19]

Johnson et al.

[11] **Patent Number: 5,577,567**

[45] **Date of Patent: Nov. 26, 1996**

[54] **STAIR CLIMBING WHEELCHAIR**

[76] Inventors: **Robert E. Johnson**; **Deborah K. Johnson**, both of 1417 Kasten Dr., Dolton, Ill. 60419

[21] Appl. No.: **360,245**

[22] Filed: **Dec. 20, 1994**

[51] **Int. Cl.**[6] **B62D 55/075**

[52] **U.S. Cl.** **180/9.23**; 180/907; 280/5.22; 280/6.1; 280/DIG. 10

[58] **Field of Search** ..... 180/9.1, 9.23, 180/9.32, 9.42, 8.1, 8.2, 907; 280/840, 6.1, 6.11, 5.2, 5.22, DIG. 10

[56] **References Cited**

U.S. PATENT DOCUMENTS

3,231,036	1/1966	Appendrodt	280/840 X
3,288,234	11/1966	Feliz	180/9.23
3,869,011	3/1975	Jensen	180/9.23
4,483,407	11/1984	Iwamoto et al.	180/9.23 X
4,566,551	1/1986	Feliz	180/907 X
4,687,068	8/1987	Pagett	180/8.2
4,688,813	8/1987	Misawa et al.	180/8.2 X
4,763,742	8/1988	Langford	280/840
4,977,971	12/1990	Crane,III et al.	280/840 X
5,123,495	6/1992	Littlejohn et al.	180/9.32
5,395,129	3/1995	Kao	180/8.2 X

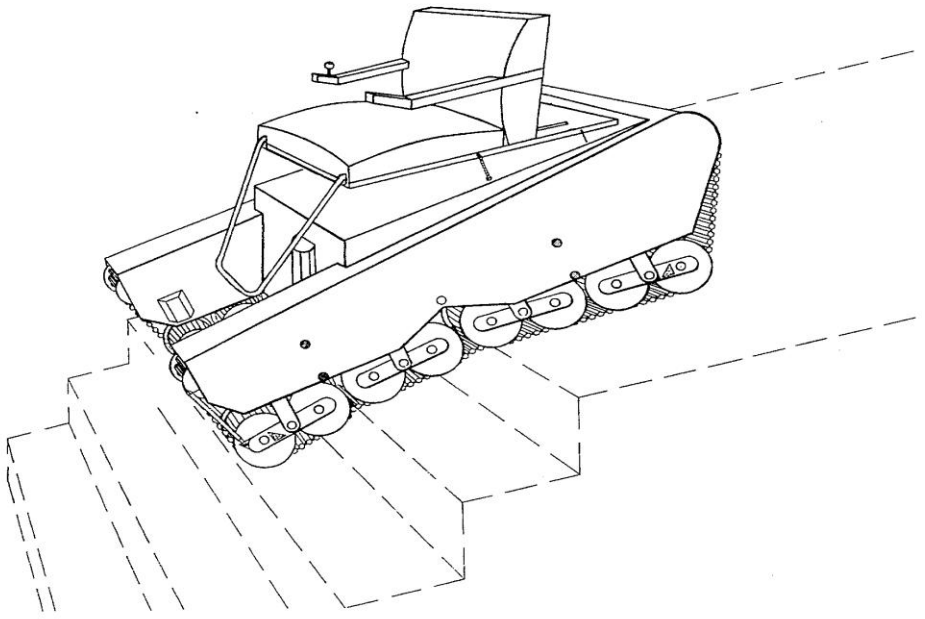
Primary Examiner—Kevin T. Hurley

Attorney, Agent, or Firm—Marshall, O'Toole, Gerstein, Murray & Borun

[57] **ABSTRACT**

In order to provide safe and effective surface climbing and descending vehicles, the vehicle includes a base for supporting a platform to be maintained in a generally horizontal orientation. The mechanism automatically raises and lowers the platform as the vehicle is descending or climbing the surface, respectively, in order to maintain the platform in the generally horizontal orientation. With this arrangement, the vehicle further includes a pair of endless belts normally to be maintained in driving engagement with the surface in a manner to conform to the surface during climbing and descending.

24 Claims, 37 Drawing Sheets



Patent 7: Chair lift for stair

US006360833B1

(12) **United States Patent**
Valencia

(10) **Patent No.: US 6,360,833 B1**
(45) **Date of Patent: Mar. 26, 2002**

(54) **CHAIR LIFT FOR STAIRS**

(76) Inventor: **Joseph R. Valencia**, 5 Porto Marino In., San Carlos, CA (US) 94070

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

(21) Appl. No.: **09/544,230**

(22) Filed: **Apr. 7, 2000**

(51) **Int. Cl.**[7] **B62D 57/00**
(52) **U.S. Cl.** **180/7.5**; 187/201; 280/5.24
(58) **Field of Search** ..... 187/200, 201, 187/202; 280/5.2, 5.24, DIG. 10; 180/7.5

(56) **References Cited**

U.S. PATENT DOCUMENTS

3,137,511 A	*	6/1964	Weil et al.	280/5.24
4,473,234 A	*	9/1984	Egen	280/5.22
4,892,323 A	*	1/1990	Oxford	180/7.5
5,179,746 A	*	1/1993	Rogers	5/625
5,253,885 A	*	10/1993	McCracken et al.	280/5.2
5,269,544 A	*	12/1993	Park	280/5.24
5,338,048 A	*	8/1994	Medina	280/5.22
5,553,548 A	*	9/1996	Eaton	104/183
6,079,517 A	*	6/2000	Payne	182/187
6,095,284 A	*	8/2000	Smith	182/103

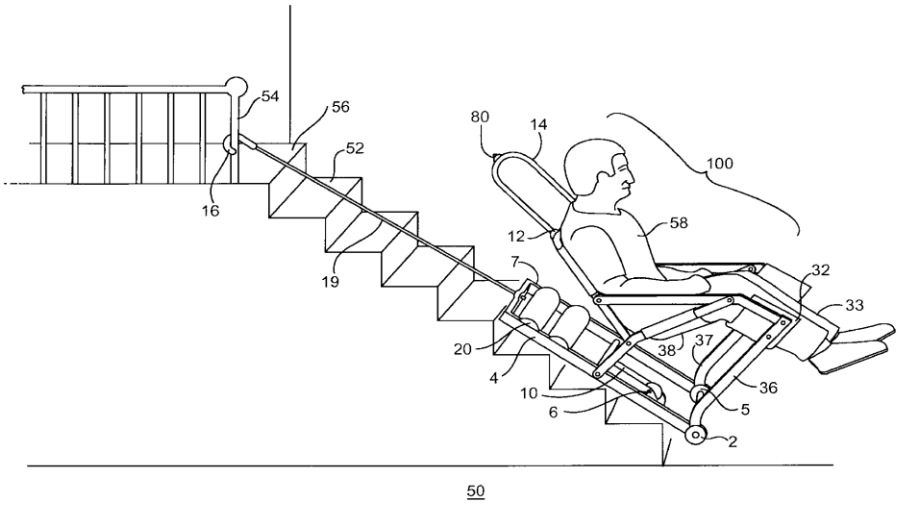
* cited by examiner

Primary Examiner—Thomas J. Brahan

(57) **ABSTRACT**

Chair Lift for Stairs with a light weight metal chair frame mounted to a pair of metal slidable sled rails, the chair frame supporting a fabric seat and back, a set of wheels mounted to the base of the rails, a thigh retaining sling mounted below the chair frame, an electric winch type mechanism mounted between the sled rails, the winch mechanism having a pulling cable located near the center line of the chair frame, the chair frame also containing a rechargeable battery to be used as a power source for said winch, said chair frame also having a manual pull strap attached to the top cross rail of said chair frame, said chair frame being collapsible for easy transport, and said chair frame also includes a retractable third wheel that can be deployed at the bottom rear center of said chair so that said chair can act as an emergency wheel chair.

1 Claim, 3 Drawing Sheets



Patent 8: Stair Walker

US006453921B1

(12) **United States Patent**
Rost

(10) **Patent No.: US 6,453,921 B1**
(45) **Date of Patent: Sep. 24, 2002**

(54) **STAIR WALKER**

(75) Inventor: **Brian Mitchell Rost**, Tacoma, WA (US)

(73) Assignee: **Brian M. Rost**, La Grande, OR (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 15 days.

(21) Appl. No.: **09/713,060**

(22) Filed: **Nov. 16, 2000**

(51) **Int. Cl.**[7] **A61H 3/00**; F16M 13/08

(52) **U.S. Cl.** **135/67**; 297/5; 135/75; 482/68

(58) **Field of Search** 135/67, 75; 297/5; 482/68; 280/87.05

(56) **References Cited**

U.S. PATENT DOCUMENTS

2,708,473	A	*	5/1955	Gable et al.	135/67
3,176,700	A	*	4/1965	Drury	135/67
3,387,618	A	*	6/1968	Swann	135/67
3,421,529	A	*	1/1969	Vestal	135/67
3,455,313	A	*	7/1969	King	135/67
3,800,815	A	*	4/1974	Birk	135/67
4,094,331	A	*	6/1978	Rozsa	135/67
4,411,283	A	*	10/1983	Lucarelli	135/67
4,777,973	A	*	10/1988	Nakajima	135/67
4,995,412	A	*	2/1991	Hirn	135/67
5,263,506	A	*	11/1993	Narramore	135/67
5,349,977	A	*	9/1994	Wood	135/67
5,499,645	A	*	3/1996	Baliga	135/67
5,603,517	A	*	2/1997	Lorman	135/67
5,636,651	A	*	6/1997	Einbinder	135/67
5,649,558	A	*	7/1997	Richard	135/67
5,740,825	A	*	4/1998	Brunengo	135/67
5,787,913	A	*	8/1998	Li	135/67
6,145,524	A	*	11/2000	Li	135/67

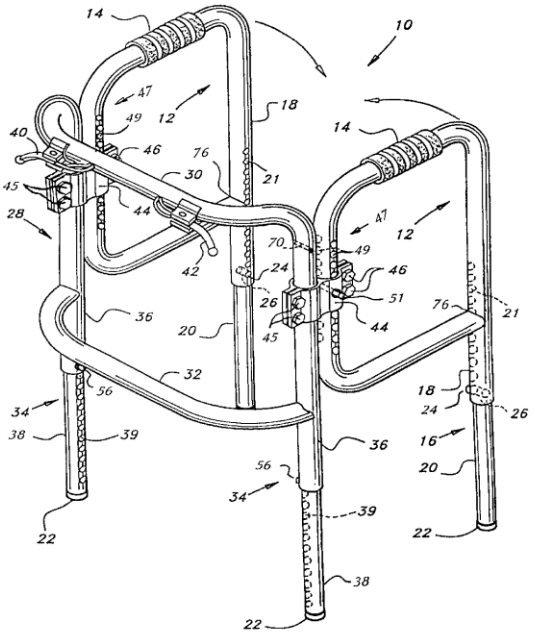
* cited by examiner

Primary Examiner—Beth A. Stephan

(57) **ABSTRACT**

A stair walker device for aiding ambulatory persons in ascending ad descending stairs, ramps and other uneven walkable surfaces. A pair of hand-controlled levers used separately or together to adjust the front legs, by controlling the extension or retraction of a pair of front leg portions. The rear legs are adjusted for the user's height once only by suitable adjustable fastening. The sides of the stair walker frame can be readily folded for storage or for carrying.

3 Claims, 5 Drawing Sheets



Patent 9: Battery powered stair-climbing wheelchair

US006484829B1

(12) **United States Patent**
Cox

(10) **Patent No.: US 6,484,829 B1**
(45) **Date of Patent: Nov. 26, 2002**

(54) **BATTERY POWERED STAIR-CLIMBING WHEELCHAIR**

(76) Inventor: **Kenneth Ray Cox**, 2711 E. Marquis Cir, Arlington, TX (US) 76016-2013

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 44 days.

(21) Appl. No.: **09/609,732**

(22) Filed: **Jul. 3, 2000**

(51) **Int. Cl.**[7] **B62D 57/028**
(52) **U.S. Cl.** **180/8.1**; 180/8.3
(58) **Field of Search** 180/8.1, 8.2, 8.3, 180/8.7

(56) **References Cited**

U.S. PATENT DOCUMENTS

2,931,449	A		4/1960	King	
4,512,588	A		4/1985	Cox	
4,674,584	A		6/1987	Watkins	
4,794,999	A		1/1989	Hester	
5,423,563	A	*	6/1995	Wild	280/250.1
5,579,857	A		12/1996	Abe et al.	
5,701,965	A		12/1997	Kaman et al.	
5,975,225	A	*	11/1999	Kamen et al.	180/21
6,311,794	B1	*	11/2001	Morrell et al.	180/8.3

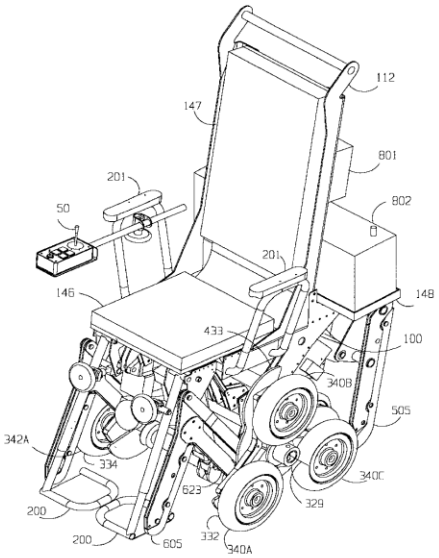
* cited by examiner

Primary Examiner—Kevin Hurley

(57) **ABSTRACT**

A self-propelled battery-powered wheelchair replaces an ordinary wheelchair and provides improved access to homes. The wheelchair includes stair climbing, slope climbing, and reclining while requiring only minimal driver skill and strength. Operation on level ground is similar to the operation of a conventional wheelchair. Support for normal operation is provided by a rear caster and wheels on the front corners. Its compact width and length enable negotiating narrow doorways and turning in small spaces. To ensure stability on stairs, moveable skids are mounted to the four corners of the wheelchair. Parallelogram linkages move the front skids down and forward during climbing. Another parallelogram linkage moves the caster and rear skids up and at an angle during climbing. The wheelchair is steerable on stairs as needed to align with the stair path and accommodate slightly spiraling stairs. The wheelchair accommodates stair steps of different riser heights and tread lengths. A pair of spoked or spider wheels with small wheels at the ends of the spokes are rotably mounted to the sides of the wheelchair. The spider wheels engage the stairs to propel and stabilize the wheelchair during climbing of stairs. Methods are provided to monitor and control the pitch attitude of the wheelchair and nearness of wheelchair supporting components to the stairs. Motion and control are provided by electric motors, sensors, a computer, and driver inputs. Propulsion power for conventional level operation, slope climbing, and stair climbing operation is transmitted through the same motors and wheels.

8 Claims, 33 Drawing Sheets



Patent 10: Collapsible chair

US006561524B1

(12) **United States Patent**
Medina

(10) **Patent No.: US 6,561,524 B1**
(45) **Date of Patent: May 13, 2003**

(54) **COLLAPSIBLE CHAIR**

(76) Inventor: **Henry Medina**, 65 Stratford Rd., Plainview, NY (US) 11803

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

(21) Appl. No.: **09/544,048**

(22) Filed: **Apr. 6, 2000**

(51) **Int. Cl.**[7] **B62B 5/02**
(52) **U.S. Cl.** **280/5.22**; 280/250.1
(58) **Field of Search** 280/5.22, 5.2, 280/5.24, 250.1, 304.1, 47.2, 526, 30, 47.371; 297/DIG. 4; 135/74, 66, 67, 65

(56) **References Cited**

U.S. PATENT DOCUMENTS

2,132,069	A	*	10/1938	Hall	280/5.22
2,715,533	A	*	8/1955	Strausburg	280/5.22
2,742,973	A	*	4/1956	Johannesen	180/8.2
3,226,128	A	*	12/1965	Grier, Jr.	280/5.2
4,033,595	A	*	7/1977	Mauch	280/5.2
4,047,724	A	*	9/1977	Shaffer	280/5.22
4,130,291	A	*	12/1978	Saethre et al.	280/5.22
4,136,888	A	*	1/1979	Bowie, Jr. et al.	280/5.22
4,473,234	A	*	9/1984	Egen	280/5.22
4,566,706	A	*	1/1986	Bihler et al.	280/5.22
4,570,954	A	*	2/1986	Mintz	280/5.24
4,648,617	A	*	3/1987	Hannappel	280/43.2
4,688,813	A	*	8/1987	Misawa et al.	280/5.22
4,786,064	A	*	11/1988	Baghdasarian	280/30
4,898,256	A	*	2/1990	Lehner	280/5.22
4,962,941	A	*	10/1990	Rembos	280/5.22
5,172,715	A	*	12/1992	Webb	135/74
5,184,835	A	*	2/1993	Huang	280/47.371
5,267,745	A	*	12/1993	Robertson et al.	280/250.1
5,269,544	A		12/1993	Park	
5,338,048	A	*	8/1994	Medina	280/5.22
5,605,169	A	*	2/1997	Light	135/67
5,727,802	A	*	3/1998	Garven, Jr. et al.	280/250.1

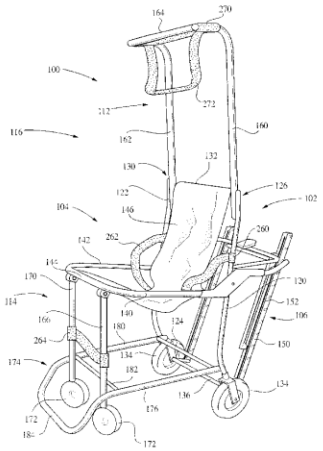
* cited by examiner

Primary Examiner—Brian L. Johnson
Assistant Examiner—Hau Phan
(74) *Attorney, Agent, or Firm*—Scully, Scott, Murphy & Presser

(57) **ABSTRACT**

A collapsible chair for transporting people up and down stairs, comprising a main frame, a seating assembly, and a rail assembly. The seating assembly is provided to form a set for a person, and this assembly is pivotally connected to the main frame for pivotal movement between open and closed positions. The rail assembly is used to support the chair for movement down steps, and this assembly is also pivotally connected to the main frame for pivotal movement between open and closed positions. In accordance with a first aspect of the invention, the chair is provided with uniquely designed gripping bars that may be used to help carry the chair upstairs. Also, the chair is provided with a set of wheels that are uniquely located to help stabilize the chair. Preferably, an improved locking mechanism is mounted on the chair to help lock the seating assembly and the rail assemblies in their open positions, and a specially designed latching assembly is provided to lock an upper frame of the chair in various positions. With the preferred embodiment of the invention, the chair is provided with a harness system to hold a person in the chair, and this system is especially designed to hold the legs of that person so that the person's legs do not interfere with someone carrying the chair upstairs.

10 Claims, 13 Drawing Sheets



Patent 11: Stair chair

US006648343B2

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

(10) **Patent No.: US 6,648,343 B2**
(45) **Date of Patent: Nov. 18, 2003**

(54) **STAIR CHAIR**

(75) Inventors: **Christopher B. Way**, Richland, MI (US); **Clifford E. Lambarth**, Portage, MI (US); **Joshua C. Colvin**, Kalamazoo, MI (US)

(73) Assignee: **Stryker Corporation**, Kalamazoo, MI (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 131 days.

(21) Appl. No.: **10/046,441**

(22) Filed: **Jan. 14, 2002**

(65) **Prior Publication Data**

US 2003/0132585 A1 Jul. 17, 2003

(51) **Int. Cl.**[7] **B65B 5/02**
(52) **U.S. Cl.** **280/5.22**; 280/250.1; 280/304.1; 280/650
(58) **Field of Search** 280/5.2, 5.22, 280/5.24, 5.28, 250.1, 304.1, 295, 297, 298, 300, 301, 303, 647, 650, 657, 658

(56) **References Cited**

U.S. PATENT DOCUMENTS

1,087,928	A *	2/1914	Diemer	280/650
4,473,234	A	9/1984	Egen	
4,962,941	A *	10/1990	Rembos	280/5.22
5,338,048	A	8/1994	Medina	
5,390,389	A *	2/1995	Rutkowski et al.	280/5.22
6,343,805	B1 *	2/2002	Roy	280/250.1

FOREIGN PATENT DOCUMENTS

WO	WO 01/08624 A1	2/2001

OTHER PUBLICATIONS

Product Brochure for IBEX TRANSEAT; 21st Century Medical Ltd; 1999; 2 pages.

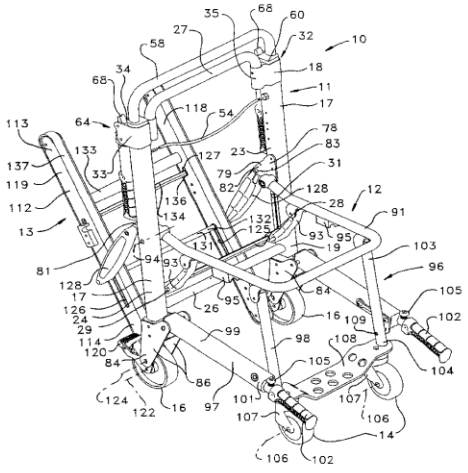
* cited by examiner

Primary Examiner—Lesley D. Morris
Assistant Examiner—Matthew Luby
(74) *Attorney, Agent, or Firm*—Flynn, Thiel, Boutell & Tanis, P.C.

(57) **ABSTRACT**

The present invention is directed to a stair chair. The stair chair includes a seat assembly mounted to a main frame and configured to pivot about a first pivot axis. A rail assembly having two laterally spaced brackets provided at a lower end of the rail assembly is included. A back wheel is rotatably supported on each bracket for rotation about a common axis of rotation. At least two mounts are provided at a lower end of the main frame, each of which is configured to pivotally connect one of the brackets to the main frame for movement about a second pivot axis. The rail assembly and seat assembly are configured to pivot about their respective pivot axes independent of movement of one another. A first spacing exists between the axis of rotation of the front wheels and the axis of rotation of the back wheels when the rail assembly in a retracted position and a second spacing exists between the axis of rotation of the front wheels and the axis of rotation of the back wheels when the rail assembly in a deployed position.

15 Claims, 13 Drawing Sheets



Patent 12: Stair chair with an adjustable glide track resistance and braking device

US007520347B2

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

(10) **Patent No.: US 7,520,347 B2**
(45) **Date of Patent: Apr. 21, 2009**

(54) **STAIR CHAIR WITH AN ADJUSTABLE GLIDE TRACK RESISTANCE AND BRAKING DEVICE**

(75) Inventors: **Charles Scott Chambliss**, New Vienna, OH (US); **Timothy J. Dietz**, Springboro, OH (US); **Steven B. Schrand**, Cincinnati, OH (US)

(73) Assignee: **Ferno-Washington, Inc.**, Wilmington, OH (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 281 days.

(21) Appl. No.: **11/462,064**

(22) Filed: **Aug. 3, 2006**

(65) **Prior Publication Data**

US 2007/0095581 A1 May 3, 2007

Related U.S. Application Data

(60) Provisional application No. 60/707,426, filed on Aug. 11, 2005.

(51) **Int. Cl.**
B62D 5/06 (2006.01)

(52) **U.S. Cl.** **180/8.2**; 280/5.22

(58) **Field of Classification Search** ..... 180/8.2; 280/5.22, 5.2, DIG. 10

See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

1,206,936	A	12/1916	Staude
2,193,283	A	3/1940	Harberson
3,111,331	A	11/1963	Locke
3,127,188	A	3/1964	Greub
3,133,742	A	5/1964	Richison et al.
3,137,511	A	6/1964	Weil et al.
3,146,841	A	9/1964	Locke
3,191,953	A	6/1965	Aysta
3,195,910	A	7/1965	Steiner
3,279,531	A	10/1966	Bowles
3,288,234	A	11/1966	Feliz
3,292,722	A	12/1966	Bamberg
3,420,540	A	1/1969	Bird
3,529,688	A	9/1970	Bruce
4,061,199	A	12/1977	Last
4,401,178	A	8/1983	Studer

(Continued)

FOREIGN PATENT DOCUMENTS

CH	666007	A5	6/1988

OTHER PUBLICATIONS

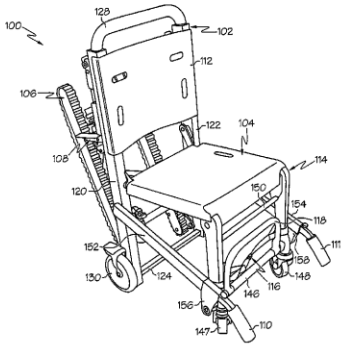
Hayes El Comino, Hydraulic Disc Brake, Installation, Service, Maintenance Manual, 45-17692Web.

Primary Examiner—Tony H. Winner
(74) *Attorney, Agent, or Firm*—Dinsmore & Shohl LLP

(57) **ABSTRACT**

A stair chair for transporting a person up and down a flight of stairs and over a surface is disclosed. The stair chair comprising a main frame and a glide track assembly to support the stair chair for movement on the flight of stairs. The glide track assembly is pivotally connected to the main frame for pivotal movement between open and closed positions. The glide track assembly has at least one endless glide track. The stair chair also provides an adjustable glide track resistance and braking device which engages the endless glide track and is configured to infinitely adjust the amount of resistance applied to the endless glide track between 0 to 100% resistance and to set a desired rolling resistance applied to the endless glide track.

25 Claims, 6 Drawing Sheets



Patent 13: Stair climbing aid

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

(10) **Patent No.: US 7,950,498 B2**
(45) **Date of Patent: May 31, 2011**

(54) **STAIR CLIMBING AID**

(75) Inventors: **Jiin-Hwa Yang**, Nantou County (TW); **Hui-Li Weng**, Nantou County (TW)

(73) Assignee: **Nan Kai Institute of Technology**, Nantou County (TW)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 583 days.

(21) Appl. No.: **12/108,690**

(22) Filed: **Apr. 24, 2008**

(65) **Prior Publication Data**

US 2008/0264722 A1 Oct. 30, 2008

(30) **Foreign Application Priority Data**

Apr. 27, 2007 (TW) ..... 96115083 A
Apr. 30, 2007 (TW) ..... 96206914 U

(51) **Int. Cl.**
E04G 27/00 (2006.01)

(52) **U.S. Cl.** **182/206**; 182/230; 52/174; 52/184; 52/29

(58) **Field of Classification Search** 182/106, 182/230; 52/174, 184, 29
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

1,785,487	A *	12/1930	McAvoy	49/70
3,121,476	A *	2/1964	Mazzarelli	187/201
4,046,226	A *	9/1977	Flinchbaugh	187/202
4,253,287	A *	3/1981	Overmoe	52/184
4,438,830	A *	3/1984	Born	187/201
4,823,524	A *	4/1989	Bednar	52/182
4,899,989	A *	2/1990	Kitson et al.	256/1
5,022,197	A *	6/1991	Aragona	52/29
5,269,227	A *	12/1993	Warren et al.	105/29.1
5,363,771	A *	11/1994	Warren et al.	105/29.1
5,522,322	A *	6/1996	Warren et al.	105/29.1
7,185,741	B1 *	3/2007	Rozenfeld	187/200
7,537,069	B2 *	5/2009	Kramer et al.	180/65.1
7,870,695	B2 *	1/2011	Manson et al.	52/184
2003/0079417	A1 *	5/2003	Bonin	52/29
2008/0093176	A1 *	4/2008	Rosenthal	187/241

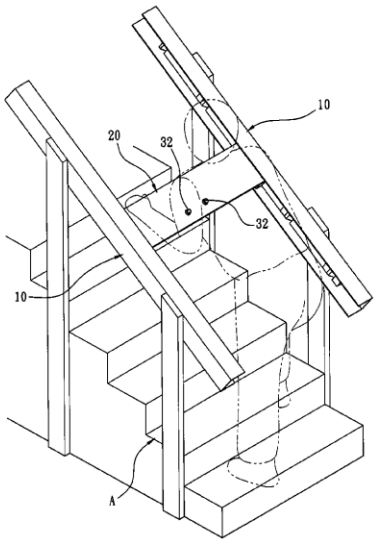
* cited by examiner

Primary Examiner — Katherine Mitchell
Assistant Examiner — Daniel Cahn

(57) **ABSTRACT**

A stair climbing aid comprises two slide rails, an assist member, a control mechanism and two positioning assemblies. The slide rails and the assist member are assembled to handrails at both sides of the stairs. The control mechanism is disposed on the assist member to be controlled by the user. The positioning assemblies are disposed at both sides of the assist member, each positioning assembly is provided with an engaging portion to be engaged in the respective positioning portions of the slide rail. Thereby, an anti-slide effect is produced, so as to prevent the user from falling down the stairs and to help the user move from step to step safely.

4 Claims, 14 Drawing Sheets



Patent 14: Wheelchair for stairs and obstacle

US 20100096194A1

(19) **United States**

(12) **Patent Application Publication** (10) **Pub. No.: US 2010/0096194 A1**

Starcevic (43) **Pub. Date: Apr. 22, 2010**

(54) **WHEELCHAIR FOR STAIRS AND OBSTACLES**

(76) Inventor: **Lazo Starcevic**, (US)

Correspondence Address:
ERIC HANSCOM
7395 PORTAGE WAY
CARLSBAD, CA 92011 (US)

(21) Appl. No.: **12/443,693**

(22) PCT Filed: **Sep. 28, 2007**

(86) PCT No.: **PCT/HR07/00029**

§ 371 (c)(1),
(2), (4) Date: **Mar. 31, 2009**

(30) **Foreign Application Priority Data**

Oct. 2, 2006 (HR) P2006032A

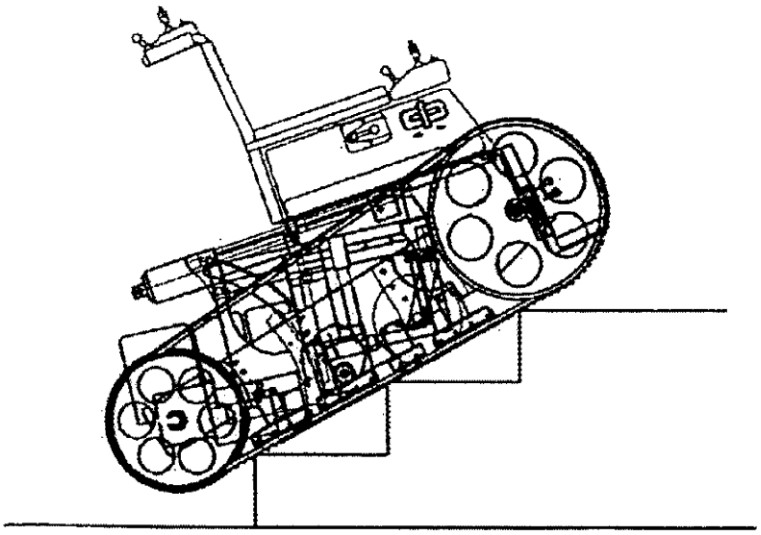
Publication Classification

(51) **Int. Cl.**
B62D 55/04 (2006.01)
B60K 1/00 (2006.01)

(52) **U.S. Cl.** **180/8.2**; 180/65.31

(57) **ABSTRACT**

The wheelchair for stairs and obstacles consists of a power supply assembly (FIG. **1**, item **8**), i.e., internal combustion motor serving as battery charger, a battery, a drive wheel-belt pulley (FIGS. **1** and **4**, item **1**), a tyre (or a full-rubber ring) of a greater diameter FIGS. **1** and **4**, item **1***a*), indented drive belts of a smaller diameter FIGS. **2**, **4** and **5**, item **26**), a foldable front wheel-pulley belt pendulum-support (FIG. **1**, item **2**, FIG. **3**), pendulum elevating assembly (FIG. **1**, items **4**, **5** and **6**), caster wheel elevator (FIG. **2**, items **23**, **24** and **25**), legrest elevator (FIG. **2**, item **18***a*), seat moving assembly to shift the centre of gravity in stair-climbing (FIG. **1** and **2**, items **9**, **9***a*, **9***b* and **9***c*), enabling the user to move comfortably indoors and on a flat surface with a partly elevated caterpillar drive pendulum (FIG. **1**), to negotiate depressions and protrusions (FIG. **6**), thresholds, curbs, etc. (FIG. **2**), to move upstairs (FIG. **7**) and downstairs (FIG. **8**), thus having an unlimited radius of movement. The user can negotiate all the mentioned obstacles riding and looking forward, keeping the seat slant comfortable and safe.



Patent 15: Chair for stair elevating lift

US00D489859S

(12) **United States Design Patent** (10) **Patent No.: US D489,859 S**
Yamada (45) **Date of Patent: ** May 11, 2004**

(54) **CHAIR FOR STAIR ELEVATING LIFT**

(75) Inventor: **Keiichi Yamada**, Osaka (JP)

(73) Assignee: **Kumalift Engineering Laboratory Co., Ltd.**, Osaka (JP)

(**) Term: **14 Years**

(21) Appl. No.: **29/162,467**

(22) Filed: **Jun. 18, 2002**

(51) **LOC (7) Cl.** **12-05**
(52) **U.S. Cl.** **D34/28**
(58) **Field of Search** ..... D34/28, 33; D12/128, D12/133; 180/907; 280/304.1; 187/200, 901, 201, 202; 414/785, 539–541, 678, 921; 5/81.1 R, 80.1, 89.1, 87.1, 600, 83.1, 81.1 T, 86.1; D24/183

(56) **References Cited**

U.S. PATENT DOCUMENTS

4,043,427	A	*	8/1977	Ackerman	187/201
4,613,151	A	*	9/1986	Kielczewski	280/650
4,614,246	A	*	9/1986	Masse et al.	180/6.5
5,035,467	A	*	7/1991	Axelson et al.	297/440.22
5,230,405	A	*	7/1993	Bartelt	187/201
D357,653	S	*	4/1995	Kruse	D12/131
D365,907	S	*	1/1996	Mishler	D34/28
5,533,594	A	*	7/1996	Tremblay et al.	187/201
5,697,465	A	*	12/1997	Kruse	180/65.1
6,176,335	B1	*	1/2001	Schaffner et al.	180/65.1
D440,728	S	*	4/2001	Schlangen	D34/28
D444,421	S	*	7/2001	Cheng	D12/131
6,332,512	B1	*	12/2001	Muranaka	187/201
D454,814	S	*	3/2002	Ou	D12/128
6,360,833	B1	*	3/2002	Valencia	180/7.5
6,378,659	B1	*	4/2002	Krumbeck	187/200
6,435,308	B2	*	8/2002	Grass	187/201
D468,669	S	*	1/2003	Hopely, Jr.	D12/131
6,533,523	B1	*	3/2003	Zamotin	414/343

* cited by examiner

Primary Examiner—Cynthia E. Ramirez
(74) *Attorney, Agent, or Firm*—Wenderoth, Lind & Ponack, L.L.P.

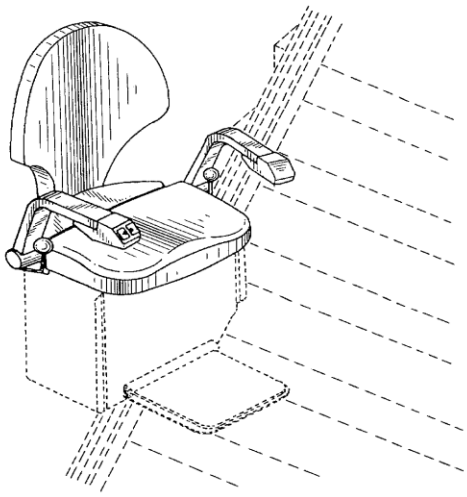
(57) **CLAIM**

The ornamental design for chair for stair elevating lift, as shown and described.

DESCRIPTION

FIG. **1** is a plan view of the chair for stair elevating lift of this Design;
FIG. **2** is a front view thereof;
FIG. **3** is a bottom view thereof;
FIG. **4** is a back view thereof;
FIG. **5** is a right side view thereof;
FIG. **6** is a left side view thereof;
FIG. **7** is a perspective view thereof; and,
FIG. **8** is a view showing how the article is used.
The broken line showing of a base, rail and stairs is for illustrative purposes only and forms no part of the claimed design.

1 Claim, 5 Drawing Sheets



Patent 16: Stair-climbing wheelchair carrier with crawlers

United States Patent [19]

Lehner

[11] **Patent Number: 4,898,256**

[45] **Date of Patent: Feb. 6, 1990**

[54] **STAIR-CLIMBING WHEELCHAIR CARRIER WITH CRAWLERS**

[75] Inventor: **Max Lehner**, Prambachkirchen, Austria

[73] Assignee: **Sunwa Sharyo Manufacturing Co., Ltd.**, Tokyo, Japan

[21] Appl. No.: **259,651**

[22] Filed: **Oct. 19, 1988**

[30] **Foreign Application Priority Data**

Oct. 20, 1987 [AT] Austria 2764/87

[51] **Int. Cl.**[4] **B62B 5/02**; B62D 55/04

[52] **U.S. Cl.** **180/8.2**; 180/907; 280/5.22; 280/9; 280/DIG. 10

[58] **Field of Search** ..... 180/8.2, 9.1, 9.22, 180/9.07; 280/5.22, DIG. 10; 414/678, 679, 921

[56] **References Cited**

U.S. PATENT DOCUMENTS

4,771,839 9/1988 Misawa 180/8.2

FOREIGN PATENT DOCUMENTS

3225679 2/1984 Fed. Rep. of Germany .

2216014 11/1984 Fed. Rep. of Germany .

3416222 5/1987 Fed. Rep. of Germany .

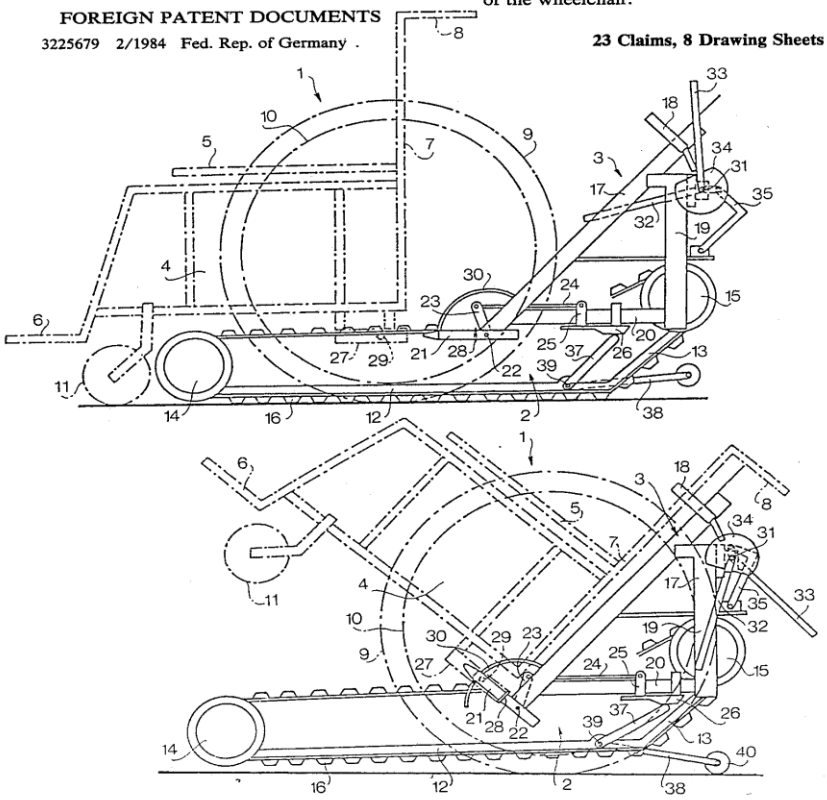
Primary Examiner—Mitchell J. Hill

Attorney, Agent, or Firm—Armstrong, Nikaido, Marmelstein, Kubovcik & Murray

[57] **ABSTRACT**

A crawler unit for coupling to a wheelchair, especially for climbing stairs, comprises an undercarriage having power-driven tracks and an adapter for securing the wheelchair in a rearwardly tilted travelling position. In order to enable the wheelchair user to couple and decouple and maneuver the wheelchair by himself, the adapter which includes a male coupling member for mating engagement with a complementary female coupling member mounted on the wheelchair is connected to the crawler unit through lifting means adapted to be operated by the wheelchair user via actuating or control elements for selectively lifting the wheelchair relative to the crawler unit and lifting the crawler unit while the wheels of the wheelchair remain on the ground, such operation being possible both in position of the wheelchair.

23 Claims, 8 Drawing Sheets

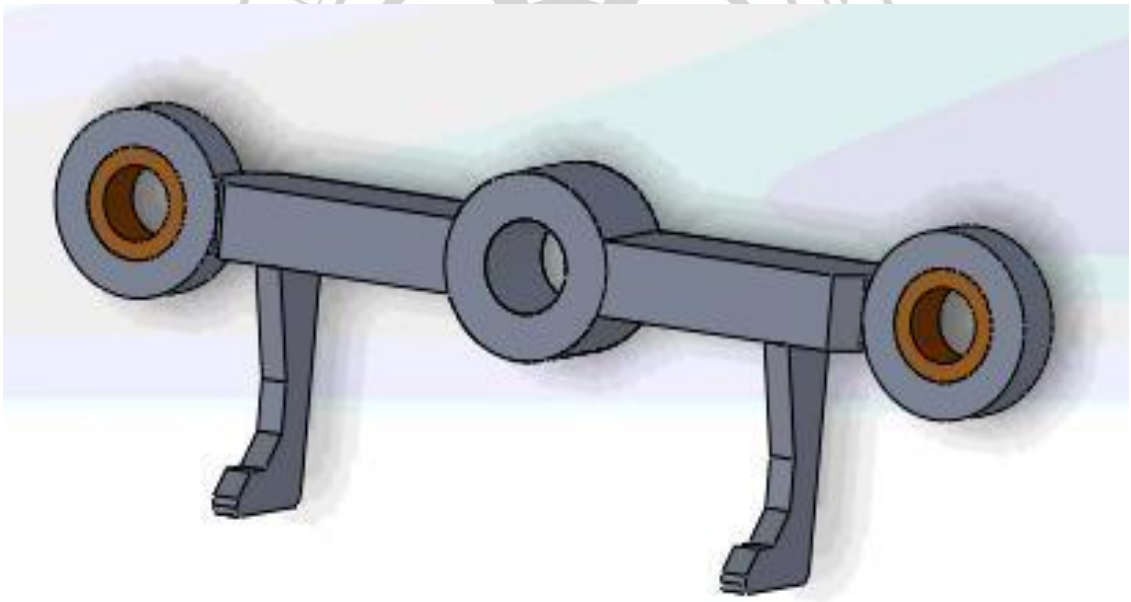


Appendix 2: Components of innovative wheelchair elevating system

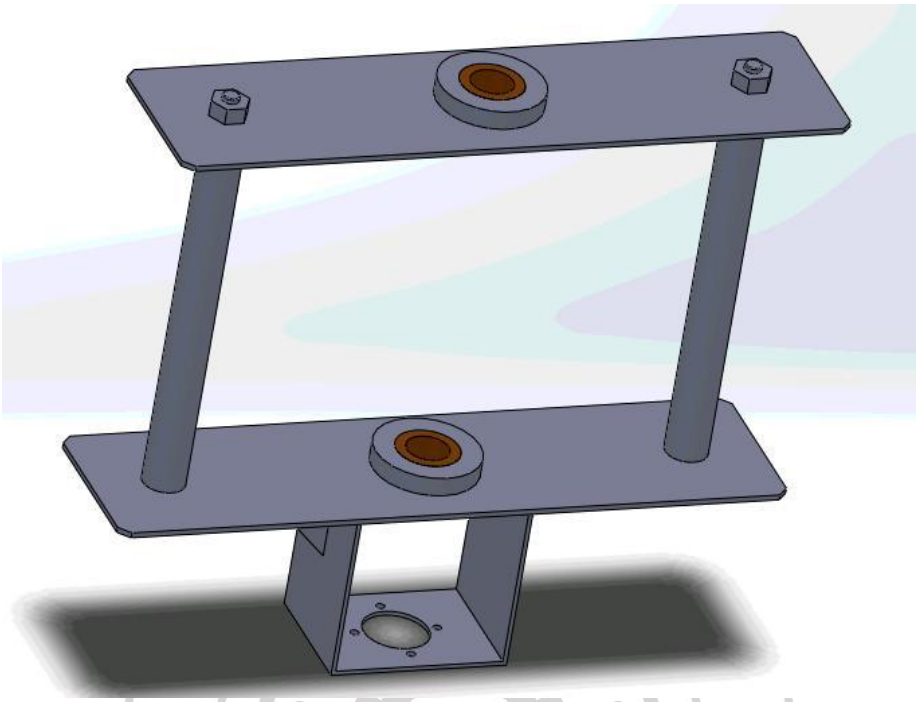
List of components in the Innovative wheelchair elevating system

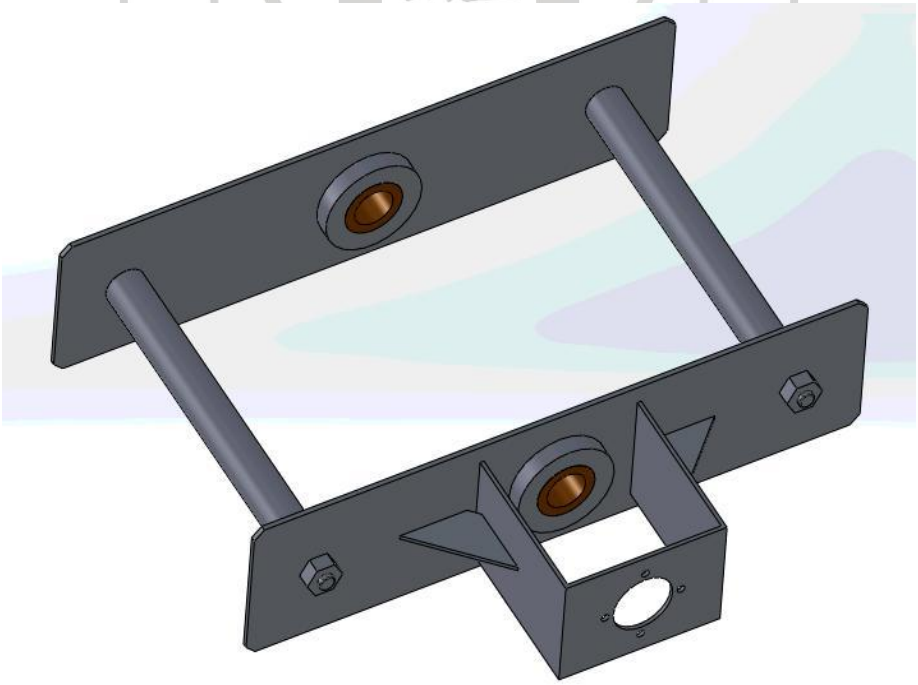
1. Hook bar	7. Connecting block 1
2. Supporting frame	8. Supporting bar
3. Motor	9. Remote control
4. Connecting block 2	10. Driving axle
5. Gearbox	11. Rail
6. Carrier	12. Wheel directing path

Component 1: Hook bar

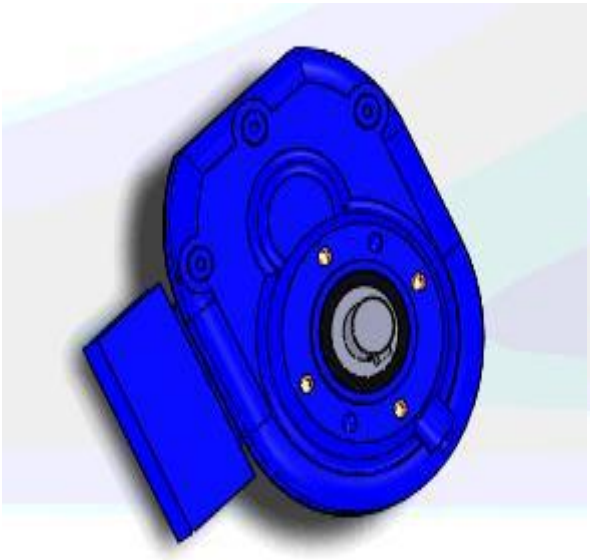


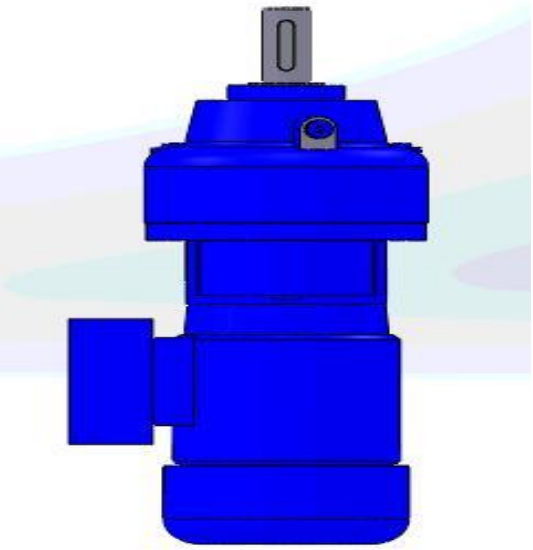
Component 2: Supporting frame

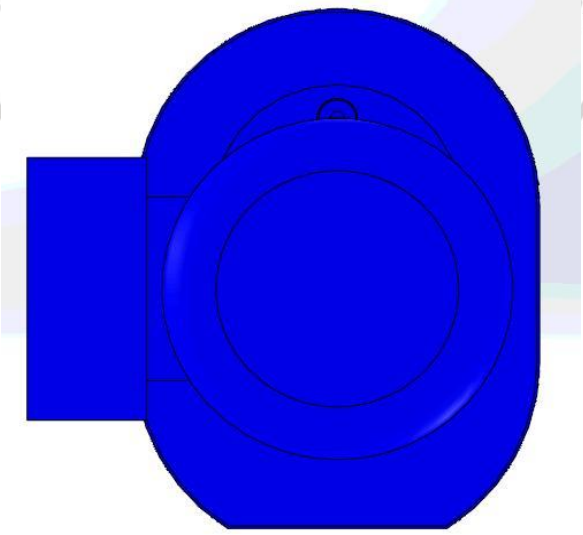




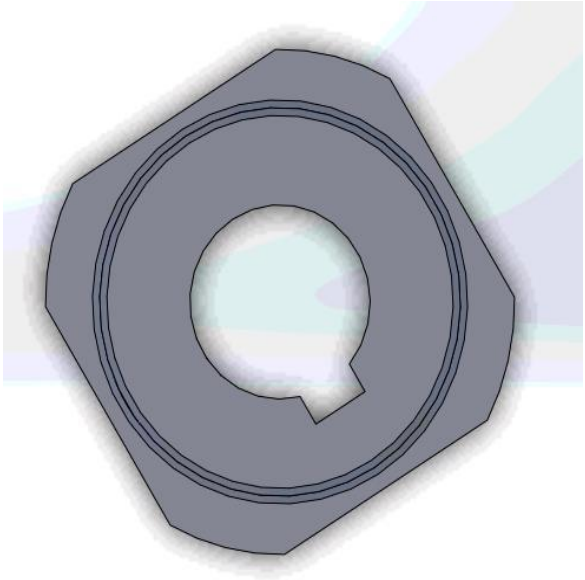
Component 3: Motor

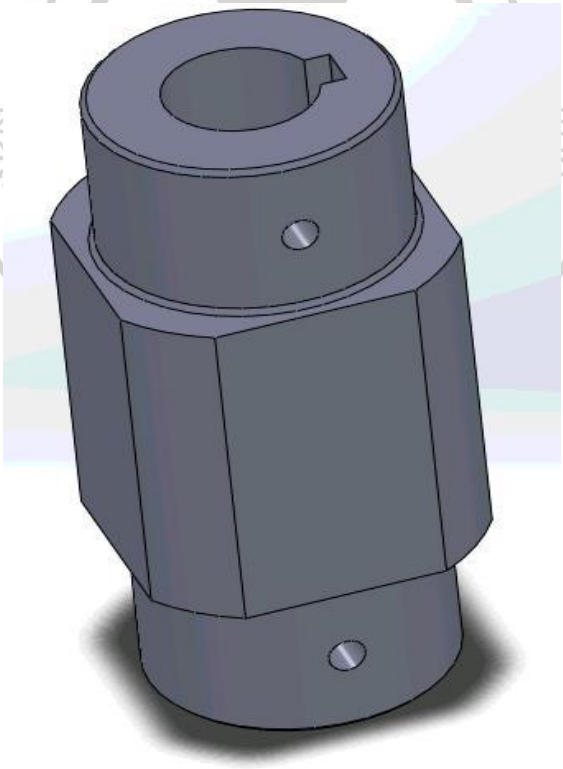




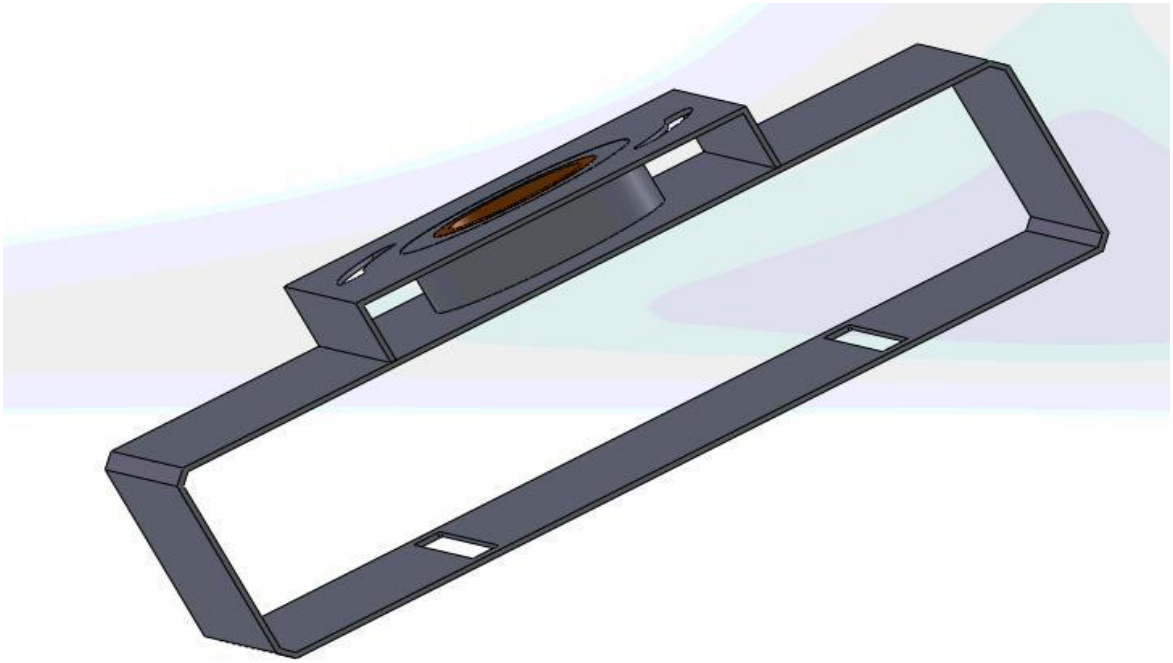


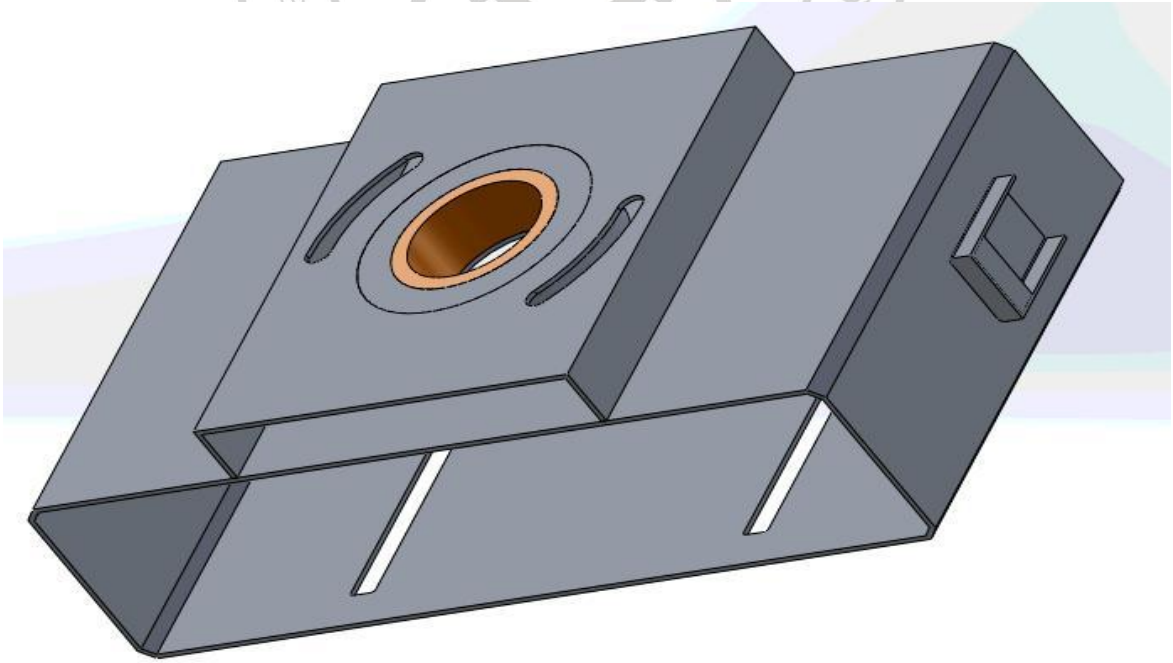
Component 4: Connecting block 2



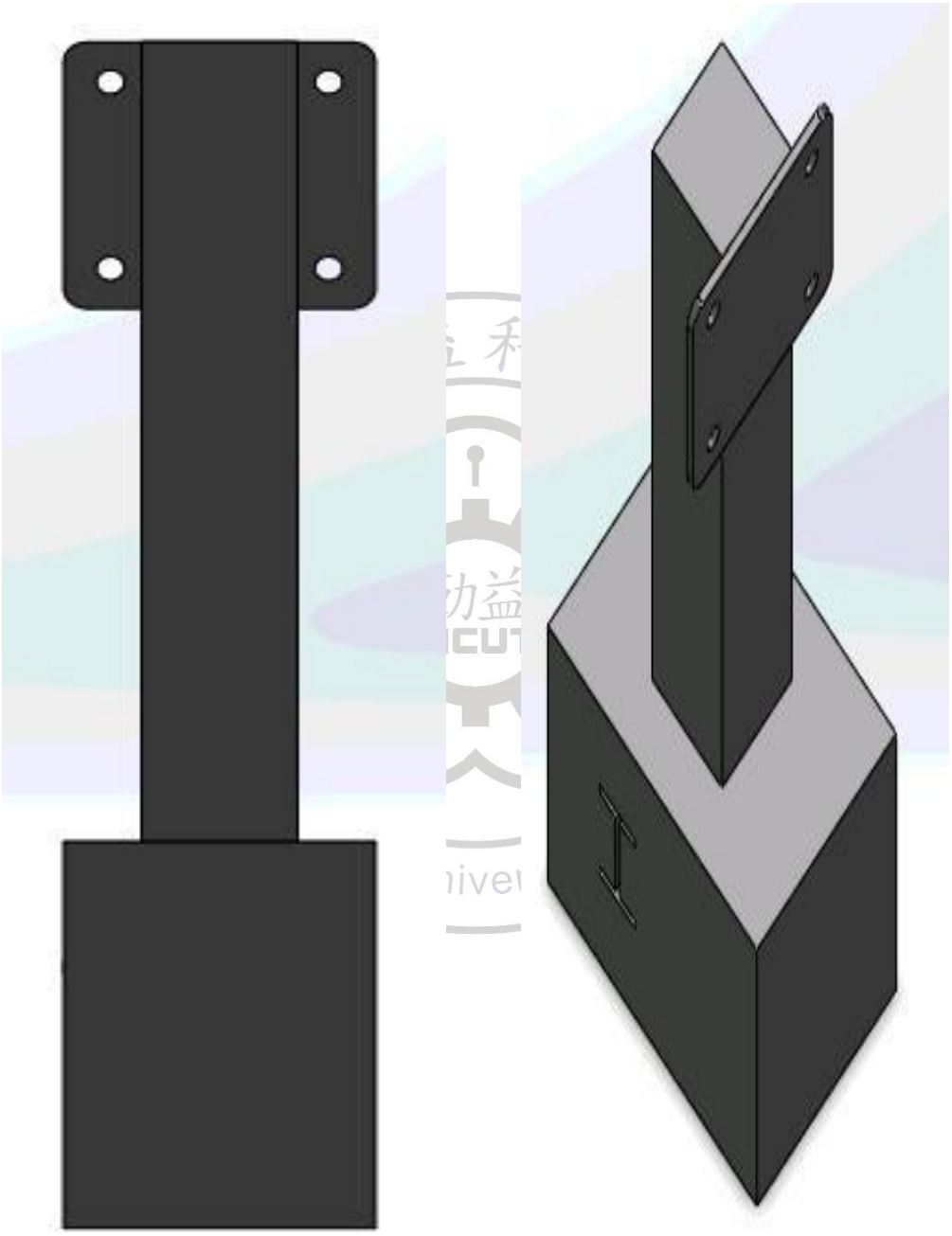


Component 5: Gearbox

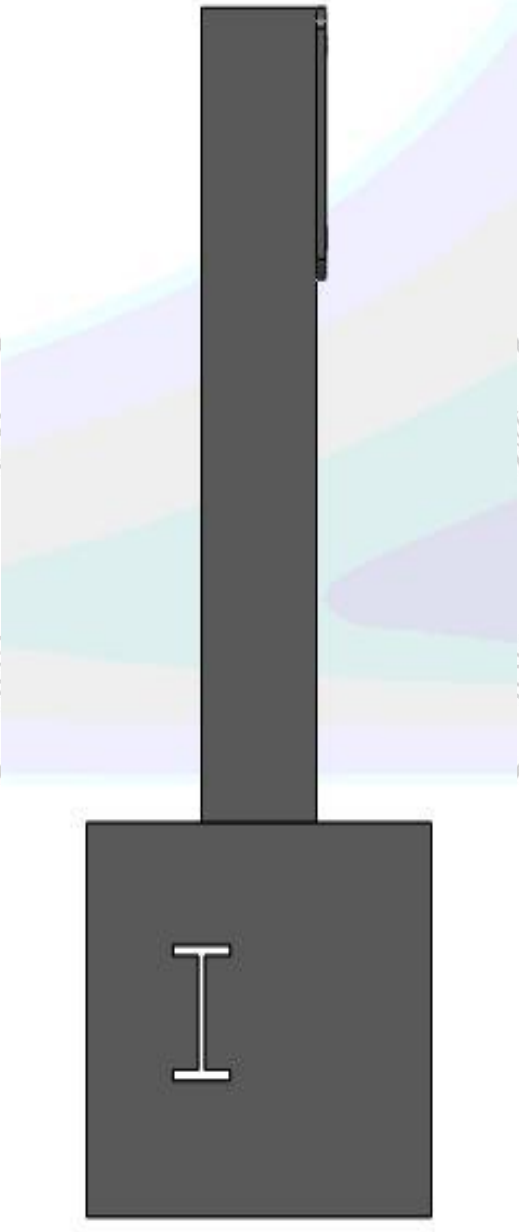




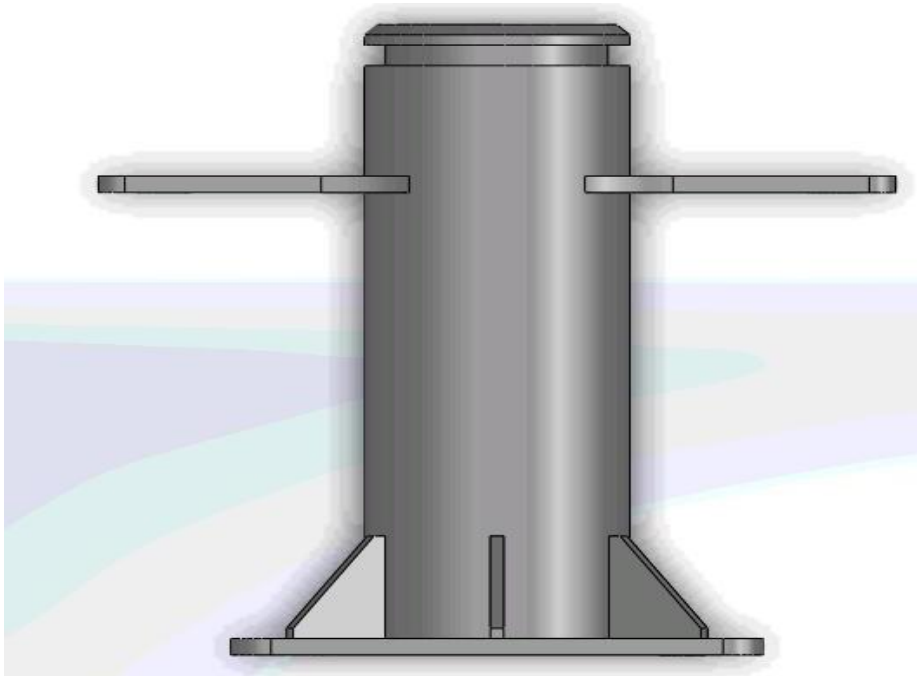
Component 6: Carrier

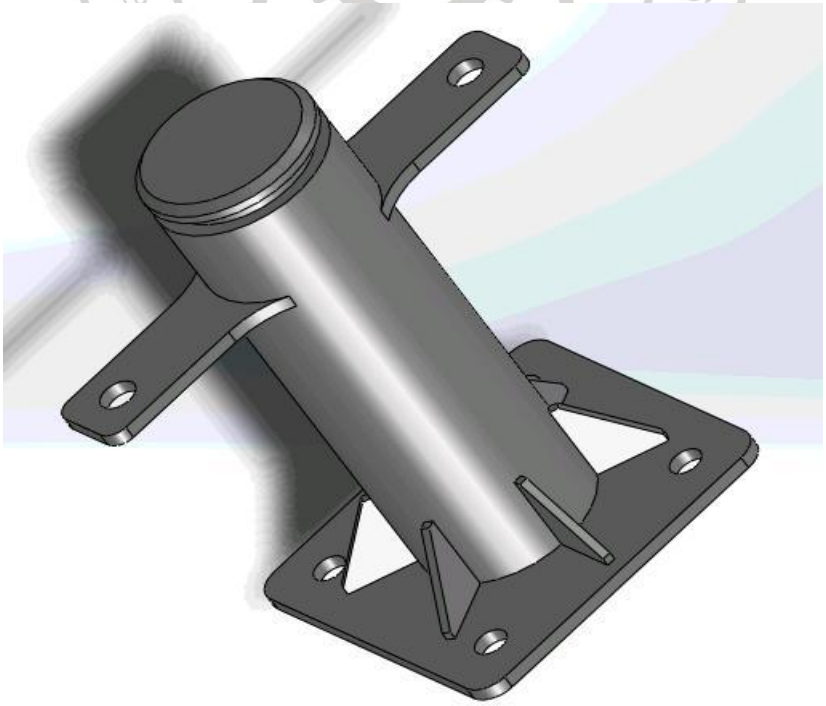


Component 6: Carrier (continue)

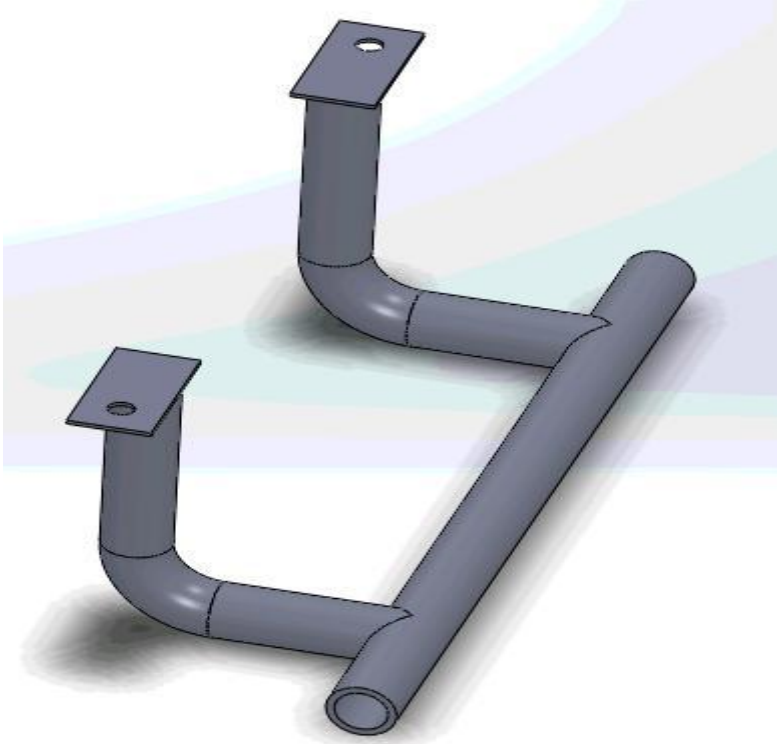


Component 7: Connecting block 1

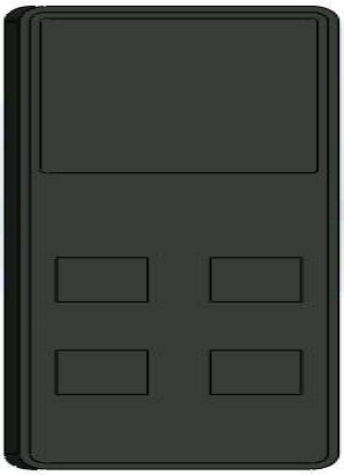




Component 8: Supporting bar

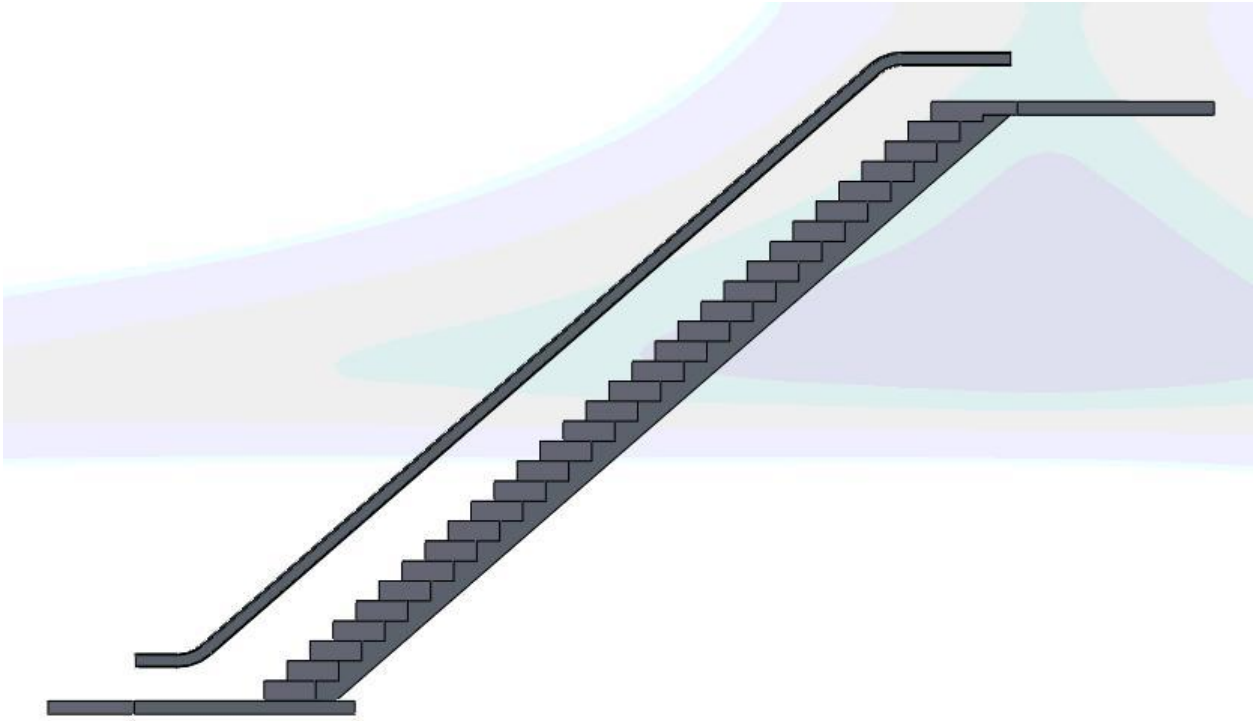


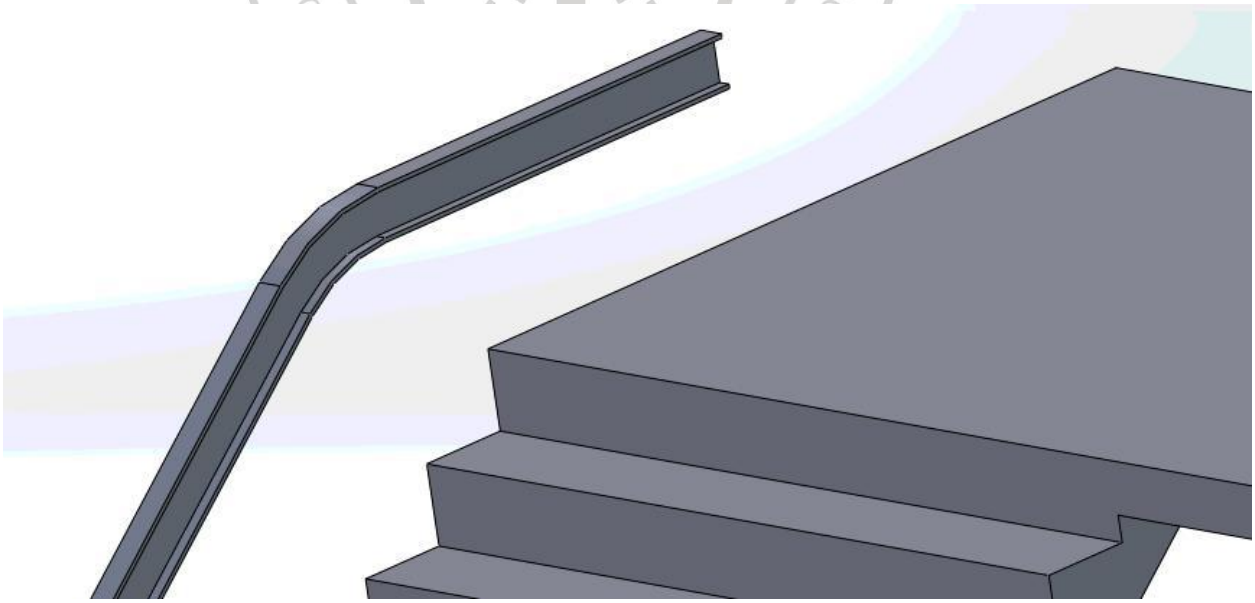
Component 9: Remote control



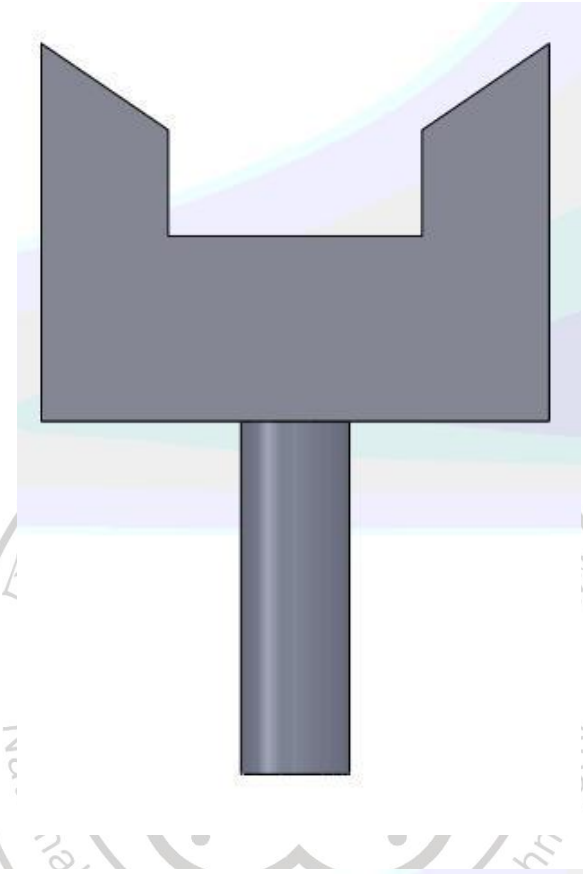
Component 10: Driving axle

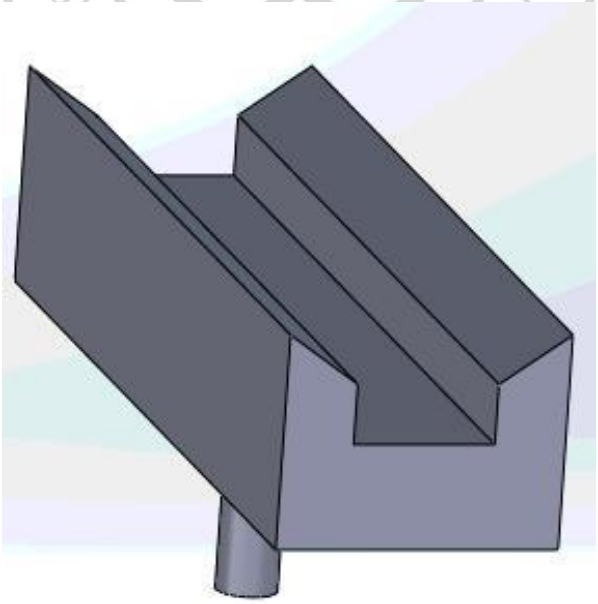
Component 11: Rail





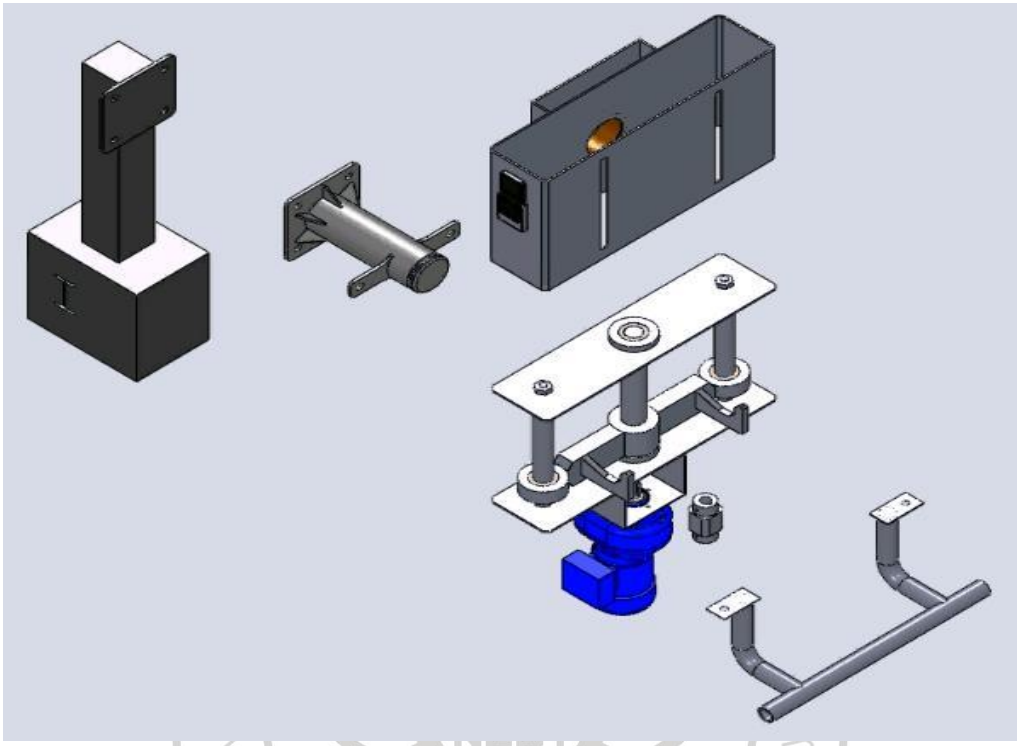
Component 12: Wheel Directing Path



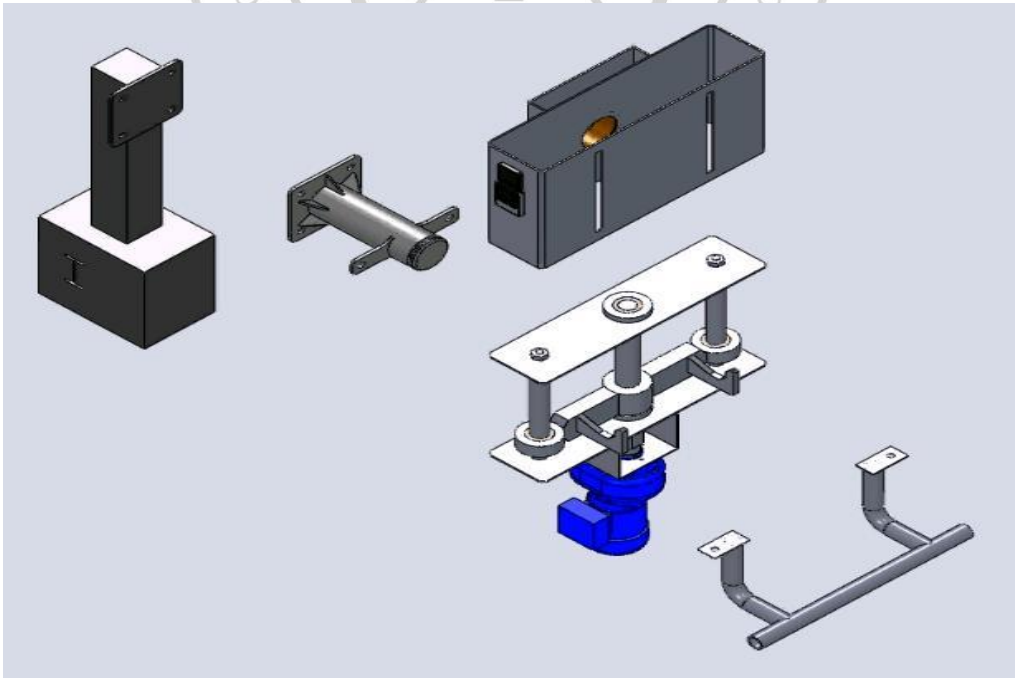


System installation steps

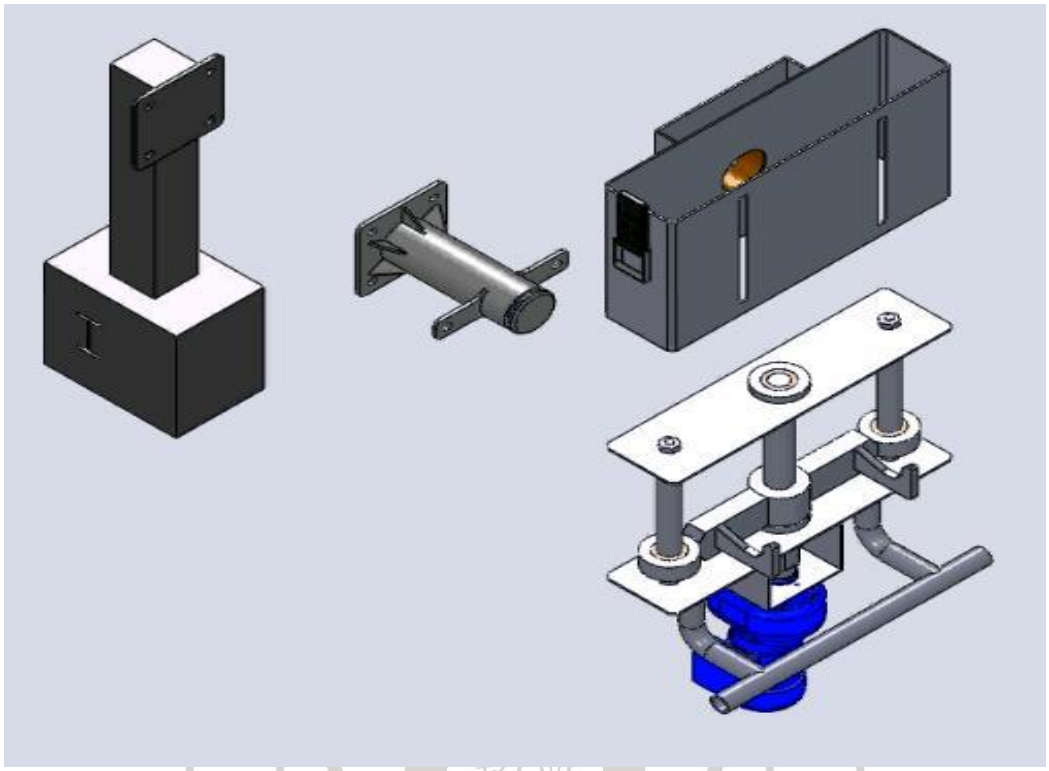
Step 1: Hook bar is installed in the supporting frame



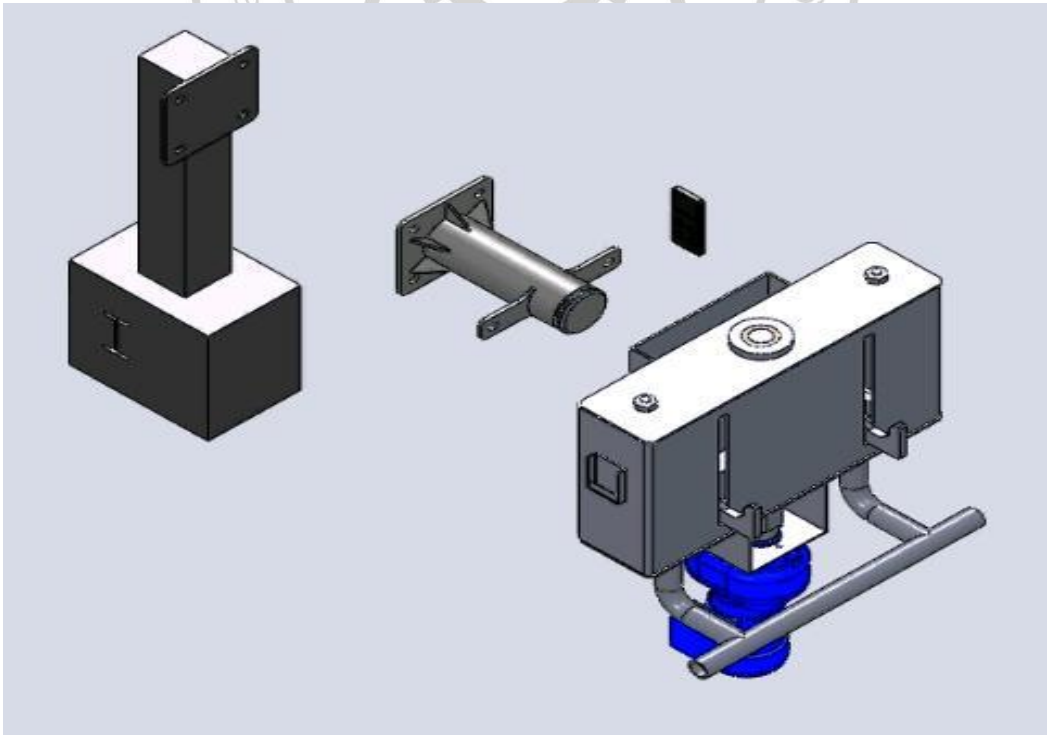
Step 2: Supporting frame connects with motor through connecting block 2



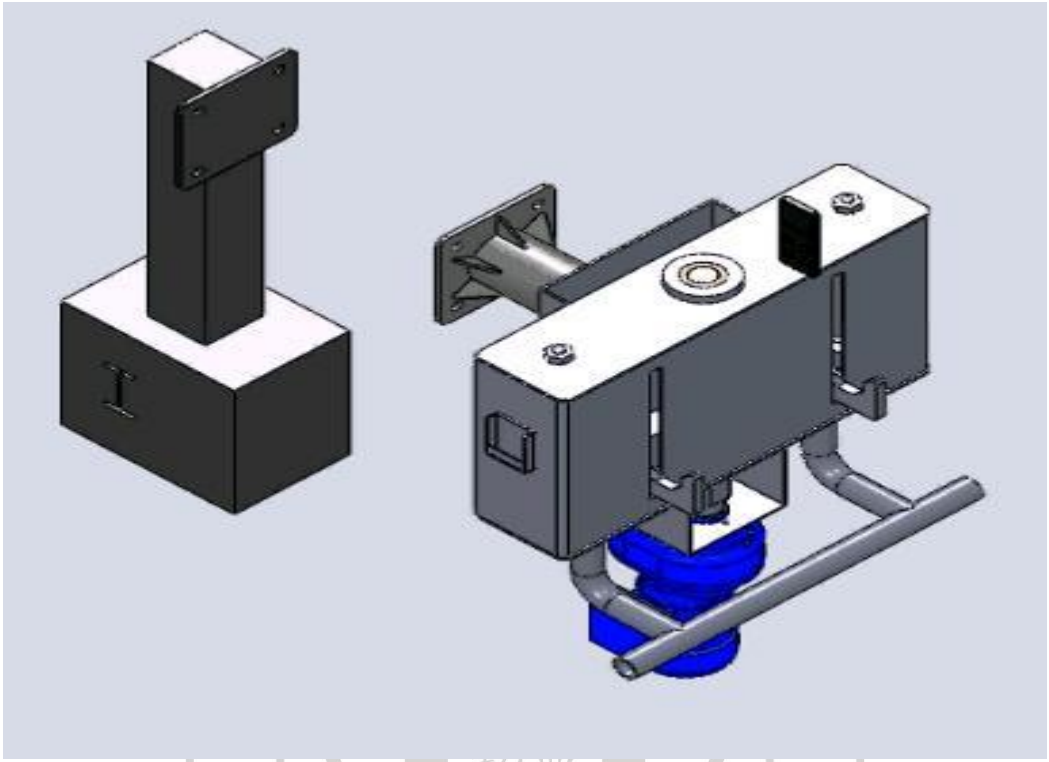
Step 3: Supporting bar is linked to supporting frame



Step 4: Gearbox covers supporting frame



Step 5: Connecting block 1 is linked with gearbox



Step 6: Carrier is installed with connecting block 1 and the remote control is located on gearbox. Installation completed.