Escola Politècnica Superior d'Enginyeria de Vilanova i la Geltrú
UNIVERSITAT POLITÈCNICA DE CATALUNYA

EPS-IDPS PROJECT 16

ROCA WC FLAPPER

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Abstract

Toilet flushing is the single highest use of water in the average home. Toilets make up about 31% of overall household water consumption. Most WC bowls used in western countries are fitted with a water trap that uses a large amount of water for preventing odor from the sewers from traveling back into the room. The current market standards differ between 6/3 liters and 4,5/3 liters using this system, and latest developments have proven that the water flush cannot be reduced further. Because of this, finding a way to replace the current water trap with another mechanical solution is the main objective for this project.

The basis of this project is to develop a mechanical flapper that would work automatically with the help of springs that would allow for a significant flush water reduction.

Key words: toilets, water consumption, flapper, odor prevention.

Introduction

1.1 Company & Program Background

The company Roca first began its business creating cast iron radiators for domestic heating, but is now well known for its china bathroom appliances which it began production of in 1936. Today, Roca's commercial network spreads over 135 countries supplied by its 76 production plants and more than 20.000 employees worldwide.

Roca's original and still principal factory is located in Gavà, and now collaborates with the Escola Politenica Superior d'Enginyeria de Vilanova I la Geltru (EPSEVG) and its European Project Semester (EPS) and International Design Project Semester (IDPS) programs.

Collaboration with the EPS program gives the company the opportunity to develop projects related to water culture from a multidisciplinary perspective and profit from the academic supervision offered by the School of Engineering.

The project team includes two Mechanical Engineers: Marcel Carrera and Sierra Lunsford and two Industrial designers: John Egan and Valeria Flores. They are supervised by their project manager from EPSEVG, Nora Martinez, and the Roca Innovation Lab project manager, Jordi Corral.

1.2 Project Overview

Most WC bowls used in western countries are fitted with a water trap that prevents odor from the sewers from traveling back into the room. This water trap system for the standard toilet was developed in 1775, and there has been little modification to the functionality of the method since. Because the water trap system has been so effective, there has been no urgent need to change it.

However, Roca has always been attentive to the changes in society related to water culture since it began its production of bathroom appliances, and latest developments have proven that the water flush cannot be reduced further. The current market standards differ between 6/3 liters and 4,5/3 liters using this system. Therefore, this year the company has assigned the EPS team the project of designing a new system for a standard toilet to reduce the water consumption of the flush.

The main objective for this project is to replace the water trap in the toilet with a mechanical trap system that:

- Meets the same functions as the current water trap
- Provides an equally robust back odor prevention by keeping an equivalent water seal,
- Allows for a significant flush water reduction.

1.3 Use Case

There are several benefits to reducing the amount of toilet water per flush. Today, toilet flushing is the single highest use of water in the average home, making up about 31% of overall household water consumption, with the average person flushing five times a day. Thus the more the water is reduced, the cheaper the water bill will be in the household. If the new design is successful, the occidental toilet user will be using an eco-friendly product without even noticing the change.

In addition, one aim of this project is to make the design applicable for use in for undeveloped environments where latrines are the common form of waste disposal, such as some regions of India and Africa. In these areas, where water is an extremely valuable resource, reducing the waste of water becomes an obvious need. Due to a lack of economic resources in such areas, it is imperative that the solution be as simple as possible to require minimal maintenance and water consumption, while still ensuring a safe and hygienic toilet. The current latrines use dry toilets and do not waste water, but they require a high amount of maintenance which is often neglected in such regions to ensure proper hygienic removal of the waste. So the development of a simple and cheap toilet which can be plugged to any water source can benefit not only the toilet company, but thousands of poor people with a hygienic way of doing their needs

2 Project Management

This project will be managed using, but not limited to, aspects of the Scrum Methodology. This is an iterative project management methodology that thrives in situations where requirements constantly shift. Scrum delivers products in short cycles that allow for quick feedback and a rapid response to change. Teams work off of time units called "sprints", which can range from a week to a month. Each sprint must end in a usable product. Sprint also emphasizes a strong team dynamic, with regular and close collaboration between team members. The main tools being used to manage this project are described below and include: Trello, Work Breakdown Structure, Gantt chart, and RACI Matrix.

2.1 Trello

Trello is a collaboration tool, which organizes projects into boards. It is essentially an online agenda, which allows the team to quickly see what tasks are being worked on, who is assigned to each task, and where each task is in a process. For this project the team also uses this application to organize sprints, and alternates project managers between each sprint. The project manager for the current sprint is in charge of the Trello board; they create cards for each task, assign members to the cards, and move the cards according to their progress into boards titled "To Do," "Doing", or "Done." The UPC supervisor monitors and comments on the TRELLO with the team, and her approval is required before tasks can be marked as complete. A sample from the team's Trello can be seen below in Figure 1.

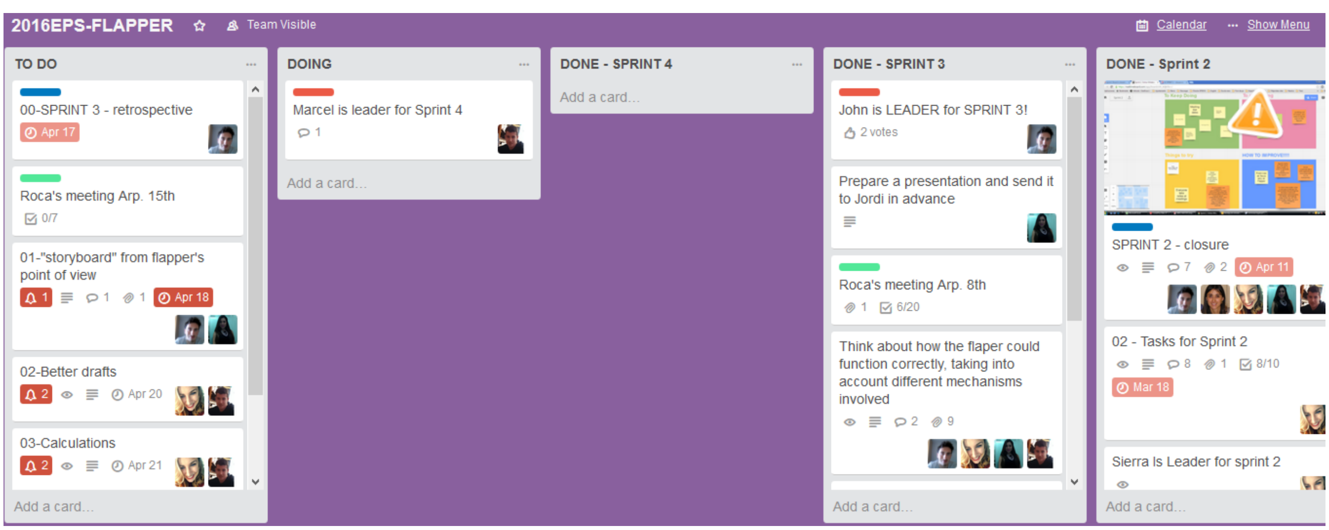


Figure 1. Sample of Trello used by Team

2.2 Work Breakdown Structure (WBS)

The work breakdown structure illustrates all of the components of the project by breaking it down into smaller, more manageable sections. As shown below in Figure 2 , the project has been divided into the 5 main sections: Investigation, brainstorming, concept development, product realization and final presentation. For a clearer version of the WBS, refer to the appendix.

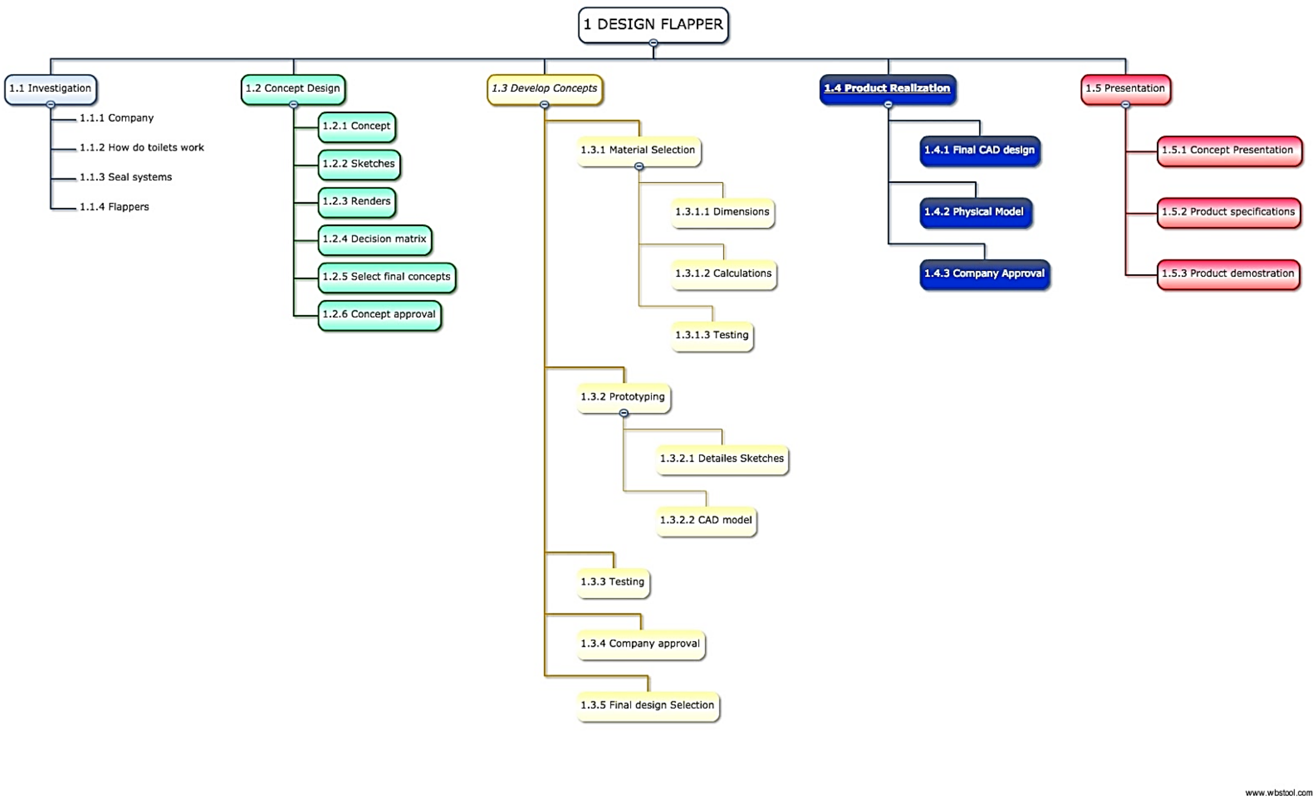


Figure 2. Work Breakdown Structure

2.3 Gantt Chart

The project is organized in a linear fashion with a Gantt chart, a sample of which is displayed below in Figure 3. Major milestones or due dates the team must meet, such as the midterm and final defense, are marked on the chart. Based on these milestones the team uses the Gantt chart to assign time constraints to previously established tasks in the WBS. A bar visually illustrates the amount of time allotted for each task. This aids the team in planning how long they should spend on each subtask to ensure everything necessary is completed by the appropriate milestone. The dates assigned for the subtasks on the Gantt chart are not definitive and can be subjected to changes throughout the progression of the project. Refer to the appendix for the complete version of the Gantt chart.

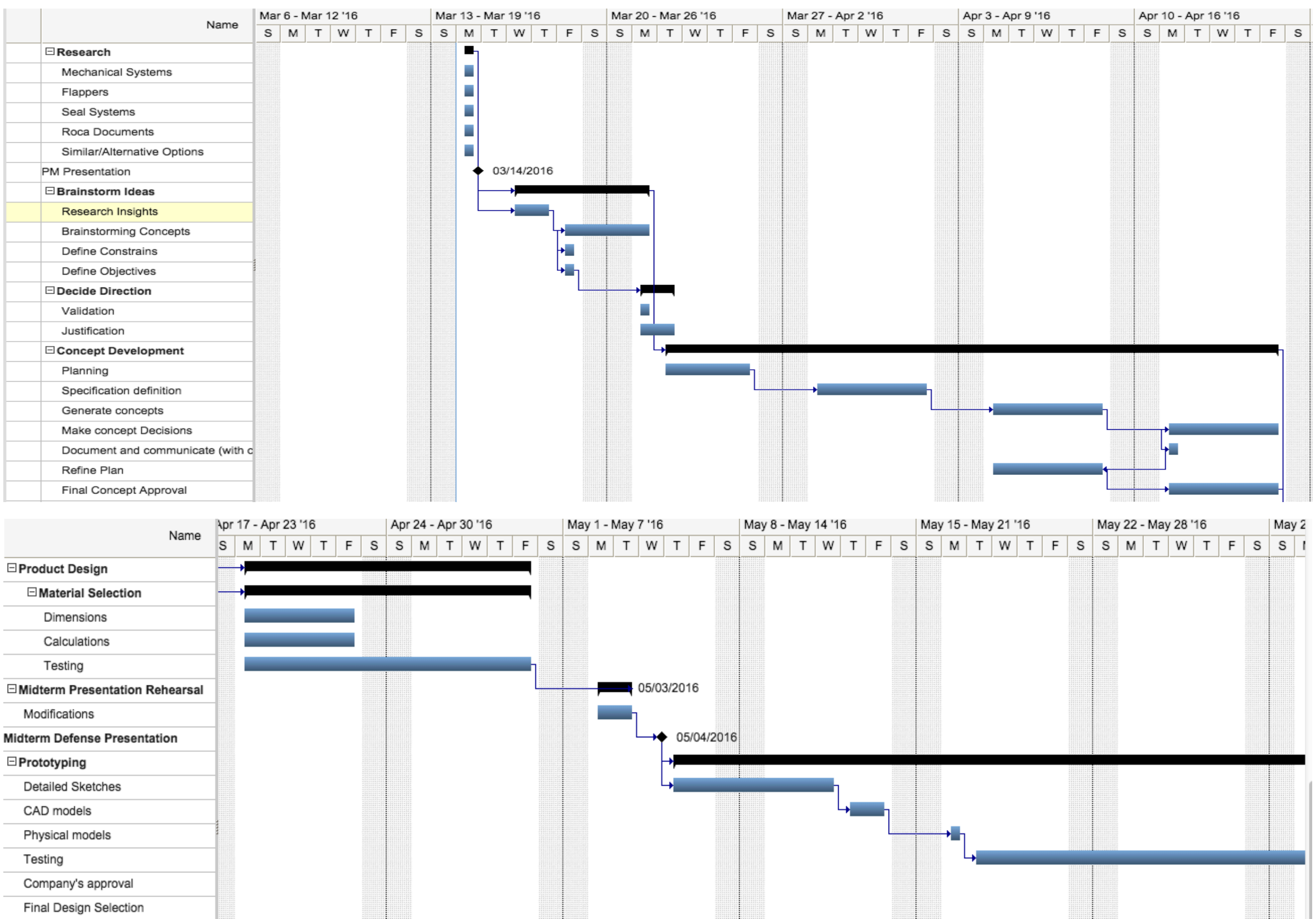


Figure 3. Sample from Gantt Chart

2.4 RACI Matrix

RACI Matrix is another important tool for tracking roles and responsibilities. It illustrates exactly what role each team member has for each of the tasks listed on the Gantt chart. This helps keep organization within the team by showing who exactly is accountable for each of the tasks, and ensures the work is evenly and logically divided among the members. Refer to the for the complete version of the RACI matrix.

RACI Charts

Steps will be highlighted if A and R are not assigned

R:	Does the step
A:	Accountable for the step
C:	Consulted with before the step
I:	Informed when the step is completed

Project: Roca Flapper

PROCEDUF	Task Assignments
UPC	EPS PROGRAM
UPDATED	1/1/2016

STEP	TASK DESCRIPTION	Marcel	Valeria	John	Sierra	Nora	Jordi
1	**Research**					I	I
2	Toilets Worldwide	A	R	A	A		
3	Flappers	R	A	A	A		
4	Seal Systems	A	A	A	R		
5	Roca Documents	A	A	R	A		
6	Similar Products	A	R	A	A		
7	**Brainstorm Ideas**						
8	Actual Solutions	R	R	R	R		
9	What are best toilet options?	A	R	R	A		
10	Best water reduction options	R	A	A	R		
11	Materials	A/R	A/R	A/R	A/R		
12	Decide Direction	R	R	R	R	C/I	C/I
13	**Concept Development**						
14	Planning	A/R	A/R	A/R	A/R		R
15	Specification definition	R	A	A	R		
16	Generate Concepts For Water Reduction	A	R	R	A		I
17	Generate Concepts For Odour Control	R	A	A	R		
18	Evaluate Concepts	A/R	A/R	A/R	A/R		
19	Make concept decisions	A/R	A/R	A/R	A/R		
20	Document and communicate (with company)	A/R	A/R	A/R	A/R	A/R	C/I
21	Refine Plan	A/R	A/R	A/R	A/R	C/I	R
22	Concept Approval					C/I	C/I
23	**Product Design**						
24	**Material Selection**						
25	Dimensions	R	A	A	R		
26	Calculations	R	A	A	R		
27	Testing	A/R	A/R	A/R	A/R		

RACI Charts

Figure 4. Sample from RACI Matrix

3 Design Problem Analysis

3.1 Design Objectives

The main objective for this project is to reduce the amount of water usage per each toilet flush, by replacing the current water trap with a mechanical trap system that will work inside the base of the toilet bowl. Project manager Jordi Corral has given instructions to try not think too much about the toilet tank or refill method of the toilet as these areas already have solutions. The objective only requires focus on the bottom third of the toilet bowl, i.e just above the current water level inside the bowl.

The "trap" is the bend in the pipe where the waste goes out of the toilet. The current water trap system consists of S or U shape piping below the toilet bowl that successfully allows the drainage of wastewater per each flush as well as keeping a level of clean water after each flush. The current usage of water per flush is five liters per each flush. The team would ideally like to significantly reduce the usage of water per flush by one and half to two liters.

The prevention of back odor is another important objective in this project. The current usage of water allows the drainage of waste as well as prevents back odor travelling back up through the piping releasing sewage odor. Removing the water, removes the current odor seal. Thus, it is vital to replace it with an alternate but equally efficient sealing system to ensure the level of prevention of bad odor is as effective as before.

In addition, the new system should have a simple design that makes no noticeable changes where the user of the toilet is concerned, yet fits the sophisticated appearance of current Roca toilets. The new design should only require the user to activate one trigger to signal the flush, it is not desirable to add any additional levers or triggers for the function of the new design.

3.2 Critical Success Factors

There are multiple critical factors given in the brief that would determine the success of the project. The design of the new mechanical trap system must:

- Meet the same functions that the current water trap
- Provide an equally robust back odor prevention by keeping an equivalent water seal
- Allow a significant flush water reduction of one or two liters of water per flush.
- Be simple enough to be industrialized.

- Be based solely on mechanics and hydraulics;
- Any use electrical or external source of power is not permitted

If the new design does not satisfy each of these requirements, the project will be considered a failure. Thus it is critical to successfully incorporate all of these aspects into the new system.

4 Design Development and Decisions

4.1 Brainstorming

To begin investigation stage of this project the team first created a mind map, shown below in Figure 5, to help assess the different aspects of the project, and clarify any questions they would need answered in order to begin forming possible concepts of solutions.

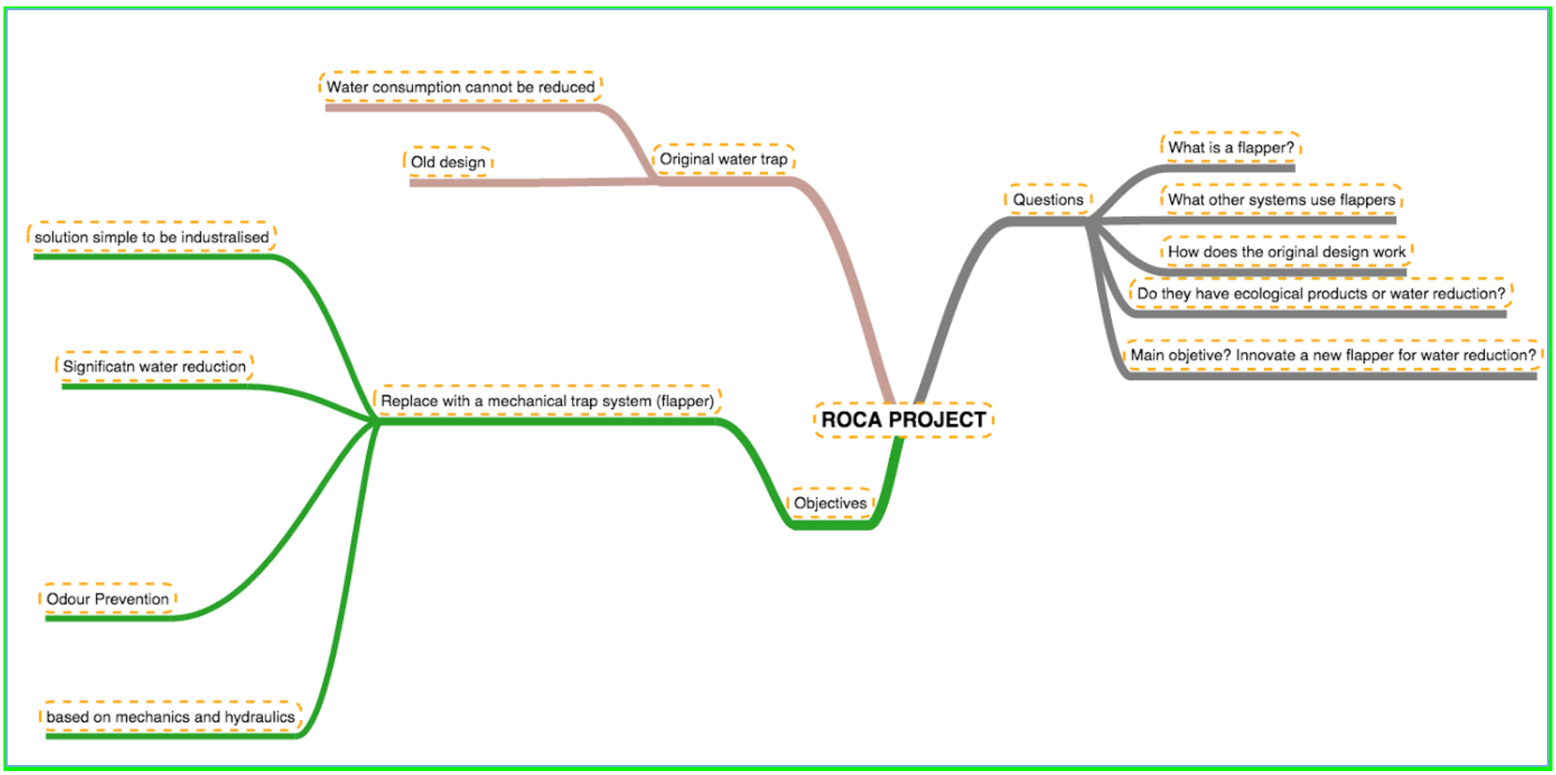


Figure 5. Mind Map for Brainstorming Requirements of Project

4.2 Research

Based on the Mind Map the team was able to decide what research should be conducted, and divided the research into the following topics: the mechanics of how current Roca toilets function, the current methods used in toilets not connected to the sewers, other mechanical trap systems, and water conservation methods in other systems . Their findings relevant to understanding the concepts described in the following section are summarized in the report.

4.1.1 Mechanics of Toilet

The working of a current toilet is very simple. There is water coming from the water supply stored in the cistern. Once the flush button is pressed, a flapper inside the cistern opens and let all this water go down to the bowl. When going down, this water pushes away all the water of the S-trap, pushing also all the waste in the bowl. As the pressure from the flush removes the wastewater, the bowl is simultaneously filled by the fresh water coming from the cistern until all of the water in the trap has been replaced.

Figure 6. Diagram of Water Trap in Standard Toilet

Figure 6 highlights the water trap of a standard toilet, this is the area that the team must re-design. The amount of water shown in blue is 2.5 L and is what functions as the current seal. This is the water the will replace with a mechanical system.

4.1.2 Functionality of Water Trap

A toilet bowl is a reservoir of water with an open bowl above and an internal S-trap below. The trap way is formed into the china fixture and bends either toward the front or back of the bowl. The direction is of no consequence. The upstream area of the trap way holds water when the bowl is full, while the downstream area of the trap way does not hold water, water flows freely into the drain from it. When the bowl is filled or primed, the water is at the top of the upstream trap way and the bowl will hold no more unless the trap way is plugged. When the primed bowl is suddenly flooded with water, the trap way floods. The air in the lower part of the trap way is pushed down the drain as the water takes its place. The lower area of the trap way, once flooded with water, will begin to empty into the drain. With the upstream and downstream areas of the trap way filled the weight of the water traveling into the drain pulls the water from the bowl by siphon action. Thus the water in the bowl and everything in the water are drawn into the drain. At the end of this sequence the bowl will be virtually empty and must be primed again.

There are two main reasons to fully prime the bowl:

1. The main function of the S-trap in the toilet bowl, or any other water trap, is to hold back the admittance of sewer gas into the room the fixture is placed in. It does this by being full of fluid. Under normal pressure sewer gas will not push the water out of its way and escape the drain. The toilet bowl is sealed against it by virtue of the water in it. For this reason the water in the trap way is called a "trap seal".
2. The other reason is almost as important. A fully primed trap way begins to flood sooner than a less than fully primed trap way does. The siphon action is greater and lasts longer insuring greater sanitation.

4.1.3 Functionality of Flappers

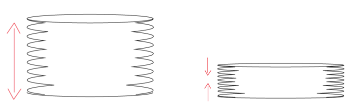
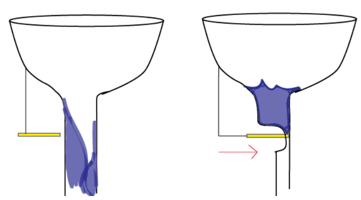
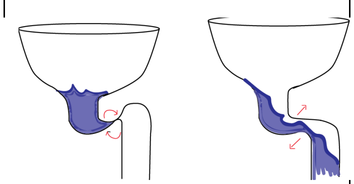
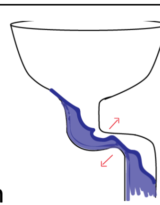
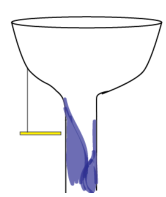
There are many different mechanical traps, such as flappers, but the working of them is very similar. There are different types of flappers, but all the flush toilets use a flapper inside the cistern. This flapper is generally disc-shaped and made of rubber. The flapper is found at the bottom of the tank, submerged in water, and attached to the base of the overflow tube by a pair of hinges. Raising the flapper would reveal a hole of mutual size. It's through this hole that water escapes whenever the toilet is flushed.

Operation of a toilet requires a careful orchestration of its parts. Once the toilet handle is pushed, an attached chain pulls the flapper up and away from the drain hole at the bottom of the toilet tank. After allowing approximately 2 gallons of water to drain from the tank, the flapper resumes its former position, sealing off the drain hole. As the filler float falls with the water level inside the tank, it activates a refill valve, which in turn begins replacing water inside the tank. The float rises with the incoming water. Once the float reaches a certain level, the float causes the refill valve to shut off.

4.2 Initial System-Level Concepts

A morphological chart is used to generate system level concepts using specific methods for each device function. To aid in their brainstorming and formation of initial concepts the team tried to break down the system into separate generalized functions that the new design would have to incorporate no matter what the final solution would be. A morphological chart was created for the functions and methods the team were able to derive and is shown below in Table 1

Table 1 Initial Morphological Chart for Generalized Aspects of New Design

Functions	Method 1	Method 2	Method 3
Odour Prevention (Seals)	Compressor 	Flapper 	Formation Plastic 
Maintenance	Non-stick spray	Some water in the bowl	Chemical Flush
Flush Systems	Current System 	Straight 	

Using the organized ideas developed during the brainstorming and creation of the generalized morphological chart the team was able to form various initial concepts for possible solutions, which are discussed below.

4.3 First Round Concepts and Evaluation

The first round of brainstorming concepts was focused on different ways in which the problem could be solved, not only focusing con mechanical flapper but trying to find other feasible solutions. The team had the liberty to explore into different directions and analysis the effectiveness of each one. The first ideas are summarized in the previous Table 1 as the initial morphological chart, and in the previous sections a more detailed description of each concept idea is stated.

4.3.1 Flexible Material

This concept involves the use of flexible material and is illustrated below in Figures 7 and 8. The idea was to use some sort of rubber or formation plastic which would use a suction force from the flush of the toilet to seal shut. The seal would open and close in a motion similar to that of an accordion, and would seal about either the vertical or horizontal axis.

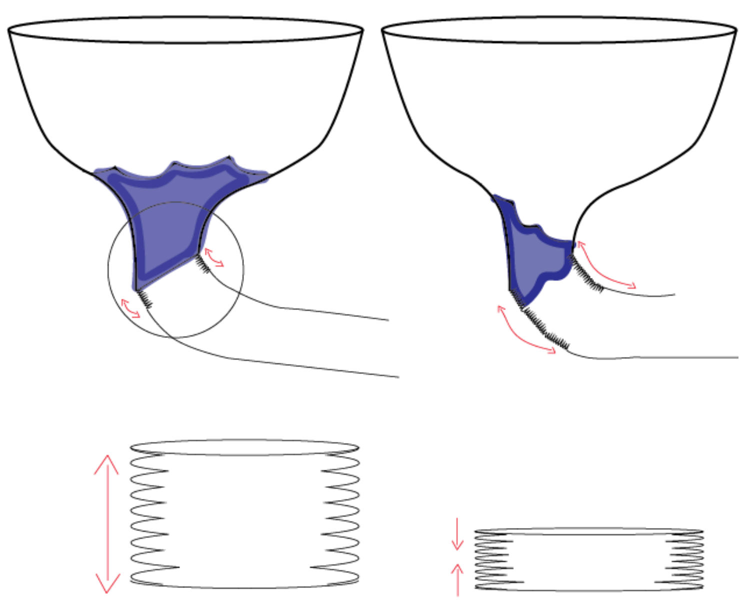


Figure 7. Flexible Seal Vertical Axis

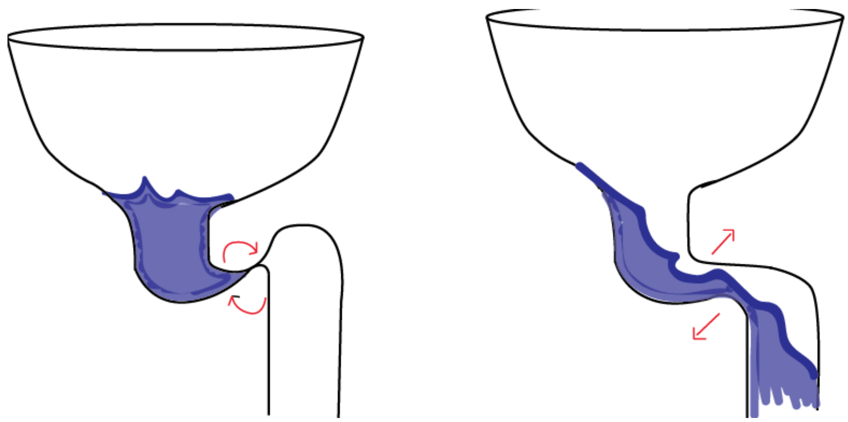


Figure 8. Flexible Seal Horizontal Axis

Rubber tube seals, shown in Figure 9, are currently used in some waterless urinals. The rubber tube is flat at the bottom when not in use, blocking odors from the sewage or storage tank, but opens when liquid is passing through. These seals require frequent cleaning, and must be replaced about once a year. The rubber material is also sensitive to solvents, acids, and deodorizing tablets [7]. Based on this research of an already functioning rubber seal, this concept was eliminated as an option due to the fact that the material is not robust, the system requires constant maintenance, and is not appropriate for solid waste which is a vital necessity for this project

Figure 9. Rubber Tube Seal for waterless urinal

4.3.2 Gate

This concept came from the idea of creating a gate that could separate the bowl from the S-trap, trying to stop all the waste and extra water until the flush button is activated. The idea came from airplanes toilets, in which a similar kind of gate is used for holding the toilet water and waste and opens as soon as the user clicks the flush button.

The main purpose of this gate in the concept is to work similar as the airplane toilets. The concept was thought of working as a both, as flapper and as an odor seal, for stop using water. The inner shape of the gate is thought to be of a rubber material that can work especially for preventing odors to come back up. Those shapes should fit each other for guarantee that water nor odors could pass once it's closed.

This idea has several cons that included how to attach the gate to the piping without using screws or similar tools. Also since it would be something that would be in constant use, the rubber should have maintenance constantly and wouldn't guarantee the effectiveness of the sealing and leaking of water when it closes. For this main reason this concept was discarded by the company.

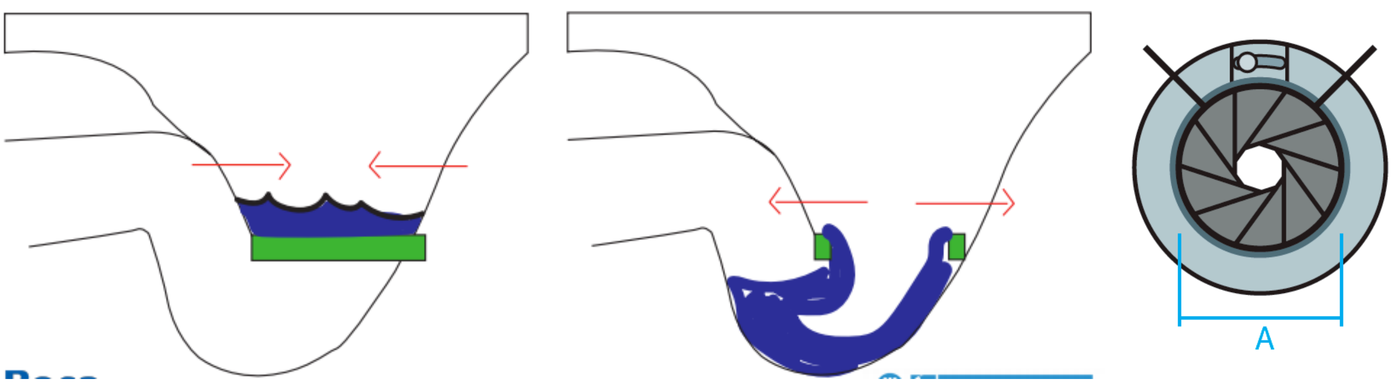


Figure 10. Gate

4.3.3 Bathtub Drain and Trap

As previously stated the new toilet needs a mechanical trap system that seals off the pipes under the toilet bowl while still maintaining a certain level of water in the bowl. While researching existing methods of various water systems the team was inspired by bathtubs that utilize a trip lever drain such as the one displayed in Figure 11.

A trip lever drain uses a plunger, located in the tub overflow pipe, to plug the drain pipe and keep water from draining. The plunger is controlled by the trip lever which is manually operated by the user. When the user flips the trip lever up, the plunger moves down into the drain to stop the pipe flow, and when the user pushes the lever down, the plunger moves up the pipe, opening the drain once more. [2]

This method is very simple and the team hypothesized that it would be feasible to redesign the toilet piping into a similar system where the flush button on the toilet would trigger a plunger or other mechanical trap. However, after speaking with the Roca Innovation Lab project manager, the team was informed it would be preferred that the new trap system was not required to be linked to the tank or flush button of the toilet. Therefore, this idea was discarded.

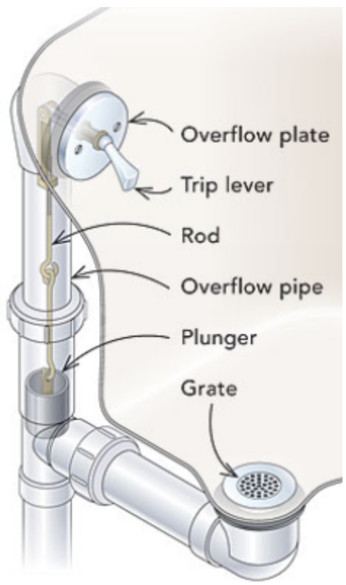


Figure 11. illustration of Bathtub

4.3.4 Flapper

This concept is as chosen by the company is the most viable solution to save water in toilet bowls. It's design is essentially creating a piece of material that separates the narrow end of a toilet bowl to the S tube/sewer piping. The flapper mechanism would replace the water currently used in the S tube piping as the trap for sealing in odors. Therefore saving one half to two liters of water. A little water would still be needed in the bowl, on top of the flapper to help with cleanliness and waste removal. .

The flapper works similar to a household door as already mentioned it separates the toilet bowl to the s tubing. It is also hinged to the back of the bowl thus enabling it to swing in an upwards and downwards action therefore allowing water and waste to pass when open. Although the design for this flapper will only allow the flapper to move in a downward direction thus helping in the preventing of bad odors from entering the toilet bowl from below. This however is not the finished design as the flapper cannot simply rely on a hinge to work, and it would remain open and let fresh water needed constantly pass. Therefore, there also has to be a mechanism that opens the flapper only when there is waste and the flush button on the water tank has been pushed.

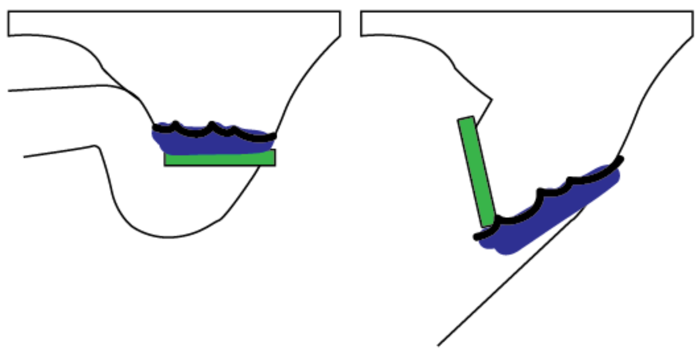
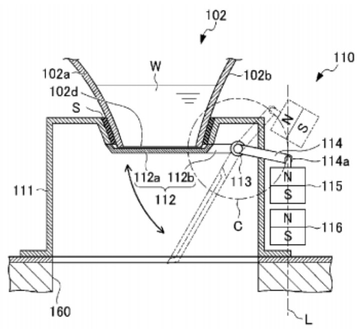
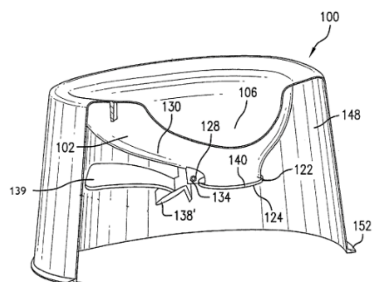
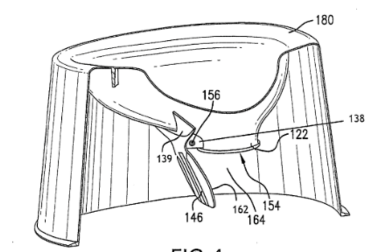


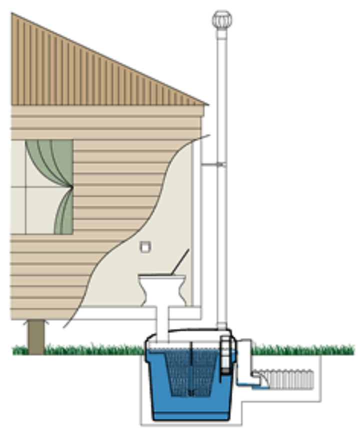
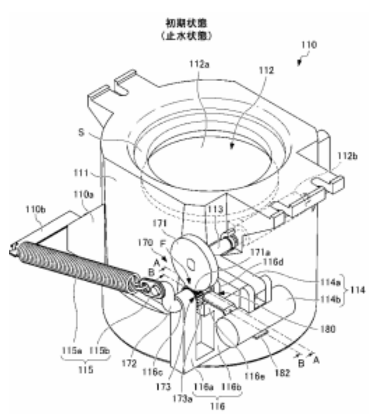
Figure 12. General Flapper Concept

4.4 Second Round Concepts and Evaluation

After it was decided a flapper would be used for the solution to the project, the company provided the team with various patents of pre-existing designs that use a flapper as the mechanical trap system inside a toilet. The team analyzed each patent in detail and created a pros and cons list for each, shown below in Table 2. This allowed the team to pull the different ideas from each patent and highlight what aspects they could possibly use from each design, and disregard those that were irrelevant or ineffective for this project. The pros highlighted in green are features of the design the team believes they could possibly incorporate in their own design. The actual patents can be referred to in the appendix.

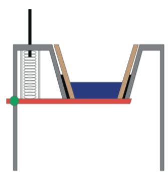
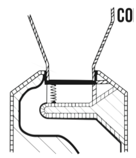
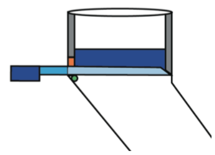
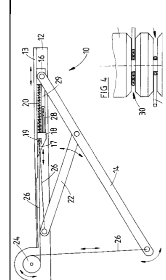
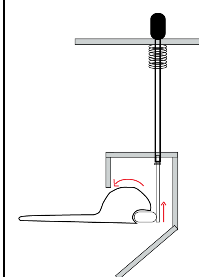
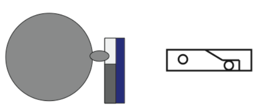
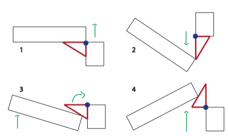
Table 2. Patent Analysis of Pre-Existing Flapper Designs

Patents	*Info*	*Picture*	*Pros*	*Cons*
(WO2015174368) TOILET DEVICE AND WASTE TRANSPORT SYSTEM	The purpose of the invention is to provide a toilet device that can prevent a flapper valve from sticking and can inhibit waste in a toilet bowl from adhering by ensuring a large amount of reservoir water and that can open and close the flapper valve with a small operation load and operation stroke.		• Simple mechanism • Use of magnets • No leaking points • Good axis for axis rotation • Two piece installation	• Magnets can stop working at some time • The flapper depends on the magnets for opening and closing • If magnets stop working all the waste would be stuck there.
(WO 2015/109301) LOW OR NO WATER USE LATRINE PANS, LATRINE PAN ASSEMBLIES, LATRINES, AND RELATED METHODS	The invention provides a latrine pan and latrine assemblies that can be used with little or no "flush water", yet provide sustainable and hygienic separation of waste from human contact. Such invention is particularly suitable and practical for use in remote, less affluent geographies where water resources are scarce.	FIG.3 FIG.4	• Very little "flush water" use • Opens with the weight of the waste. • Simple open/close mechanism • Collections basin and flapper • Uses counterbalance device and counterbalance device	• counterbalance device is substantially equal to or slightly greater than a pivotal force attributable the cover plate. • water is applied using a "squirt bottle" or another similar manual water dispensing vessel that dispenses water at a higher water pressure than is generated by simple pouring.

GTL-0000-17 **GTL-0000-18** **Hybrid Toilet System- Microflush pedestal**	The special bowl has been designed to flush clean using only 300ml of water. Combining this flush technology with the Hybrid Toilet System has brought a new level of toilet cleanliness and user familiarity to on-site treatment and minimal water use. The waste enters the primary tank which is filled with water, where it is acted upon by bacteria and is broken down to 5% of its original mass. Via displacement, the clarified effluent then travels to the secondary treatment unit. On completion of treatment (approx 120 days) the effluent is then dispersed to ground via a gravel bed.		• pedestal drop toilet where faeces and urine are deposited directly into a primary tank filled with water.	• Uses 2 big tanks • solids remain in the tank • No flapper
JP 2015-224437 A 2015.12.14 Toilet equipment and waste transport system	The present invention has been made in view of the above, the object can open and close the flapper valve with a small operation load than conventional, water stool in bowl to provide a toilet bowl device can be reliably prevented flooding to the outside		• 2 piece: flapper and bassin • Uses counterweight • Spring used to open flapper • Spring doesn't have contact with water or waste.	• Complex mechanism • Uses springs and cogwheels. • Depends on many pieces.

Using ideas pulled from the patent analysis in conjunction with their own ideas, the team created a new morphological chart focusing solely on different functions or aspects of the flapper design including: how it will open and close, how it will lock, and how it could be attached. General methods or solutions for each of these features are illustrated below in Table 3.

Table 3. Initial Morphological Chart Comparing Solutions for Different Functions of Flapper

Functions	**Method 1**	**Method 2**	**Method 3**	**Method 4**	**Method 5**
Open / Close	**Tension Spring** 	**Compression Spring** 	**Counterweight** 	**Window** 	**Hook** 
Lock	**Lock 1** 	**Lock 2** 			
Attach	**One Piece**	**Two Pieces**			

4.4.1 Concepts for Opening and Closing the Flapper

Open/Close Method 1

This concept incorporates the force of a spring to open and close the flapper, similar to a method in the patent JP 2015-224437 (see appendix). Simple schematics illustrating the basic design using either a tension or compression spring are shown below in Figure 4.9 and 4.10. This design would be fairly easy to produce once the perfect spring was found, but it is predicted the team may encounter some difficulty finding a spring that both has enough strength to push or pull the flapper back into the closed position and hold it there while still being flexible enough to open with simply the force of the flush. There is also concern from the team that over time the spring will experience too much fatigue and more maintenance than what is desired will be required. Another challenge for this design will be where to position the mechanisms to protect them from splash and waste from the flush.

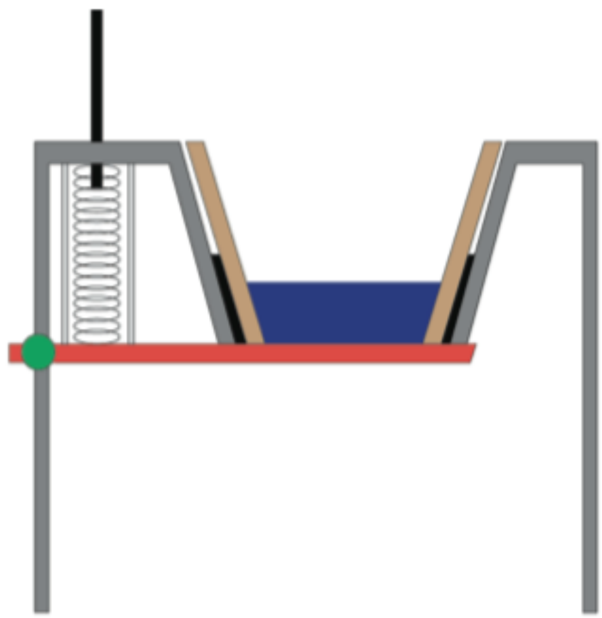


Figure 13. Tension Spring

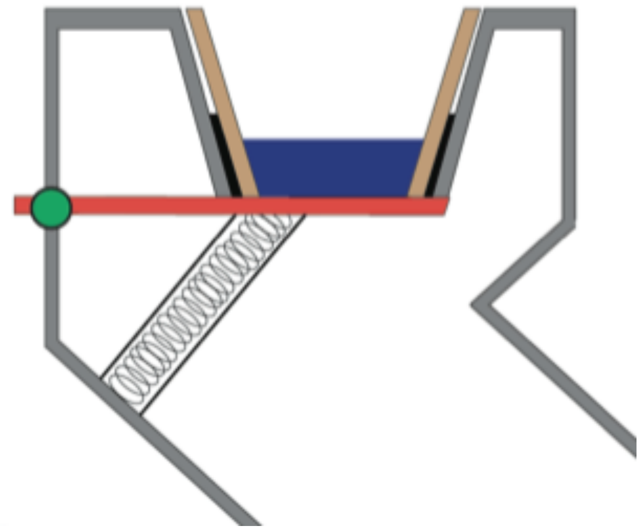


Figure 14. Compression Spring

Upon further examination and feedback from the company the concept of using springs was decided to be one of the most feasible solutions and was selected to move into the final round of concept evaluation. Although it is not currently clear exactly the type or position of spring; further calculations and analysis are needed to produce a final design.

Open/Close Method 2

This concept is centered on the idea of a counterweight. The overview of this concept is illustrated below in Figure 15. The plan for this design would be that the flapper remains closed until the user flushes the toilet, and the flapper would then open strictly with the force of the flush. The counterweight would be connected to a refill system; when the toilet is flushed, the counterweight begins to fill with water, and as the weight increases it lifts the flapper back into the close position. Once the flush is complete, and the flapper is back in the close position the water from the counterweight could then be used to refill the tank.

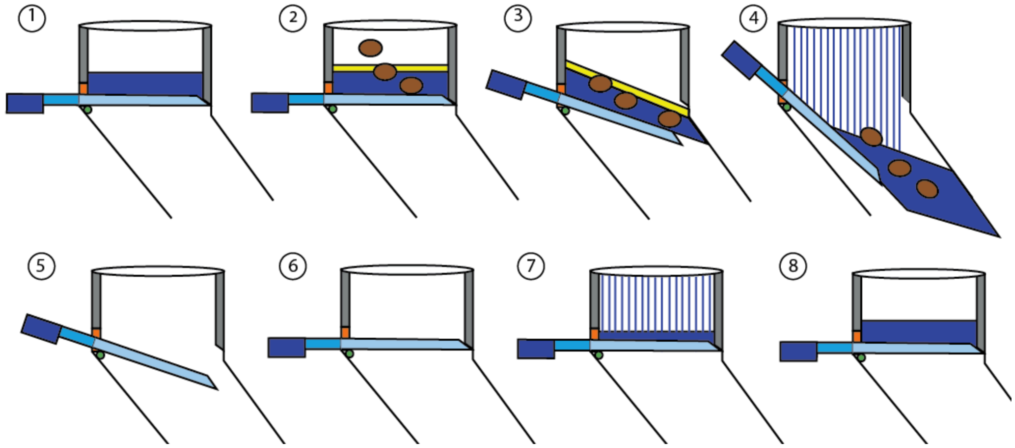


Figure 15. Counterweight

Although it is not yet defined exactly how the refill system would function for the counterweight, the general idea of using a counterweight appeared to be the simplest solution during this round of concept evaluation. It does not have the concerns of fatigue or durability that the spring design has, and would close the flapper in a more controlled motion. Thus, this concept was also chosen for the last round of concept evaluation.

Open/Close Method 3

This concept is based on the drawers or windows that can be found in an average household which automatically close on their own with just a slight touch. A diagram of this mechanism is shown below in Figure 16, which is from a patent that can be referred to in the appendix section. "The opening/closing mechanism has a hinge arrangement with two linked arms (14, 22) pivoting from a runner which may be attached to the window frame. One or both of the pivoting arms is mounted to the runner on a slider (16) which is movable along the runner in relation to the pivot mounting of the other arm. The mechanism is operable by way of a cable or cord (26) which has portions wound around a spool (24) which is rotatable by the user." [39]

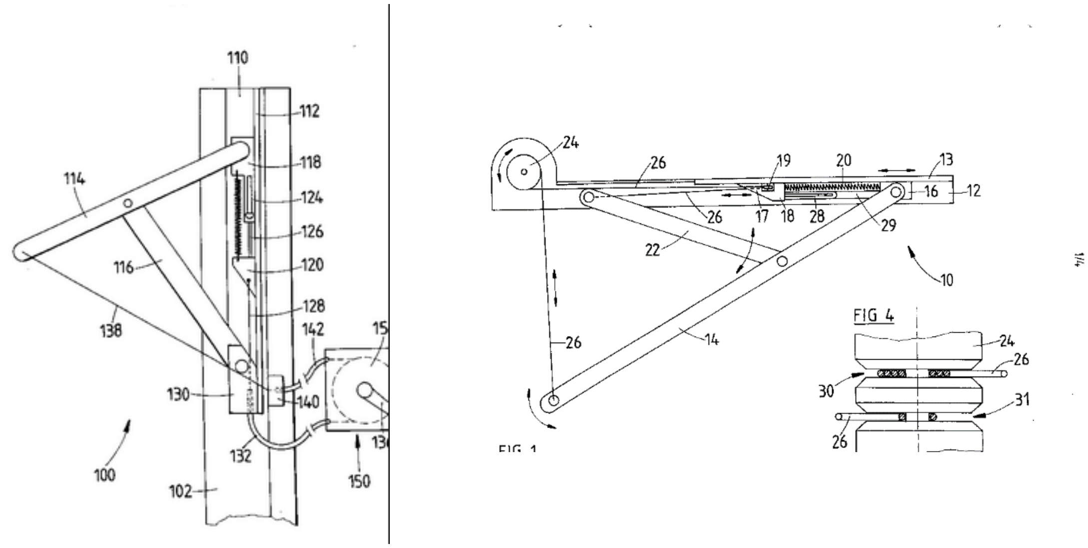


Figure 16. Automatic Drawer Closing Hinge

The most appealing feature of this design is the amount of control and fluidity of the movement of the opening and closing of the drawer or window. This is due to the fact that “when tension is first applied to the opening cable portion, initial limited movement of a wedge member (17) can be used to initiate angular movement of the arms whilst the respective pivot mountings thereof are substantially aligned along the runner.” [39] However, the company instructed that they want a design that is as simple as possible, and if the team chooses this concept direction they must prove that it is substantially more efficient than the other spring designs. Due to time limitations of this project the team ultimately decided this design is over-engineered and they could accomplish their main objective with a less complex solution. However, if the team chooses a spring system for their final concept, they may still use some features of this design as an idea on how to control the movement of the springs.

Open/Close Method 4

As shown in Figure 17, this design would require the user to pull a flush valve instead of pushing a button, as can be found in some older models of Roca toilets. This method appears to be a very simple solution to open and close the flapper in a secure manner. However the pull valve is not as visually appealing as the current push button, and it would be harder to incorporate a dual flush system using this design. In addition, as stated earlier in the section 4.3 the company would be prefer that the new trap system not be linked to the tank or flush button of the toilet. Thus although it was agreed this idea is feasible, it has been labeled as a back-up design to be used only if the concepts which open strictly with the force of the flush fail.

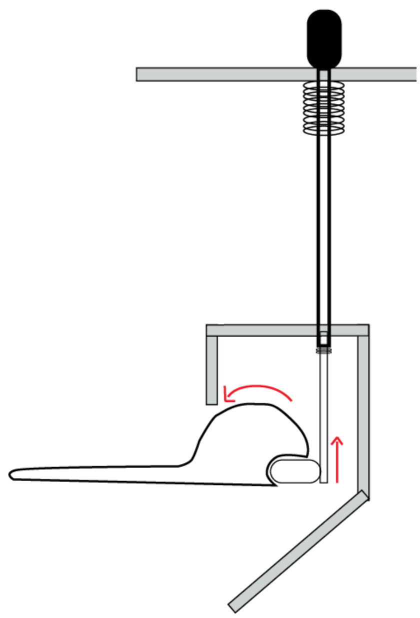


Figure 17. Manual Pull Lever and Hook

4.4.2 Concepts for Locking Mechanism of Flapper

The team briefly brainstormed some ideas for locking the flapper into place when in the closed position. Some general sketches of possible locking mechanisms are shown in the morphological chart as well as below in Figures 18 and 19.

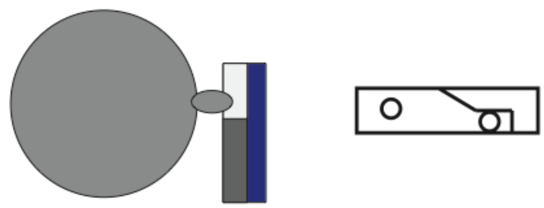


Figure 18. Lock 1

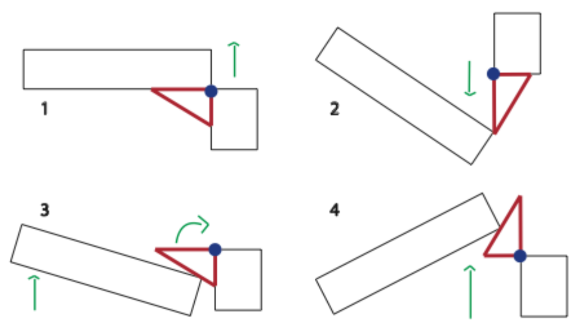


Figure 19. Lock 2

However, any form of locking mechanism would again require that the system be connected to the flush button or tank of the toilet in order to release the lock. There is still debate between the team and company as to whether a flapper design can really be sealed and secure without a locking mechanism. However, for now the team has been asked to attempt a design without any form of locking, thus these ideas have been put on hold.

4.4.3 Concepts for Attaching the Flapper

One of the biggest challenges presented for this project is how to attach the flapper. Several of the designs in the patent analysis utilize a completely separate piece with the flapper design that is added under the bowl of the toilet. There is much debate between the supervisors and the team as to whether having a connecting piece such as those in the patents, or connecting everything directly to the bowl will be more efficient. At this stage it is not yet decided which direction the team will take. With the current design of the two final concepts: the spring or the counterweight, the spring concept requires a separate piece, whereas the counterweight could theoretically be attached directly to the bowl. Ultimately this aspect will not be decided until the final concept definition has been created.

4.5 Third Round Concepts and Evaluation

As stated in the previous section, two concepts were selected for the final round of evaluation: the concept incorporating springs and the concept involving a counterweight. In order to conduct further analysis, more detailed diagrams and storyboards were created for each of the concepts to aid in calculations and to ensure that every team member and supervisor had the same understanding of exactly how each concept would function. These are shown below in Figures 20-23

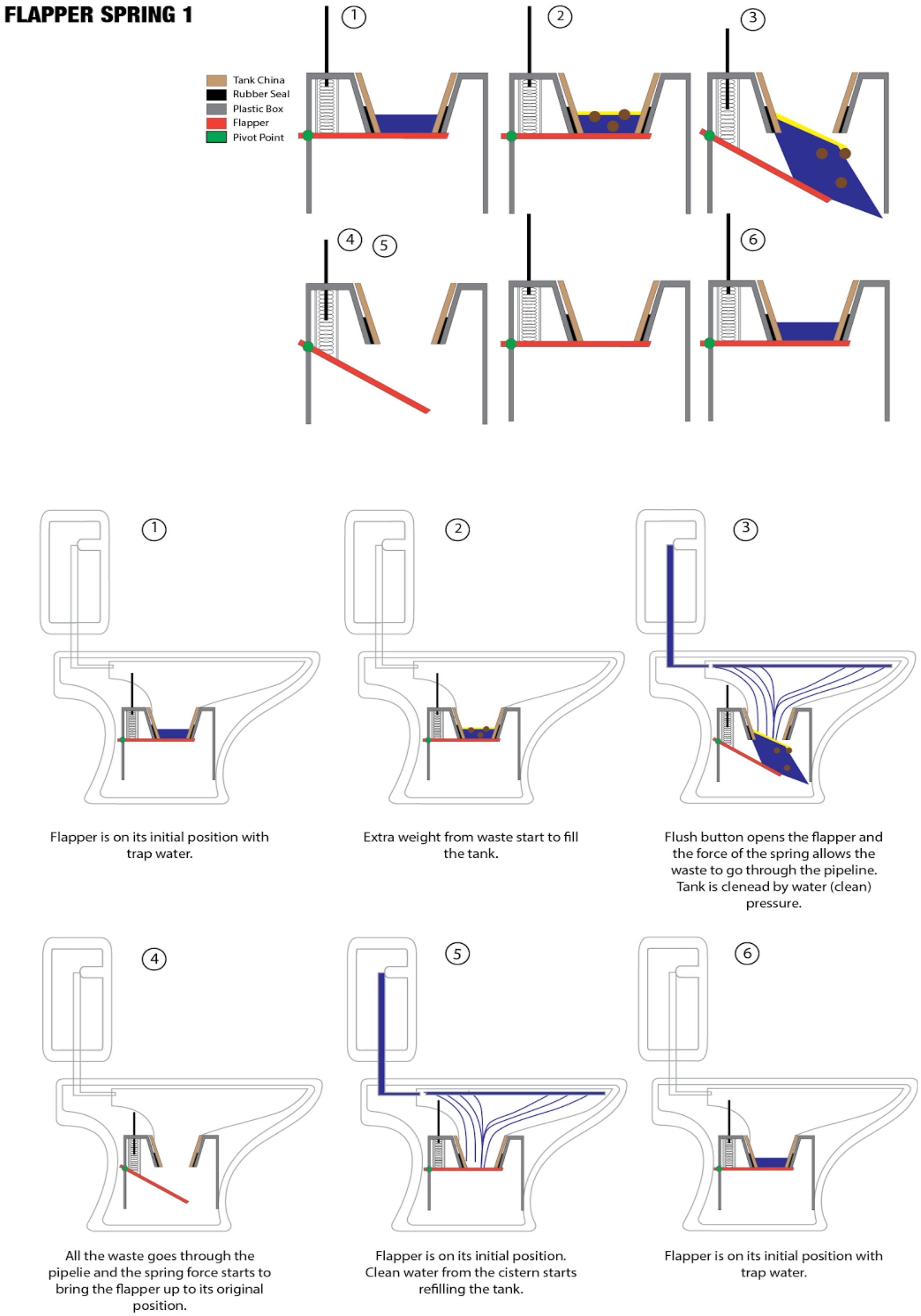
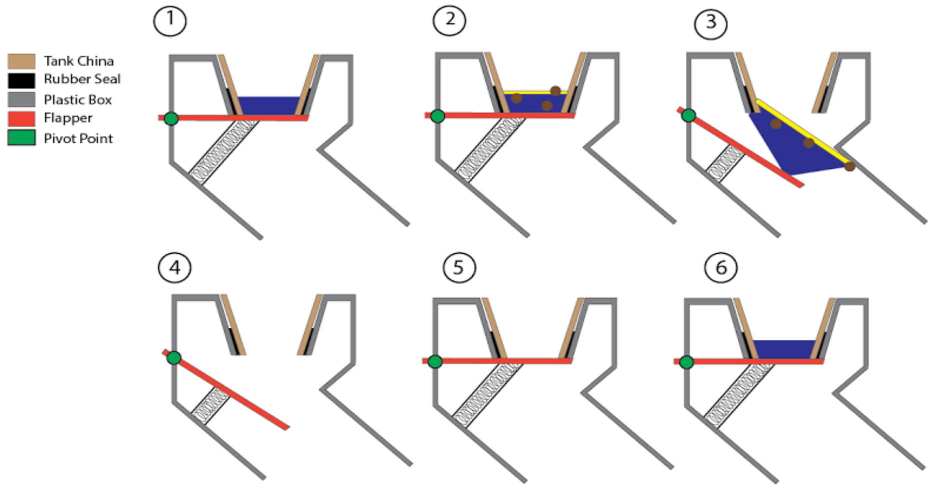
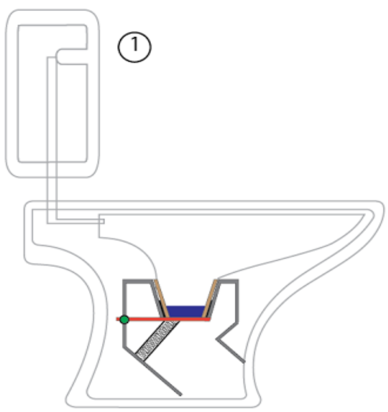


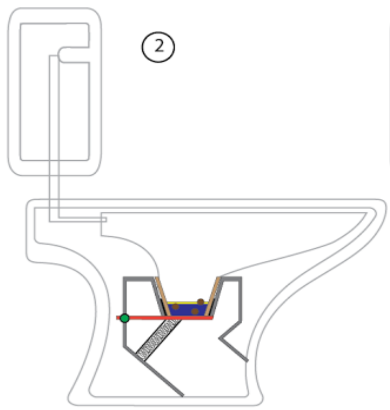
Figure 20. Detailed Diagram and Storyboard for Tension Spring

FLAPPER SPRING 2

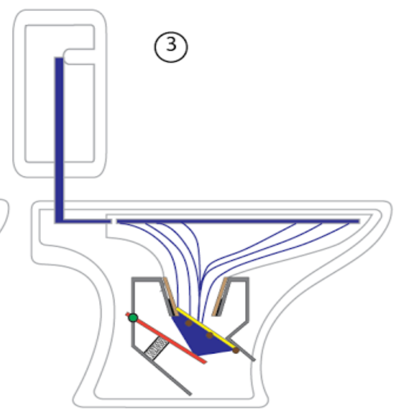




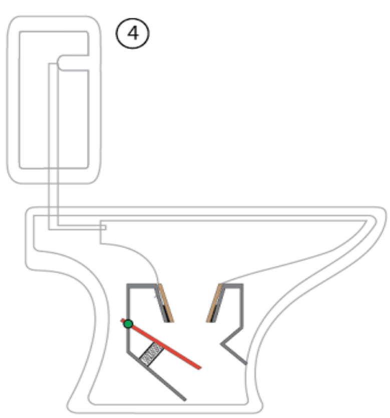
Flapper is on its initial position with trap water.



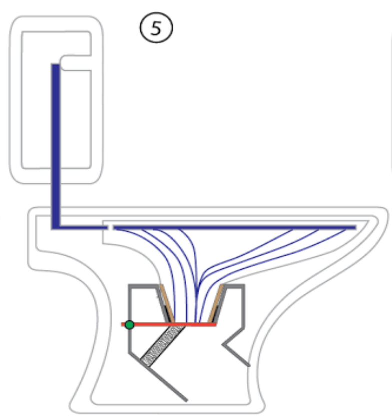
Extra weight from waste start to fill the tank



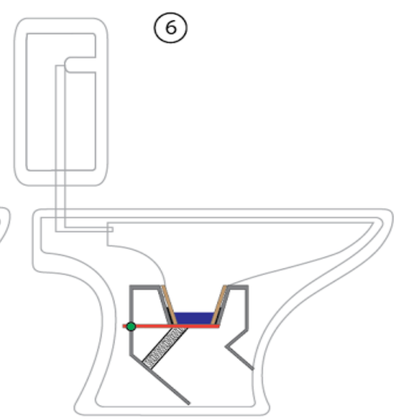
Flush button opens the flapper and the force of the spring allows the waste to go through the pipeline. Tank is clenead by water (clean) pressure.



All the waste goes through the pipelie and the spring force starts to bring the flapper up to its original position.



Flapper is on its initial position. Clean water from the cistern starts refilling the tank.



Flapper is on its initial position with trap water.

Figure 21. Detailed Diagram and Storyboard for Compression Spring

Spring Concept Storyboard

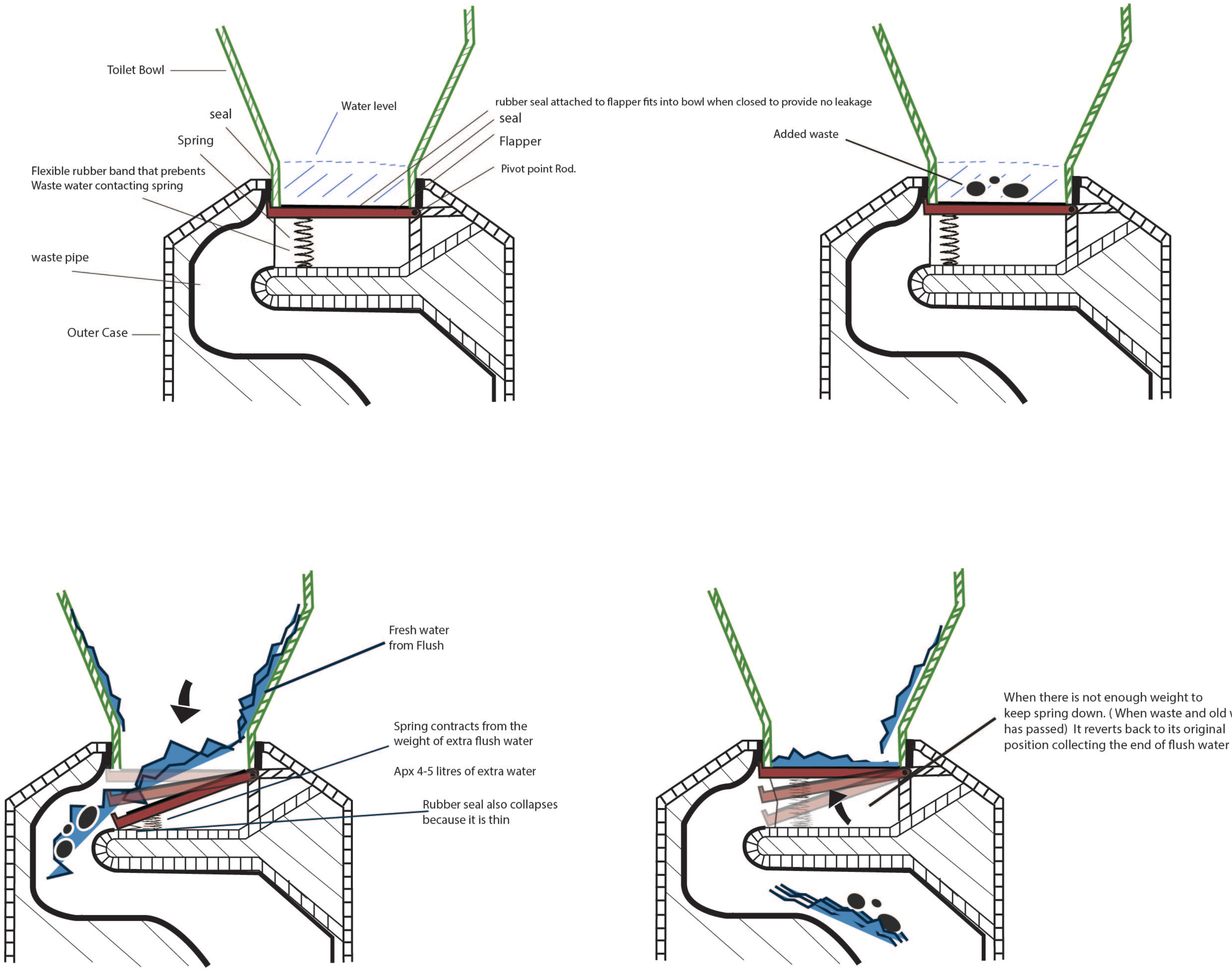
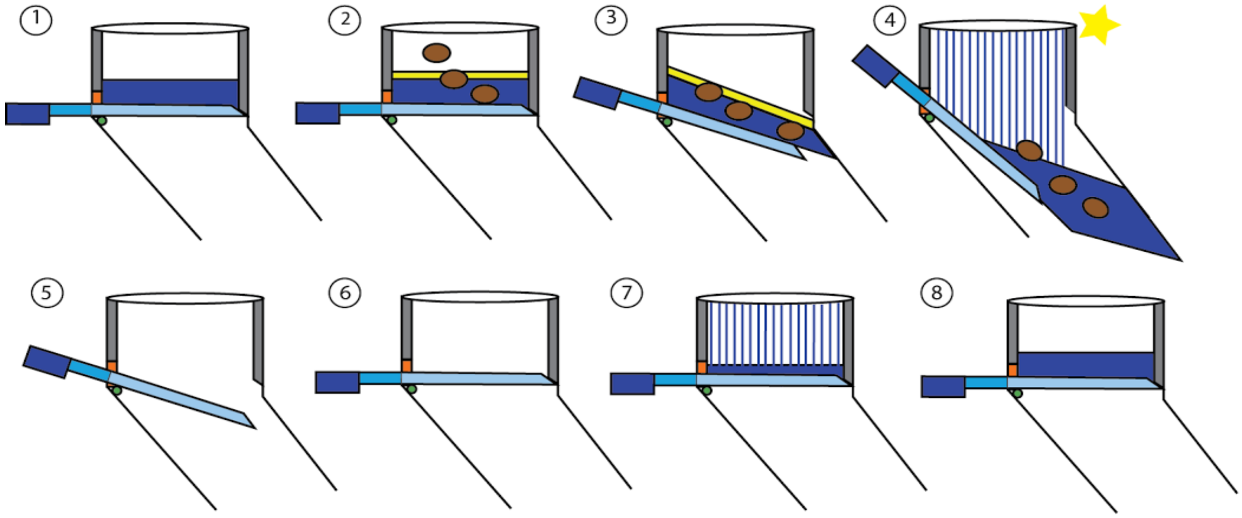
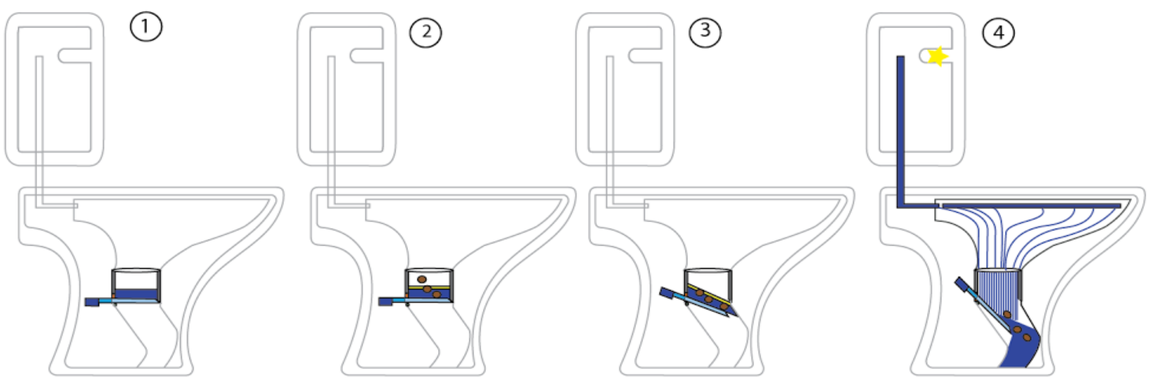


Figure 22. Storyboard for Spring

FLAPPER COUNTERWEIGHT



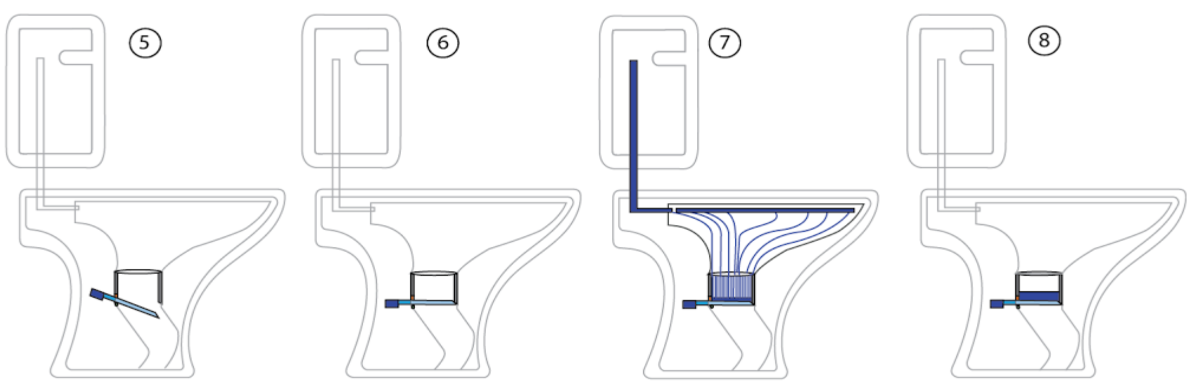


1. Flapper in initial position with water trap.

2. Extra weigh of waste start to fill the tank.

3. Since the amount of weight on the flapper is greater than the amout of water in the counter-weight, the flaper will open.

4. Flushing will cause clean water from the cistern to clean the tank and the flapper. Water preassure is needed.



5. All waste and water will go through the pipeline. Flapper will start closing thanks to the weight difference.

6. Flapper in initial position

7. Tank will start refilling automatically just like actual toilets do.

8. Flapper in initial position with water trap.

Figure 23. Detailed Diagram and Storyboard for Counterweight

After the analysis with the company, the concept options got reduced even more. The concept of the counterweight was discarded since it presented some disadvantages such as: the minimum amount of water calculated maintaining the flapper closed was not as favorable as expected, the size of the counterweight box in which the needed water should be stored would take a bigger space than planned and finally, the effect when the counterweight has when closing could present some problems in which waste and water could shoot up the bowl. Because of these, the team member and supervisors decided to narrow even more the possible solutions and focus only on flappers that would open and close using different types springs.

5 Final Concept Decisions

For the final concept, a merge of all concepts was designed since all of them had some advantage that could be used for a better result. The final concept is a combination of forces, forces that would help to maintain the flapper closed, to open and to go back to its initial position. A counterweight and a traction spring will be used to maintain the flapper closed and balance when it is only holding clean water with no waste on it. For the flapper to open, extra weight needs to be deposit but cannot open until the user flushes. The flapper will open until the extra weight of the waste and water flush are deposit on the bowl (step 1). This force will make the flapper to loose balance and will open since the force on the opposite side of the counterweight is greater. For the flapper to open at an acceptable angle for the waste and water to start circulating through the pipes, the flapper need to open to 25º and the counterweight need to be exactly at the top of the pivot point (step 2). For the flapper to open to its maximum angle (55º), the counterweight should pass the pivot point (step 3) and it's force and the inertia forces would maintain the flapper open for a few seconds. After this the weigh on the flapper will be reduces and he counterweight would be able to close the flapper and maintain it closes as its starting position. These steps are illustrates on Figure 24.

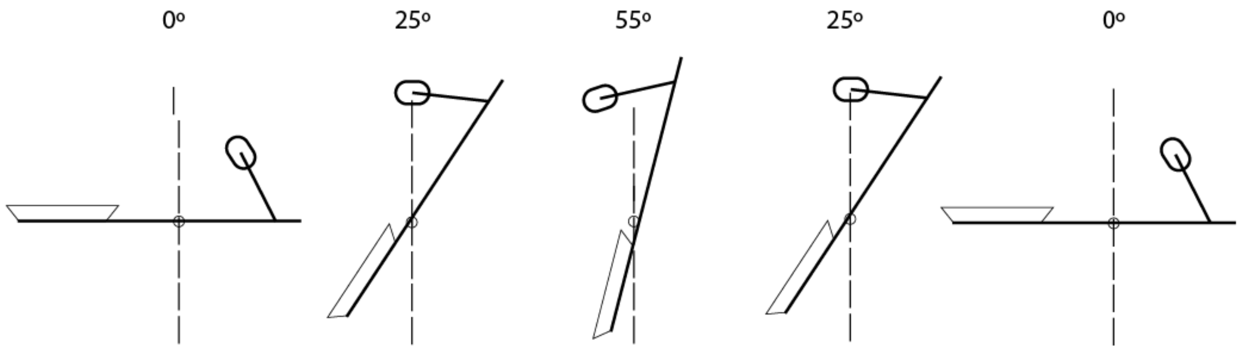


Figure 24. Counterweight Steps

Some of the major problems faced, was that the weight the counterweight needed to maintain the flapper closed and balance was big, almost 10 kg were needed, according to calculations and approximations with data given by the company about the minimum amount of water needed in the toilet and waste weight. So the teamed played with different materials with different densities for reducing as much as possible the size of the counterweight. Also since the main objective at this point was to reduce the size, an extra force was added for making it easier for the counterweight to bring the flapper back, so here is were the springs form previous concepts take action. A compression spring was added to compensate that force that the counterweight was doing. Figure 25 illustrates were the spring is placed and how it works in combination with the counterweight.

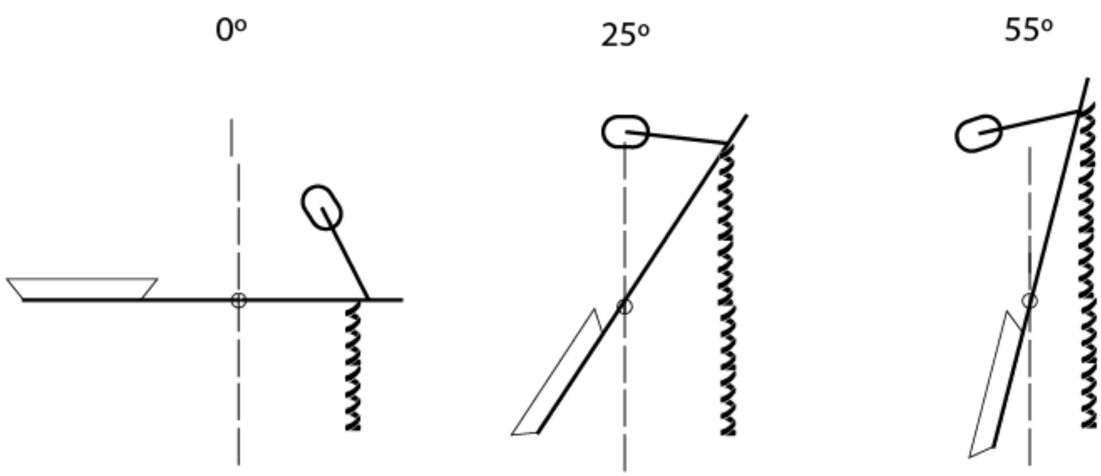


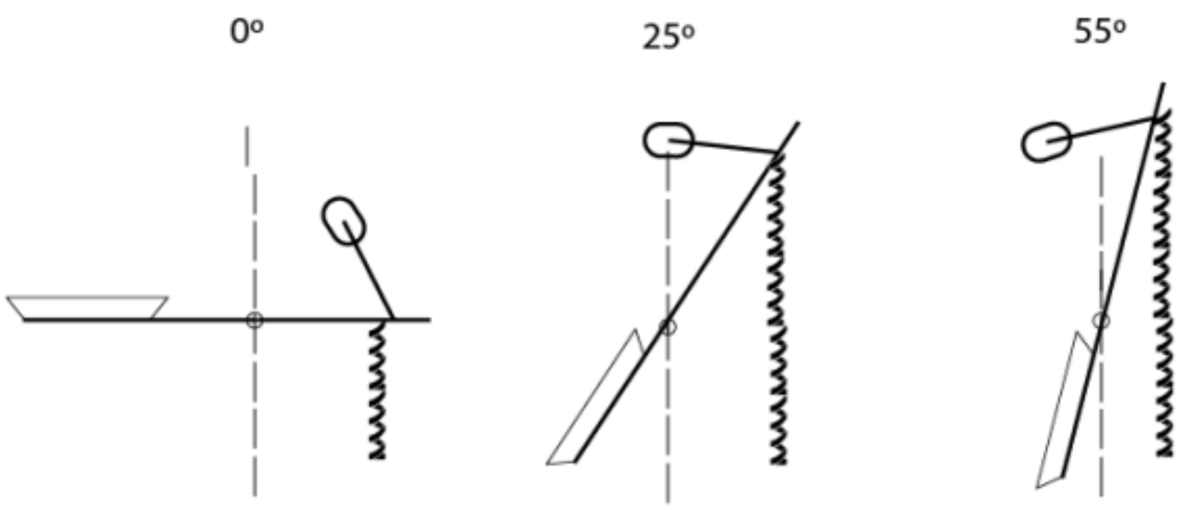
Figure 25. Counterweight and Spring Steps

As a result, the final design is a flapper that is closed thanks to the force of the counterweight and the traction spring that are in balance with the weight of the water in the bowl (.5L), and when extra weight, including human waste and others (the team calculated that the maximum weight the flapper needed to hold was 1.5 grams, including water and waste), is introduced into the bowl the counterweight and spring are still heavier so the flapper is still closed. After the user flushes, the flapper will open 25º and once the counterweight passes the pivot point it would open to its maximum angle of 55º in which all waste and water will be able to evacuate. Finally the flapper will return slowly thanks to the force of the spring and the counterweight.

On the following section, a full explanation of all the calculations and formulas needed for the flapper to work will be explained.

6 Calculations

As the main concept of this design revolves around the use of a counterweight, calculating appropriate weights and distances was imperative to create a system that would stay in balance. The three vital positions of the system are displayed below in Figure 26.



P1: Closed **P2: In Equilibrium** **P3: Fully Opened**

(Counterweight not acting)

Figure 26. Schematic of Vital Position of Counterweight System

The first set of calculations were done considering the flapper in position 1 (P1), in order to determine the maximum amount of weight or force the flapper will need to hold while still remaining fully closed. The following equation was used to determine this maximum weight:

Equation 1

$$W_{total} = W_{water} + W_{solid} + W_{urine} + W_{flapper}$$

Where W_{total} is the total weight acting on the flapper, W_{water}, is the weight of the water in the bowl, W_{solid} is the maximum weight of solid waste that could occur, W_{urine} is the maximum weight of urine that could occur, and $W_{flapper}$ is the weight of the flapper.

Table 4, shown below, displays the given values that were provided by the company based on previous research.

Table 4. Provided Values

ρ_{water}, Density of Water	**1000 kg/m^3**
h_w, height of water in flapper/bowl	30 mm
W_{solid}, maximum weight of solid waste	500 grams
V_{urine}, maximum volume of urine	250 mL
V_{flush}, volume of flush water	1.5 – 2 Liters

Table 5. Densities of Related Materials

ρ_{urine}, Density of Urine	**1015 kg/m^3**
ρ_{PPE}, Density of Polypropylene (flapper material)	**946 kg/m^3**
ρ_{brass}, Density of Brass (counterweight material)	**8700 kg/m^3**

Using the data from Table 4 and 5 and Equations 2 and 3 all variables from Equation 6.1 could be calculated. Equation relates density (ρ), mass (m), and volume (V), and Equation 6.3 related weight (W) and mass (m) where g is the constant acceleration due to gravity of 9.81 m/s. The results are shown below in Table 6.

Equation 2

$$\rho = \frac{m}{V}$$

Equation 3

$$W = mg$$

Table 6. Calculated Values of Weight acting on Flapper

W$_{water}$, Weight of water in bowl	454 g -> 4.45 N
W$_{urine}$, Weight of urine	257.5 g -> 2.52 N
W$_{solid}$, Weight of solid	500 g -> 4.91 N
W$_{flapper}$, Weight of flapper	235.46 g -> 2.22 N
W$_{Total}$, Total max weight of closed flapper	1446.96 g -> 14.19 N

W_{Flush} Weight added by flush	1.5 kg -> 14.72 N

After the maximum weight acting on the flapper at rest was determined, the necessary weight of the counterweight and spring force needed to keep the system in position one could be calculated. A free body diagram of the system in position one is shown below in Figure 27.

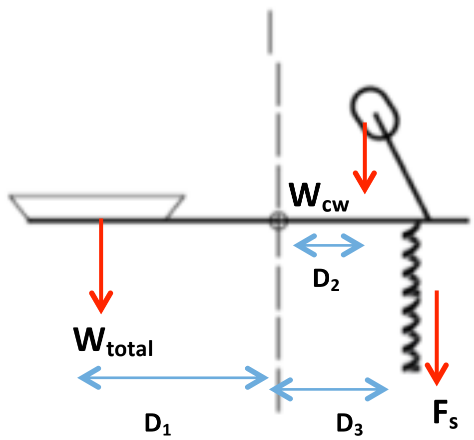


Figure 27. Free Body Diagram of System at Rest

W_{total} : Maximum weight flapper must hold at rest

W_{wc} : Weight of counterweight (including bar)

F_s : Spring force

D: Distance from center of gravity of force to point of equilibrium

The required weight of the counterweight and spring force needed to balance the system at W_{total} was calculated by summing the moments of the system about the equilibrium line. The resulting equation is shown below in Equation 4.

Equation 4

$$\sum Mo = W_{total} * D_1 - (W_{cw} * D_2 + F_s * D_3)$$

Because the system should stay at rest or not moving with the force of W_{total}, it can be assumed that the summation of the moments ($\sum Mo$) equals 0 at this point. Thus the equation becomes:

Equation 5

$$W_{total} * D_1 = (W_{cw} * D_2 + F_s * D_3)$$

The D values were simply measured from the 3D CAD prototype of the system and are shown in Table 7.

Table 7. Distances from Center of grevity of Forces to Equilibrium line

D_1	180 mm
D_2	68 mm
D_3	100 mm

Due to size limitations there was a maximum volume that the cylinder could have to enable the system to function properly within the attachment box. After testing various sizes and shapes of counterweights within the CAD design, it was decided the most functional form for the counterweight would be two smaller cylinders with a total volume of 91.95 cm^3 each one.

Knowing the material of the counterweight and therefore the density of the counterweight, Equations 2 and 3 were then used to find the desired weight of the counterweight.

Once W_{cw} was calculated, it could be plugged into Equation 5 along with the values in Table 7 to solve for Fs, the necessary spring force. The calculated values for these balancing forces are shown below in Table 8.

Table 8. Final Values for Forces Acting to Balance System

W_{cw}, Weight of Counterweight	1.6 kg

F_s, Spring Force	1.072 N

Equation 6

$$F = kx$$

With the Fs calculated, we use the equation 6 to find the approximated characteristics of the spring, constant (k) and the distance displaced by the spring. Using an initial displacement of 15 mm, we find that the k of our spring should be 0.0714 N/mm

Table 9. Spring Characteristics

k	0.0714 N/mm
x	15 mm

After all the calculations of the rest position were done, it is necessary to check if the spring chosen is able to turn back the flapper to the rest position

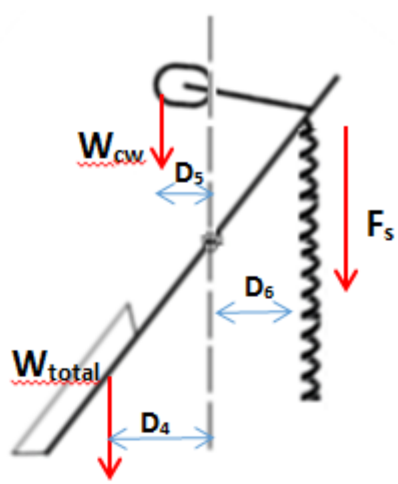


Figure 28. Free Body Diagram of System at 55º

Once the new distances are known (table 8), they can be plugged into the the Equation 5, taking in consideration that now the weight of the counterweight (W_{cw}) is acting in the other direction, working now against the spring.

Table 10. Distances from Center of Gravity of Forces to Equilibrium line at 55º

D_4	103.24 mm
D_5	13.4 mm
D_6	57.36 mm

As a result, we come up with a spring force of **2.534 N.** So, as we expected, the maximum force of the spring remains in reasonable values.

7 Materials

7.1 Material Selection

For this project, choosing the right material is a crucial part. According to Michael Ashby in *Material Selection in Mechanical Design*, the design of engineering components involves three interrelated problems: (i) selecting materials, (ii) specify a shape and (iii) choosing a manufacturing process. Getting these components right since the beginning of the process can bring enormous benefits such as lowering the product cost, faster tome-to market, a reduction in the number of in-service failures and sometimes, significant advantages relative to the competition. [47]

In this case, for guarantee better results on the manufacture of the flapper, the material that was going to be chosen needed to accomplished the following characteristics:

- Durable
- Resistant to chemical attacks such as in-tank bowl cleaners and most important: urine chemicals

- The material should maximize the leak free life of the flapper
- Smooth and even surfaces
- Impact of environmental factors such as heat, cold, expansion, contraction, corrosion, pH and bacteria levels.
- Low cost material
- Low maintenance

The material that is chosen can't have any warping, swelling, blistering to high temperature nor crack under any circumstances.

7.2 Plastics vs. Metals

According to the previous needs and considerations, the team started to look for possible materials in which metals and plastic were the one that could meet the conditions established. For the next steps, the advantages and disadvantages of both of them needed to be in consideration. After doing research, the advantages of fabricating in plastic are listed below :

- Ease of forming: Plastic can be formed into basic and complex geometries with relative ease due to its low melting point.
- Reduced finishing: Unlike most metals, plastics can be colored prior to fabrication, eliminating the need for certain post-treatment processes.
- Faster production: Plastic fabrication most of the times involves quick cycles times and fast turnover rates.
- Lighter weight: Plastics typically weight less than metals of comparable dimensions.
- Chemical resistance: Plastics are generally less susceptible than metal to damage from chemicals or chemicals reaction. [48]

Also, a few disadvantages of fabricating in plastic were found, such as: limited wear resistance. This means than since plastic has a low resistance threshold for elevating temperatures, acidity, and other corrosive elements. Also plastic's structural weaknesses are unsuited for applications requiring high structural strength, such as heavy equipment components and most building materials.

On the other side, metals generally provide the following advantages over plastic fabrication:

- Heat resistance: Metals typically have higher melting points and are less likely to degrade under elevated temperatures.
- Improved strength: Metal grades tend to be stronger, harder, and more durable than their plastic counterparts.
- Versatility: Metals can be fabricated through a wide range of processes such as casting, welding, forging, soldering, and others.
- Cost-effectiveness: Particularly in high volume or long-term production runs metals are usually a cost effective option. [48]

Even though fabricating in metal offers numerous benefits, metal is not ideal for every application. Some of the disadvantages include secondary operations, such as post-fabrication processes, which can be time-consuming or costly. Design limitations for crafting highly complex geometries or shapes thanks to the viscosity and molten flow behavior of some metals. And finally high start-up feed, this means the metal tooling costs are typically more expensive than comparable plastic fabrication tooling.

Taking in consideration these lists of advantages and disadvantages and discussing with the company, the team decided that plastics should be better for manufacturing the flapper and most of its components of the design since the advantages were more than fabricating with metals, and also plastics helped to fulfill the needs and characteristics that the team needed and listed in the beginning of this section.

7.3 Plastics

Plastic is made from hydrocarbons found in oil and natural gas. It’s created when small molecules, called monomers, are bonded together into chains called polymers. Different monomers, when bonded together, create different kinds of plastic; some are soft and pliable, some hard and durable, and others somewhere in between. [53] Because of this, further investigation among the different kinds of plastics and their properties was needed for a better understanding on how each material behaves and which one would fit better to the project’s needs. A summary of the different kinds of plastics and their characteristics are specified in the table 11.

Table 11. Plastics Classifications and Properties

Plastics classification	Molecular chains	Formability	Melting points	Others
Thermoset plastics	Three-dimensional molecular chains	They can no longer be shaped after hardening.	Cannot be melded after hardening.	Good chemical resistance and a high level of thermal stability
Elastomers	"Knotted" molecular chains	High Level of dimensional stability but are still elastically malleable.	Cannot be melded before after hardening.	By applying load (for instance tensile load) the chains become disentangled, but after removal of the load they relax again.
Thermoplastics	Molecular chains are not cross-linked	The formability is reversible.	Thermosormable (meltable and weldable)	

Since the flapper has to be durable and resistant since it is planned to last as long as possible with the minimum maintenance, have a good chemical resistance for preventing any kind of material cracking or deformation thanks to in-tanks bowl cleaners or urine acids, and resistant to environmental factors such as heat, cold, corrosion, pH, etc, Also the material chosen has to avoid any kind of warping and swelling. The team reduced the options into choosing between thermoset plastics and thermoplastics, since are the ones that better fit to these characteristics. On the following tables, a list of the classification and several uses of thermoplastics and thermoset plastics are listed.

Table 12. Thermoplastics Classification [49]

Thermoplastics can be heated and shaped many times.

Properties and uses of thermoplastics.

Name	Properties	Principal uses
Polyamide (Nylon)	Creamy colour, *tough*, fairly *hard*, resists wear, self-*lubricating*, good resistance to chemicals and machines	Bearings, gear wheels, casings for power tools, hinges for small cupboards, curtain rail fittings and clothing
Polymethyl methacrylate (Acrylic)	Stiff, hard but scratches easily, durable, *brittle* in small sections, good electrical *insulator*, machines and polishes well	Signs, covers of storage boxes, aircraft canopies and windows, covers for car lights, wash basins and baths
Polypropylene	Light, hard but scratches easily, tough, good resistance to chemicals, resists *work fatigue*	Medical equipment, laboratory equipment, containers with built-in hinges, 'plastic' seats, string, rope, kitchen equipment
Polystyrene	Light, hard, stiff, transparent, brittle, with good water resistance	Toys, especially model kits, packaging, 'plastic' boxes and containers
Low density polythene (LDPE)	Tough, good resistance to chemicals, flexible, fairly soft, good electrical insulator	Packaging, especially bottles, toys, packaging film and bags
High density polythene (HDPE)	Hard, stiff, able to be sterilised	Plastic bottles, tubing, household equipment

Table 13. Thermoset Plastic Classification [49]

Thermoset plastics can only be heated and shaped once.

Properties and uses of the thermoset plastics.

Name	Properties	Principal uses
Epoxy resin	Good electrical insulator, hard, brittle unless reinforced, resists chemicals well	Casting and encapsulation, adhesives, bonding of other materials
Melamine formaldehyde	Stiff, hard, strong, resists some chemicals and stains	Laminates for work surfaces, electrical insulation, tableware
Polyester resin	Stiff, hard, brittle unless laminated, good electrical insulator, resists chemicals well	Casting and encapsulation, bonding of other materials
Urea formaldehyde	Stiff, hard, strong, brittle, good electrical insulator	Electrical fittings, handles and control knobs, adhesives

For the flapper, the team decided that according to the material properties, using polypropylene as the main material would guarantee a better performance and a better life cycle of the product. Some of the most important properties of polypropylene that the flapper needs to have are: rigid material, good chemical resistance, though, good fatigue resistance, integral hinge property and a good heat resistance. Another important factors are that PP does not present stress-cracking problems, offers an excellent chemical resistance at higher temperatures, lower density, higher rigidity and hardness compared to those of Polyethylene and also this material offers the option that additives can be applied in order to protect the polymer during processing and to enhance end-use performance.

The production of polypropylene was also an important factor for the team to choose this material. The manufacture of the flapper needs to be as simple as possible and also a cheap process. Polypropylene can be processed by virtually all thermoplastic-processing methods. Most typically PP Products are manufactured by: Extrusion Blow Molding, Injection Molding, and General Purpose Extrusion.

Polypropylene is a relatively easy material for injection molding. When injecting the pieces, there are some rules that have to be in consideration at the time of designing the form of the flapper. The most important rules to consider are [50]:

- Decrease the maximum wall thickness of a part to shorten the cycle time and reduce the part volume.
- Uniform wall thickness will ensure uniform cooling and reduce defects.
- Round corners to reduce stress concentrations and fracture
- Inner radius should be at least the thickness of the walls
- Apply a draft angle of 1º to 2º to all walls parallel to the parting direction to facilitate removing the part from the mold
- Add ribs for structural support, rather than increasing the wall thickness.
- Orient ribs perpendicular to the axis about which may occur.
- Thickness of the ribs should be 50-60% of the walls to which they are attached
- Height of the ribs should be less than three times the wall thickness

Resist to any kind of chemical attack needed to be in consideration for choosing a materials since the flapper would be exposed to different kind of acids, especially those acids that can be found on the urine. Polypropylene resistance to some chemicals can be shown on table 14.

Table 14. Polypropylene Chemical Resistance

	Rating
Dilute Acid	Very Good
Dilute Alkalis	Very Good
Oils and Greases	Moderate (Variable)
Aliphatic Hydrocarbons	Poor
Aromatic Hydrocarbons	Poor
Halogenated Hydrocarbons	Poor
Alcohols	Very Good

After analyzing all the characteristics of the plastic and the ones that the flapper needed to have, the team concluded that polypropylene would be the primary material used in the final design. Also polypropylene would be used in other components of the design such as the box and holders. This would be described in later sections of this report.

For protecting the whole mechanism and for adapting it to the toilet, a box was designed which also needed to have the same characteristics of durability, strength and resistance as the flapper. Since the box is the one that is going to be in constant contact with the user and is the one that will give the first impression of the product, the team decided to use PP as well, not only because of its properties, but also because of the aesthetics that plastic can give.

7.4 Metals

In section 7.2, metals were discarded as an option for the fabrication of the flapper, but another part of the design is the counterweight. The counterweight will play a very important role since is the one would maintain the flapper closed, would open the flapper when flushed, and would help close the flapper back again to its initial position. The flapper need to hold closed about 1.5 liters of water and some extra weight from human waste, and any extra weight, in this case, of the flushing water, will open the flapper since it would weight more than the counterweight. After calculations, the counterweight needed to be from 1 to 3 kilograms, which is still something that the team is working on reducing.

Another major challenges the team faced is the final size of the counterweight. The team needs to have a counterweight with a reasonable size for placing in on top of the flapper and inside the box. Because of this, the material for the counterweight needs to have a big density for having the greater weight in a smaller size. Because of this, different kinds of metals were analyzed since there are the ones with the highest densities.

Table 15. Metal Counterweight Comparison

	Metal counterweight comparison						
	Stainless steel	Lead	copper	Bronze	Tungsten	Alluminium	Iron
Density	8.05 g/cm³	11.3 G	8.96	7400 - 8900	19.25 g	2.7	7.87
Resistance to corrosion	Has good resistance to corrision very strong and durable material	Lead has been used as piping in old houses aswell as gutter and water seals very good resistance However can release toxic chemicals	Copper is still used as piping for hot and cold water very strong resistance	Bronze has a copper base therefore is also good although not as strong as copper	fairly resistant to water corrosion however difficult to test over a long period	used in the manufacturing of small and light boats also sume gutter piping fairly resistant	not resistant to corrosion when in direct contact with water. Prone to rust
Cost P/Pound	$38	$0.40	$2.07	$2	$19.85	$0.75	$0.14-.18*/LB

As we can see on table 15, Tungsten is the metal with the highest density. Tungsten steel is a type of metal alloy made from a combination of tungsten and iron. Thanks to its excellent hardness and resistance to heat, equipment made from tungsten steel maintains a high performance and a high resistance to wear at high temperatures. Tungsten steel is commonly used in industrial tools and machinery used for working other metals such as dies and cutting tools. Unfortunate, because of its hardness it makes it a very difficult material to work with and to manufacture increasing the price of production. Because of this, tungsten was discarded as an option and lead and stainless steel became the next options.

When the counterweight was calculated with stainless steel, the size of the counterweight was still considered big and rough. For reducing the size of the counterweight using this material, the box and the stem of the flapper needed to be bigger and longer respectively, which wasn't convenient for the design. Also the company decided to leave stainless steel because of the cost, having a mass production with the dimensions of the counterweight, would result in a very expensive toilet. Because of this, the company and the team decided to redesign the counterweight in base of using lead, looking to reduce the size of the counterweight without scarifying the weight and the size of the box and longitude of the stem.

The team and company are well aware of the implications and ecologic problematic of using lead as its primary material, but since one of the main objectives was reducing sizes, the company agreed that for this stage of the prototyping and testing it would be fine to use lead, and for later stages of the project, dedicate to find another material with similar densities as lead.

For the final product proposal, the material for the counterweight is brass, which is mainly an alloy that consists of copper with zinc added. Brasses can have varying amounts of zinc or other elements added. Brass has a density of 8520 kg/m3 which gave the team a good margin for modifying and testing the counterweight size and volume.

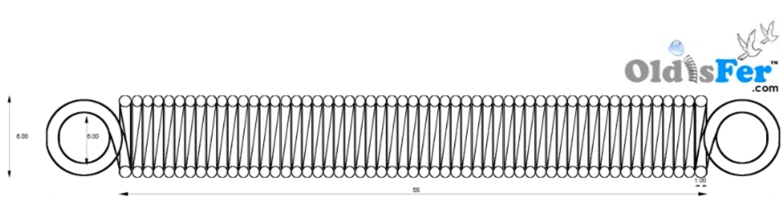
8 Prototype

8.1 First stage prototyping

A **prototype** is an early sample, model, or release of a product built to test a concept or process or to act as a thing to be replicated or learned from [52]. For the first stage, the whole concept was going to be tested, the team wanted to prove if the counterweight theory of passing the pivot point will be enough for opening and closing the flapper and most important, how strong the spring needed to be for helping the counterweight to act.

The first rough prototype was barely similar in shape to the original design, but since the function was the one that was being tested, the team focused the minimum in appearance for this stage. Pictures of the prototype are shown below.

From this stage, the results were favorable. In theory, a counterweight of 1.5 kg with a certain unknown traction spring would maintain the flapper on balance with water and human waste. After testing a several range of springs, the spring that had the better performance was spring 21231 (OldisFer Ferretería) with the following characteristics:



Código de muelle: 31232	
Material: inox: ALAMBRE DE ACERO EN 10270- 3 "1.4310"NS (INOX-AISI 302)	
Largo parcial:	55
Largo total:	71
Hilo:	1.00
Espiras útiles:	55.00
Diámetro exterior:	8.00
Diámetro interior:	6.00
K (DaN/mm):	0.0663

Figure 29. Spring Characteristics

The counterweight of 1.5 kg with this spring, could maintain the flapper perfectly balance and closed just before the user flushes the toilet. When the user flushes and extra kilogram of fresh water is introduced in the bowl, this extra force opens the flapper making the counterweight pass the pivot point and open to its maximum 55º. When all the extra weigh is eliminated the flapper return to its initial position.

The problem faced in this stage was the returning of the flapper. When all the weigh was discarded from the flapper the return was strong since the counterweight and the spring were acting against nothing. So the challenges after this stage were finding a way to slow down the return of the flapper and also, redesign the flapper so that the shape could help the water and waste run smoothly to the pipes.

8.2 Second stage prototyping

For this stage, the company provided an actual toilet bowl for the team to adapt the mechanical system of the flapper to a more realistic scenario. As the original design, the S-trap was removed form the vitro china toilet as shown in Figure 30. The main objective of this stage was to test shapes and forms. Since the functionality of the mechanism had been testes in previous stages, now the team faced the challenge of making a functional prototype with the mechanism and as close as possible to the final and original design in terms of appearance of the product. For making it more realistic, the flapper was 3D printed and the material of the counterweight was changed into cast iron for a similar form as the final design.

Figure 30. Vitro China Toilet with no S-Trap

The main problems faced during this stage were fitting the whole mechanisms inside the toilet. Trying to find new ways to reduce sizes, the team started playing with the positions and shape of the counterweight to find if it could work with less weight. As a result, the team managed to reduce the size of the counterweight from 1.5 grams to 1.34 grams, reducing significantly the size. Also for reducing the size, the team introduced some lead bass drops pieces used in fishing just like figure 31 shows. With this the team succeed to have the effect and function of the counterweight with a considerable size that fit perfectly in the toilet.

Figure 31. Lead Bass Drops

Other problem faced was the shape of the flapper. The team discovered that for the mechanism to work, the flapper should hold the water and not let it escape, since if this happens, the weight needed to open would never be reached. Since the flapper had the shape shown in figure 32, water easily escape from the front part since it didn't have the proper seal and proper fitting to the toilet. So the team decided to try sealing it and change the shape of the flapper for a better fit. The final shape of the flapper is shown in figure 33.

Figure 32. Initial Flapper Concept

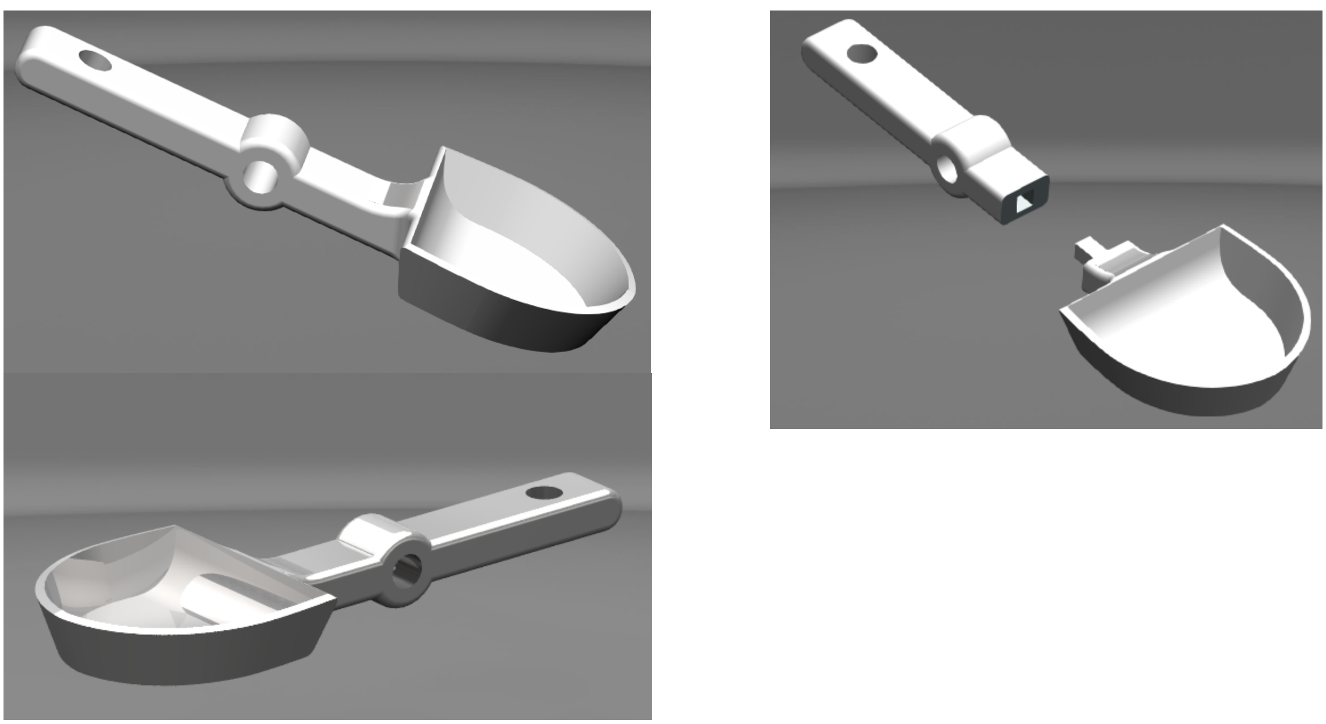


Figure 33. Final Flapper

With this final shape the team prevents the escape of water and allows the flapper to hold the water until the necessary weight is reached for open the flapper. Also the shape of the flapper avoids that any waste, including human waste and paper, stick in the flapper.

9 Final Prototype

The result form the prototype stage is shown from figure 34 through 37. With this prototype the concept of having a counterweight passing the rotation point at certain angles and with extra force of a traction spring, would help the flapper to open fast for discarding the waste and a slow and most important, control close up, avoiding splashes and material crashing.

With the prototype the team was able to make important changes and modifications to the final product, such as the weight needed to maintain the flapper closed in balance and to help the flapper open quickly was smaller than calculated. Also the shape of the flapper was improved thanks to the results in this stage. All this benefited the final design especially in terms of shapes and sizes. The team was able to reduce the initial sizes for the elements having as a result a more compact product.

Figure 34. Closed Flapper Prototype

Figure 35. open Flapper at 25º Prototype

Figure 36. Fully Open Flapper Prototype

Figure 37. Flapper Prototype

10 Final Product

As a result of extensive research, calculations, and prototyping, the team made a fully mechanical system in which 1.5 L of water is saved. This product is ideal for environments that use latrines and need a low maintenance and a low cost product. The final product is illustrated on the following images.

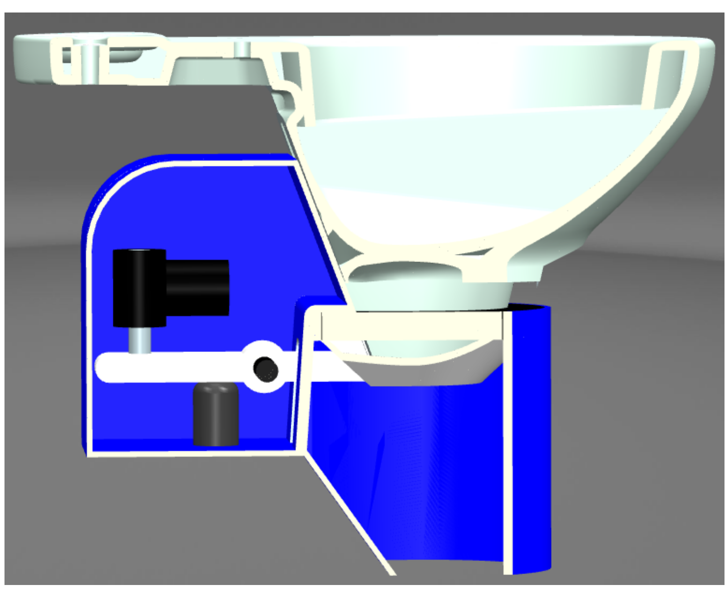


Figure 38. Final Flapper Closed

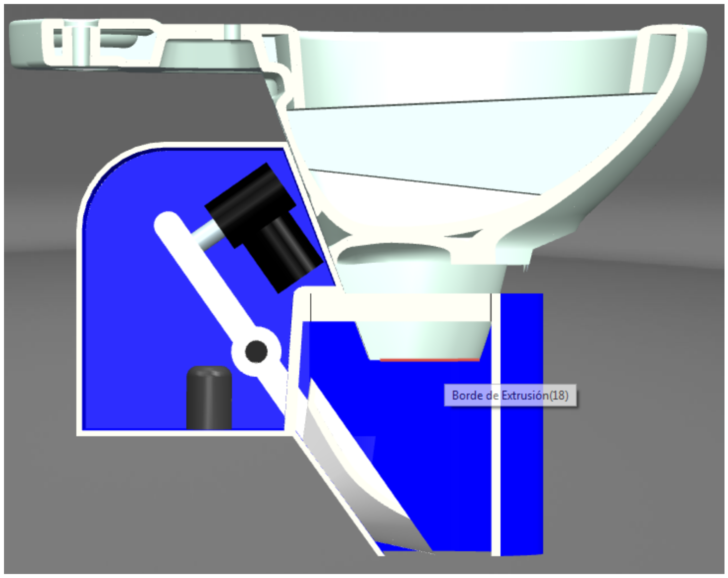


Figure 39. Final Flapper Fully Open

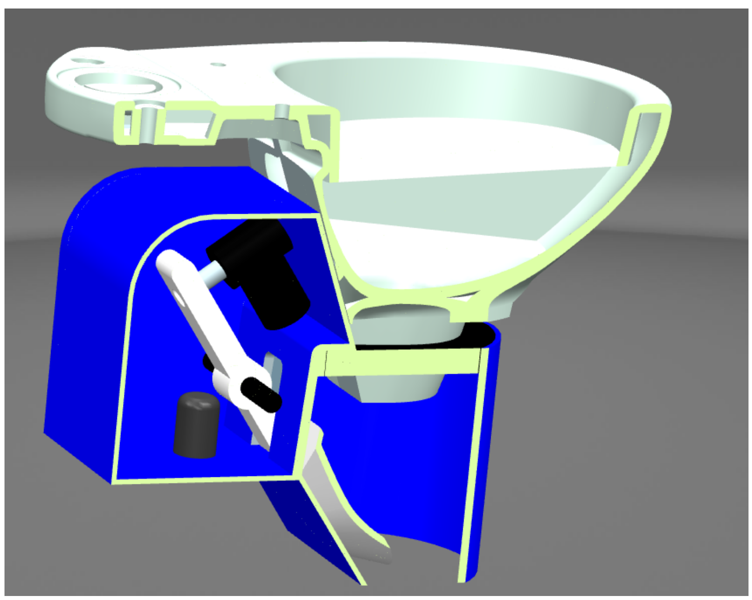


Figure 40. Final Flapper Fully Open

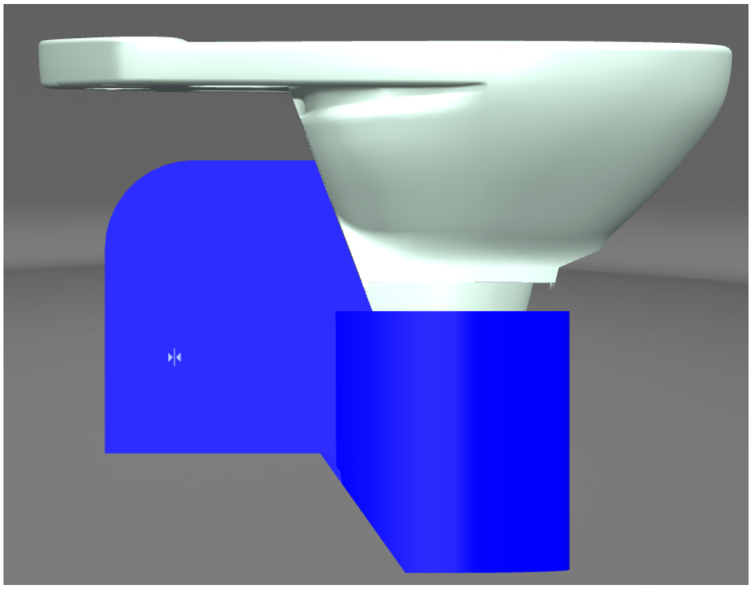


Figure 41. Final Flapper Box

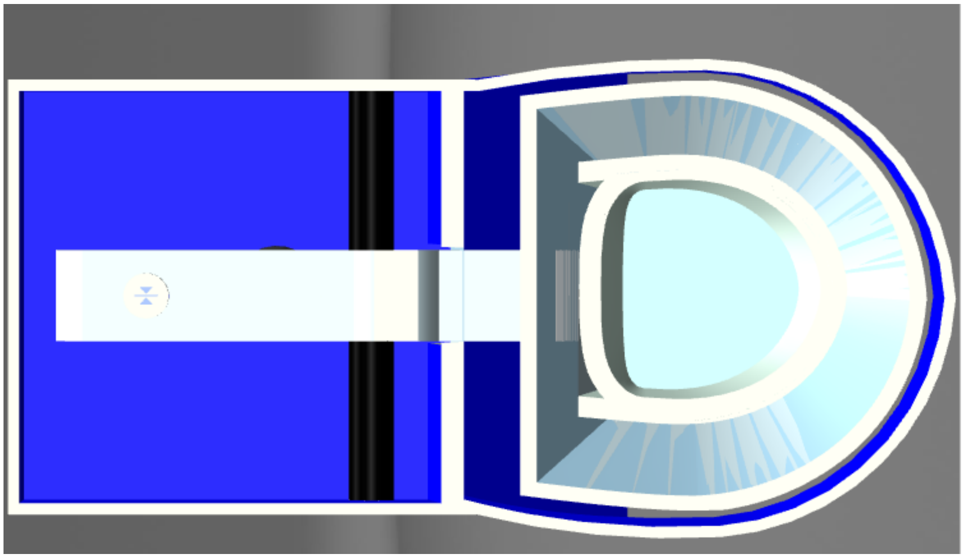


Figure 42. Final Flapper Top view

11 Cost Analysis

Company				
Roca				
W.S.T.F	**Water Saving Toilet flapper**			
Cost Analysis				
Product	**Flapper and Box placed below Toilet**			
Part	**Material**	**Quantity**	**How it will be Manufactured**	**Cost**
Flapper	Polyprofelyne	110mm length arm + front bowl 50mm legth 30 mm height	3d Manufactured	10-12 euro (average cost is around 45 cent for 1 metre and 3mm thickess) plus electricity and labour 17 euro

Counterweight	Brass	1.2 kg	Bought per kg after manufacter to design	5 euro (1kg costs around 3 .50) + further manufacturing/Labour. Total 10-12 euro
seal	Rubber	3mm thick seal 7mm depth	manufature by roca company	5-8 euro
Axix pipe	Alluminium	50mm length 20mm diameter	bought and equiped	5 euro per length
outer case	Polyvinylchloride Pvc	1 meter length 0.5 metre width	injection moulded	25-30 euro
			Overall Cost Apx	72 euro approx estimation

12 Conclusions and Recommendations

As previously stated in this report the main objective for this project was to replace the current water trap in the toilet with a mechanical trap system that:

- Meets the same functions as the current water trap
- Provides an equally robust back odor prevention by keeping an equivalent water seal,
- Allows for a significant flush water reduction.
- Be based solely on mechanics and hydraulics

The new flapper design succeeds in significantly conserving the water used during the flush by reducing the water used in the trap system from 3-4.5 liters to 1.5 L, thus saving a total of 1.5-3 liters of water per flush. The seal added between the box and vitro china in conjunction with a small volume (.5 liters) of water in the bowl maintains an equivalent level of odor prevention as the previous water trap system design. Along with odor prevention the water in the bowl helps to maintain the cleanliness of the flapper by preventing waste from sticking to the mechanism. In addition the system is designed to only need the force of the flush to open, and functions with the use of only the mechanical systems of springs and a counterweight. Therefore this project successfully met the required objectives of conserving water while still maintaining the same functions as the previous system.

However further testing is required before this design can be manufactured on a broad scale. Because this design relies on springs it is imperative to do fatigue testing to calculate the exact life of this design to determine whether the maintenance cost for this design is reasonable or not. Although the overall cost of the system was calculated to be approximately 72 euros, if it requires constant maintenance then it is not usable.

The team also has several recommendations for the improvement of this design that they were not able to complete due to a time limitation. In addition to fatigue testing, the use of different springs such as a torsion spring that could be incorporated into the attachment of the flapper instead of an outside mechanism should be experimented with. Although the current linear spring technically works to keep the flapper closed and pull it back to the closed position once it is opened, the team is not convinced it is the most efficient solution at this time.

Furthermore, a bumper is currently being used to soften the return of the flapper and prevent it from having a hard impact against the vitro china. However, further investigation should be done to determine if there is a method that will produce two motions of the flapper such that there is a high resistance against the opening of the flapper until an angle of 25 degrees and then a low resistance after 25 degrees, and the opposite effect upon closing. Having a mechanism that would work this way throughout the motion of the flapper, instead of just stopping it at the end of the desired motion, would allow for a smoother close of the flapper which in turn would reduce fatigue over time and prevent the flapper from creating splashes upon its return.

Finally, the greatest challenge still pending for this project, is reducing the size of its components. Originally the team desired to make this product applicable both for latrines and the average home, but with the current design it is only suitable for latrines. The total height of the toilet with this design is 472 mm while the toilet in the average home currently stands at a maximum of 410 mm; for a latrine part of the box can be placed underground but for the house it is not reasonable. Also the flapper currently opens in the opposite direction from the way the current toilet pipes run into the sewage system, and due to size limitations it is not possible to rotate it to the other side.

In conclusion, although the design of the new system successfully meets the objectives and is simple enough to be industrialized the team recommends making the improvements mentioned above before actually manufacturing this product.

14 Acknowledgments

After this four moth of work, the team would like to express our appreciation to all the parties involved in the WC Flapper project:

First of all, the team wants to thanks to UPC Supervisor Nora Martinez for her continuous support and constant feedback during the whole process. Her constant advises, guidance and specially her energy helped the team to get the best results.

Beside the university supervisor, the team would also like to express their gratitude to the company Roca for defining the project in which bot, designers and engineers, could apply their knowledge and learn even more about engineering and design issues. From Roca, the team would specially thanks supervisor Jordi Corral, who even with his important agenda, he always found time to be at every meeting and giving very important feedbacks and recommendations to the team. Also, for giving the team all the tools and resources necessary for the team to accomplish their objectives.

Thanks to Universitat Politècnica de Catalunya, Escola Politècnica Superior d`Enginyeria de Vilanova i la Geltrù for performing this programs in which they give their students the opportunity to get along with students from different nationalities and also for the opportunity of working in a real project with real clients and companies. Especial thanks to the university supervisors, especially Neus Salleras, for administrating and coordinating the EPS/IDPS project.

Last but not least the team would like to thanks their universities at home for allowing this kind of experiences abroad: Tecnologíco de Monterrey, Mexico. Institute of Technology Sligo, Ireland. Michigan Techonologial University, USA. Escola Politècnica Superior d`Enginyeria de Vilanova i la Geltrù, Sapin.

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16 Table of Tables

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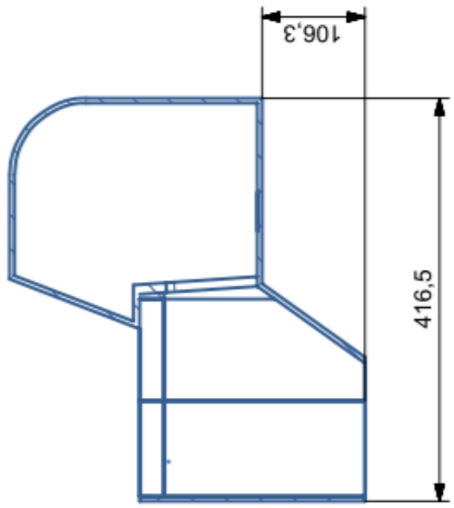
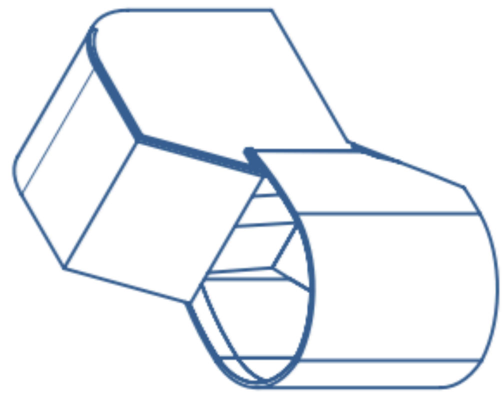
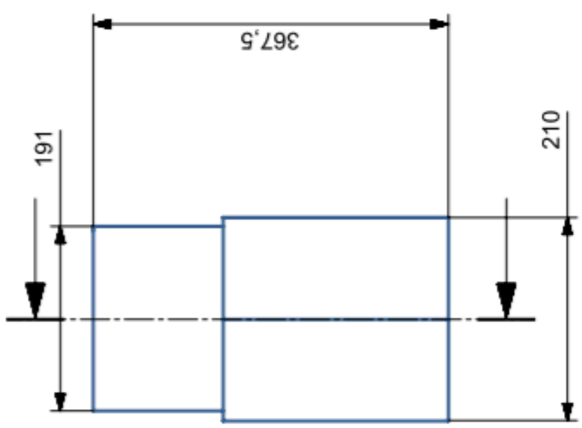
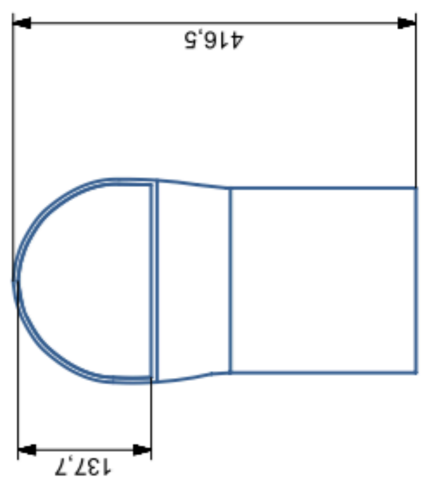
19 Appendix

19.1 Box Measurements

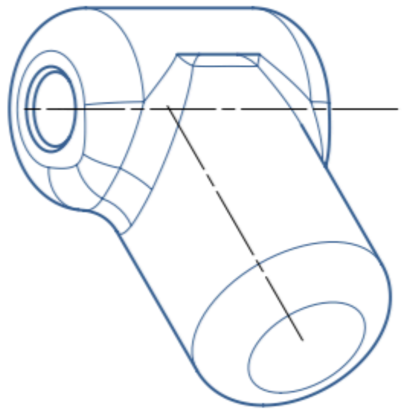


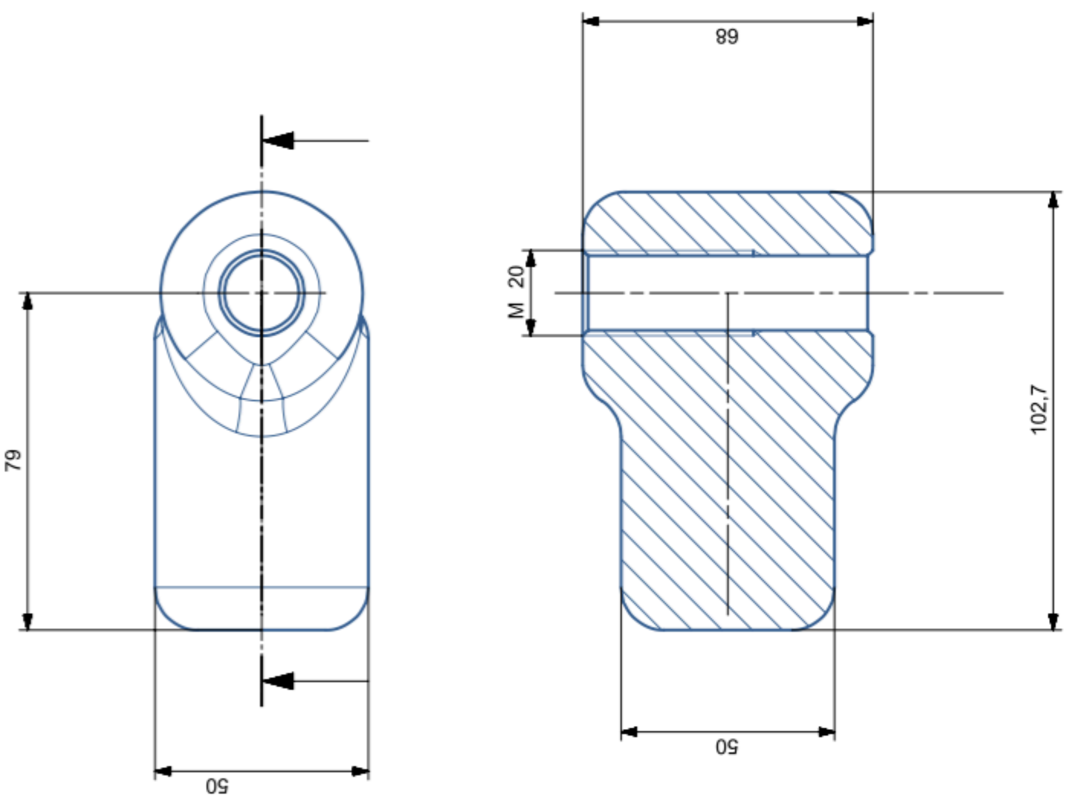




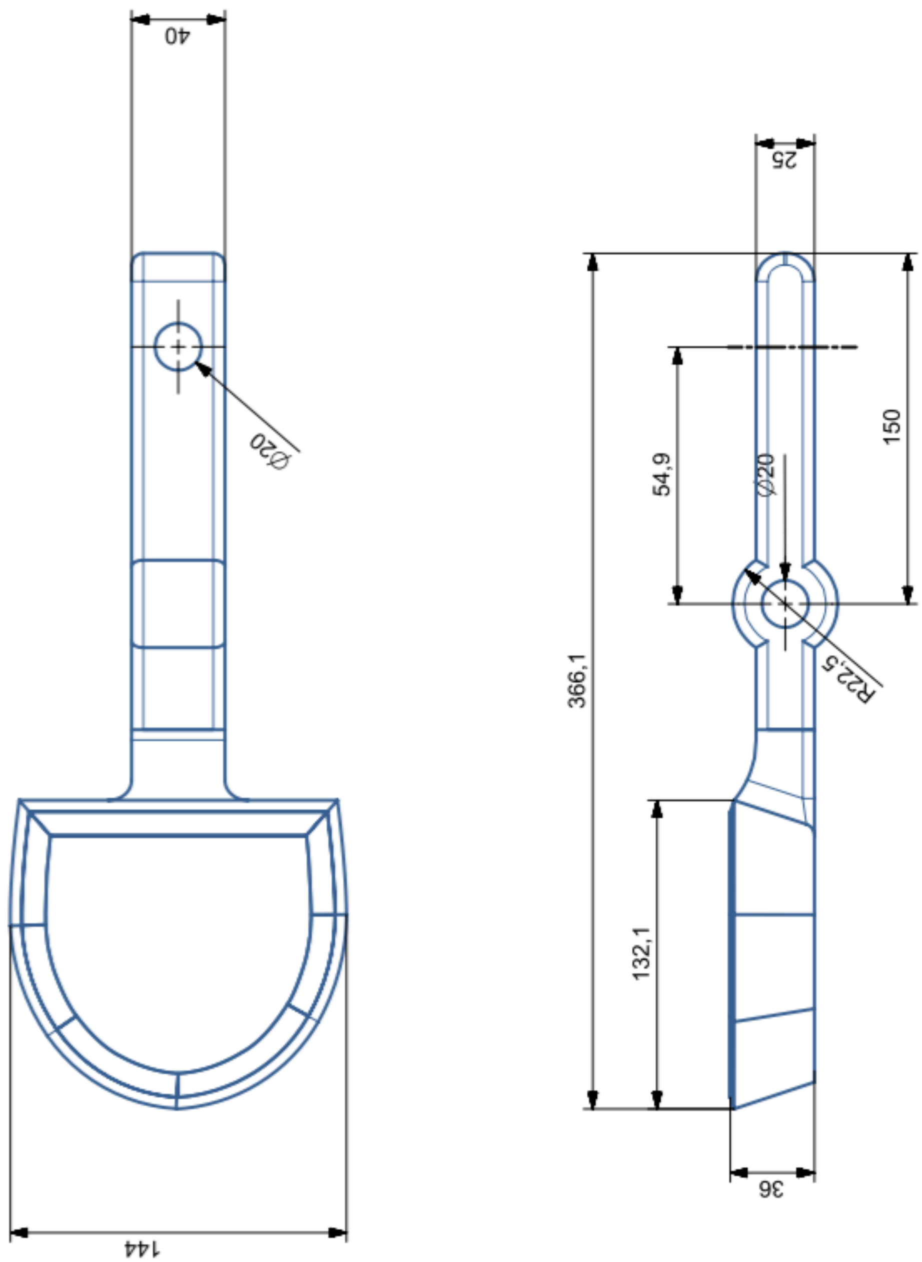


19.2 Counterweight Measurements

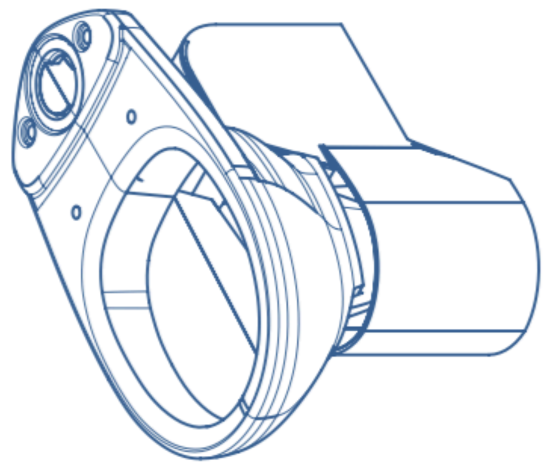


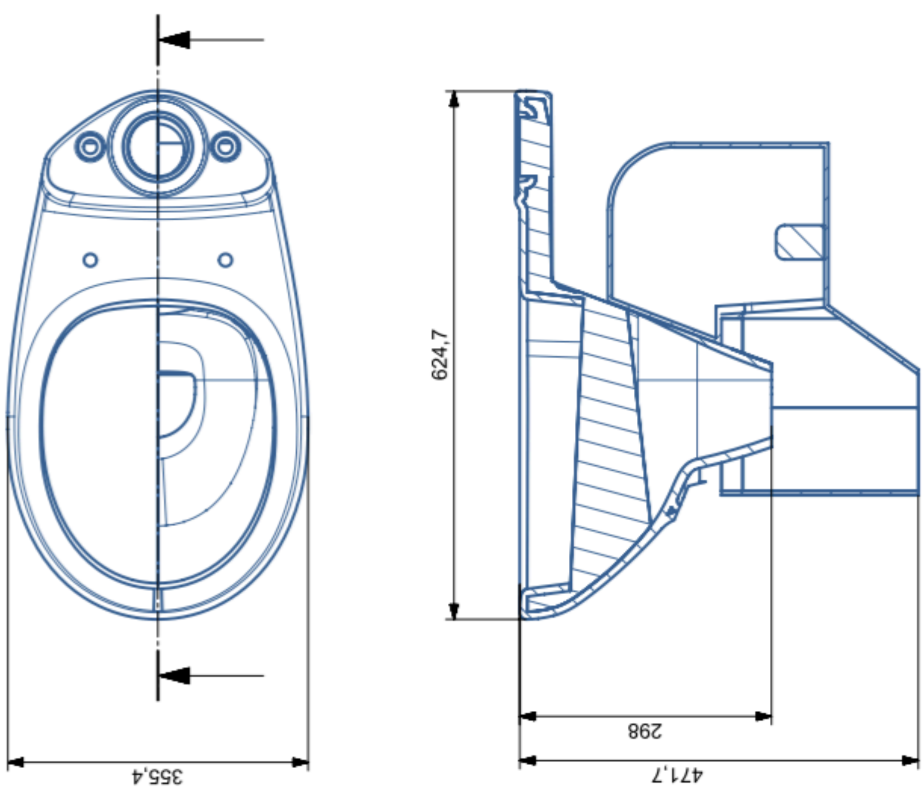


19.3 Flapper Measurements

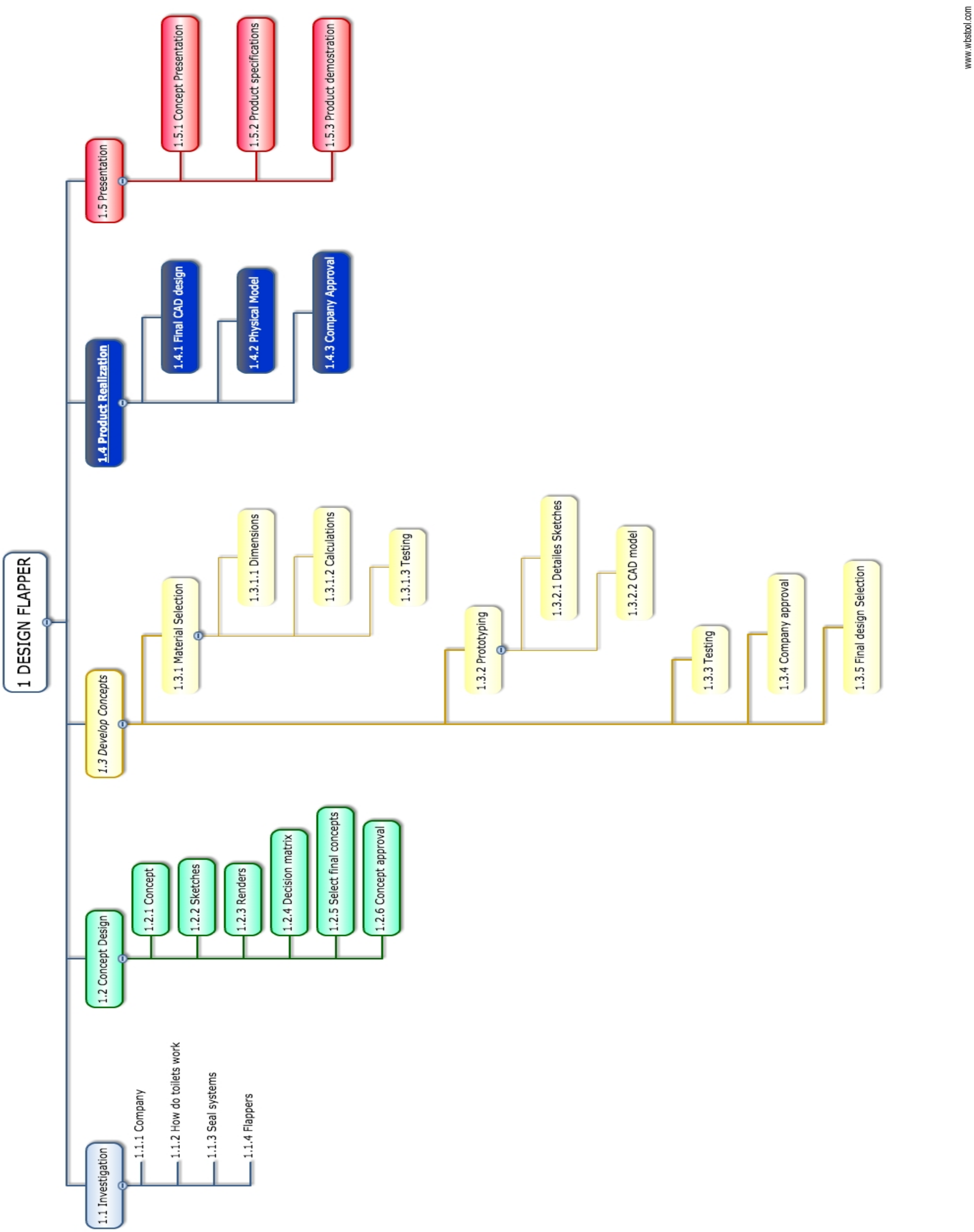


19.4 Final Product Measurements





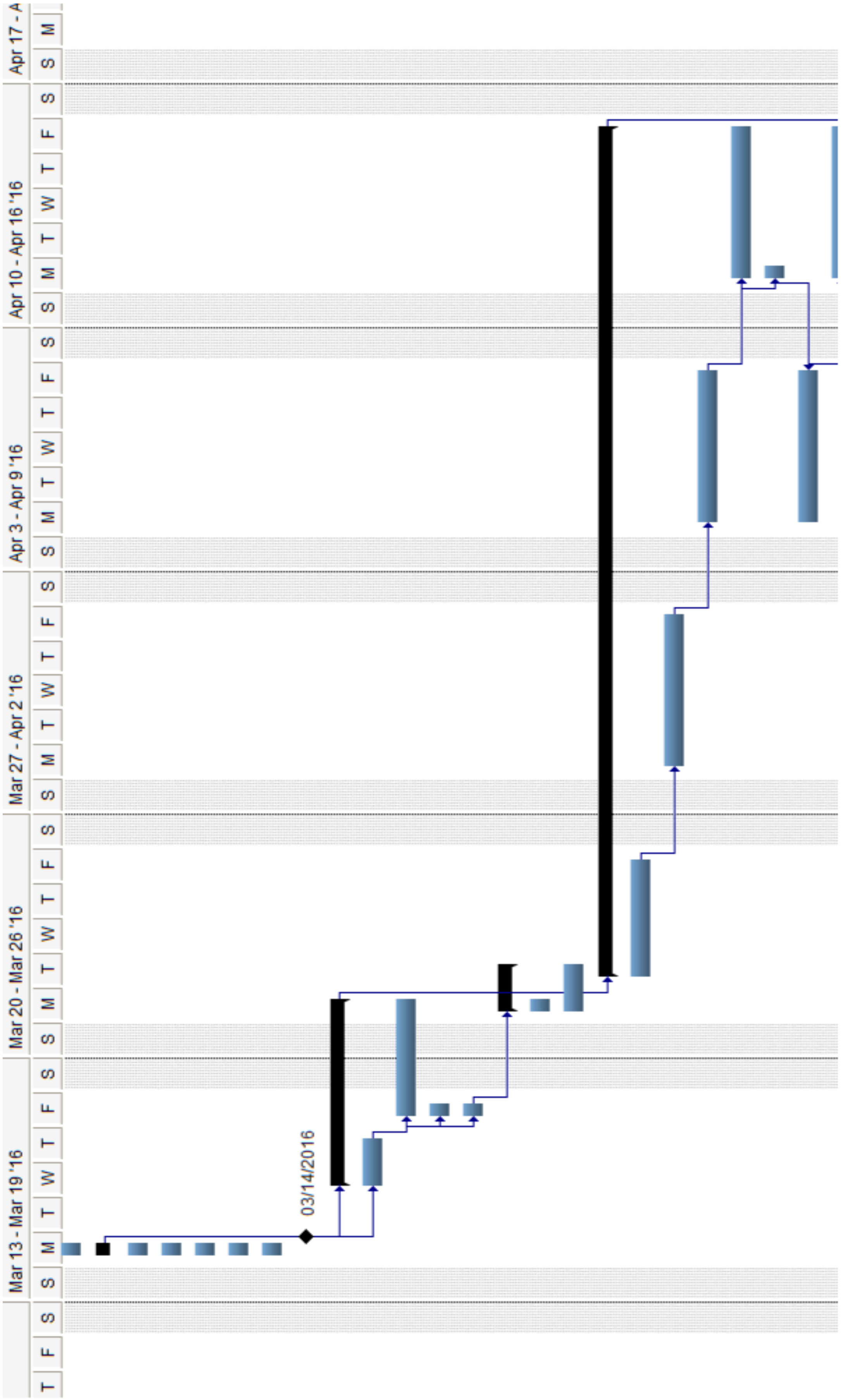
19.5 Work Breakdown Structure (WBS)



19.6 Gantt Chart

	Name	Duration	Start	Finish	Predecessors	Resources
1	WC Flapper ROCA	1d?	03/14/2016	03/14/2016		
2	⊟**Research**	**1d**	**03/14/2016**	**03/14/2016**		
3	Mechanical Systems	1d	03/14/2016	03/14/2016		
4	Flappers	1d	03/14/2016	03/14/2016		
5	Seal Systems	1d	03/14/2016	03/14/2016		
6	Roca Documents	1d	03/14/2016	03/14/2016		
7	Similar/Alternative Options	1d	03/14/2016	03/14/2016		
8	PM Presentation	1d?	03/14/2016	03/14/2016		
9	⊟**Brainstorm Ideas**	**4d**	**03/16/2016**	**03/21/2016**	**2**	
10	Research Insights	2d	03/16/2016	03/17/2016	2	
11	Brainstorming Concepts	2d	03/18/2016	03/21/2016	10	
12	Define Constrains	1d	03/18/2016	03/18/2016	11SS	
13	Define Objectives	1d	03/18/2016	03/18/2016	12SS	
14	⊟**Decide Direction**	**2d**	**03/21/2016**	**03/22/2016**	**13**	
15	Validation	1d	03/21/2016	03/21/2016		
16	Justification	2d	03/21/2016	03/22/2016		
17	⊟**Concept Development**	**19d**	**03/22/2016**	**04/15/2016**	**9**	
18	Planning	4d	03/22/2016	03/25/2016		
19	Specification definition	5d	03/28/2016	04/01/2016	18	
20	Generate concepts	5d	04/04/2016	04/08/2016	19	
21	Make concept Decisions	5d	04/11/2016	04/15/2016	20	
22	Document and communicate (with company)	1d	04/11/2016	04/11/2016	21SS	
23	Refine Plan	5d	04/04/2016	04/08/2016	22SF	

24		Final Concept Approval	5d	04/11/2016	04/15/2016	23	
25		⊟**Product Design**	**10d**	**04/18/2016**	**04/29/2016**	**17**	
26		⊟**Material Selection**	**10d**	**04/18/2016**	**04/29/2016**	**24**	
27		Dimensions	5d	04/18/2016	04/22/2016		
28		Calculations	5d	04/18/2016	04/22/2016		
29		Testing	10d	04/18/2016	04/29/2016		
30		⊟**Midterm Presentation Rehearsal**	**2d**	**05/02/2016**	**05/03/2016**	**29**	
31		Modifications	2d	05/02/2016	05/03/2016		
32		Midterm Defense Presentation	1d?	05/04/2016	05/04/2016	31	
33		⊟**Prototyping**	**24d?**	**05/05/2016**	**06/07/2016**	**32**	
34		Detailed Sketches	5d	05/05/2016	05/11/2016	32	
35		CAD models	2d	05/12/2016	05/13/2016	34	
36		Physical models	1d?	05/16/2016	05/16/2016	35	
37		Testing	10d	05/17/2016	05/30/2016	36	
38		Company's approval	5d	05/31/2016	06/06/2016	37	
39		Final Design Selection	1d?	06/07/2016	06/07/2016	38	
40		⊟**Product REalization**	**8d**	**06/08/2016**	**06/17/2016**	**39**	
41		Final CAD design	3d	06/08/2016	06/10/2016	39	
42		Physical Model	5d	06/13/2016	06/17/2016	41	
43		Company's Approval	1d	06/08/2016	06/08/2016	41SF	
44		Final Delivery UPC Supervisors	1d?	06/10/2016	06/10/2016		
45		Final Project Delivery to Neus	1d?	06/17/2016	06/17/2016		
46		⊟**Final Project Defences**	**2d?**	**06/20/2016**	**06/21/2016**		
47		Concept Presentation	1d?	06/20/2016	06/20/2016		
48		Product Specifications	1d?	06/21/2016	06/21/2016	47	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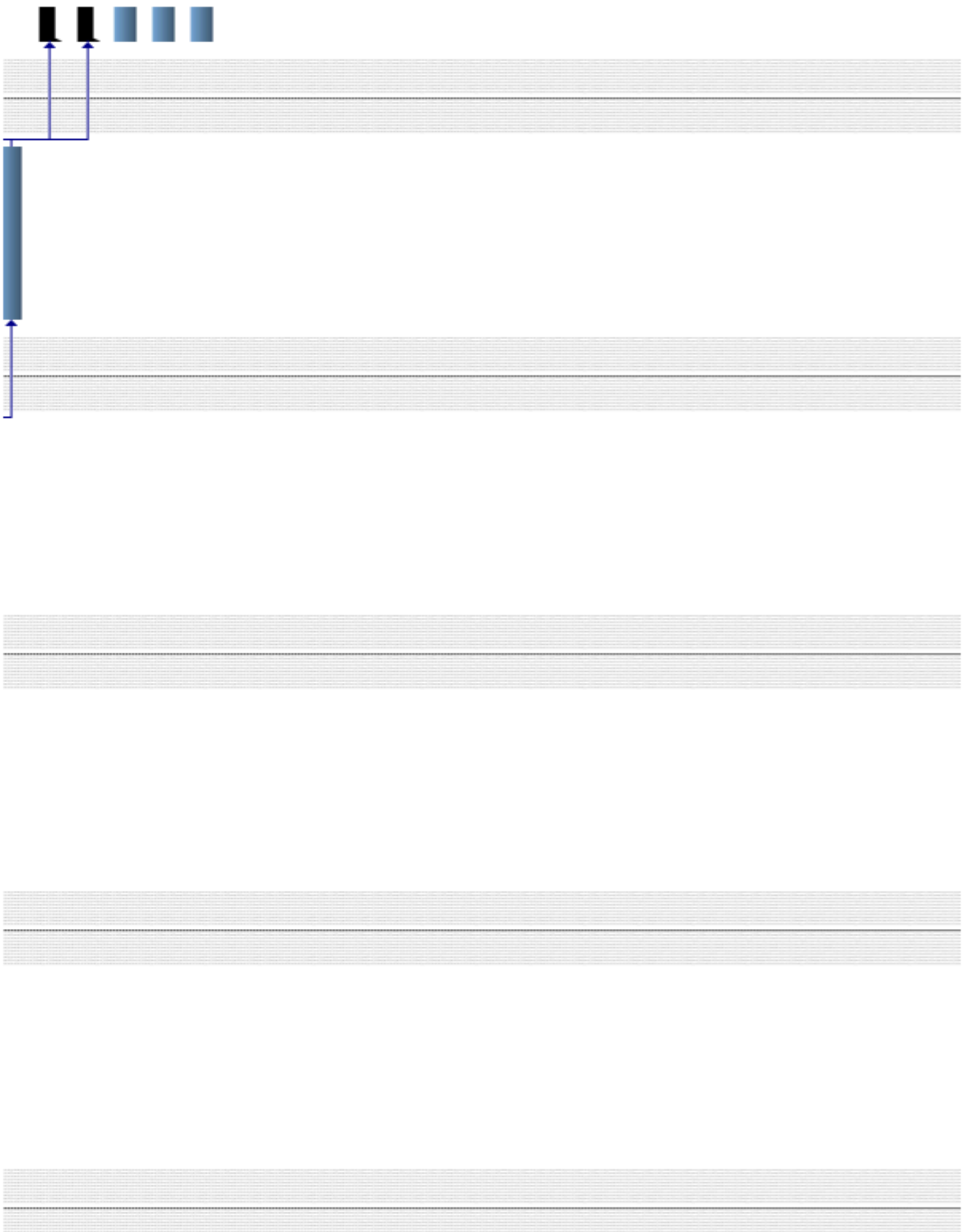

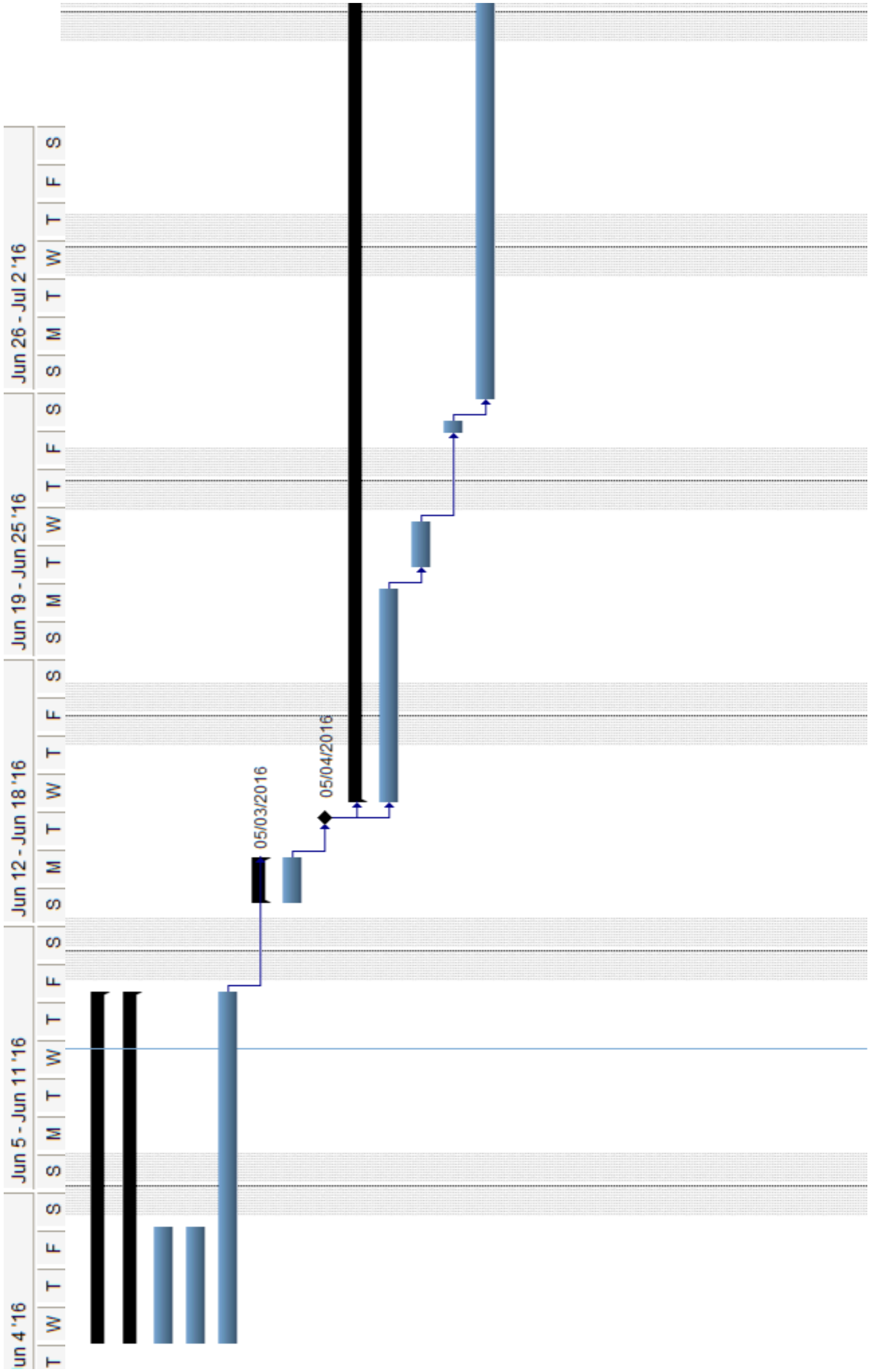
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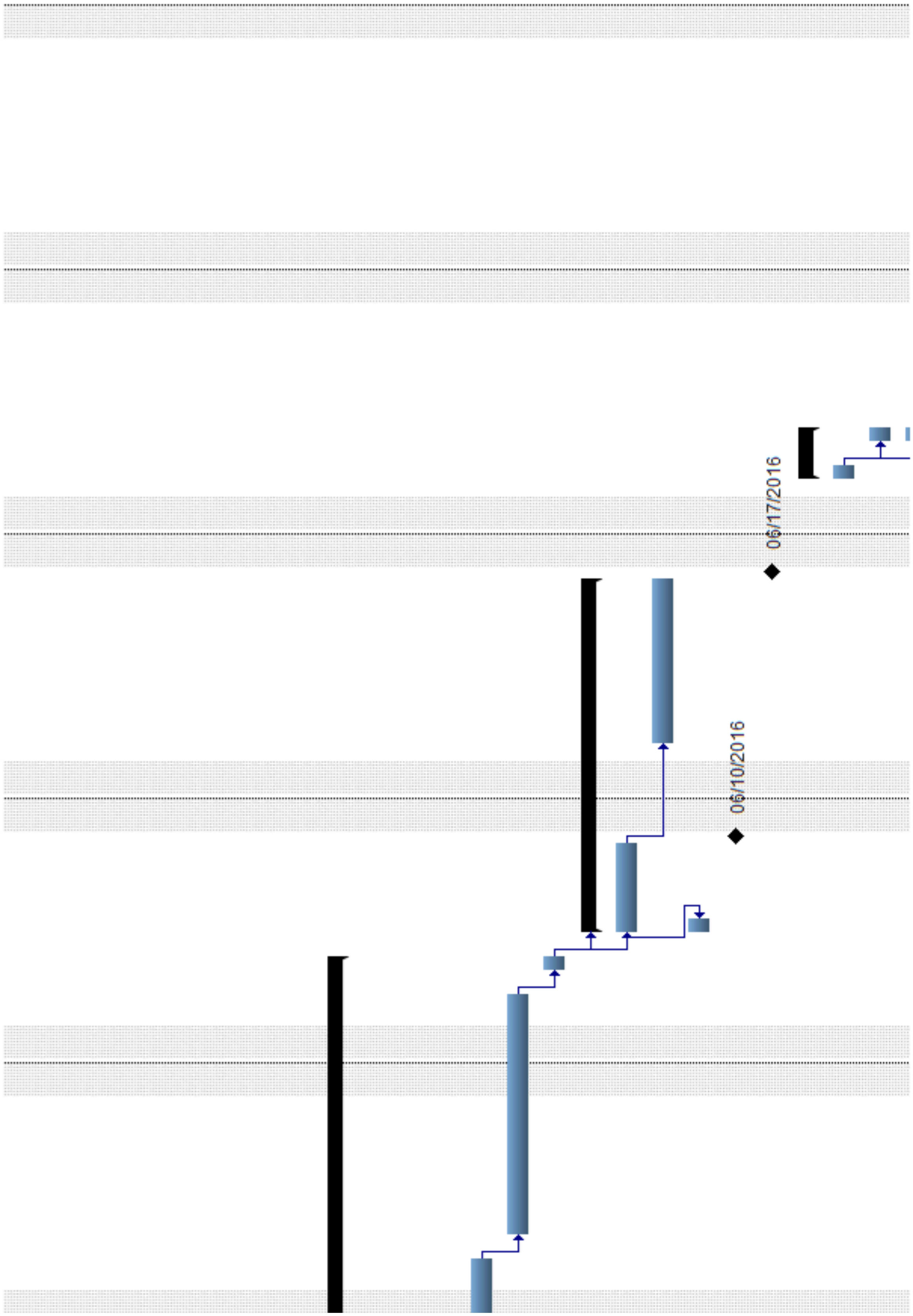
05/04/2016


06/17/2016
06/10/2016

19.7 RACI Matrix

RACI Charts

Steps will be highlighted if A and R are not assigned.

R:	Does the step
A:	Accountable for the step
C:	Consulted with before the step
I:	Informed when the step is completed

Project: Roca Flapper

PROCEDURE	Task Assignments
UPC	EPS PROGRAM
UPDATED	1/1/2016

STEP	TASK DESCRIPTION	Marcel	Valeria	John	Sierra	Nora	Jordi
1	**Research**					I	I
2	Toilets Worldwide	A	R	A	A		
3	Flappers	R	A	A	A		
4	Seal Systems	A	A	A	R		
5	Roca Documents	A	A	R	A		
6	Similar Products	A	R	A	A		
7	**Brainstorm Ideas**						
8	Actual Solutions	R	R	R	R		
9	What are best toilet options?	A	R	R	A		
10	Best water reduction options	R	A	A	R		
11	Materials	A/R	A/R	A/R	A/R		
12	Decide Direction	R	R	R	R	C/I	C/I
13	**Concept Development**						

14	Planning	A/R	A/R	A/R	A/R		R
15	Specification definition	R	A	A	R		
16	Generate Concepts For Water Reduction	A	R	R	A		I
17	Generate Concepts For Odour Control	R	A	A	R		
18	Evaluate Concepts	A/R	A/R	A/R	A/R		
19	Make concept decisions	A/R	A/R	A/R	A/R		
20	Document and communicate (with company)	A/R	A/R	A/R	A/R	A/R	C/I
21	Refine Plan	A/R	A/R	A/R	A/R	C/I	R
22	Concept Approval					C/I	C/I
23	**Product Design**						
24	**Material Selection**						
25	Dimensions	R	A	A	R		
26	Calculations	R	A	A	R		
27	Testing	A/R	A/R	A/R	A/R		
28	**Prototyping**						
29	Detailed Sketches	A	R	R	A		
30	CAD models	R	A	A	R		
31	Physical models	R	A	A	R		
32	Testing	A/R	A/R	A/R	A/R		
33	Company's Approval					C/I	C/I
34	Final Design Selection	A/R	A/R	A/R	A/R	C/I	C/I
35	**Product Realization**	[redacted]					
36	Final CAD design	R	A	A	R		
37	Physical Model	R	A	A	R		
38	Company's Approval	A/R	A/R	A/R	A/R	C/I	C/I

39	**Presentation**						
40	Concepts	**A**	**R**	**R**	**A**		
41	Product Specification	**R**	**A**	**A**	**R**		
42	Product Demonstration	**A/R**	**A/R**	**A/R**	**A/R**	**C/I**	**C/I**

19.8 PATENT WO2015174368) Toilet device and waste transport system

(12) 特許協力条約に基づいて公開された国際出願

(19) 世界知的所有権機関
国際事務局

(43) 国際公開日
2015 年 11 月 19 日(19.11.2015)

WIPO | PCT

(10) 国際公開番号
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(51) 国際特許分類:
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(21) 国際出願番号: PCT/JP2015/063475

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(25) 国際出願の言語: 日本語

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(30) 優先権データ:
特願 2014-099041 2014 年 5 月 12 日(12.05.2014) JP

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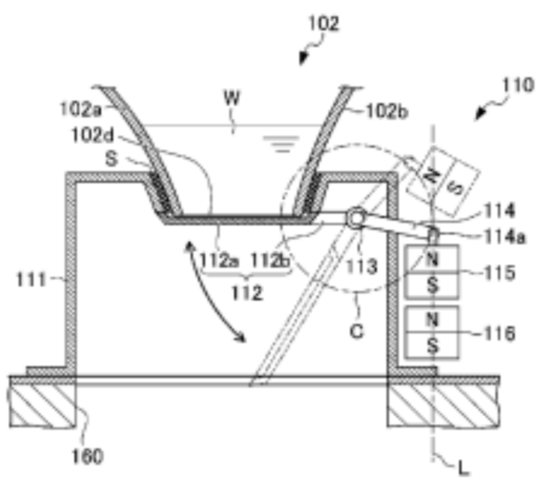
(81) 指定国 (表示のない限り、全ての種類の国内保護が可能): AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, KE, KG, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM,

[続葉有]

(54) Title: TOILET DEVICE AND WASTE TRANSPORT SYSTEM

(54) 発明の名称 : 便器装置及び汚物搬送システム



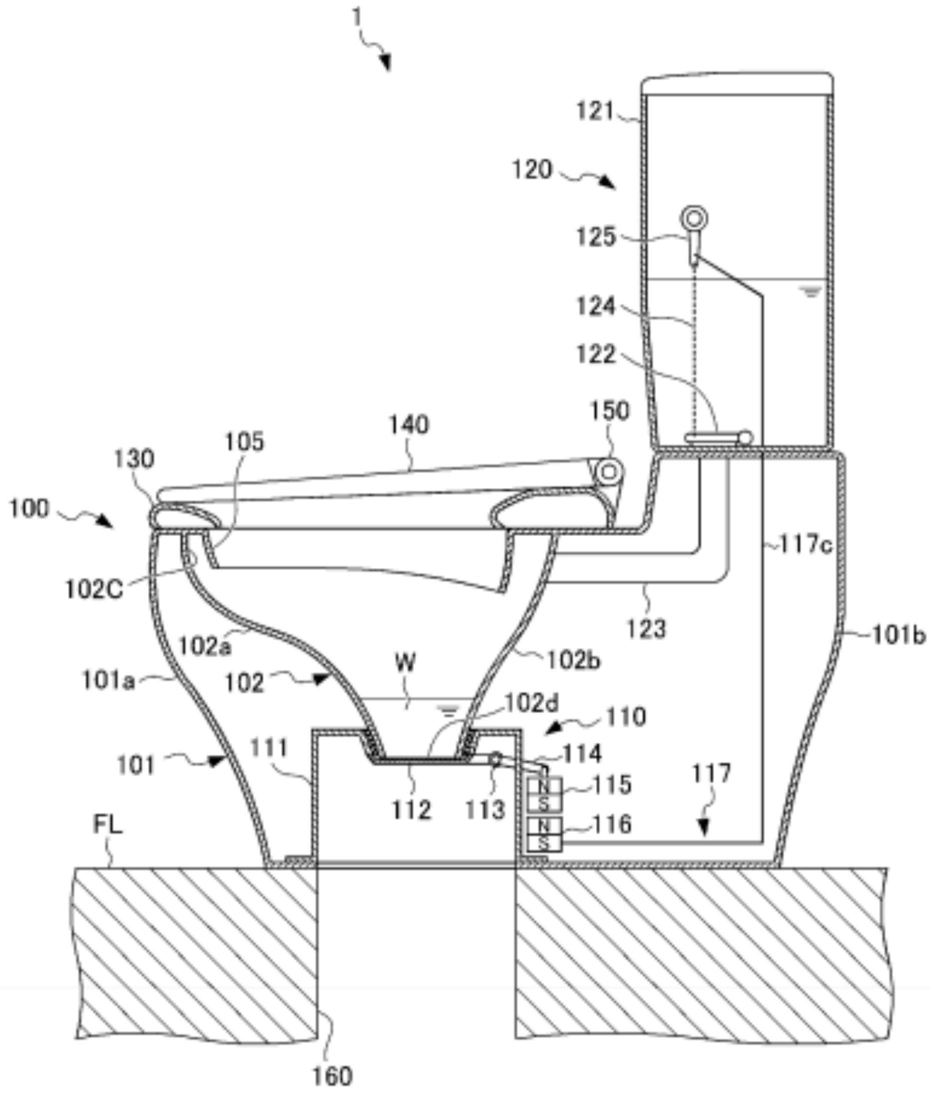
(57) Abstract: The purpose of the invention is to provide a toilet device that can prevent a flapper valve from sticking and can inhibit waste in a toilet bowl from adhering by ensuring a large amount of reservoir water and that can open and close the flapper valve with a small operation load and operation stroke. A toilet device (1) comprises: a flapper valve (112) that opens and closes a discharge opening (102d) of a toilet bowl (102); a flapper valve rotary shaft (113) by which the flapper valve (112) rotates; a leverage point (114a) that is coupled to the flapper valve rotary shaft (113) and by which the force necessary to rotate the same is applied; a first magnetic member (115) that is coupled to the leverage point (114a) by being disposed in the direction of a tangent (L) to a circle (C) created by rotating the leverage point (114a) about the flapper valve rotary shaft (113); a second magnetic member (116) that is disposed to face the first magnetic member (115) in the direction of the tangent (L) and biases the flapper valve (112) in the opening direction by way of the magnetic attracting force generated with the first magnetic member (115) in the direction of the tangent (L); and a moving mechanism (117) that moves the second magnetic member (116) in a direction that is substantially orthogonal with respect to the direction of the tangent (L).

(57) 要約:

[続葉有]

WO 2015/174368 A1

[図1]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102C
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102a
101b
102b
101a
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102d
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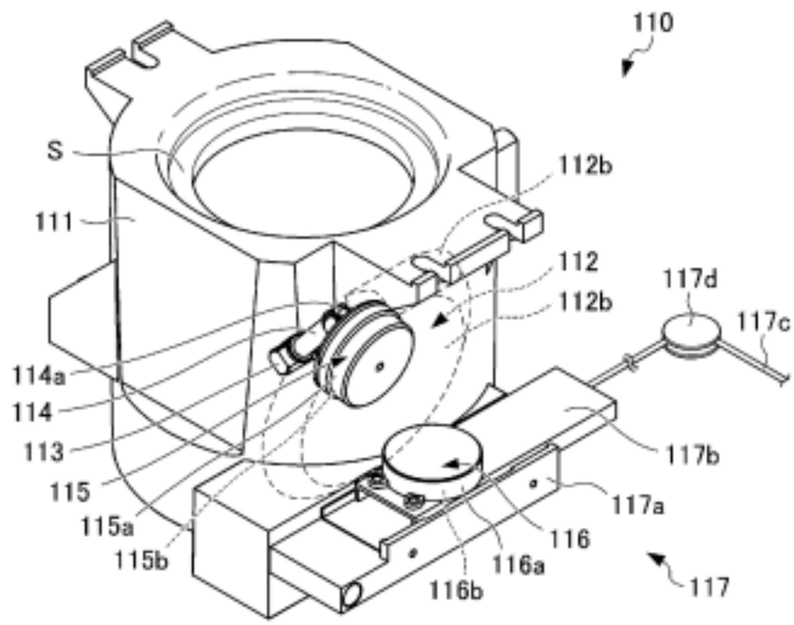
111
114
101
115
112
113
117
N
S
116
N
S
FL
160

[図4]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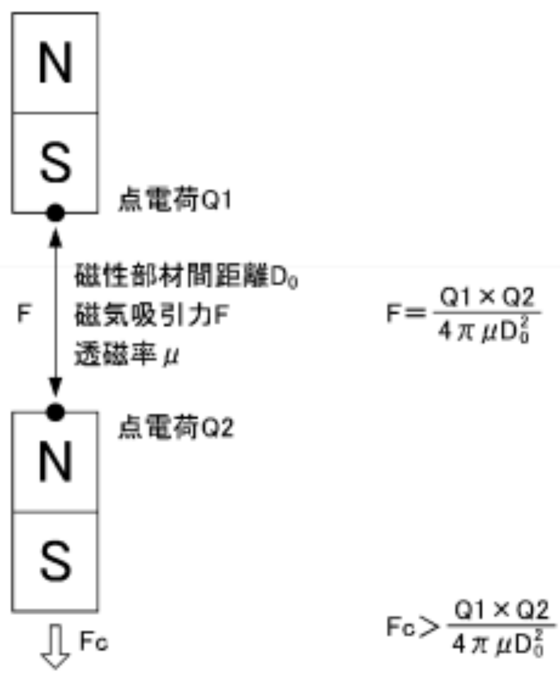
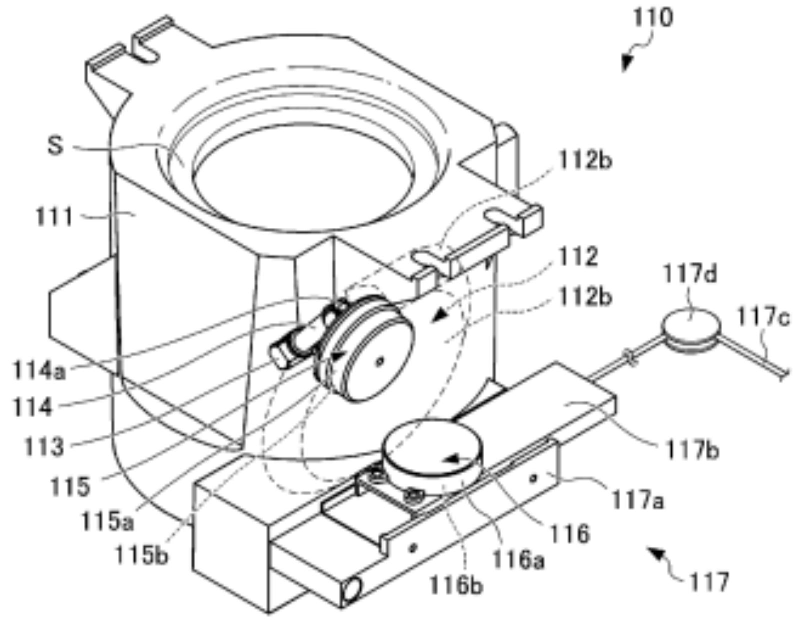
116a
116b
117

[図5]


N
S
点電荷Q1
磁性部材間距離D_0
F
磁気吸引力F
透磁率μ
点電荷Q2
N
S
Fc
$F=\frac{Q1\times Q2}{4\pi\mu D_0^2}$
$Fc>\frac{Q1\times Q2}{4\pi\mu D_0^2}$

[図4]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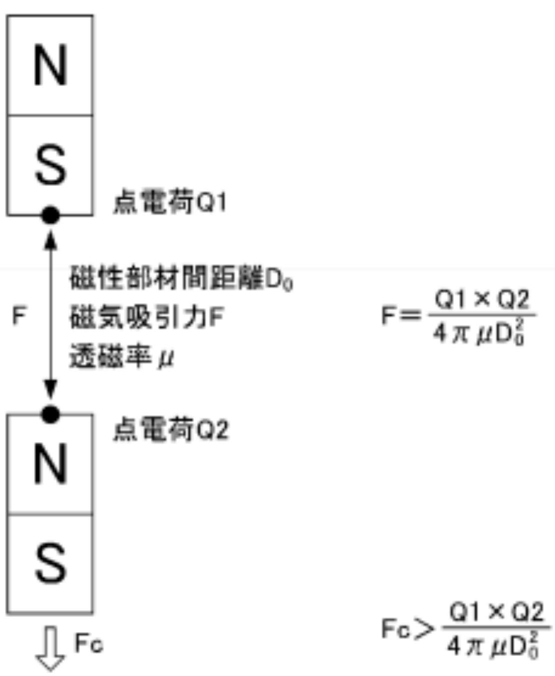
116
116a
116b
117

[図5]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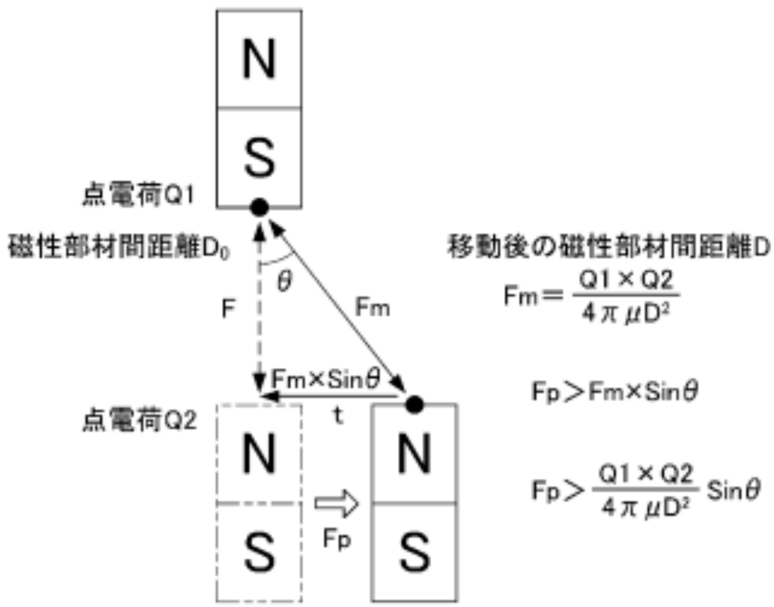
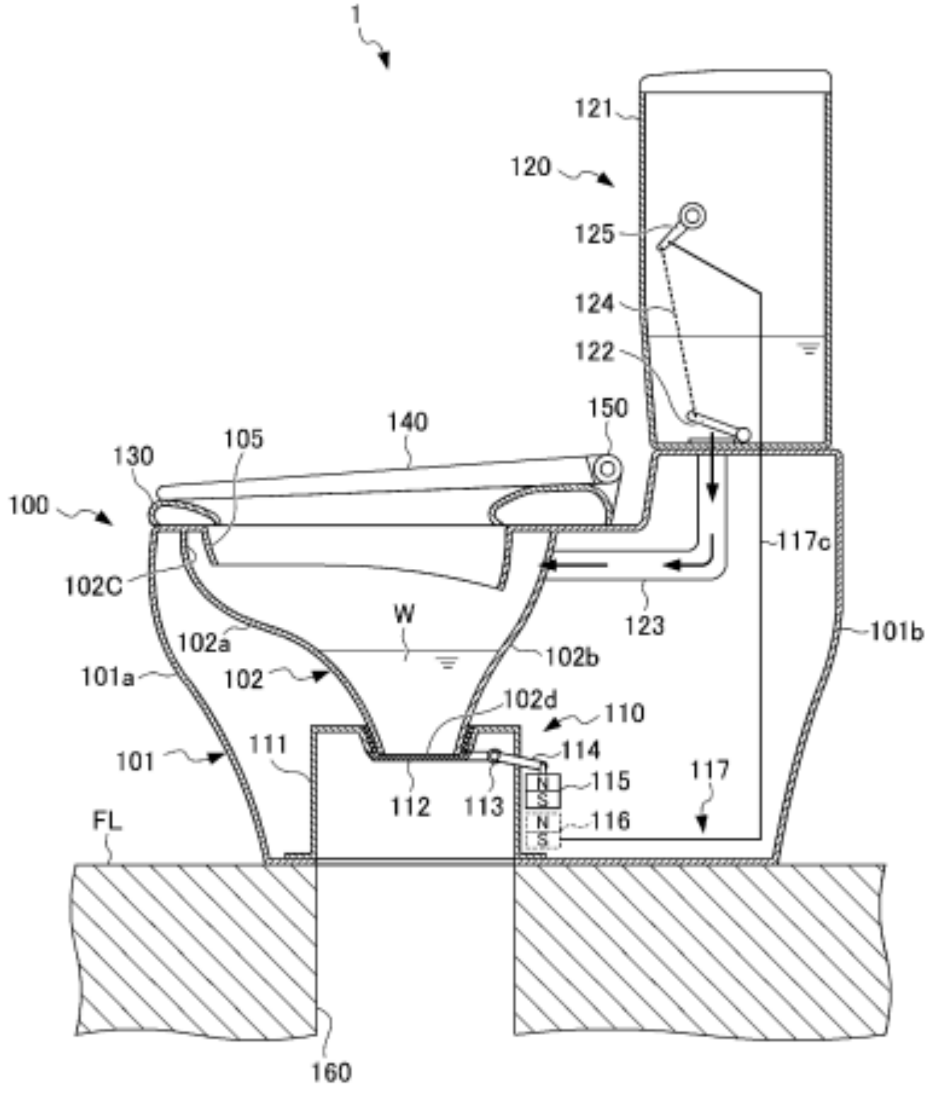
点電荷Q1
F
磁性部材間距離D_0
磁気吸引力F
透磁率μ
$F = \frac{Q1 \times Q2}{4 \pi \mu D_0^2}$
点電荷Q2
N
S
Fc
$Fc > \frac{Q1 \times Q2}{4 \pi \mu D_0^2}$

[図6]


N
S
点電荷Q1
磁性部材間距離D0
θ
F
Fm
移動後の磁性部材間距離D
Fm＝Q1×Q2 / 4πμD²
Fm×Sinθ
t
Fp＞Fm×Sinθ
点電荷Q2
N
S
Fp
N
S
Fp＞Q1×Q2 / 4πμD² Sinθ

[図7]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117c
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101a
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102d
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101
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117
112
113
116
FL
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N
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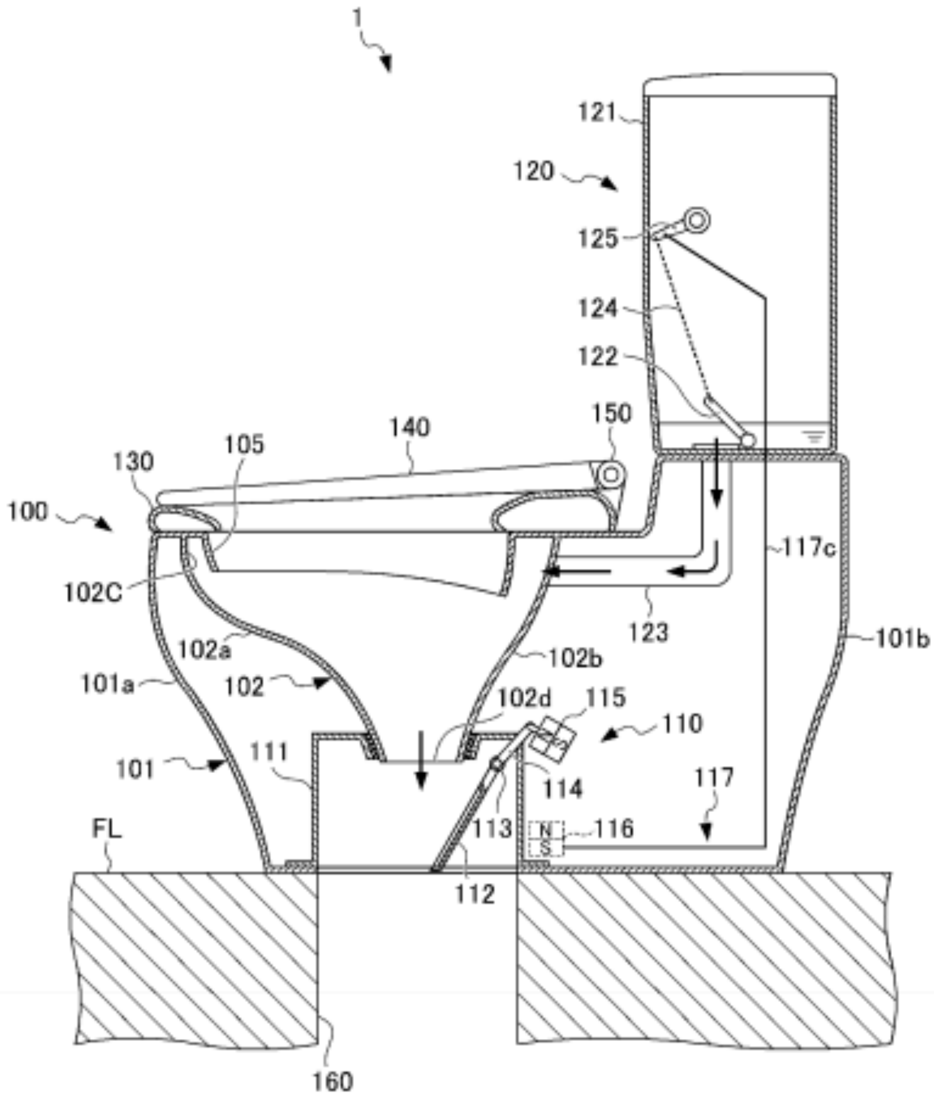
N
S

[図8]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130
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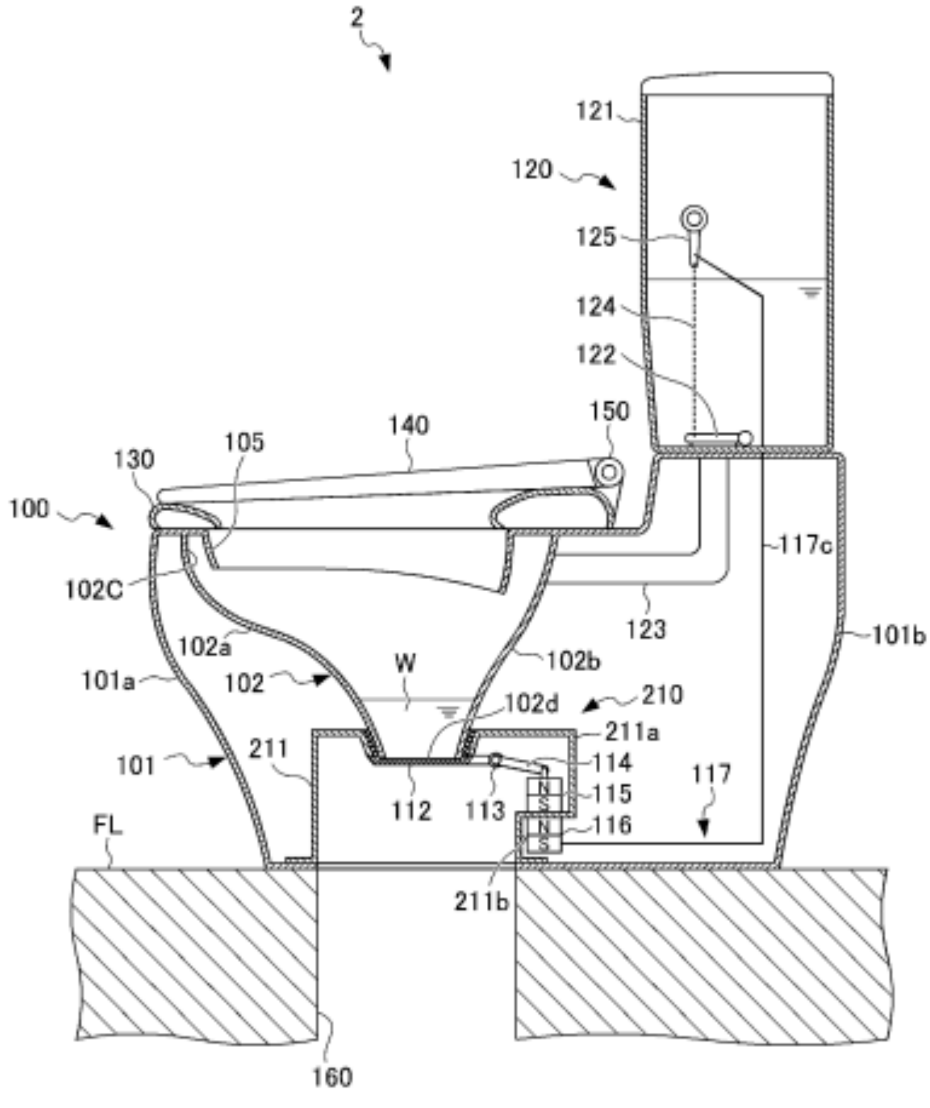
102C
117c
123
101b
102a
102b
101a
102
102d
115
110
111
101
114
117
113
116
N
S
FL
112
160

[図9]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102b
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211a
211
114
101
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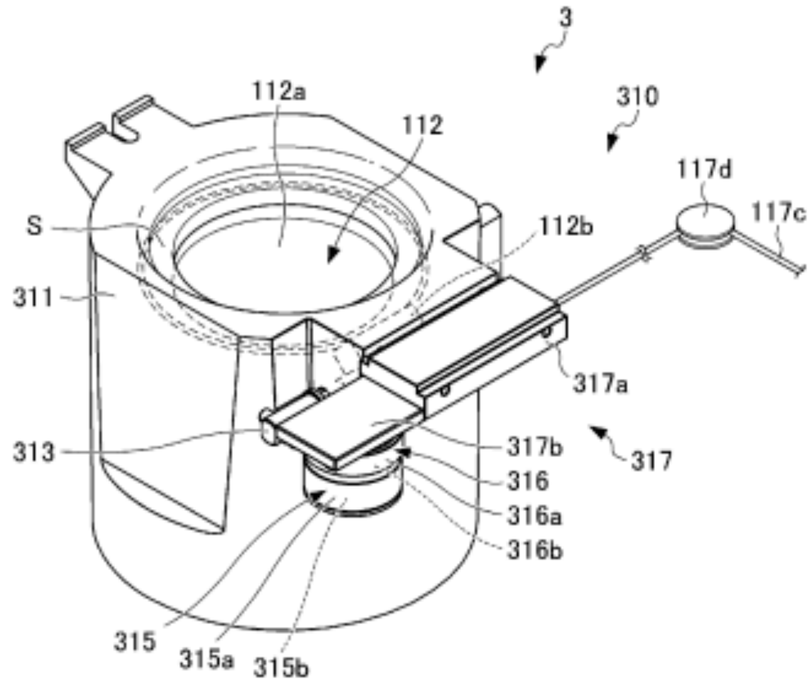
117
112
113
116
FL
211b
160

[図10]


3
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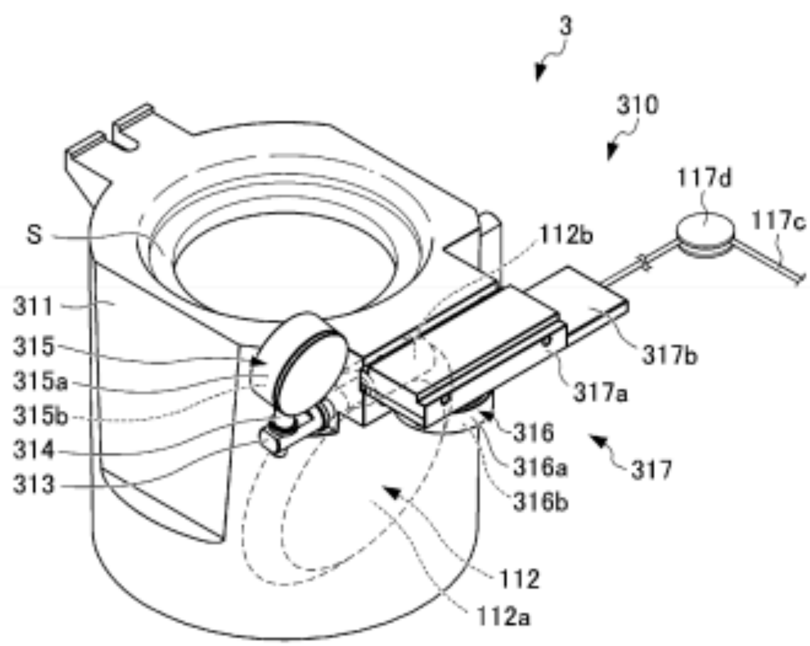
112a
112
117d
117c
S
112b
311
317a
313
317b
317
316
316a
316b
315
315a
315b

[図11]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315b
314
313
317b
317a
316
316a
316b
317
112
112a

19.9 PATENT (WO 2015/109301) Low or no water use latrine pans, latrine pan assemblies, latrines, and related methods

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(19) World Intellectual Property Organization
International Bureau

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WIPO | PCT

(10) International Publication Number
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(26) **Publication Language:** English

(30) **Priority Data:**
61/929,351 20 January 2014 (20.01.2014) US

(71) **Applicant: AS IP HOLDCO, L.L.C.** [US/US]; One Centennial Avenue, Piscataway, NJ 08855 (US).

(72) **Inventors: GATARZ, Gregory**; 311 Milltown Road, East Brunswick, NJ 08616 (US). **ISHIYAMA, Daigo**; 120 Essex Road, Summit, NJ 07901 (US). **MCHALE, James**; 48 Riverview Terrace, Hillsborough, NJ 08844 (US).

(74) **Agents: BULLOCK, Kristyne, A.** et al.; Flaster/Greenberg P.C., Four Penn Center, Suite 200, 1600 John F. Kennedy Boulevard, Philadelphia, PA 19103 (US).

(81) **Designated States** *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) **Designated States** *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Declarations under Rule 4.17:

— *as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii))*

[Continued on next page]

(54) **Title:** LOW OR NO WATER USE LATRINE PANS, LATRINE PAN ASSEMBLIES, LATRINES AND RELATED METHODS

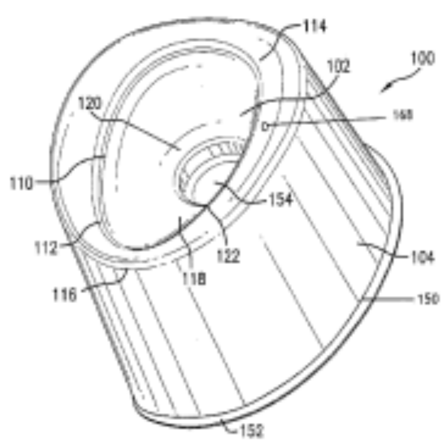
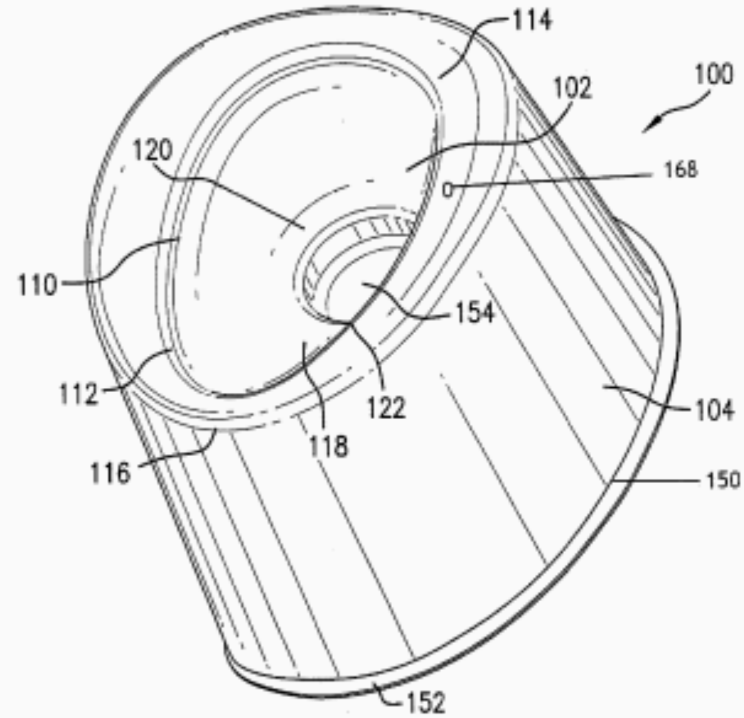


FIG.1

(57) **Abstract:** The latrine pan includes a collection basin and a flapper. The collection basin has an upper bowl portion tapering from an upper rim having an outer surface to an outlet 5 extending through a wall of the collection basin at a lower portion of the collection basin. The flapper includes a counterbalance device and a coverplate disposed on opposite sides of a pivot and the counterbalance device has a plurality of counterweight arms. The coverplate has an upper face adapted to cover the outlet of the collection basin when the upper face is engaged against the lower portion of the collection basin. The flapper is pivotally mounted 10 against the collection basin such that the coverplate engages against the lower portion of the collection basin when a pivotal force attributable to the counterbalance device is substantially equal to or slightly greater than a pivotal force attributable the coverplate.


114
100
102
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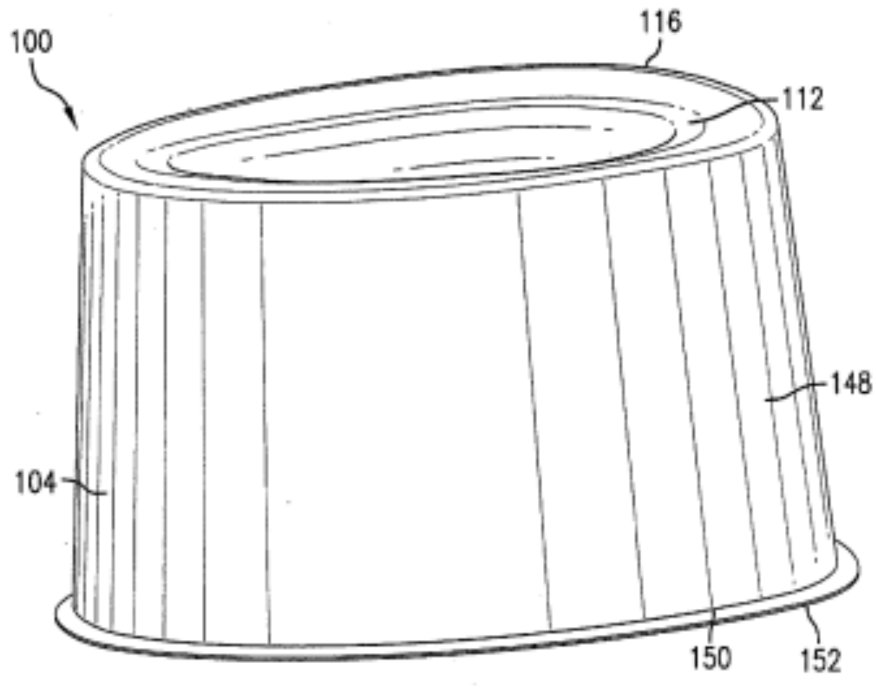
168
110
154
112
122
104
118
116
150
152

FIG.1


116
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152

FIG.2

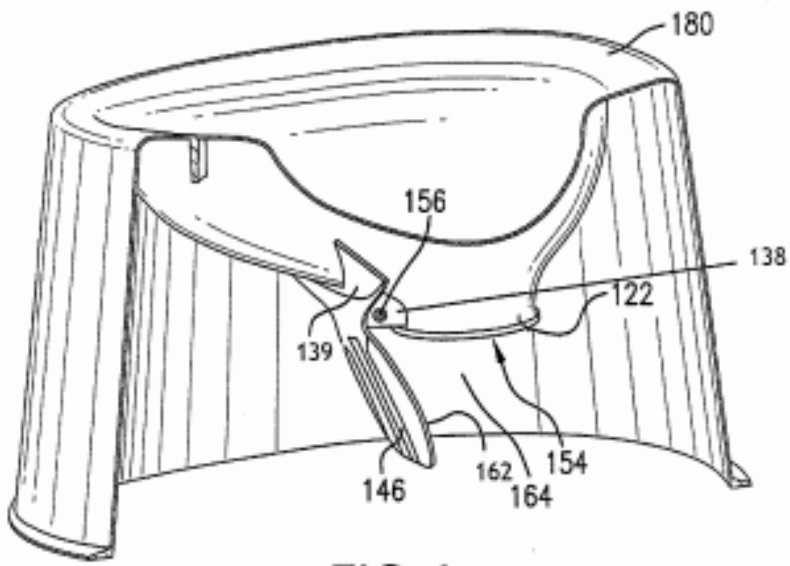


FIG.4

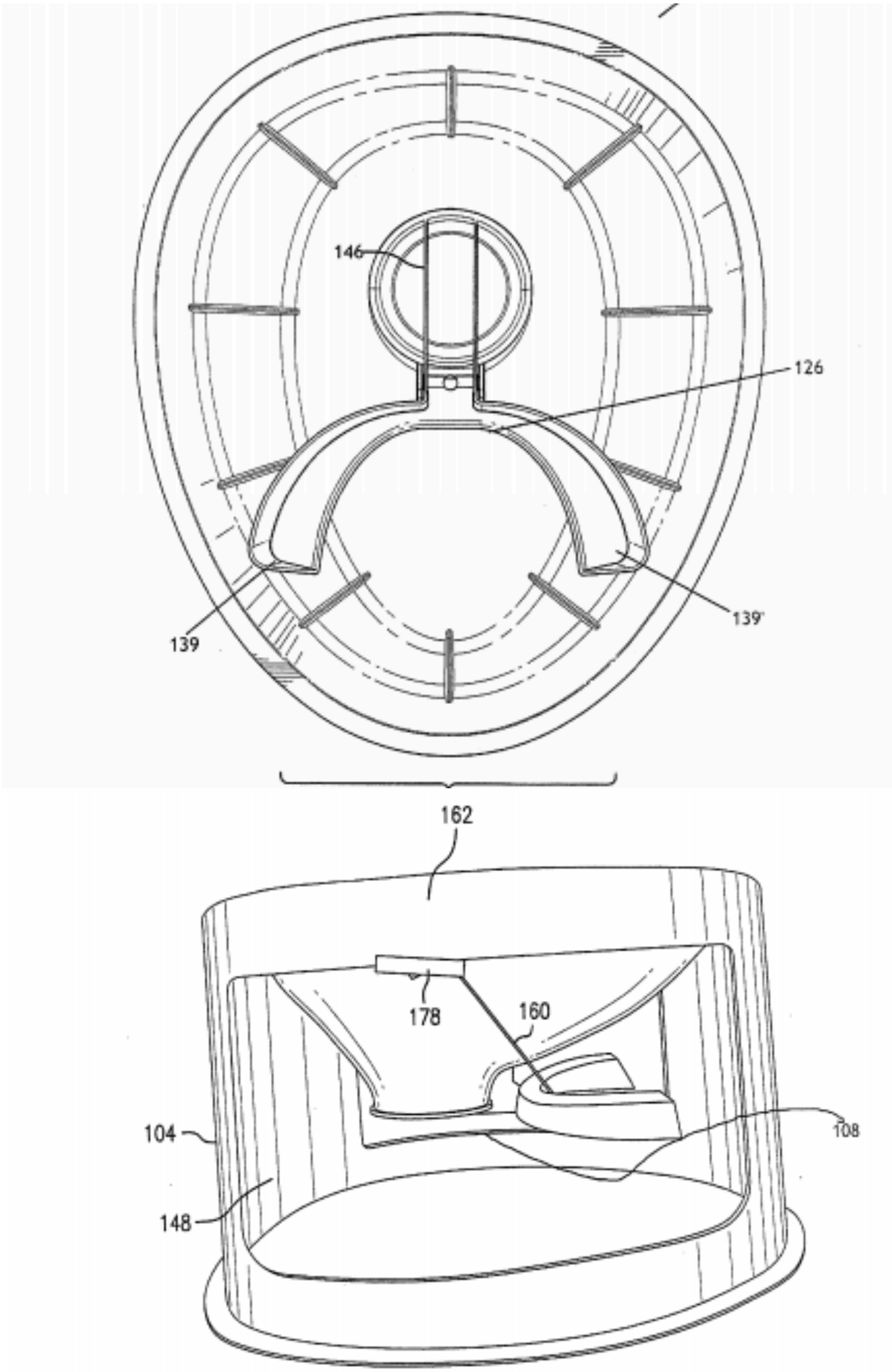


FIG.11 A

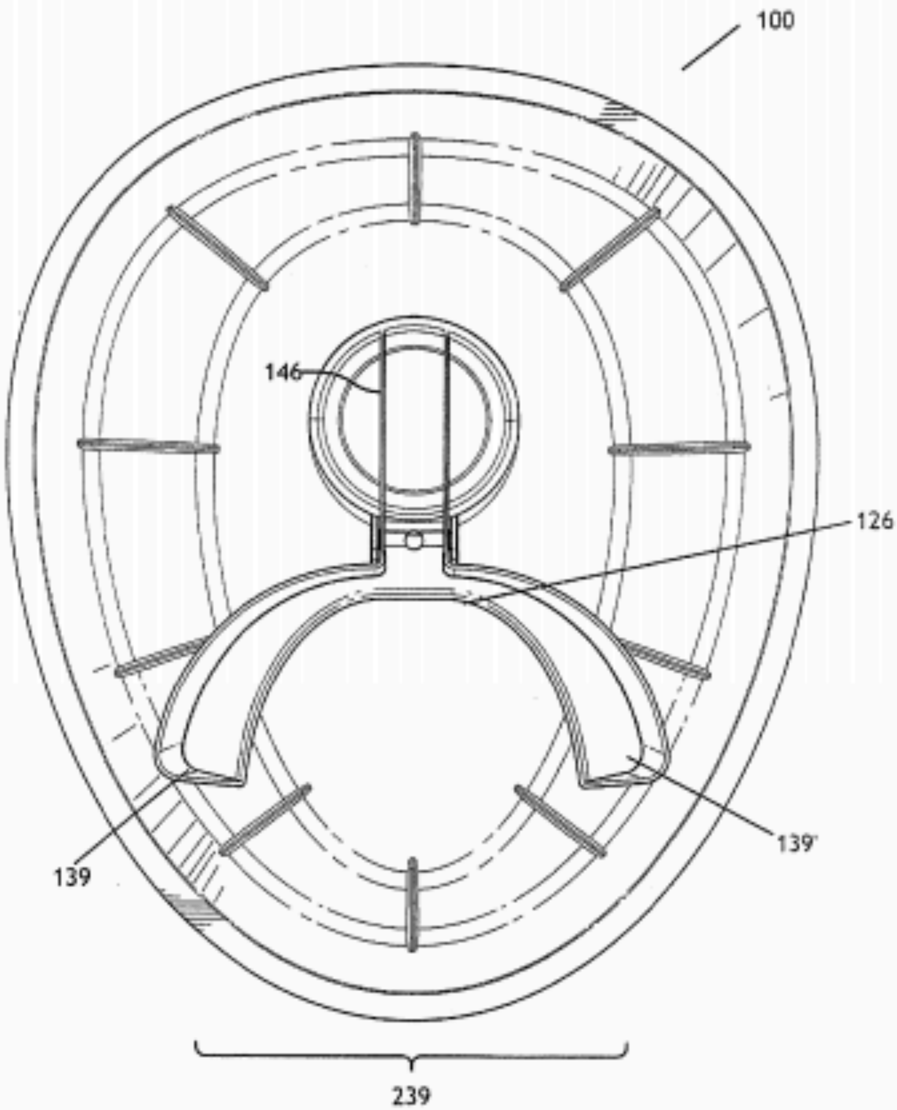


FIG. 16

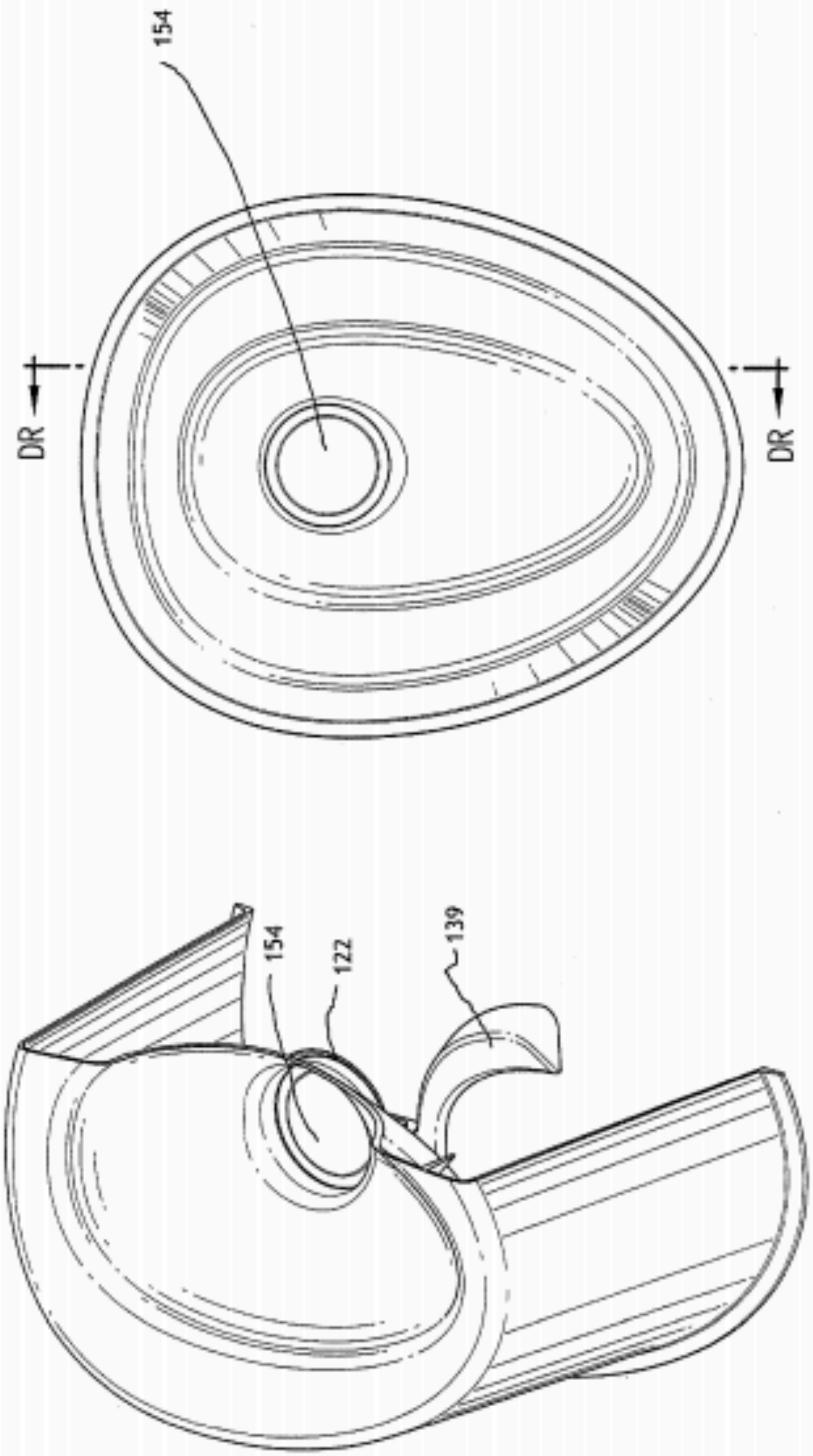


FIG.17

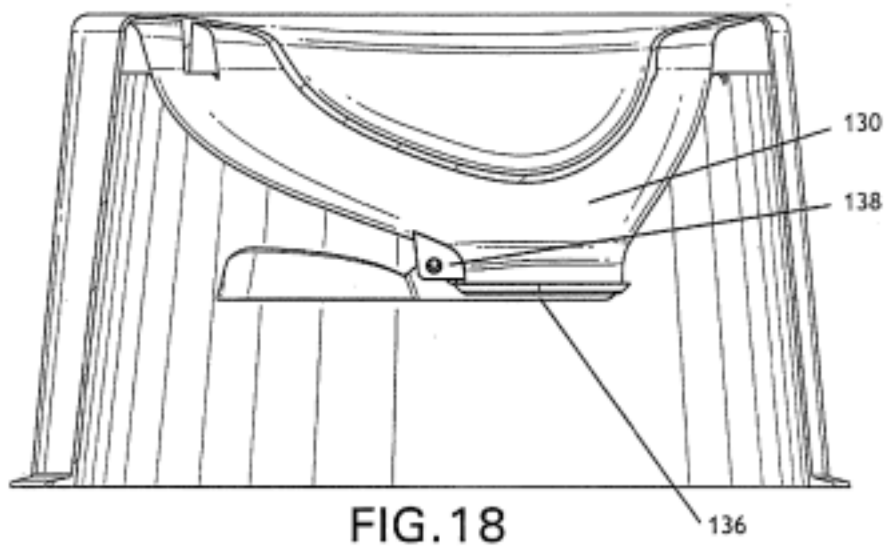


FIG. 18

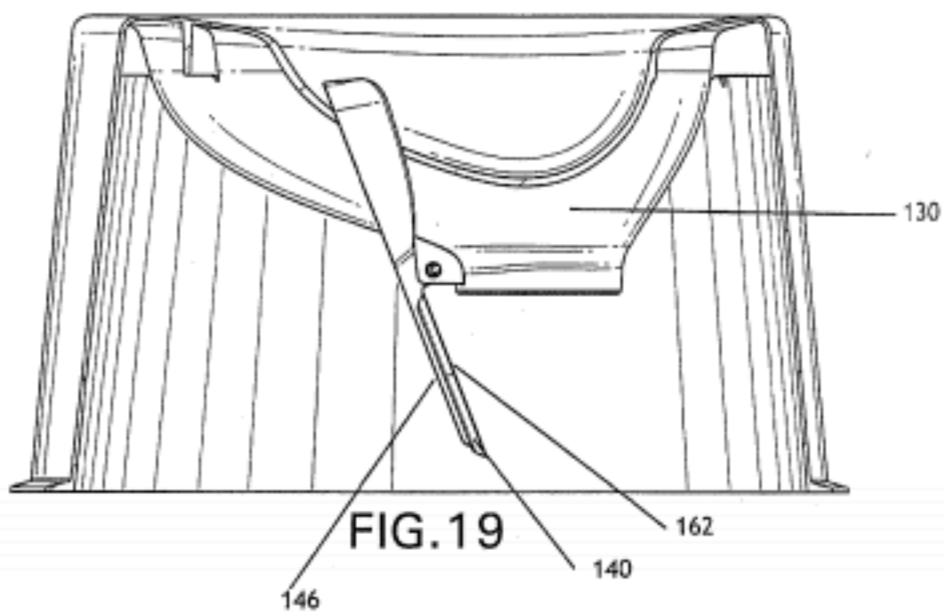
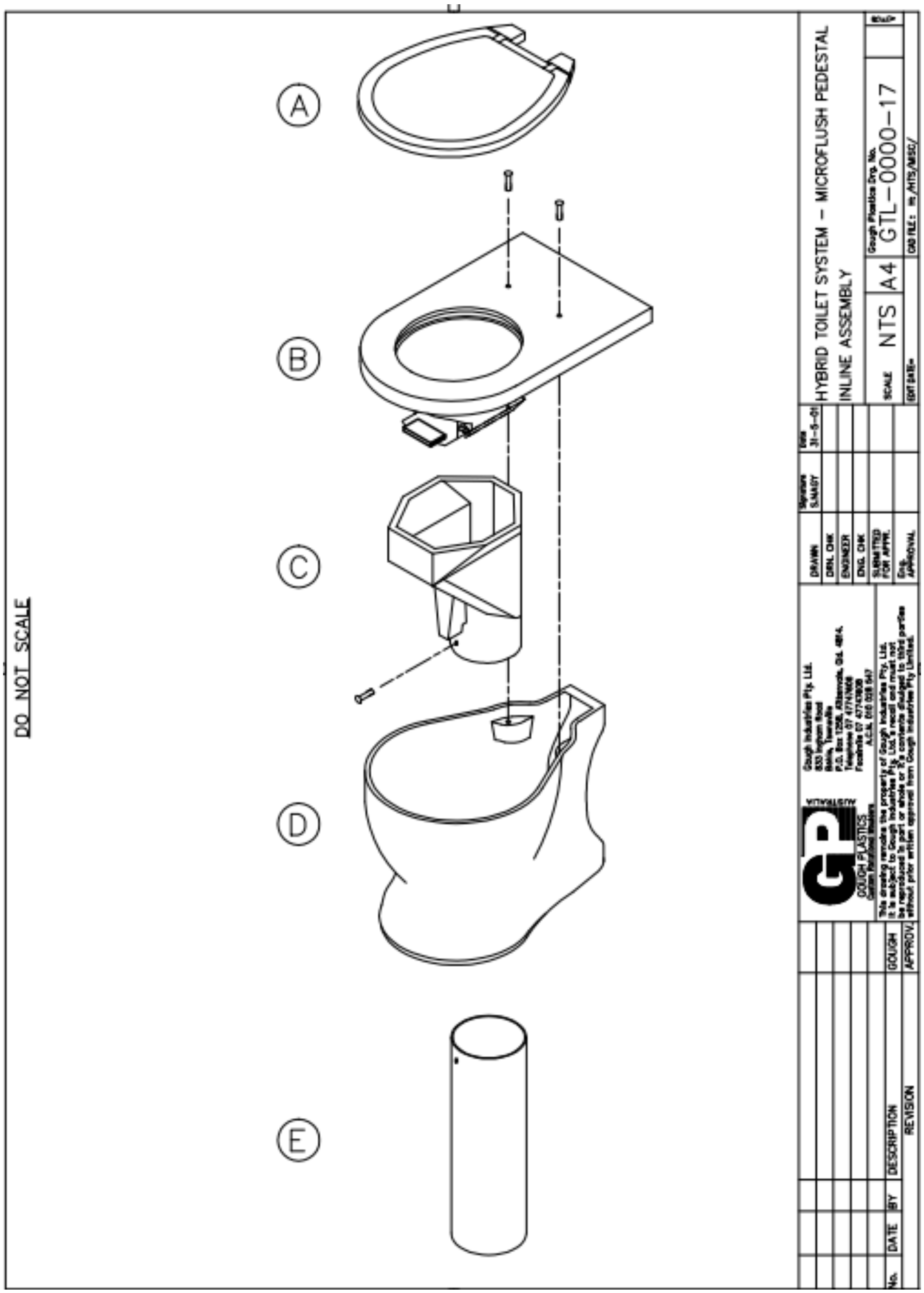
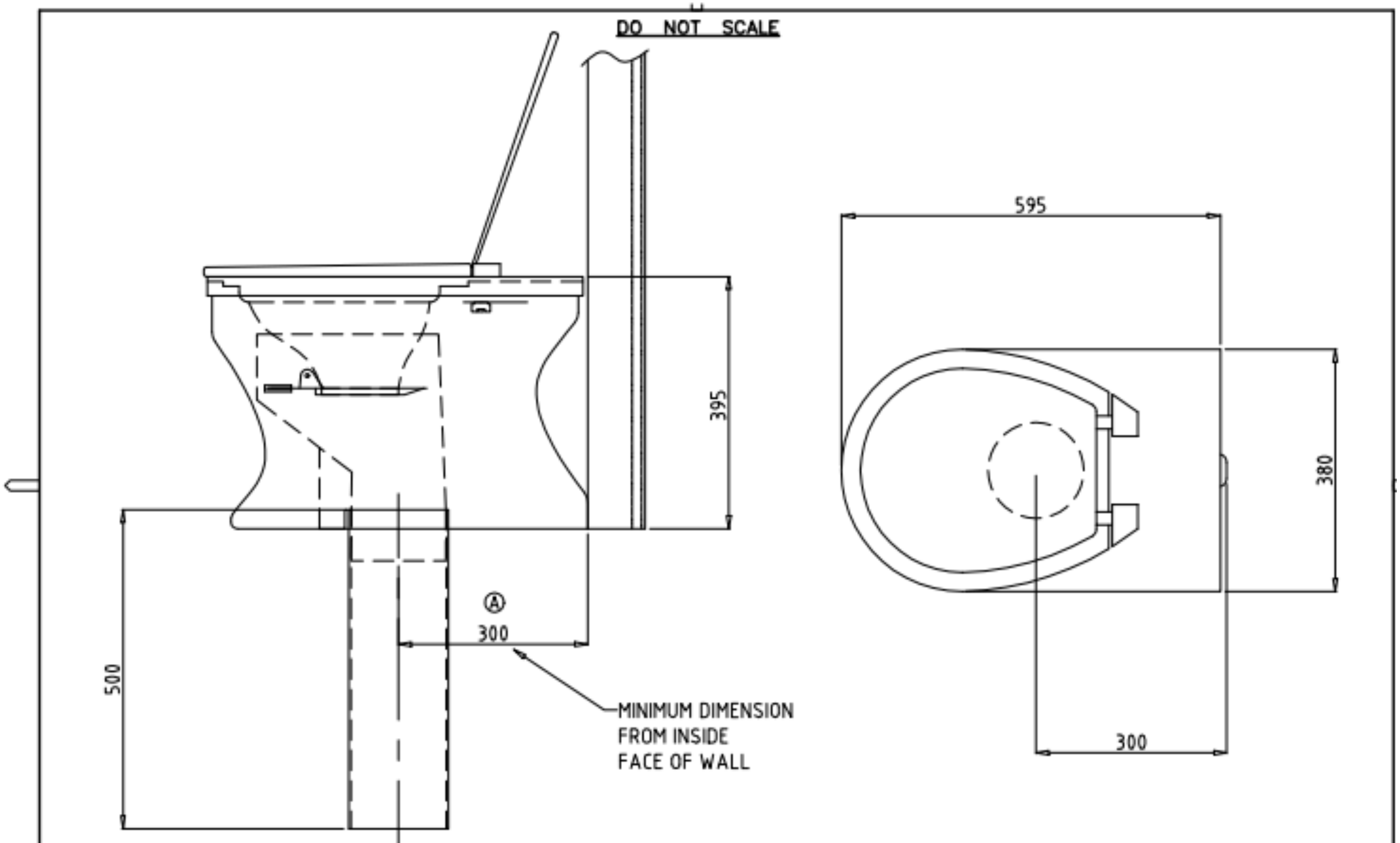


FIG. 19

19.20 PATENT GTL-0000-17 GTL-0000-18 Hybrid Toilet System- Microflush pedestal





HYBRID TOILET SYSTEM – MICROFLUSH PEDESTAL
GENERAL ARRANGEMENT

SCALE	1:8	A4	Gough Plastics Drg. No. GTL–0000–18
EDIT DATE=			CAD FILE : H:/HTS/MISC/

	Signature	Date
DRAWN	S.NAGY	31-5-01
DRN. CHK		
ENGINEER		
ENG. CHK		
SUBMITTED FOR APPR.		
Eng. APPROVAL		

No.	DATE	BY	DESCRIPTION	GOUGH
			REVISION	APPROV.

GOUGH PLASTICS AUSTRALIA
Custom Rotational Moulders
Gough Industries Pty. Ltd.
833 Ingham Road
Bohle, Townsville
P.O. Box 1258, Aitkenvale, Qld. 4814.
Telephone 07 47747606
Facsimile 07 47747608
A.C.N. 010 026 547

19.21 PATENT JP 2015-224437 A 2015.12.14 Toilet equipment and waste transport system

JP 2015-224437 A 2015. 12. 14

(19) 日本国特許庁(JP)

(12) 公 開 特 許 公 報(A)

(11) 特許出願公開番号

特開2015-224437

(P2015-224437A)

(43) 公開日 平成27年12月14日(2015. 12. 14)

(51) Int.Cl.			F I			テーマコード (参考)
E03D	11/10	(2006.01)	E03D	11/10		2D036
E03C	1/122	(2006.01)	E03C	1/122	Z	2D039
A47K	11/00	(2006.01)	A47K	11/00	108	2D061

審査請求 未請求 請求項の数 7 OL (全 25 頁)

(21) 出願番号 特願2014-108578 (P2014-108578)

(22) 出願日 平成26年5月26日 (2014. 5. 26)

(71) 出願人 302045705

株式会社LIXIL

東京都江東区大島2丁目1番1号

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弁理士 芝 哲央

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弁理士 岩池 満

(74) 代理人 100160794

弁理士 星野 寛明

(72) 発明者 清水 晃治

東京都江東区大島二丁目1番1号 株式会社LIXIL内

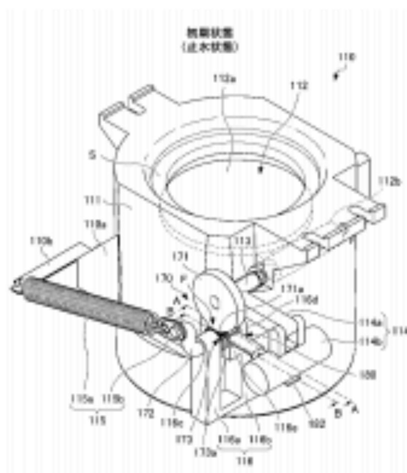
最終頁に続く

(54) 【発明の名称】便器装置及び汚物搬送システム

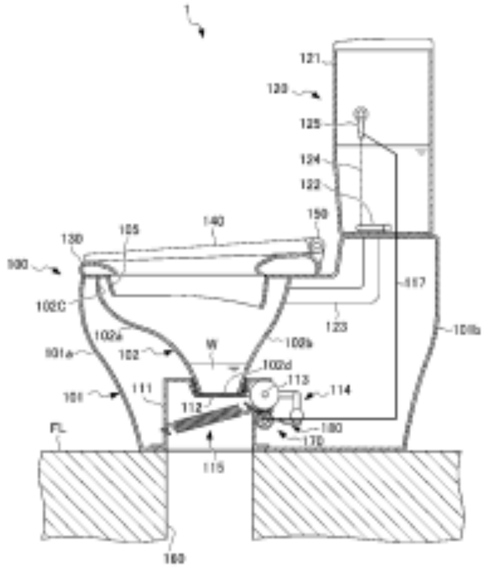
(57) 【要約】

【課題】従来よりも小さい操作荷重でフラッパ弁を開閉でき、便鉢内の水が外部に溢れるのを確実に回避できる便器装置を提供すること。

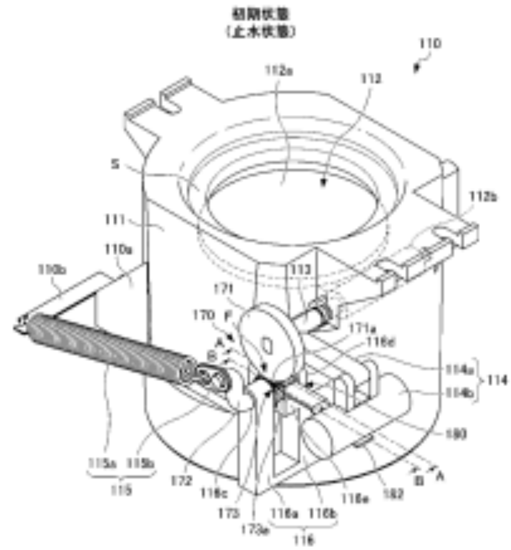
【解決手段】排出口102dが形成された便鉢102を有する便器100を備える便器装置1であって、排出口102dに配置され、排出口102dを開閉するフラッパ弁112と、フラッパ弁112を回動させる第1回動軸113と、第1回動軸113に連結され、フラッパ弁112の回動に必要な力が付加される力点部Fと、力点部Fにおける第1回動軸113を中心とした回動円Cの接線L方向に付勢力が作用するように配置されるとともに力点部Fに連結され、フラッパ弁112を閉方向に付勢する付勢部115と、力点部Fと付勢部115とを連結する連結機構170と、を備え、連結機構170は、フラッパ弁112の開度が所定値以上のときに、力点部



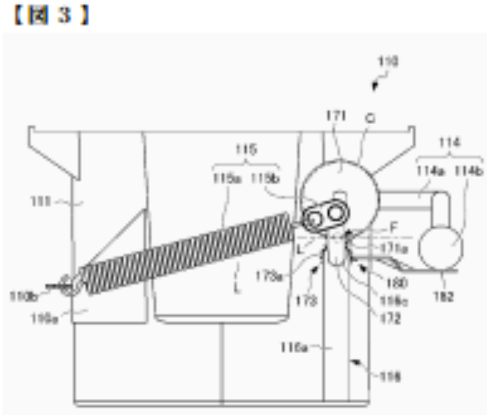
【図１】



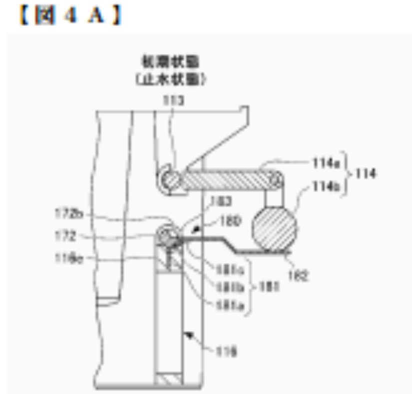
【図２】



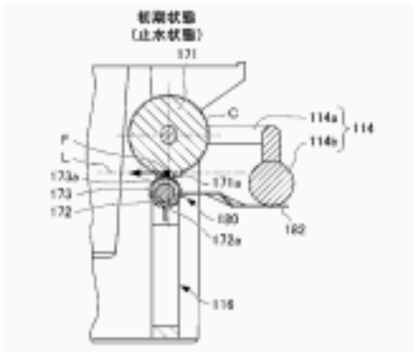
【図３】



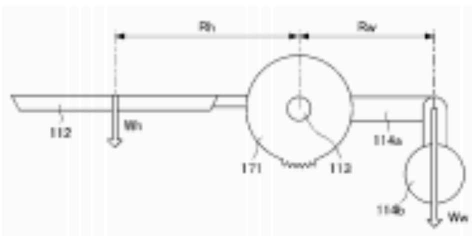
【図４Ａ】



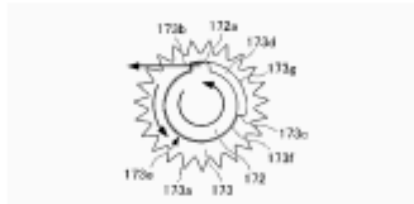
【図４Ｂ】



【図５】



【図６Ａ】



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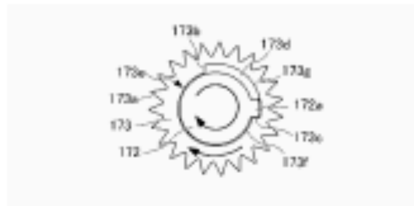

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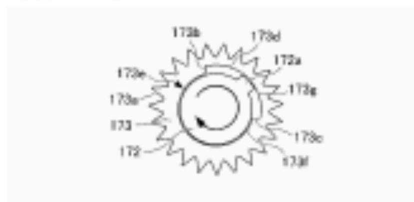

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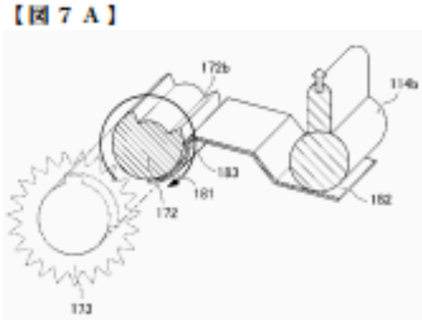

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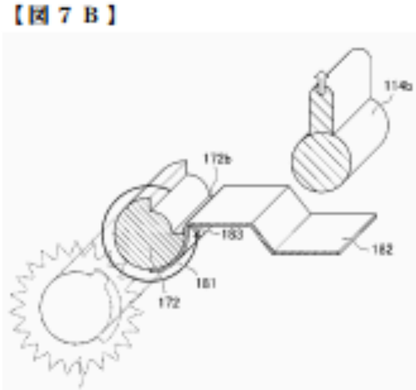

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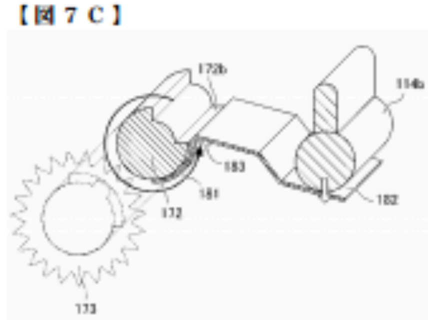

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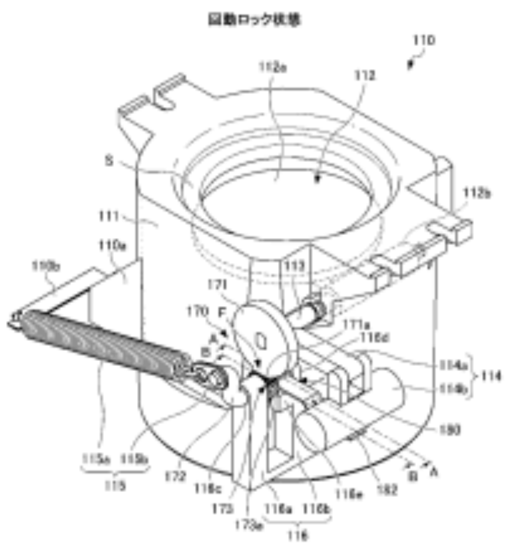

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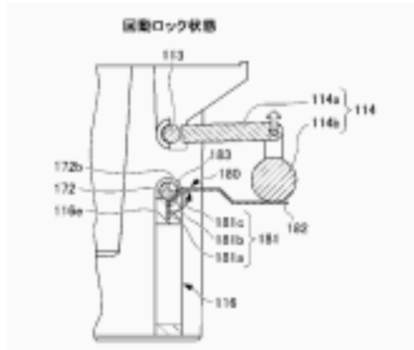

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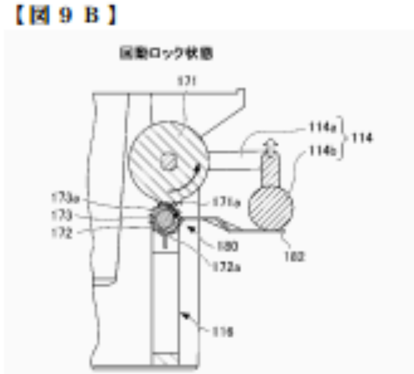

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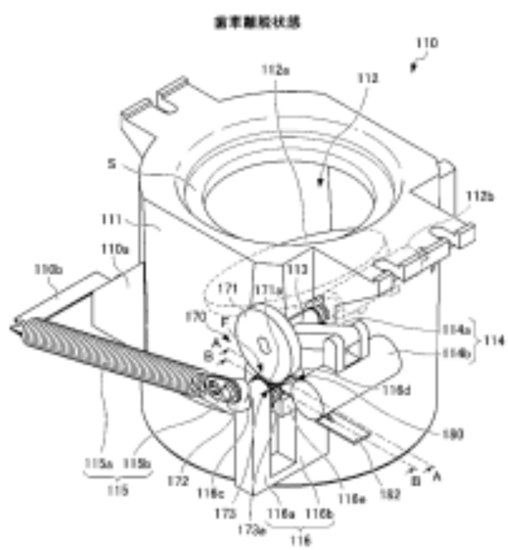

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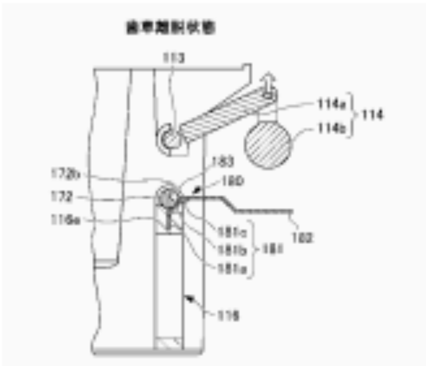

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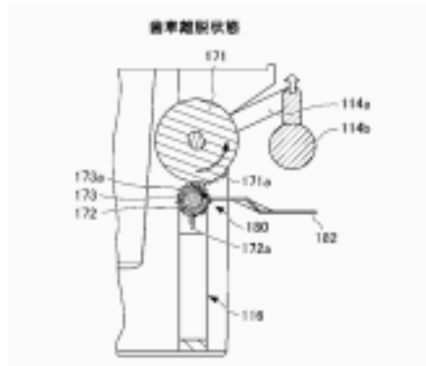

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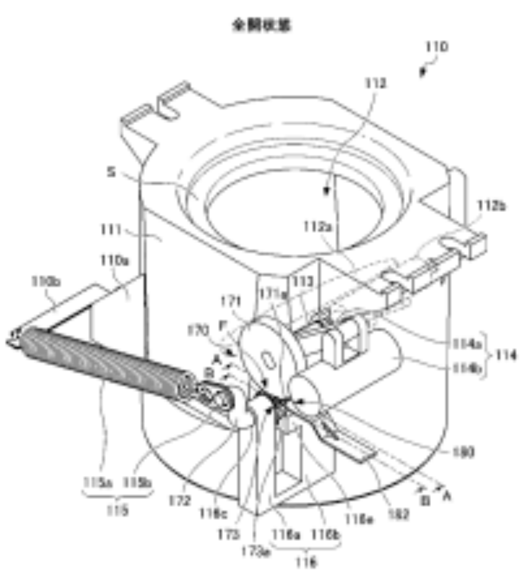

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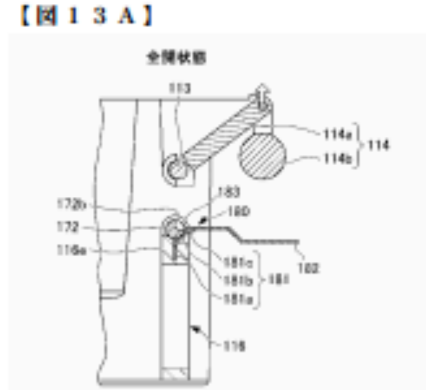

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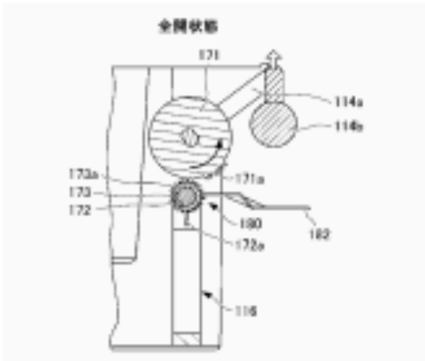

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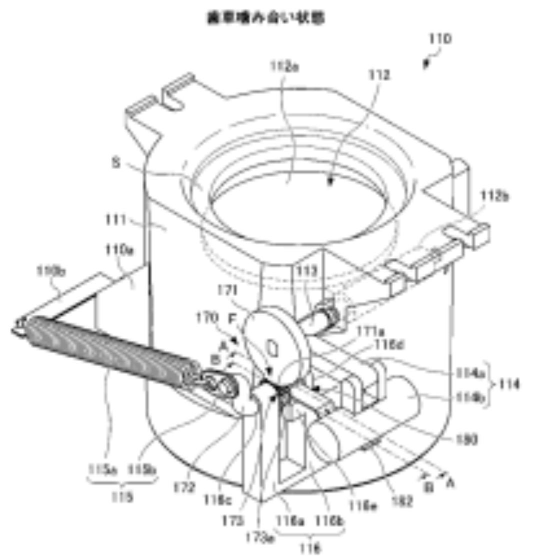

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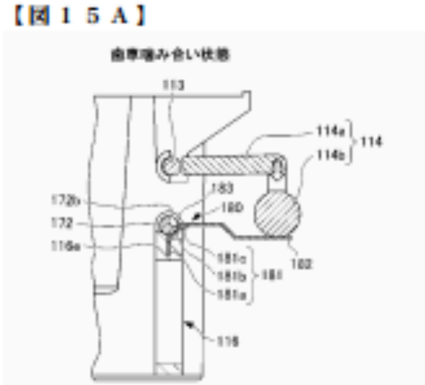

【図１５Ｂ】