

## A Design Analysis of the Bissel ZING 2156 Vacuum Cleaner

### *Part 1: Design and Evaluation, Displays, and Controls*

#### **Topic**

While vacuum cleaners have made cleaning convenient in a vast majority of households across the United States, vacuum cleaning continues to be one of the most dreaded household chores known to mankind. In this report, I will be analyzing the Bissell ZING 2156 vacuum cleaner and proposing redesign solutions that address some usability issues that contribute to this continued dislike of vacuuming.

#### *Stages of human factors in the product life cycle*

#### **Front-end analysis**

User Analysis: The target users of the Bissell ZING vacuum cleaner are homeowners between the ages of 18 and 64. Users can be either male or female, and have basic cognitive and reading skills. Users will have the physical ability to stand, walk, bend over, move parts of the appliance through movement of hands and arms, and also carry the appliance while moving. Most users will have familiarity with this type of product, as this is a cleaning appliance that is common in most households in the United States. According to a report on Statista on the vacuum cleaner market in the United States, by the end of 2017, 31.52 million pieces of product had been purchased by users (2018). The Bissell vacuum cleaner retails for an affordable price thus, the typical user will have a low to average disposable income. The user will also be responsible for maintaining, monitoring, and disposing of this appliance.

The goals of the user would be to be able to clean dust and debris from floor surfaces and furniture in their homes. Another goal would be to be able to clean dry surfaces in a quick and efficient manner. Users would also like to be able to vacuum difficult areas like stairs and corners. In terms of the maintenance of the vacuum cleaner, users would like to be able to clean the appliance less frequently and in a hassle-free manner. The user would also prefer to be able to discretely store such an appliance in small spaces within the home. The environments in which the user will potentially use this type of appliance are smaller-sized houses and apartments, thus

the appliance would be used indoors. The work environment will consist of different types of surfaces such as hardwood floors, carpeted floor areas, stairs, upholstery, and curtains and drapes. Some flat surfaced areas of the environment will be wheelchair accessible, however surfaces such as stairs would not. With a vacuum cleaner, a user typically would like to accomplish the cleaning of dirt from various surfaces in their home easily and swiftly.

Function and task analysis: The main function of this type of product includes the suctioning of dust, debris, and dirt on a variety of surfaces to produce clean surfaces. The vacuum cleaner also holds any of the dirt collected in the 'dirt container', until cleaning of the appliance is required. The appliance also moves smoothly in the direction pulled or pushed due to the attached wheels. The floor tool holder on the back of the vacuum holds the handle and the floor tool in place during storage.

When examining the task sequence, the first task when using the vacuum cleaner would be to assemble the device. The floor tool can be replaced with any of the two additional tools, based on the specific cleaning task. The second task would be to move vacuum to area that needs vacuuming. The first subtask under this task would be to locate the area that needs vacuuming. Once the area is located, grasp the vacuum from the 'carry handle' on top and lift the vacuum off of floor. Carry the vacuum to the needed location. Place the vacuum on the floor or keep holding vacuum from handle.

The second task involves beginning the vacuum cleaning process. The first subtask would be to locate a power outlet to plug in power cord. Next, pull and unwind the power cord out of the space on the right side back of the vacuum to get the desired length. Plug in the power cord to the outlet. Grasp handle to lift floor tool off of floor tool holder and place floor tool flat on the surface. Press the green power button located on the left side back of the vacuum to power up vacuum. Next, while grasping the 'telescopic wand', glide the floor tool back and forth along the surface. Repeat this action until the total surface area of the surface has been covered with the floor tool, and any visible debris, dirt and dust has been picked up. Pull or shift the 'telescopic wand' and 'hose' to move the vacuum cleaner forwards or change the direction of movement

from side to side to reach the all areas in the surface. Once surface is completely vacuumed, turn off vacuum by pressing the green power button as before.

The third task will be to end vacuuming and store the vacuum in a suitable space. The first subtask would be to place the handle and floor tool in the floor tool holder in the back of the vacuum as previously. Then unplug the power cord from the power outlet. Next, press the 'cord rewind button' on the right side back of the vacuum to rewind power cord. Once the power cord is wound grasp the 'carry handle' and lift the vacuum. Carry vacuum to storage location and place the vacuum in an upright position.

### **Iterative design and testing**

#### **System specifications & production**

One of the overall objectives of this product is to clean and pick up dirt and debris effectively and swiftly. Another is to pick up dirt from various types of surfaces such as carpets, rugs, hardwood floors etc. Some other objectives would be to hold a substantial capacity of dirt temporarily, to maneuver the appliance easily and without much force when in use, and to carry and transport the appliance easily when in use and when not in use (portable). More objectives include, storing the vacuum in small spaces, to clean the vacuum filters and dirt cup easily, to store floor tool, handle, and extensions in compact manner, and to vacuum hard-to-reach areas such as stairs and corners.

Some of the performance requirements for this product are a cyclonic cleaning system with a 3-stage filtration process and a 10.1" width floor tool to ensure a quick and efficient cleaning process without the loss of suction in the vacuum. The vacuum has a switchable brush tool in the floor tool (see figure 1), which can be toggled when vacuuming between hardwood floors and carpets. Users can adjust the suction power with an adjustable switch on the handle (see figure 2) or with an adjustable knob on top of the vacuum that controls suction power (see figure 4).

The vacuum comes with attachable tools (see figure 3) that can be used when vacuuming other types of surfaces such as furniture, curtains and drapes and a 'telescopic wand' that allows

cleaning in hard-to-reach areas like ceilings. In terms of functional allocation of storage, by installing grooves on the sides of the vacuum (see figure 5) users can store additional tools with the appliance, thus decreasing the possibility of misplacing them. The vacuum consists of a dirt cup with a two liter capacity, a multi-directional small wheel in front of the vacuum and two larger wheels in the back (see figure 6), a 'carry handle' on top for lifting (see figure 7), and weighs 10lbs. The dirt cup has an indicator (see figure 8) of when to clean the vacuum, the canister is removable for cleaning purposes, the dirt cup can be opened at the push of button, and the filters can be removed and washed. The floor tool can be attached to the floor tool holder when the vacuum is parked or in storage.

One of the design constraints in the development of this product is the cost. Since this vacuum is in the lower end of the typical retail price for this type of appliance, the appliance is targeted towards households with a low to average disposable income. Adding features that are typically found in higher end vacuum cleaners, such as a control to adjust the suction power of the vacuum to suit the surface being cleaned (see figure 4), could increase the cost of manufacturing this appliance and ultimately the retail price as well. Another design constraint would be the size and weight of the appliance. The Bissell canister vacuum is designed for cleaning small living spaces and hard-to-reach places such as stairs, thus portability and being lightweight is important. By installing features such as the storage components for the attachable cleaning tool (see figure 5), there may be an increase in the size and weight of the appliance.

The supporting materials or the owner's manual of the appliance is delivered in a small booklet that is easy to read. The safety instructions, warranty, and service information are presented in detail in English, French, and Spanish. All other information such as package contents, product features, assembly instructions, maintenance, and troubleshooting instructions are presented step-by-step in graphical form (see figure 9). The user is able to read the user manual, and understand the manual very easily due to the graphical representation.

Heuristic evaluations and usability testing: Overall this product meets most human factors criteria. One of the areas that must be addressed for improvement is the legibility/visibility of the



buttons on the vacuum cleaner (see figure 10). Although they are of a contrasting color and have meaningful icons to represent their function, these icons are not contrasted against the green background of the button (see figure 11). However, the button for rewinding the power cord does follow the proximity compatibility principle, and is located on the side of, and closest to the power cord storage location on the vacuum (see figure 12). The suction power adjustability switch, although visible against the handle, does not offer a meaningful label, other than arrows in the directions in which the switch can be pushed. This label does not meaningfully indicate the function of the switch. Thus, these aspects of the appliance do not follow human factors criteria.

Overall this appliance would be easy to understand and use. The learnability of this vacuum cleaner is high, as some of the universally meaningful labels (power button) and the graphically presented owner's manual would allow first-time user's to learn how to operate the appliance easily. Since the steps in operating the vacuum cleaner are not cognitively complex, the memorability of this appliance is high. Users would be able to use the appliance effectively even after a long period of time since their last interaction with the vacuum. Overall, this appliance is quite user-friendly.

### **Implementation and evaluation**

While the Bissell canister vacuum cleaner appears user-friendly in terms of the simple task sequence and the appropriate labeling, user feedback indicates several functional errors. The first is the tendency for the extension wand to separate from the handle. User reviews found on the Bissell website indicate the inconvenience of this issue as they describe the need to have to manually hold together the extension to the handle when vacuuming certain surfaces (S, 2018).

The functioning of the switch on the floor tool that activates the brush extensions is also not effective when used on carpeted surface areas. Some users mentioned in their online reviews that the vacuum wasn't as effective on carpeted surfaces compared to surfaces like hardwood floors. Through the personal experience of using the vacuum cleaner, I found that when used on the carpet, the abrasion of the brush extensions on the carpeted surface caused the switch to

snap into the opposite position and retract the brush extensions, due to pressure. The issues in functionality stated above were found in this stage of the design cycle.

### **System operation and maintenance**

The user carries out the system operation and maintenance. Other than the issues found in the previous stage in the design process, the system operation of the appliance runs smoothly. One issue that may arise during the operation of the appliance is the length of the cord. Since this type of appliance will be used in small living environments, the 16-inch power cord seems sufficient for effectively reaching areas within the living space. However, a common issue when using the vacuum at the maximum length of the power cord is the tendency for the power cord to detach itself from the power outlet when pulled. By having an indicator, such as a loud auditory tone that indicates that the power cord has reached the maximum length, may prevent this issue and increase the safety of using this appliance.

In terms of the maintenance of the vacuum cleaner, the process of cleaning the vacuum is made easy by the 'easy empty' dirt cup. The user simply needs to press a button (see figure 13) to remove the canister. Then they would simply press the button on the back of the canister to open the bottom cover of the dirt cup to empty the collected dust and debris. The filter can be removed and washed for a more thorough clean. However, a more salient way of identifying whether the vacuum needs to be cleaned would be useful for users. The current design has a simple label (see figure 8) to indicate maximum dirt capacity but no other indicator of the need to clean the vacuum. This could be implemented by a simple LED display on the top of the vacuum that would indicate the need for emptying the dirt cup and cleaning the filter by flashing red (see figure 14). Such improvements would enhance the user experience of this appliance.

### **System disposal**

The user also carries out system disposal. The appliance can be disposed of by being dropped off at a local recycling center. The Bissell website indicates ways in which the product can be recycled, which is by shipping the product to Bissell's recycling center in Texas or by

dropping the product off at their recycling location in West Michigan. The manufacturers recommend recycling the battery of the vacuum cleaner.

## ***Part 2: Anthropometry, Workspace Design, and Work Physiology***

### **Anthropometry**

The target users of this device fall within the 18 to 64 age range and will be small household owners. Since this group consists of a number of age groups, the product must be suitable to the physical characteristics of all the users across this age range, such as the varying average heights of these age groups. The target population for this product will include both male and female users, users from all races and ethnic groups in the United States, and also belong to the civilian population.

The body dimensions that will be relevant for the design of this product and the workspace are the following when standing, forward functional reach, specifically the acromial process to function pinch, waist height, knuckle height, shoulder height, stature; and the following for hand dimensions, hand breadth, hand thickness, breadth of digit one and digit three (Interphalangeal joint), and the grip breadth (inside diameter).

Although this appliance is targeted towards 62.9% of the population, this vacuum cleaner is designed for the extremes. Specifically this device is designed for users with smaller anthropometric dimensions. Since portability and storage in small spaces are some of the key design objectives of this device, this device is designed for the smallest dimensions appropriate for the target population. Parts of the appliance such as the 'carry handle', and the handle are designed for the smaller extremes as to ensure that the smaller users will be able to grasp and maneuver the device securely (see figure 7). However, users with larger dimensions will also be able to easily and securely grasp the device. Also due to the objectives of this device being compact and portable, the height of the device and the handle attached are designed for the shorter extremes. With the 'carry handle' on top of the vacuum at 12.5 inches height, users with the smallest dimensions will have to bend over to pick up the vacuum cleaner. This may be difficult for older individuals with and individuals with back pain. The percentile values of

anthropometric dimensions used for the design of this device are of the 5th<sup>th</sup> percentile. Hence, in terms of dimensions this device will accommodate 95% of the population. The anthropometric data used will be pulled from the 'Anthropometric Source Book. Volume II: A Handbook of Anthropometric Data' published by NASA in 1978.

### **Principles of workspace design**

In terms of the workspace for this particular device, the clearance requirements for the largest users are met. The only feature that requires a clearance for larger users is the width of the dirt cup. The dirt cup can be reached into to remove the filter within to wash during the maintenance and cleaning of the vacuum. While this feature has been designed to have a capacity of two liters, the dirt cup also has a width of 5 inches, giving a significant clearance in width for the largest users.

The reach requirements for the smallest users have also been fulfilled in the design of this device. For example, the maximum height of the handle, hose, and telescopic wand combined during the use of the vacuum is below the 5th percentile dimension for elbow height, which is 38 inches. This allows for the smallest of users to comfortably grasp the handle and telescopic wand below elbow height to maneuver the floor tool while cleaning.

The user is responsible for the maintenance of this device, thus the special requirements of maintenance people must fulfill the user's requirements. Most of the features for maintenance of the product are easily accessible by the user due to the ability to remove canister from vacuum as well as the availability of graphical step-by-step instructions on how to clean the vacuum in the user manual. However, one feature that does not fulfill a requirement of the maintenance person is the lack of allergen control. This device does not consist of HEPA filter, which collects smaller particles including allergen materials. In a study done by Liroy, Wainman, Zhang, and Goldsmith (1999), assessing the features of typical household vacuum cleaners that are efficient at collect fine particles, results showed that with the addition of a HEPA filter, the motor emissions from the same vacuum cleaner showed a more than 99.9% reduction in fine particles. Since this vacuum is bagless and does not have a HEPA filter, users are at a risk of getting ill

during the cleaning process of the vacuum. This feature of the vacuum cleaner workspace must be improved.

The product also consists of features that allow users to adjust to the workplace surrounding the product. One of them is the telescopic wand that allows users to adjust the reach of the product and expand their workspace. For example, the telescopic wand allows users to reach areas such as ceilings and fixtures, thus expanding the area that users are able to clean with this device. This is an example of adjustment of the tools to adjust the workplace. Another example of an adjustment of the device tools to make the workplace more comfortable when carrying the device or during storage is a hose holder clip on the top of the 'carry handle' of the vacuum (see figure 15). By adding this feature, the bulky hose can be neatly snapped into place to reduce the area of the workplace when carrying the device.

Since there is no visual material and displays on the device or in the surrounding workplace the principle of visibility and normal line of sight is not applicable. Since the operation of this device requires movement of the body, such as the back and forth movement of the arms while maneuvering the handle and floor tool, the visible line of sight will constantly change due to movements of the head corresponding to these body movements (users will tend to shift line of sight according to movement of floor tool to keep track of whether dust and dirt is being picked up by vacuum).

Component arrangement in this device has been fulfilled to create the optimal workspace. For example, the most frequently used control, the power button, is located on the left side of the vacuum cleaner. On the assumption that majority of users will be right-handed and will maneuver the device while standing on the left side of the workplace, the power button is conveniently located on the left side for quick access by feet or hands. This example follows the frequency of use principle. Thus, the design of the surrounding workspace of the Bissell ZING vacuum cleaner effectively follows the principles of workspace design.

**Seated versus standing**

The workspace for this product requires the user to be in a standing position. The user must be in a standing position as they must be able to make frequent movements to guide the handle and floor tool of the vacuum. The device itself, although lightweight enough to be carried, is too large of an object to be placed on top of a work surface. When considering the work surface height during the operation of the vacuum cleaner on a floor surface, the workspace follows the rule of thumb of having a maximum height 5cm below the elbow. With a maximum height at 89cm, this work surface height is suitable for heavy work. The work surface depth may extend to the maximum defined work area when extending arm from shoulder. This will be the maximum movement distance when operating the handle, hose and floor tool of the vacuum when vacuuming surfaces.

**Energy cost**

The energy cost of using this vacuum cleaner can be considered as moderate at about 4.2 Kcal per minute. The workspace does not cause an increase in energy cost as features such as the appropriate work surface height and depth allows users to use the device with the least energy cost for this type of activity. Adjustable tools such as the telescopic wand allow users to reach and clean areas that would otherwise be difficult to reach and cost a lot of energy. As this device involves dynamic work, measures such as oxygen consumption, heart rate, and subjective measurements can be used to measure the energy expenditure.

**Energy expenditure and worker capability**

If the energy expenditure of operating the vacuum exceeds the user's capacity, reducing the weight of the vacuum can lighten the workload. Thus, users will not have as much of an energy cost when vacuuming areas such as stairs, which requires the user to carry the appliance while performing the vacuuming movement. An ergonomic handle can also be installed on the vacuum handle in order to reduce the energy cost of the vacuuming movement. With an ergonomic handle (see figure 16), the user would be able to vacuum difficult surfaces such as

carpeted floors more efficiently and with less effort. Thus, taking these steps can reduce the energy expenditure of using the Bissell ZING vacuum cleaner.

## References

- Aguirre, S. (2018). *Vacuum Cleaner Features*. Retrieved from <https://www.thespruce.com/vacuum-cleaner-features-1901184>
- Bissell. (2018). *End of Product Life Disposal Instructions*. Retrieved from <https://www.bissell.com/about-us/sustainability/end-of-product-life-disposal-instructions>
- Burgess, K. (2018). *Buying Guide: Vacuums*. Retrieved from <https://www.consumersearch.com/vacuum-cleaners/how-to-buy-an-upright-vacuum>
- Canister Vacuum Cleaner. (2017). *Should you choose an upright or canister vacuum cleaner?*. Retrieved from <http://www.canistervacuumcleaner.net/advantages-canister-vacuum-cleaner/>
- Consumer Reports. (2018). *Vacuum Buying Guide*. Retrieved from <https://www.consumerreports.org/cro/vacuum-cleaners/buying-guide/index.htm>
- HouseHoldMe. (n.d.). *Bissell Zing Canister Bagless Vacuum, 2156A Review*. Retrieved from <http://www.householdme.com/bissell-zing-canister-bagless-vacuum-2156a-review/>
- Kornstein, A. (2018). *7 of the best canister vacuums to help keep your home spotless*. Retrieved from <https://mashable.com/roundup/best-canister-vacuums/#rDT6g73lkqq>.
- Lee N., Lee S., Lee B., Jung H., & You H. (2016). Ergonomic Evaluation on Handle Designs of Vacuum Cleaner. *Proceedings of the Human Factors and Ergonomics Society 2016 Annual Meeting*, 1058-1062. DOI :10.1177/1541931213601245
- Lee, W., Jung, K., You, H. (2014). Development of a Comprehensive Usability Testing and Analysis Protocol for Ergonomic Product Design: Proceedings from *the XVIIth Triennial Congress of the International Ergonomics Association*. [790 – 784]. Pohang, South Korea: Department of Industrial and Management Engineering.
- Lioy, P. J., Wainman, T., Zhang, J. & Goldsmith, S. (1999) Typical Household Vacuum Cleaners: The Collection Efficiency and Emissions Characteristics for Fine Particles, *Journal of the Air & Waste Management Association*, 49:2, 200-206, DOI: 10.1080/10473289.1999.10463789



- National Aeronautics and Space Administration. (1978). *Anthropometric Source Book, Volume II: A Handbook of Anthropometric Data*. Retrieved from <https://ntrs.nasa.gov/archive/nasa/casi.ntrs.nasa.gov/19790005540.pdf>
- S. (2018, October 9). I would NOT buy this product again. [Comments about the Zing Bagless Canister Vacuum | 2156A]. Message posted to <https://www.bissell.com/zing-bagless-canister-vacuum-2156a#downloads>
- Statista. (2018). [Graph illustration Vacuum cleaner market volume in million pieces February, 2018]. *Vacuum Cleaner – United States, Statista Market Outlook*. Retrieved from <https://www.statista.com/outlook/16020100/109/vacuum%25C2%25A0cleaner/united-states#market-onlineRevenueShare>
- United States Census Bureau. (2011). [Graph illustration Age Distribution and Median Age: 1960 to 2010]. *Age and Sex Composition: 2010*. Retrieved from <https://www.census.gov/prod/cen2010/briefs/c2010br-03.pdf>
- Vacuum Cleaner Market. (2018). *Vacuum Cleaners by need*. Retrieved from <https://www.vacuumcleanermarket.com/vacuums-by-need/>.

Figures and Graphs



Figure 1. Toggle switch for brush extensions on floor tool.



Figure 2. Switch to adjust suction power.



Figure 3. Attachable tools.

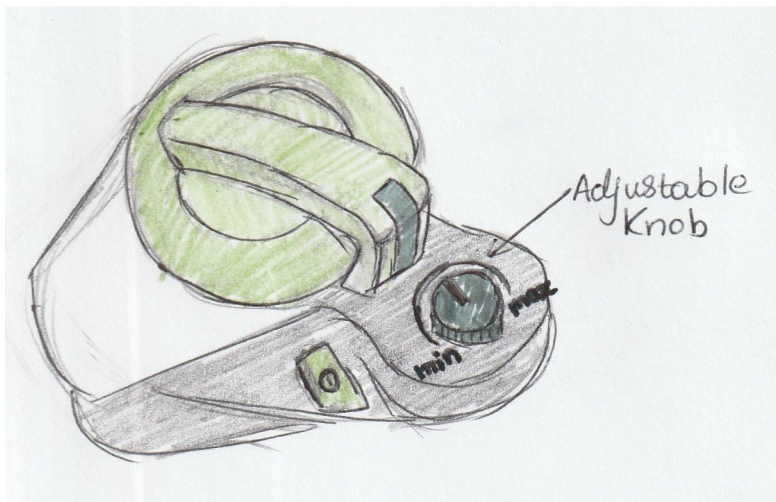


Figure 4. Adjustable control for suction power adjustment.

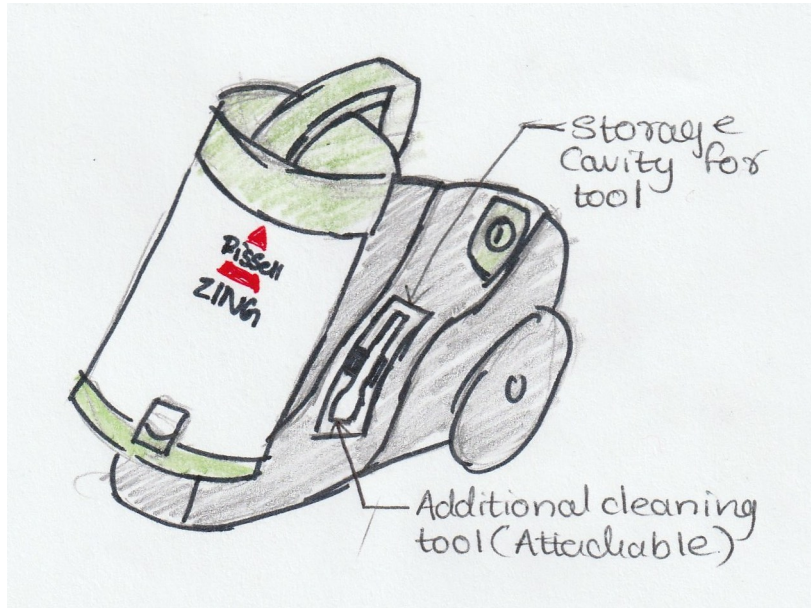


Figure 5. Storage for attachable tools.



Figure 6. Wheels on vacuum cleaner.





Figure 7. Carry Handle.

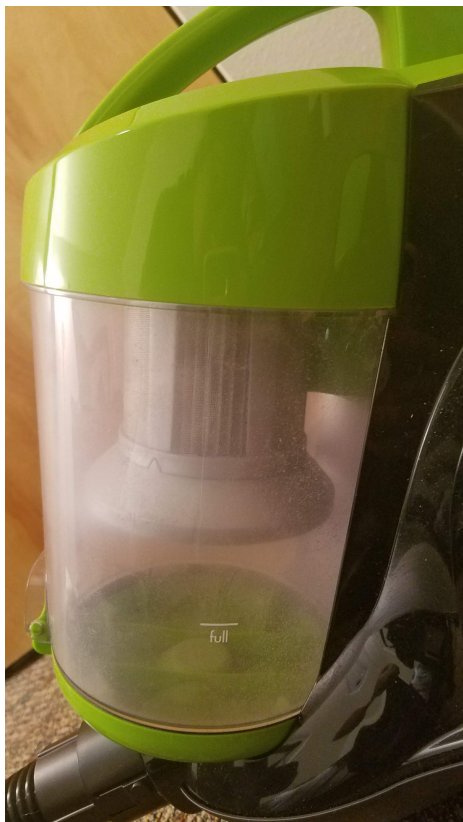


Figure 8. Dirt cup “full” indicator.

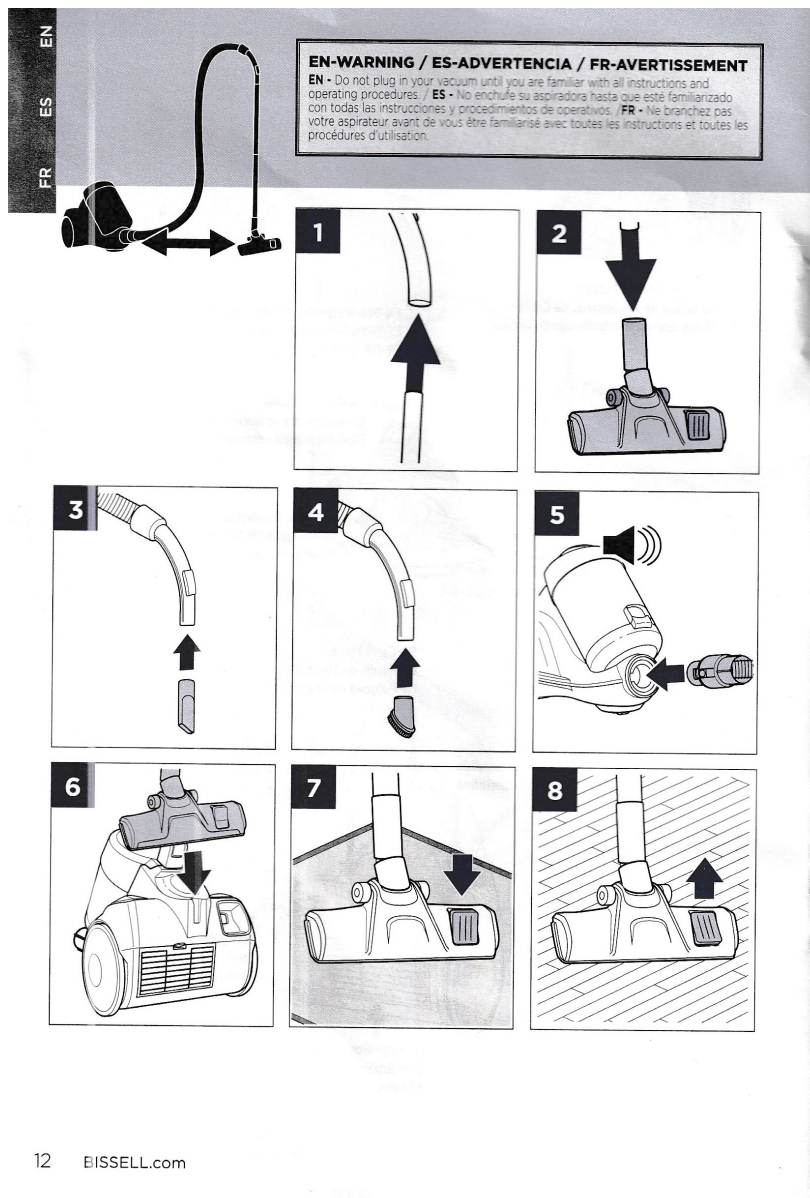


Figure 9. User manual. How to assemble vacuum.



Figure 10. Buttons.



Figure 11. Power Button.



Figure 12. Power cord rewind button.



Figure 13. Button to remove canister.



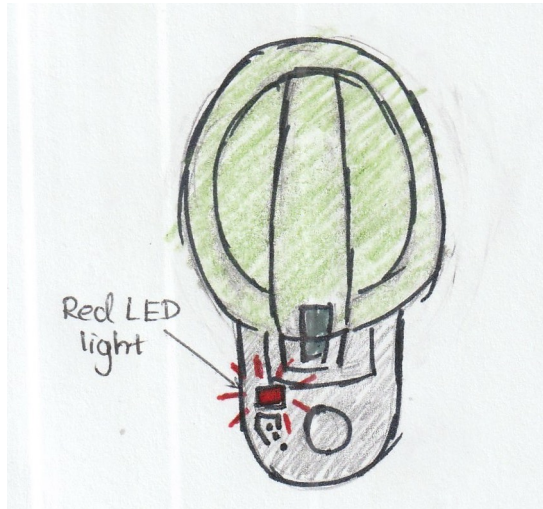


Figure 14. LED indicator for cleaning vacuum.

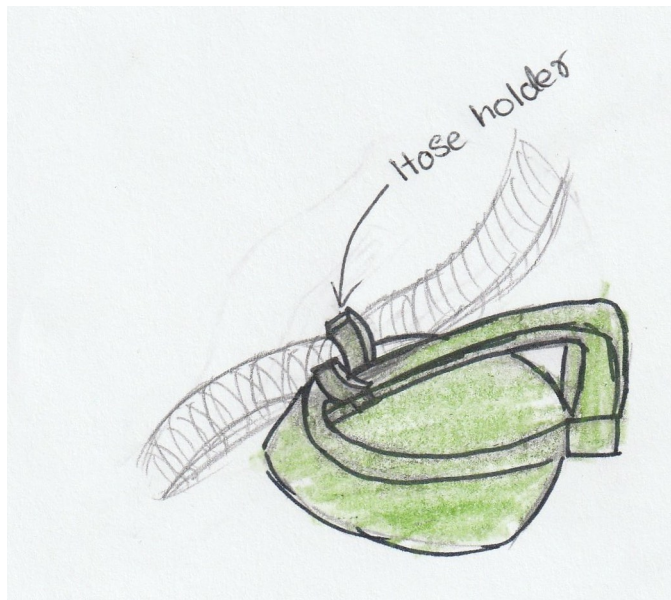


Figure 15. Hose holder clip.

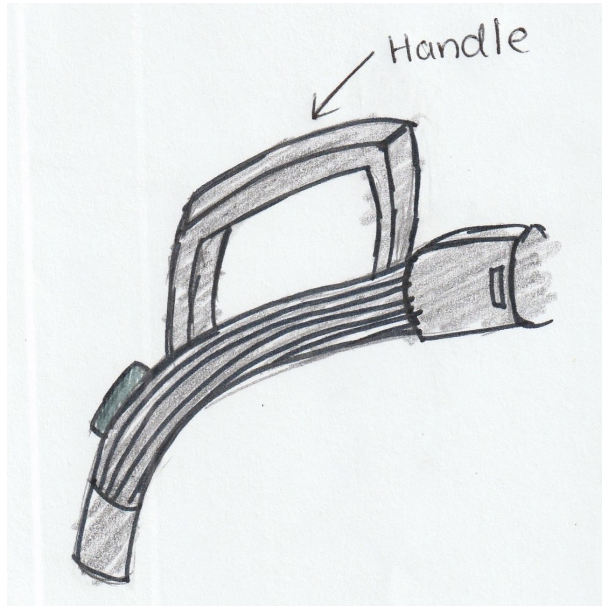


Figure 16. Ergonomic handle.



Figure 17. The Bissell ZING 2156 vacuum cleaner.



Figure 18. The Bissell ZING 2156 vacuum cleaner top view.