

Wheelchair Warning System

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Structures that are handicap accessible are a primary concern of the disabled since they make everyday life less problematic. Our point of concern deals not with inanimate objects, but rather with the maneuvering through masses of pedestrians. Several accidents can occur and further injury may be the consequence. A device must be designed that will cause others to be made aware of their surroundings by seizing their attention. In order to aid this procedure, suggestions have been made to create a mechanism that can be controlled and used by the disabled person, regardless of his or her physical capabilities.

§1 Problem Statement:

A major problem for wheelchair users is their inability to alert others of their presence. This problem is magnified when users are unable to vocally identify themselves. Such is the case for our client's daughter, Jessica, who suffers from cerebral palsy. This impairment not only affects her vocal capabilities, but also restricts the movements in her left hand. Her mother, Sandra Rodriguez, assists her daughter around on a daily basis. Currently there is no system that can be attached to Jessica's wheelchair to alert the public of her presence. Ms. Rodriguez has requested that we develop an audible warning system to inform others of her daughter's presence.

§2 Client Requirements:

When developing a client's project, several requirements must be considered. These necessities will assist our team when developing methods for a final design.

This device is designed to grasp the attention of the public. When being guided around by her mother, Jessica needs a product that will alert the people in her close proximity that she is nearby. They can then avoid these obstacles with ease. Her mother would also like to be notified that someone is in the path of the wheelchair by Jessica, in case she does not spot them herself. The overall layout of the device must be fitted to Jessica's wheelchair. However, our client would like the apparatus to have the ability to be modified slightly to fit any wheelchair. When implementing the final project onto the wheelchair, we must consider its daily purpose. The pieces of equipment must not interfere with the normal use of the wheelchair when operated by Jessica and her mother. Normal function of the wheelchair must not be inhibited when our device is attached.

The signal to notify others and Jessica's mother must be an audible amplification. Our client would like a non-computerized noise from a speaker that can be easily identified by herself and others near Jessica. Due to Jessica's impairment, the design must be right hand activated and not require a great amount of physical force to operate.

§3 Background & Competitive Products

As previously mentioned, our client's daughter, Jessica, suffers from cerebral palsy (CP). CP is not a disease or illness; rather, a physical disorder which affects movement and fine motor skills. There are three main classifications of CP: *SPASTIC*, *ATHETOID*, and *ATAXIC*. Spastic is the most common form of CP and is characterized by stiff, jerky movements. Athetoid is a form of CP in which the individual is affected by unwanted movements and loss of posture. Ataxic is associated with balance problems, shaky hand movements, and irregular speech.

Since the degree of impairment can vary greatly between patients, it is often difficult to distinguish one form of the disorder from another. In our case, Jessica has limited motor skills in her left hand, a speech impairment, and a minor walking disability. On this account, it is necessary for her to employ the use of a wheelchair when traversing crowded areas such as theme parks. This gives rise to the problem of alerting others of her presence.

Currently, Ms. Rodriguez verbally attempts to draw the attention of those seemingly unaware of Jessica's presence. However, when Jessica detects a trouble situation, she is unable to do the same because of her speech impairment. After meeting with Ms. Rodriguez and her daughter, it was decided that an ideal solution to the problem

would be a system capable of producing an audible and/or visual output that could be activated by either the wheelchair user or operator.

Students from Elizabethtown College have developed a similar device for a woman affected by cerebral palsy. Their fully automated design uses proximity sensors to produce an audible output which increases in intensity as the wheelchair nears stationary objects such as water fountains or walls. A major concern with this type of design is the over-activation of sensors in crowded areas. This constant triggering would render the warning system useless in the specific problem scenarios we intend to encounter.

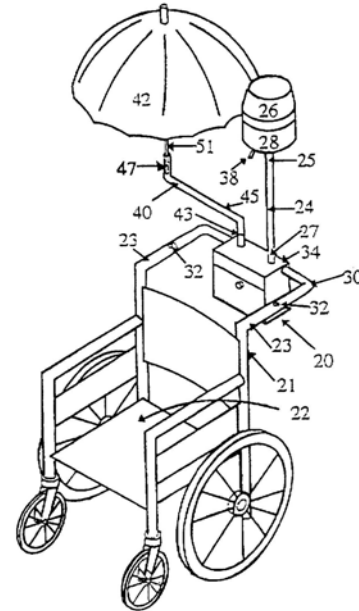


Fig. 1 Patent #5,791,761

Further investigation, involving a patent search, yielded various types of wheelchair warning systems which are summarized in the following table:

Table 1

Patent No.	Device Description
5,477,211	A device utilizing gravity sensitive switches to activate auditory/visual/sensory alarms when tilted beyond specified angle.
5,791,761	Removable wheelchair accessories: lamp/umbrella/storage apparatus (Fig.1)
6,163,249	Device producing an audible warning in order to draw attention to an individual in distress.

It is important to note that all of these warning systems are automatically activated audible outputs with the sole intent of identifying wheelchair users in distress,

such as a toppled chair. Our design differs in that we aim to utilize both audible and visual outputs that can be manually activated to alert others of the user's presence.

§4 Alternative Solutions

The three proposed design alternatives that will be further discussed are the dual control panels, the infrared sensor, and the two-way switches. Each design contributes its own advantages and disadvantages, which also will be analyzed. As part of the client specification, the warning systems should engage an audio warning, but it was later determined that each design should activate a visual warning as well. The use of a design matrix will compare the three designs considering the factors of ease, cost, safety, and effectiveness.

§4.1 Dual Control Panels

Just as a television remote can incorporate distinct functions into a single device, the control panel in this design offers the user options on how to operate the warning system. This dual control panel system offers a versatile way for both the person occupying and the person guiding the wheelchair to warn others of their presence.

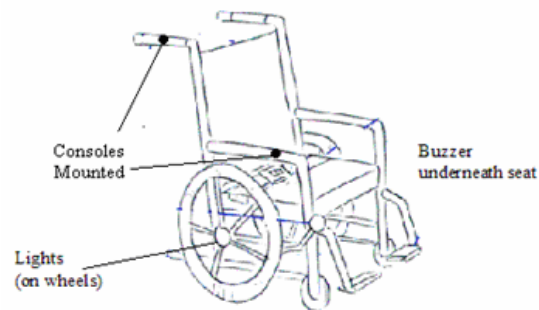


Fig. 2 Dual Control Panels

As the name suggests, this design is composed mainly of two control consoles that are mounted on both on the back handle and the right armrest of the wheelchair (Fig. 2). Each of these rectangular

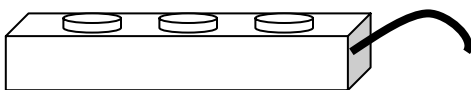


Fig. 3 Three push button switches

consoles house three push-button switches (Fig. 3). One switch activates the sound buzzer mounted

underneath the seat to give a monotone warning. A second switch sets off the red, white and blue warning lights on wheels of the wheelchair. The third switch of the circuit would activate both the visual and audio warnings simultaneously. These switches in conjunction give the option of activating the alarm to the person who detects the obstacle first – may it be the occupant or the person guiding the wheelchair.

For each control panel, the circuit is composed of two diodes, three push-button switches, a light, an audio buzzer, and a 9-volt battery (Fig. 4). The diodes in the circuit allow for the various functions of the switches, but along with the increased flexibility of the system, there is an associated voltage drop of approximately 0.7 volts per diode. This voltage drop, in turn, results in reduced intensity of light and sound.

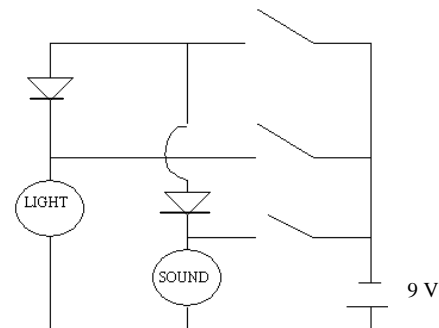


Fig. 4 Dual Control Panel schematic

Overall, this design offers a cost-effective and versatile solution to the problem, but diodes in the circuit lessen the effectiveness of the warning. Also, the control panels are not as ergonomically friendly, which is a problem for a person with limited use of his or her hands. The panels would be awkward and cumbersome when mounted, and detract from the usability of the system.

§4.2 Infrared Sensor

The infrared sensor design utilizes a sensor to detect obstacles that are too close to the wheelchair and activates the audio and visual warning. This system allows the presence of the wheelchair to be known, in addition to also alerting the users to the obstacle.

The inspiration for this design was the parking proximity sensor sold by Parkingsensors.co.uk. These sensors are used in many vehicles to assist the driver in parallel parking by sounding an audio warning when the vehicle bumper is near another

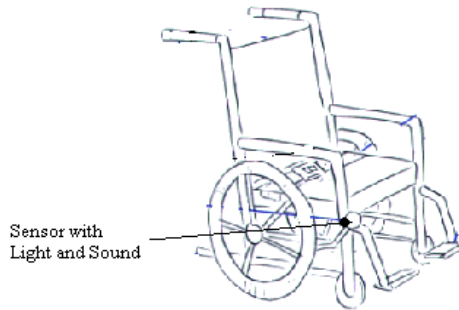


Fig. 5 Infrared Sensor

bumper. This design would include a modified sensor in which both lights and sound would activate once an obstacle is detected. The range and coverage of the sensor would also be modified so that the sensor is suitable for detecting objects at

knee-level on a wheelchair. The sensors, the light and the audio speaker would be mounted together on the front-right vertical bar of the armrest (Fig. 5), which would be also connected to a 12-volt battery source underneath the seat.

Once the sensor was triggered, one of three different audio warnings would be emitted from the speaker depending on the proximity. The nearer the object is to the wheelchair, the shorter the time interval would be between the beeps emitted. The red, white and blue lights would start gleaming immediately when the speaker is first activated and would last for the duration of the audio warning.



Fig. 6 Infrared Proximity Sensor

This system offers an automated way for the wheelchair's presence to be known in case the users of the wheelchair fail to detect an obstacle. Infrared proximity sensors (Fig. 6), however, are at times prone to misdetections and could prove to be unreliable. If the sensor fails to detect an obvious obstacle in his or her path, the user would have to

resort to manually announcing her presence. The sensor is convenient for the user, but the system is not as effective.

§4.3 Two-way switches design

The third design alternative is similar to the dual control panels design in that there are two control panels located at the back handle and right armrest of the wheelchair (see Fig. 2). Identical red, white, and blue warning lights, along with a monotone buzzer are also used in the two-way switches design. The warning lights are attached to the wheel and the buzzer is mounted underneath the seat. For each control

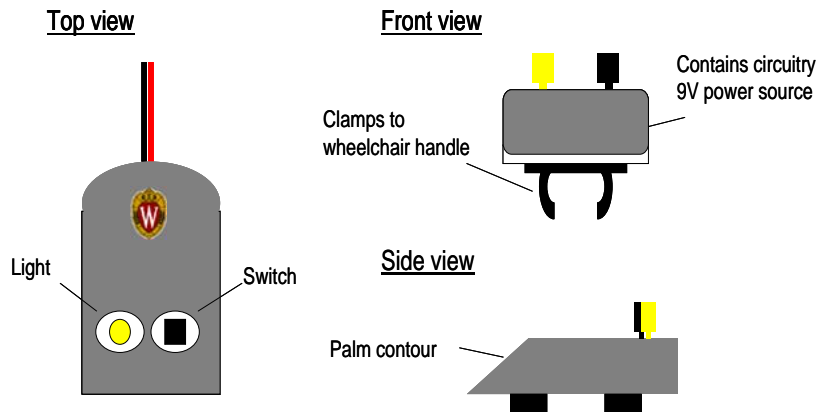


Fig. 7 Control panels located at back handle and armrest of wheelchair

activate both the lights and the buzzer. The control panels are attached to the handles of the wheelchair by circular clamps. The panels are designed with an ergonomic palm contour to allow the occupants more comfort while operating the alarm system (Fig. 7).

The major characteristic of the third design is the use of single throw double pole (STDP) two-way switches. By using a two-way switch, either the occupant or the wheelchair operator is able to activate the lights or buzzer individually. As seen in the circuit schematic (Fig. 8), the light and buzzer are connected in parallel with a 9-volt

panel, one switch is designated for operating the warning lights and the other is for operating the buzzer. Either the occupant or the guider of the wheelchair is able to

battery. Each circuit element is connected in series with a two-way switch which allows the operation of each element from the two control panels. The user is able to switch on each of the elements individually or both simultaneously.

The two-way switch design has numerous

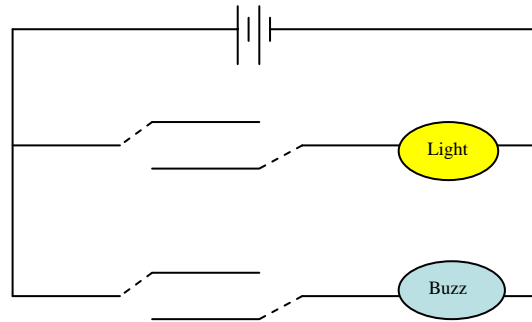


Fig. 8 Circuit Schematic of Two-way Switch Design

advantages that lead us to consider it as our final design. The two way switches design is cost effective because only a light and a buzzer are involved. In addition, the system is easily operable by a person who has limited use of his or her hands. Furthermore, circuit malfunctions can be easily found because the alarm elements are in parallel. In the event of a malfunction, the functional elements of the circuit need not be disturbed while repairing the defective component.

A disadvantage of the circuit is that the circuit's connecting wires are somewhat lengthy. This is a result of the switches being located at the back handle and the wheelchair armrest, while the buzzer is mounted underneath the seat.

§5 Results & Discussion

After considering the factors of ease, cost, safety, reliability and effectiveness in the design matrix, the dual control panel design had problems mainly with ease, reliability and safety. The multiple options for the user could make for a longer decision when it is best for the user to activate the system immediately. The less intense lights and

sound of the system reduce the effectiveness of the system. The dual control panel design is cost-effective, but the decision was made that the overall effectiveness of the warning was more important. The automatic activation of the infrared sensor design provides the user with an easy way to alert others, but the \$140.87 cost of the sensor coupled with the unreliability of the sensor prevents the design from proceeding. The switches system of the third design

scored highest in the areas of reliability, safety and effectiveness – the areas most important for a successful product. The efficiency of the circuit, as well as the manner by which the lights and sound work

Table 2 – Design Matrix

	Dual Control Panels	Infrared	Two-way Switches
Ease	6	10	8
Cost	6	2	7
Safety	5	8	8
Reliability	4	3	9
Effectiveness	8	3	8
Total	29	26	40

together, make this design the preferred method to complete this project.

§6 Future Work

Further work lies ahead in order to construct a model of this device. Meetings with the client must be established to receive feedback on all proposed solutions. These meetings will allow our group to see exactly how the device would be used and if it meets the client requirements. Changes may be made in order to satisfy the number of client requirements while effectively achieving the desired goal. Also, more work on the circuit must be done to ensure adequate lighting and audio signaling. In order to expand our proposed solution, we must test the circuit to make sure it is working properly. The lights need to be modified so that the user can operate them. After ordering the desired components, additional analyzing of Jessica's

wheelchair must be completed in order to mount the device and ensure simplicity.

Precise measurements will allow our group to mount the prototype onto the wheelchair.

§7 Ethics

The wellbeing of Jessica and her mother is a top priority. Our goal is to ensure our client that there are no hazards that may interfere with daily operation of the wheelchair. Also, no parts of the prototype will require excessive force from Jessica or include components that could affect her condition. The goal of this project is to alert or notify other people of Jessica's presence. We must take into account the noise levels that will be used so pedestrians do not receive any excessive noise to damage their hearing. From the visual aspect, no blinding lights can be integrated that may affect others. Failure to meet these goals would be unethical. The audible threshold and visual notification must be reasonable and it is our objective to follow these limits by thinking about the people that are affected by our design.

§8 Conclusion

From our design matrix and discussion of design alternatives, the chosen method is the idea of including two-way switches. This method is very reliable and Jessica can easily control the operations with her right hand, due to her limitations by cerebral palsy.

This design upholds our ethics concerns and has been approved by Sandra Rodriguez. The setup includes the circuit with switches for both Jessica and her mother to control.

Our group will meet as much as possible to discuss probable materials for construction. Time management is critical when dealing with a client and conflicting schedules. We will effectively collaborate and focus on our goal through much conversation and experimentation. The cost of this route for the design will be inexpensive and consist of circuits, integral components, and waterproof materials for building. Next, we will fit our device onto the wheelchair and observe it in use by Sandra and Jessica. The rest of the semester will include ordering materials, testing, and construction of a prototype to be delivered to the client.

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Wheelchair Warning System

Product Design Specification

Team Members: YikNing Wong (Team Leader), Jimmy Fong (BSAC), Farshad Fahimi (BWIG), Tyler Witt (Communications)

Date Last Updated: October 7, 2005

Abstract: A major problem for wheelchair users is their inability to alert others of their presence. This problem is magnified when users are unable to vocally identify themselves. Such is the case for our client's daughter who suffers from cerebral palsy. This impairment not only affects her vocal capabilities, but also restricts the movements in her left hand. Her mother, Sandra Rodriguez, assists her daughter around on a daily basis. Currently there is no system that can be attached to Jessica's wheelchair to alert the public of her presence. Ms. Rodriguez has requested that we develop an audible warning system to inform others of her daughter's presence.

Function: The expected device needs to alert others of the wheelchair's presence to reduce confusion and potentially harmful accidents.

Client Requirements:

- Specific to Jessica's wheelchair but may be tweaked to fit all wheelchairs
- Audible warning system to alert others and Jessica's mother
- Mechanism may not disrupt daily use of wheelchair
- Device can be used by both Jessica and her mother
- Easily activated by Jessica's right hand
- Must not require an 'extensive' amount of force to operate

Design Requirements

1. Physical and Operational Characteristics

- Performance Requirements:* The warning system should be able to be activated by both the person in the wheelchair and the person guiding the wheelchair. The activation system for the person in the wheelchair must be such that only a simple press or slide of a switch is necessary. Once engaged, the device should emit an audio warning and a visual beacon to pedestrians in the immediate vicinity warning them of the wheelchair's presence. A signal should also be sent to the person guiding the wheelchair alerting him or her of the activated warning. The warning system should be attached to the wheelchair, but also should have the ability to be removed and attached to a different wheelchair.

- b. *Safety*: The system should be kept sealed, clean and free of debris. It also should not interfere with the path of the wheels when the system is mounted. When engaged, the system should not startle the pedestrians, but should just alert them.
- c. *Accuracy and Reliability*: The audio warning should be at a constant tone and at a constant volume every time the system is activated. The system should be able to withstand the vibrations caused by the terrain and not be affected by it. The light on the system should be bright enough such that if the audio warning were ineffective, the light would be able to compensate. If the power source for the audio warning fails, the visual warning should still function on its separate power source.
- d. *Life in service*: The desired device should last as long as possible allowing for wear over time. However, the batteries will run out of power and must be replaced.
- e. *Shelf life*: Should be able to keep for a number of years. Client should be able to change the battery easily.
- f. *Operating Environment*: The product would be used mostly at outdoors which it will be exposed to heavy sunlight or rain. The device should be able to withstand the high temperature and be water proof. This device will also be used in crowded and noisy environments. The light source and alarm should be strong enough to grasp attention
- g. *Ergonomics*: Activating the button should be fairly simple and not require much force. The client should not have a hard time replacing the batteries no matter where they are located. The device should be attached securely to the wheelchair handle and act as part of the wheelchair and not an obstacle.
- h. *Size*: The switch or button should be large enough so that Jessica can use it right away. The compartment for the power source should be small enough so that it does not interfere with use of the wheelchair.
- i. *Weight*: The product must be light enough so that Jessica can place the box in her lap and move it with ease. The final device should not make it any harder for Ms. Rodriguez to advance the wheelchair.
- j. *Materials*: Plastic covering for the power source box and for the switch. Insulated wire will stretch from the power source to the switch box. Small LED lights are to be used that will shine bright enough to attract attention. A piezo-electric speaker will be attached to the circuit.

- k. *Aesthetics, Appearance, and Finish:* No blinding lights or painful noises must emanate from the device. The design should be integrated and fitted into the wheelchair well so that it does not attract too much attention when not in use.

2. Production Characteristics

- a. *Quantity:* One device that has the ability to be activated in two separate locations.
- b. *Target Product Cost:* No specific target cost was established; however, one can assume lowest cost method to efficiently and effectively provide a solution would be preferred.

3. Miscellaneous

- a. *Standards and Specifications:* None.
- b. *Customer:* Any audible output must be somewhat appealing. Monotone, annoying responses are strongly discouraged.
- c. *Patient-related concerns:* Any design must incorporate right hand activation due to loss of motor skills in left hand. Conceivably, activation methods could be modified in different scenarios.
- d. *Competition:* A patent search provides Patents: 6,163,249; 5,791,761; 6,160,493 as comparable devices. Also, research reveals device employing proximity sensors in order to detect stationary objects producing audible output varying in tone intensity.