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F•O•U•R BROTHERS INCORPORATED

Monday, November 10th, 1997

Prof. H. R. Whiteley, P. Eng.,
School of Engineering,
University of Guelph,
Guelph, ON N1G 2W1

Dear Prof. Whiteley,

re: Final Design

Four Brothers Inc. is pleased to reveal our final design to fulfill the course requirements for Engineering and Design I (05-210). Enclosed is the report *A System to Maintain Driver Alertness*, which describes the final design which we were commissioned to provide after the presentation of our proposal on Friday, October 3rd 1997. This design and report was carried out exclusively by the Four Brother's design team. We would appreciate any constructive feedback which would enhance our presentation on Friday, November 21st.

Sincerely,

Richard Audette

Marianne Maertens

Matthew Ng

Kyle Poole

Prepared for

Professor Whiteley
School of Engineering
University of Guelph
Guelph, ON N1G 2W1

A System for Maintaining Driver Alertness

by

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Team FB
Engineering and Design 05-210

Monday, November 10th 1997

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Executive Summary

Four Brothers set out with the desire to develop a system to maintain driver alertness in order to reduce the number of accidents that occur on the nation's roadways. This includes a system which combats driver fatigue, integrating detection and alarm components into the design. The detection component would monitor and detect when the driver was loosing alertness. The alarm component would wake up the driver to renew alertness. Together these components will keep drivers alert, driving safely and the roads a safer place for all.

The optimal solution was achieved by applying a decision matrix and careful analysis to the two major components, the detection and alarm, in the system. Each alternative solution was described in detail, and subjected to the quantitative analysis of the decision matrix.

The final design is both simple and effective, utilizing several components to maintain driver alertness. The unit itself is attached to the driver's head, and a tilt switch detects when a head tilt of over 20° has lasted for longer than 3 seconds. The tilt switch then activates the transmitter, which sends an encoded signal to the receiver located behind the dashboard. The receiver, in turn, activates the air conditioning unit to lower the cabin temperature, increasing the driver's alertness. Simultaneously, the tilt switch activates the alarm, emitting a loud beeping noise to wake up the driver. When the driver's head returns to a level position, the tilt switch is turned off and the beeping stops.

To increase marketability and versatility, the base will be manufactured along with several alternatives to attach the device to the driver's head. The primary attachment will consist of a bendable plastic hook so the device can be worn on the driver's ear. Another alternative is using a Velcro strip to attach the unit to the driver's head. A third alternative will be an attachment that will allow the driver to wear the device on the driver's hat.

Four Brothers Inc is proud to present such an effective and reliable product to maintain driver alertness.

1.0 Statement of Problem:

1.1 Introduction

In a review of in-depth studies, police reports and driver surveys from around the world, it has been concluded that the contribution of fatigue to accidents in articulated vehicles probably ranges between 5 and 10% of all crashes, about 20-30% of casualty crashes and about 25-35% of fatal crashes[5]. The safety of automobile drivers and their passengers are constantly at risk due to fatigue.

A loss in driver alertness is a result of fatigue, characterized by increased reaction time, less effective reaction, and a decrease in psychophysiological arousal (measured by changes in body temperature, brains waves, and heart rate). Often, drivers do not realise how fatigued they are. Factors which contribute to driver fatigue consist of many hours of driving, irregular work schedules, poor quality of sleep, boredom, adverse-weather driving and a poor driving environment.

A system is needed to help maintain driver alertness to ensure the safety of our roadways.

1.2 Objectives

The system must awaken the driver when they begin to lose consciousness. The unit must not interfere with driving and should work in all vehicles. In order to be effective, it must also be accurate, durable and reliable.

2.0 Method:

2.1 Background Information:

In order to meet the objectives outlined in section 1.2, the system must have a sleep detection measure, which would trigger an alarm. There are several methods of determining that a person is sleeping. There are external physical signs, such as the eyelids closing and the head leaning forward. Other signs include a change in eye movement, respiratory patterns, heart rate and brain wave patterns[6]. A loss of driver alertness can be detected by monitoring the driver's response to stimuli. A certain level of variation could set off an alarm. The alarm would consist of anything that would alert the driver's senses using auditory, tactile, or visual alarms.

2.1.1 Constraints and Criteria

The final system must meet the following constraints and criteria.

Constraints

- device must prevent driver from entering sleep
- device must not interfere with driver performance
- must be integrateable with all types of vehicles
- must be durable and reliable
- must meet industry standards

Criteria

- effectiveness
- aesthetically pleasing
- low driver interference
- minimal production costs
- ease of installation, can be installed by mechanic

2.1.2 Description of Alternatives

The system will incorporate several detection measures and alarms. These will provide a method to decide whether the driver needs to be alerted and several methods to ensure that the driver becomes alert. The detection systems would trigger a series of alarms and these detection options are as outlined below.

Detection Component

Button Pushing: A strategically placed button would have to be pressed within a predetermined amount of time or an alarm would be triggered. This would ensure that the driver is sufficiently alert.

Eye Movement: Changes in ocular patterns pertaining to sleep would be detected by a monitoring device. Once this level of activity was reached a signal would be sent to an alarm.

Foot Pattern Movement: The detection of erratic foot movement could be detected by sensors on the acceleration and brake pedals. A movement by the foot would be detected by the sensor and analysed by a computer. If the movement was a reaction that deviated from normal driving patterns a signal would be sent to an alarm.

Head Movement Monitor: A device that measures head bob and thus the occurance of sleep. Prolonged downward or backward head translation would set off an alarm.

Brain Wave Monitor: The monitor would detect the difference that appears in the brain wave pattern relating to a lack of cognitive response as a result of sleep. When a change in brain waves was sensed, a signal would be emitted to an alarm.

Alarm Component

An alarms would respond to a signal from a monitoring device. The alarm component is designed to alert the driver once sleep has been detected.

Air Temperature Change: This is an air temperature response to drop the cabin air temperature to wake or re-alert the driver after receiving initiation signal.

Electric Shock: A brief shock would be emitted after the detection device is triggered.

Flash of Light: A flash of light would be emitted inside the car after being triggered by a detection mechanism.

Vibrating Steering Wheel: A signal from a triggered monitoring device would cause the steering wheel to start vibrating.

Audio Alarm: A traditional or integrated alarm could go off after receiving the proper signal, waking up the driver. The alarm must not be too loud as to disturb other motorists but must cause the driver to wake up.

Smell Emission: Once transmission has been received to emit the offensive smell, the driver would have to stop this emission by turning off a switch and all the meanwhile becoming alert.

All of the components of the system are to be chosen for the final design by application of the decision matrix. To develop an optimum system a detection system must be incorporated with multiple alarms.

2.2 Analysis of Most Viable Options

The system to maintain driver alertness consists of two components: a detection module and an alarm module. Three criteria were used in the selection of the solution: effectiveness at detection of sleep (40%), low interference with driving (35%) and affordability (defined in criteria, 25%). Using research and the combined knowledge of the group, a decision matrix was created and the results were used to determine the detection module.

Values for the decision matrix (Appendix A) were based on the following analytical information.

Button Pushing: Button pushing would require the driver to take their concentration off of the road, which interferes with driving. There would be false alarms when the driver tries to concentrate on difficult driving conditions. The button pushing device is not very complex and the average consumer would be able to install it. Therefore, the cost would be minimal.

Brain Wave Monitor: The brain wave monitor would monitor brain wave activity, an accurate indicator of sleep[6]. The sensory pads and wires that would be required to monitor the driver would inhibit movement and affect driving through lack of comfort. The technology that would be required to monitor the information received by the sensors is highly specialized and out of the normal driver's price range.

Head Movement Monitor: This device is an excellent indication of sleep as the neck muscles of a sleepy driver become relaxed, and the head tends to move forward. The only interference would be how wearing the device itself affects each individual driver. The technology of the required components exists and is within the affordable price range.

Foot Pattern Monitor: The sensory devices required for this monitor would allow for many false alarms. This is due to the fact that the sensors would measure a change in driving patterns and this could be the result of not only fatigue, but changing road conditions. This variable response would interfere with driving and with false alarms delineate the overall effectiveness of the design. The technology required is relatively expensive with the combination of two motion sensors and the tools to compare each foot motion against the usual driving patterns of the driver still in experimental stages.

Eye Movement Monitor: This monitor would analyse the ocular movements of the driver. There would be no interference with driving as the device is purely one of observance by a video camera. The technology required is quite in-depth as a monitoring software would be required as well as an interface between the program and the video camera. This level of technology is still in the experimental stage and out of the price range of the consumer.

The head movement monitor was determined to be the best method of detection (Appendix A). needs expansion

Alarm Components

The selection of an alarm was also made using a decision matrix. Effectiveness (60%), acceptance (30%) and minimal cost (10%) were the criteria used in this selection process. A combination of alarms was deemed to be the most effective way to signal the driver when he/she lost alertness. With the head movement monitor in mind, a decision matrix was applied to the various alarms.

Audio Alarm: A loud burst of sound is effective at causing a driver to regain alertness. This is acceptable, as most people wake up in the morning by an alarm and this level of technology is already present. The only drawback is that the alarm could be a distraction for other passengers in the vehicle.

Flash of Light: A flash of light is quite effective in causing a sleepy driver to regain alertness, but the driver would have decreased visibility due to the effects of shining bright lights directly into the retina. This negative result would have short term effects on the driver's vision. This method is inexpensive.

Electric Shock: An electric shock will awaken a driver. This method would not be widely accepted due to the negative sensation associated with electric shocks. The degree of technicality of this is minimal , therefore the cost is within the affordable range for the consumer.

Air Temperature Change: A decline in the temperature is an effective method to remain alert while driving. Individuals often drive with their windows down to remain alert. The device that would cause a change in air temperature is within the affordable price range.

Smell Emission: Epsom salts are often used to bring users to consciousness, however this method is not always effective. Generally, society views these smells as offensive, therefore this method would not be acceptable. The source of the smell would constantly need to be restocked, therefore there would be a maintenance cost.

Vibrating Steering Wheel: This measure would have a high degree of effectiveness as a driver must have their hand(s) on the steering wheel to drive. In general, people would not find this intrusive. The major drawback is that with any vibrating device a possibility of mechanical failure exits. This alarm would be fairly complex and expensive.

The audio alarm and temperature control were selected as the best method to alert the driver. The alarm would awaken the driver and a drop in temperature would help maintain driver alertness.

2.3 Final Solution Description:

The final design solution consists of a head movement detector with both an audible alarm and temperature control response. The components of the device were selected based on product specifications and cost (see Appendix B). All of the components will be mounted inside a plastic base of dimensions 20x20x40mm (see Appendix H). The components included in the device are described below (see Appendix G for block diagram):

Power Source: The power is supplied to the unit through a 3V coin cell 10mm in diameter. The battery is located at the base of the unit so it can be replaced easily by sliding off the bottom cover. Since the circuit is only activated for very short periods of time, power consumption will be minimal and the battery will last a long time.

Tilt Switch: Head movement is detected by the tilt switch. Initially, the design made use of a mercury switch to detect tilt. However, since mercury is a heavy metal and therefore dangerous, this type of switch was deemed to be unsafe for this purpose. Therefore, a ball based tilt switch was incorporated into the design plans. A tiny stainless steel ball makes contact with the terminals and completes the circuit when it is tilted at an angle of more than 20° in any direction. A simple capacitor is used on the integrated circuit to ensure that the tilt switch must be activated for at least 3 seconds before setting off the alarm or transmitter. The tilt switch is only 8x8x8mm and will be mounted in the device in a level position.

Alarm: The alarm is activated when head movement causes the tilt switch to complete the circuit. The former consists of a tiny high-pitched beeping device similar to those found in watches. The alarm is mounted on the circuit board and takes up a negligeable amount of space.

Transmitter: When the tilt switch completes the circuit, the transmitter sends a coded signal to the receiver. The transmitter works similar to a garage door opener, emitting a signal at 300MHz. The signal is encoded, meaning it will not interefere with similar devices nearby. The transmitter will take up most of the circuit board, which will be 15 x 25mm in dimension.

Receiver: The receiver is installed behind the dashboard and connected to the air conditioning unit. When the encoded signal is received from the transmitter, the air conditioning unit is activated by simply supplying a current to the correct wire, as if the driver had turned it on. The cooler air will help keep the driver awake.

The base will be able to connect to one of several attachments made for the comfort of the driver. The primary attachment consists of a bendable plastic hook that allows the device to be hooked on to the driver's ear (see Appendix I). The second attachment is a velcro strap so that the base can be strapped to the back of the driver's head. A third attachment is an alternate hook so the device can be worn on the back of a hat.

3.0 Conclusion

3.1 Summary

Four Brothers set out to develop a system to maintain driver alertness in order to reduce the number of accidents that occur on the nation's roadways. A system which combats driver fatigue would integrate both detection and alarm components into the driving environment. The detection component would detect when the driver was loosing alertness. The alarm component would wake up the driver, resulting in renewed alertness. Together these components will keep drivers driving safely and the roads a better place to drive.

The optimal solution was achieved by applying a decision matrix and careful analysis to the two major components, the detection and alarm, in the system. Each alternative solution was described in detail, and subjected to the quantitative analysis of the decision matrix.

The design presented meets the requirements established in the objectives (section 1.2). The lightweight components ensures that the device will not be intrusive to the driver, while the multiple attachments improve its versatility. The tilt switch included in the device is a very effective way to detect when the driver's head nods, indicating lack of alertness. The beeping alarm fulfills the requirements for a device which wakes up the driver, while the air conditioning controller ensures that the driver will be more alert for the remainder of the trip.

3.2 Recommendations

This design is a method of protection from falling asleep at the wheel. It will not detect poor driving performance, a symptom of driver fatigue. This could be solved by combining this design with another alternative, such as monitoring foot movement. The data from both detection methods could be analysed, providing superior performance. However, this would raise the cost of the entire system. This system could be manufactured and sold for a profit due to the low cost of the parts used.

Although this system was designed with the intention of maintaining driver alertness, it could also be used in other instances where an operator is prone to falling asleep. This would include pilots, locomotive engineers, and people who monitor equipment. A version without the temperature control transmiter and receiver could be marketed for use in other areas where individuals are prone to falling asleep, such as students in lecture halls.

This design, like any other, is subject certain limitations and failure, such as battery depletion. All drivers should avoid driving when they are not sufficiently alert. To maintain alertness, drivers can participate in conversations with their passengers, listen to the radio, use stimulants such as caffeine and make regular stops. If these measures do not help, the driver should pull over to the side of the road and take a nap.

Four Brothers feels confident in the design that has been developed and refined over the past month to provide the consumer with the best product on the market to maintain driver alertness.

References

1. Andrews, G.C. and H.C. Ratz. *Introduction to Professional Engineering*, 5th ed. University of Waterloo, Waterloo, 1996.

2. Audette, R. Maertens, M. Ng, M. Poole, K. September, 1997. *Proposal to Design a System for Maintaining Driver Alertness*. 05-210 design proposal, School of Engineering, University of Guelph, Guelph, Ontario.

3. *Auto and Road User Journal*. Transafety, Inc, http://www.usroads.com/journals/aruj/9702/ru970204.htm: last version: February, 1997.

4. Colemere, M.Dale Jr., *SafeAuto*, http://ourworld.Compuserve.com/homepages/DColemereJr/Safeauto.htm, last version: October, 1997.

5. *Commercial Motor Vehicule Driver Fatigue and Alertness Study*, Transport Canada, http://www.tc.gc.ca/TDC/publicat/tp12876/english/12876.html, November, 1996.

6. Empson, Jacob. *Sleep and dreaming*, 1st ed. Faber and Faber, London, England, 1989. p. 36.

7. *Miscellaneous Switches - For Sale - Surplus*, Surplus Traders, http://www.73.com/a/0114.shtml, November, 1997.

8. *New Product and Technology Division*, Duracell Inc., http://www.duracellnpt.com/explor.d/litsumsh.html, 1996.

9. *RC300 Series Remote Control System*, Radio Design Group Inc., http://www.radiodesign.com/rc300.htm, November, 1997.

Appendix A: Decision Matrix

Detection Measures Decsision Matrix

	Effectiveness at Detection (40%)	Low Interference with driving (35%)	Affordability (25%)	Total
Button Pushing	26	18	23	67
Brain Wave Monitor	37	29	13	79
Head Movement Monitor	36	30	20	86
Foot Pattern Monitor	28	31	15	74
Eye Movement Monitor	33	28	15	76

Alarm Components

	Effectiveness at Prevention (60%)	Acceptance by Society (30%)	Affordable for User (10%)	Total
Audio Alarm	53	22	8	83
Flash of Light	47	20	6	73
Electric Shock	54	6	7	67
Air Temperature Change	50	27	9	86
Smell Emission	32	14	6	52
Vibrating Steering Wheel	51	24	5	80

Appendix B: Component Specifications

Transmitter/Receiver[9]

Supply Voltage:	1.9 Volts Minimum 3.0 Volts Nominal 3.5 Volts Maximum
Supply Current:	Less than 15 Milliamps
Frequency Range:	260 to 470 MHz
RF Output Level:	0 dBm (1 milliwatt) Adjustable to meet FCC Part 15 Field Strength Levels
Operating Temperature Range:	-10 to +70 degrees C
Spurious Emissions:	-60 dB Minimum
Oscillator Stability:	8 PPM Minimum 5 PPM Typical
Transmitter Rise Time:	5 mS Maximum
Data Input Level:	0 to 3 Volts (3 Volt Supply)

Tilt Switch[7]

Part Number:	YKS1B
Description:	Tilt switch
Size:	7.3 mm square body. 8 mm cap.
Rating:	DCV 0.1mA-100mA
Dielectric strength:	AC 250V for 1 minute
Actuation angles:	On to Off about 20-65 degrees Off to On about 60 to 20 degrees
Temperature range:	-10 C to 60 C
Storage temperature range:	-25C to 75C

Battery[8]

Product ID:	DL2018
Description:	Microlithium Coin Cell
Nominal Voltage:	3V
Typical Voltage:	3.1 to 3.3V
Max. Discharge Current:	4mA cont. 15mA pulse
Size:	10mm dia x 1.6mm height
Weight:	1.8g

Appendix C: Task Chart

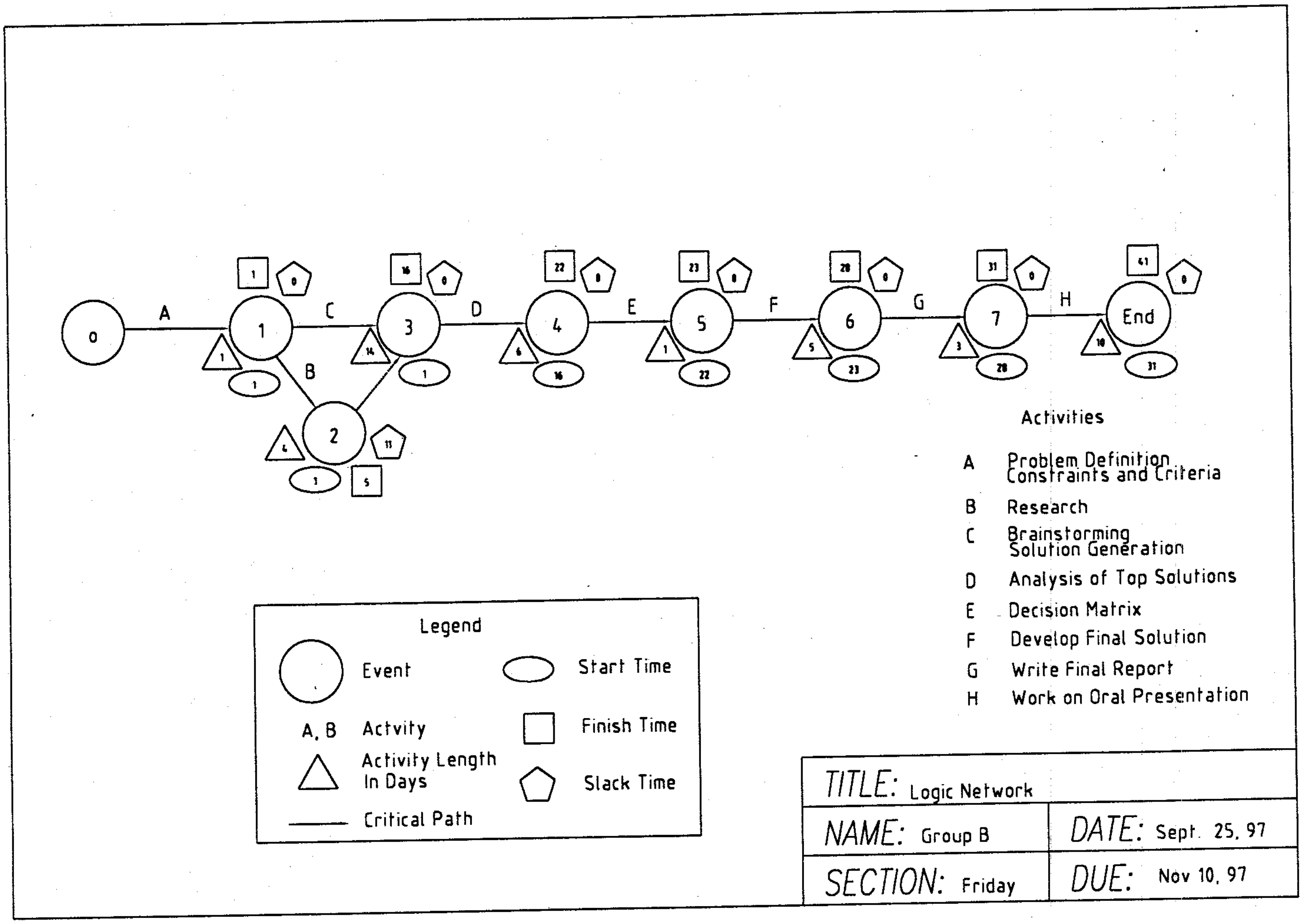
Table 1: Task Timetable		
Activity Letter	**Activity**	**Time Scheduled**
A	Problem Definition Constraints and Criteria	October 6
B	Research	October 7
C	Brainstorming Solution Generation	Oct. 6 - Oct 10
D	Analysis of Top Solutions	Oct 10 - Oct 26
E	Decision Matrix	October 27
F	Develop Final Solution	Oct 28 - Nov 2
G	Write Final Report	Nov 3 - Nov 6
H	Work on Oral Presentation	Nov 10 - Nov 21

Appendix D: Budget

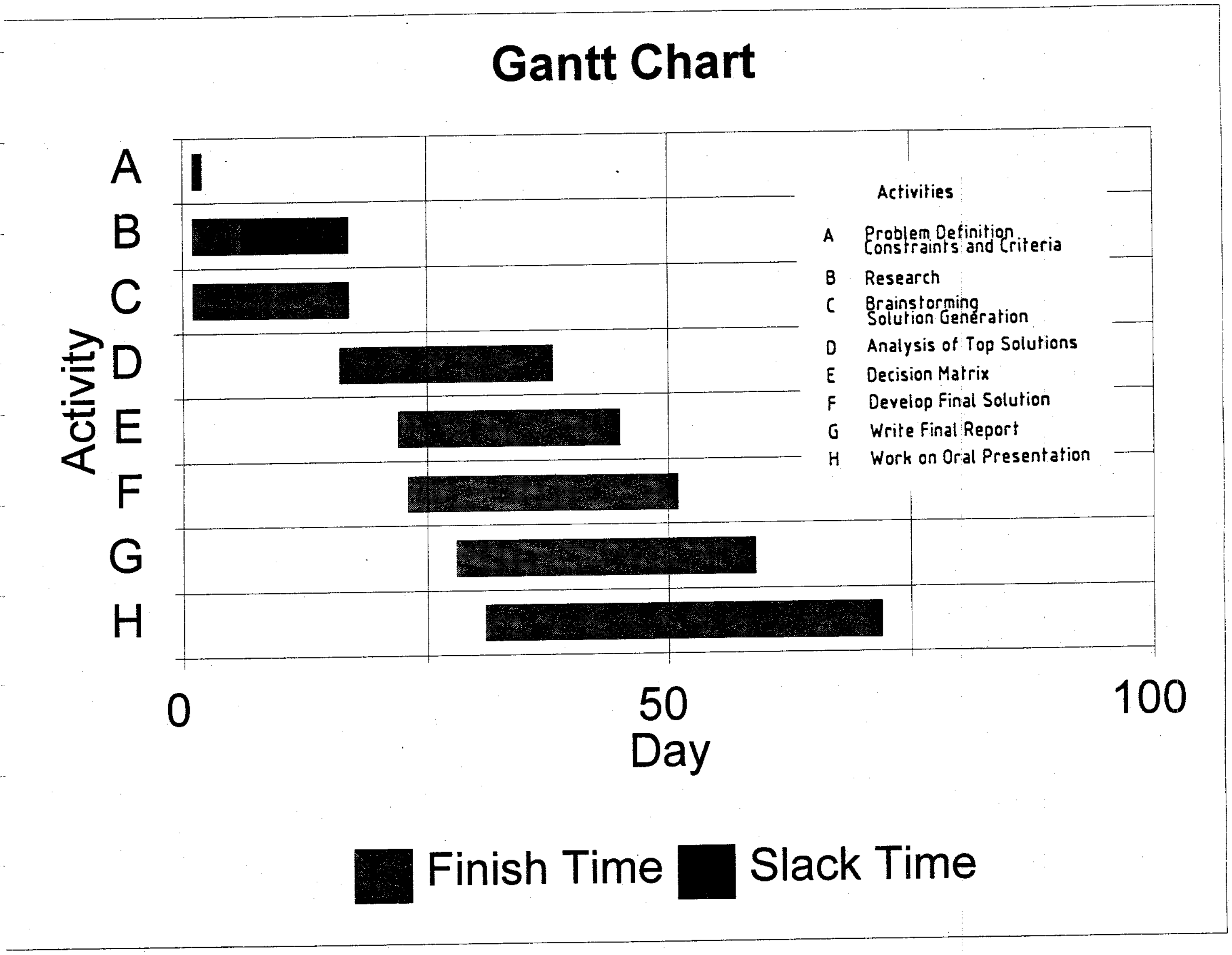
Design Budget	
Item	**Cost ($)**
4 disks to save documents	2
Binding for Proposal and Final Design	10
Stationary	5
Time (4 people x 35 hrs x $20/hr)	2800
Total:	2817

Budget for Unit	
Component	**Cost ($)**
3V battery	5.00
Tilt Switch	0.20
Alarm	0.20
Transmitter	5.00
Receiver	5.00
Plastic case	6.00
Wire	3.99
Velcro Strap	1.30
Total:	26.69

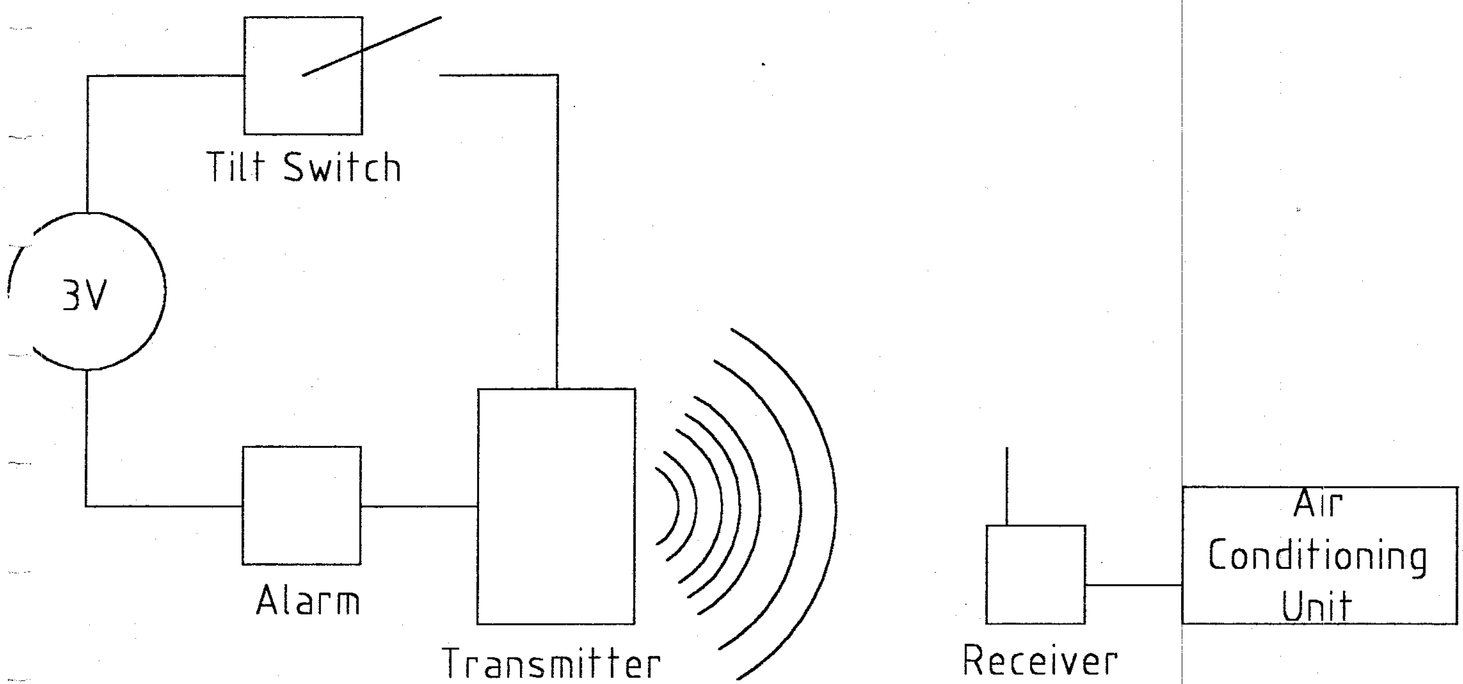
Appendix E: Logic Network



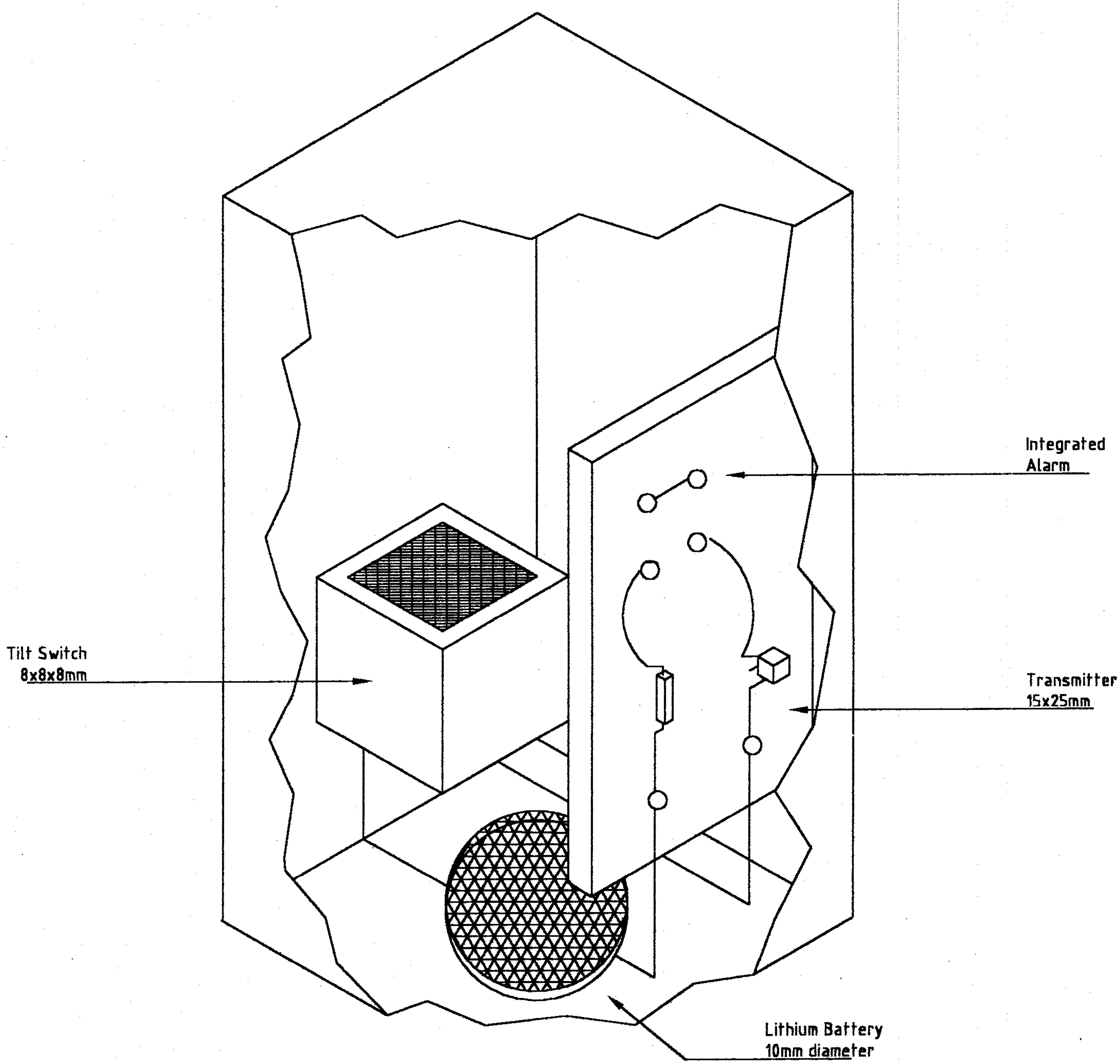
Appendix F: Gantt Chart



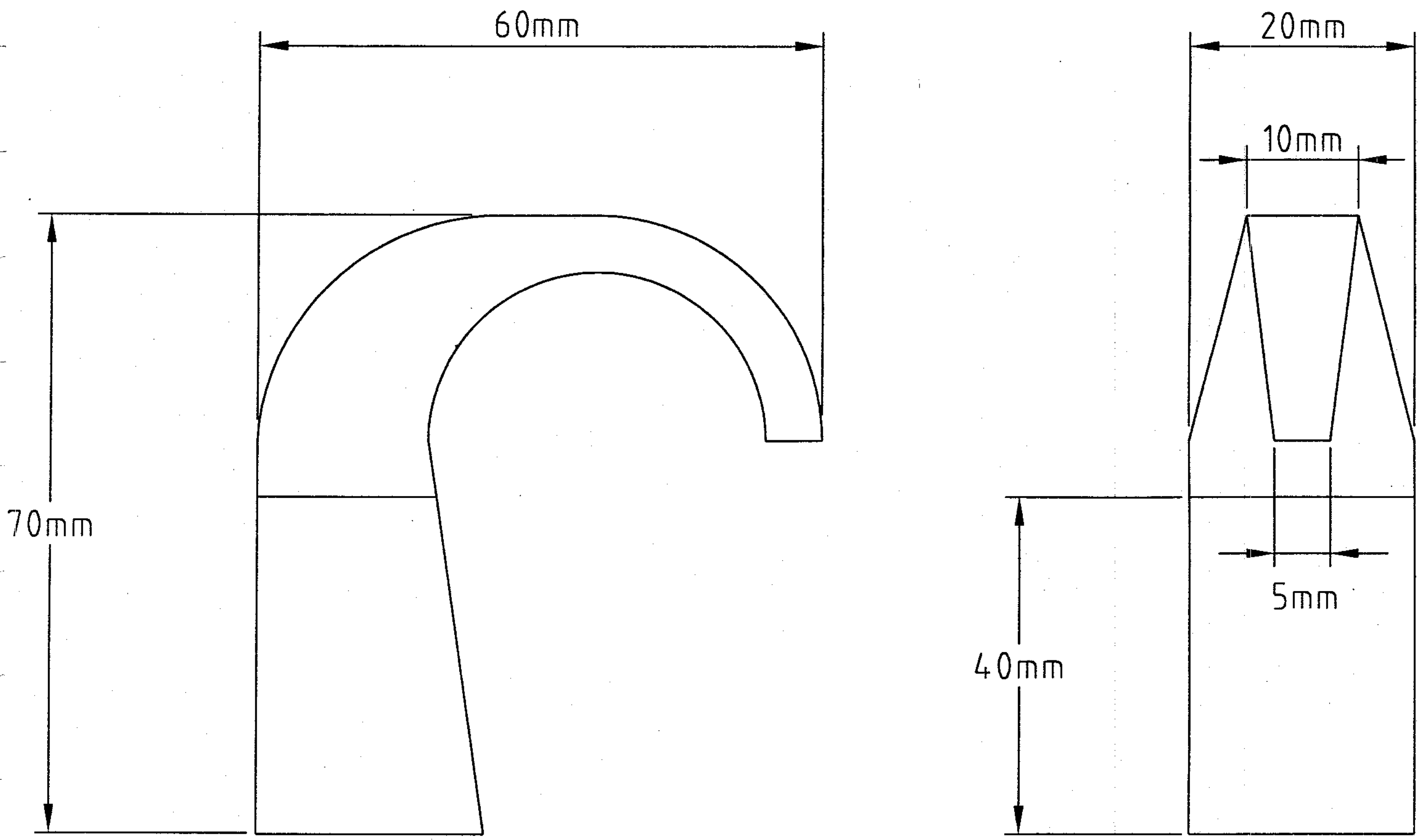
Appendix G: Block Diagram of System



Appendix H: Cut Away View of System Components



Appendix I: Unit Dimensions (with ear attachment)



Appendix J: Credentials

Richard Audette:

Richard grew up in Gloucester, a suburb of the Nation's Capital, Ottawa. Attending french schools from pre-kindergarten to OAC, Richard is bilingual. Work experience includes working at a small local computer store and at the National Research Council as a computer technician. He enjoys bicycling both on and off road in his spare time. Experience with late night driving consists of being designated driver. Richard is currently second year Engineering Systems and Computing student at the University of Guelph.

Marianne Maertens:

Marianne grew up in a small rural community outside of Aylmer Ontario. Her work experience extends throughout the farming and silviculture industries. Marianne recently completed a contract of employment with Environment Canada as a Hydrometric Gauge Station Attendant. Her spare time is taken up with varsity and club running. Having to wake up at the crack of dawn to get to work on time, Marianne has plenty of experience with loss of alertness while driving. Currently she is in her second year Water Resource Engineering at the University of Guelph.

Matthew Ng:

Matthew grew up in Hong Kong. Attending school in Hong Kong from kindergarten to From 4 (Grade 10), he became tri-lingual, speaking English, Cantonese and Mandarin. Matthew has work experience as a chef's assistant. Having to work late, Matthew is accustomed to driving home while sleepy. His interests include sports activities such as soccer. He is currently in his second year at the University of Guelph in Water Resources Engineering.

Kyle Poole:

Kyle originates from a small community just west of Kitchener. He is very proud to have graduated from his high school at the top of the honour roll. During the summer, Kyle researched driving fatigued by delivering late-night pizzas. During his spare time, Kyle enjoys playing intramural volleyball. Kyle is a second year Biological Engineering student at the University of Guelph, with plans to continue on to a Masters degree in Biomedical Engineering.

05-210 INTRODUCTION TO DESIGN
MARKING SCHEME FOR WRITTEN REPORT

GROUP FB

CONTENT		MARKS
Front Matter	Letter of transmittal	4 /5
	Title Page	5 /5
	Executive Summary	5 /5
	Table of Contents	5 /5
Problem Statement	Introduction	4 /5
	Objectives of the design	4 /5
Body of Report	Background, (with constraints, criteria)	4 /5
	Description of options considered skimpy	4 /5
	Analysis of most viable options (description of calculations and results)	7 /10
	Selection of final alternatives and justification of selection (appropriate selection criteria)	8 /10
Conclusion	Summary of final selection with confirmation that objectives are met	4 /5
	Recommendations	4 /5
Style		
Organization	Logic, connectivity, completeness	9 /10
Grammar	(Including spelling, syntax, sentence structure, paragraph structure)	9 /10
Appearance	(Of text and illustrations)	8 /10
	(84)	TOTAL 100

Comments:

- Good component Specification
- Good problem and feasible solution
- Competent job
- More use of analysis good