QND Medical Devices

School of Engineering Science
Burnaby, BC
V5A 1S6
qnd-medical@sfu.ca

September 25, 2000

Dr. Andrew Rawicz
School of Engineering Science
Simon Fraser University
Burnaby, British Columbia
V5A 1S6

Re: ENSC 340 Project Proposal for a Brain Wave Monitoring Alarm Clock

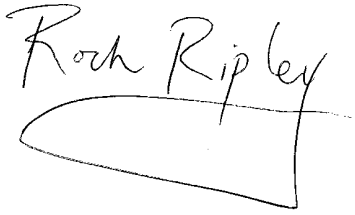
Dear Dr. Rawicz:

The attached document, *Proposal for a Brain Wave Monitoring Alarm Clock*, outlines our project for ENSC 340 (Engineering Science Project Course). Our goal is to design and implement a system that triggers an alarm clock based mainly on a sleeping person's brain waves. Such a system would ensure that a person never awakens feeling groggy or tired.

Our proposal contains an overview of our proposed product, our sources of information, probable sources of funding, and information on our group's members and structure. Other possible design solutions are also mentioned, but we provide ample justification as to why our design solution is used. Additionally, a projected budget, Gantt chart, and milestone chart are included. The commercial marketability of our proposed product is also discussed.

QND Medical Devices is comprised of five highly dedicated, ambitious, and intelligent fourth-year engineering students --- **Roch Ripley**, President and CEO; **Hiten Mistry**, CFO; **Matt Ward**, VP Marketing; **Stephen Liu**, VP Engineering; **David Lee**, VP Operations. Should you have any questions, concerns, or comments about our proposal, please feel free to contact me at (604) 421-6126 or via the e-mail address listed above. Thank you for your time.

Sincerely,



Roch Ripley
President and CEO
QND Medical Devices

Enclosure: Proposal for a Brain Wave Monitoring Alarm Clock

Proposal for a
Brain Wave Monitoring Alarm Clock

Project Team: David Lee
Stephen Liu
Hiten Mistry
Roch Ripley
Matt Ward

Contact Person: Matt Ward
(604) 929-7889
E-mail: qnd-medical@sfu.ca

Submitted to: Dr. Andrew Rawicz (ENSC 340)
School of Engineering Science
Simon Fraser University

Steve Whitmore (ENSC 305)
School of Engineering Science
Simon Fraser University

Date Submitted: September 25, 2000

EXECUTIVE SUMMARY

"I'm tired."

-- Any emergency room doctor, long-haul trucker, airline pilot, ENSC 340 student …

Any occupation in which human safety is at risk requires the utmost level of concentration and alertness. An example of such an occupation is airline pilot. A pilot's alertness degrades with time, and a groggy or tired pilot is not one whom anyone would want dealing with a potentially dangerous situation. Stimulants can turn a groggy pilot into a groggy and nervous pilot; that image doesn't instil much more security in passengers. Sleep is the only true solution for a pilot, but, like many other people in the year 2000, the pilot doesn't have time for a full night's sleep. Neither does the trucker in command of an 18-wheeler, the emergency room doctor in charge of lives, the student worrying about finals, or the countless other busy people for whom sleep has become a luxury.

Many see the lack of time available for sleep not as a problem that should be treated, but as an unavoidable consequence of our increasingly busy lives. In deciding to create our product, we saw opportunity where others saw hopelessness. We intend to capitalize on the societal trend of less sleep for more work by allowing people to feel refreshed in less time than originally thought possible.

This document proposes the development of a portable system to awaken users so that they feel alert and energetic. The device mainly monitors a sleeping person's brain waves to determine in which stage of sleep they are. Based on this information, we can minimize the amount of "sleep inertia," and thus grogginess, a person feels upon awakening. Such a system would allow people to efficiently nap during the day and ensure a virtually constant state of alertness.

No such system currently exists. The only time many have to get a full night's sleep is on weekends. Even then, one may oversleep and consequently be fatigued. In today's hectic world, in which sleep is often traded for work, coffee is the only solution for many. We intend to take a bite out of Starbucks' market share.

The social implications for our device are encouraging. Quantitatively, we could see increased productivity at work and fewer airline, hospital, and traffic accidents, to name only a few possibilities. Qualitatively, quality of life could be improved for millions as they are finally able to get some well-deserved rest.

QND Medical Devices is composed of five fourth-year engineering students, each possessing unique experiences with analog and digital systems. Our development period spans 13 weeks and is scheduled to end December 11, 2000. During this period the project will be researched and designed, and a prototype will be constructed. The estimated budget for the project is $1135, to be funded through a variety of sources.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

INTRODUCTION

I am sleepy while writing this. You are probably sleepy while reading this. We could both use a nap.

…

But we don't have the time to nap for long, and we're not the only ones who lack both time and sleep. Available statistics show that a third of all Americans sleep less than 6 ½ hours per night; 45% of all Americans readily admit that they sleep less in order to be more productive. The statistics for young adults (18 – 29 year olds) are even more dire: 55% report sleeping less in order to do more, while 33% report significant daytime drowsiness.

Few products exist, however, that help a person use the hours available for sleep more efficiently. Stimulants often have negative side effects, while a standard alarm clock does little to ensure that a person's awakening is pleasant.

We intend to develop a product that relies on a combination of brain and eye input signals to determine the best time to awaken someone. Through our input signals, we will analyze when a person is just beginning to enter rapid eye-movement (REM) sleep from Stage 4, or "deep," sleep, and trigger an alarm clock at that time. Waking someone during the transition from Stage 4 to REM sleep translates into a person who will experience the least amount of sleep inertia, or grogginess, immediately upon awakening. Additionally, our product can also be used over the course of a full night to ensure that oversleeping, and the fatigue that sometimes accompanies it, does not occur.

The possible positive societal impact is great. Airline pilots, police officers, hospital interns, truckers, and rush hour commuters are among the people who are forced to perform potentially dangerous tasks daily. For these people, fatigue can be fatal, not only for them but for the people with whom they interact as well. American drowsy drivers in 1999 alone were responsible for at least **100,000** crashes, **71,000** injuries, and **1,500** deaths. By significantly reducing the fatigue people feel, we would literally make the world a safer place.

This document is a proposal providing an overview of our solution outlining design considerations, sources of information and funding, a projected budget, and project organization information. Alternate system implementations are discussed and reasons for their rejection are given. Scheduling information, in the form of Gantt and milestone charts, is also included.

SYSTEM OVERVIEW

System operation is outlined in Figure 1 below. Electrodes are attached to the user, monitoring sleep signals that are passed onto the processing unit. The processing unit analyzes its inputs to generate an appropriate output for the clock. A suitable alarm tone is used to wake up the user.

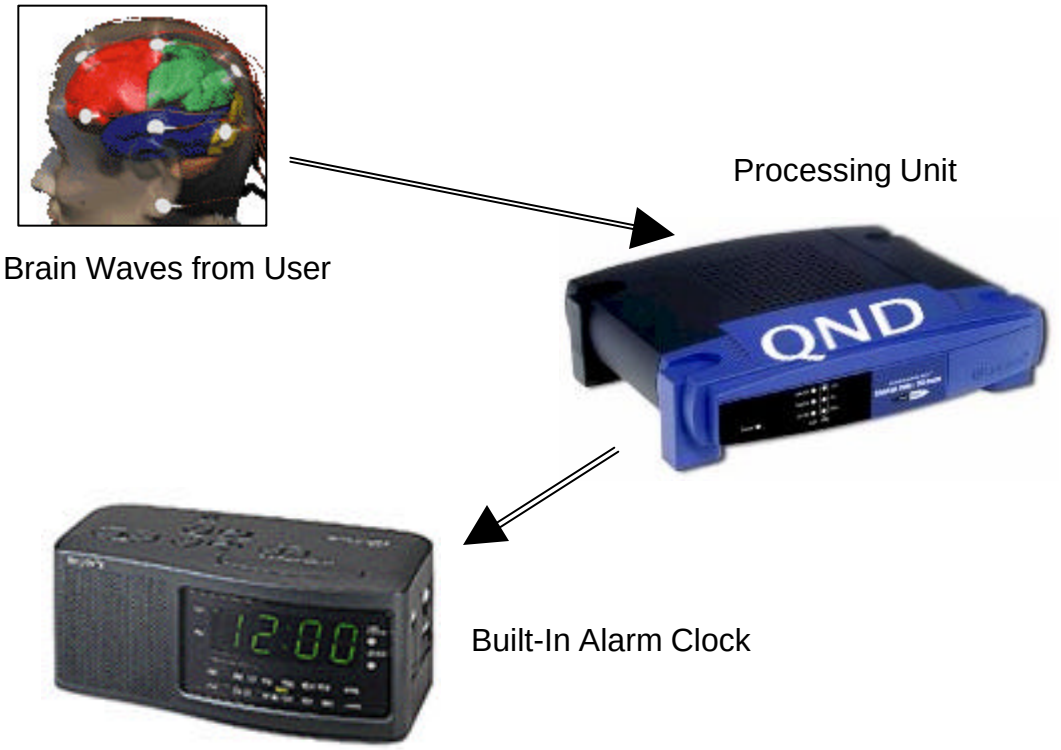


Figure 1: System Overview

First, the processing unit improves the received electrode signals via amplification and filtering. It then analyzes the sampled data to determine which stage of sleep the user occupies. When the time comes to wake up the user, an output tone is generated. This process is illustrated below in Figure 2.

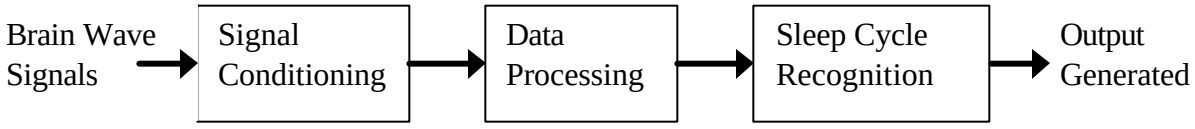


Figure 2: System Block Diagram

POSSIBLE DESIGN SOLUTIONS

Most people have waken up on at least one occasion with a tired feeling that has persisted throughout the first part of their day. Regardless of whether someone has just arisen from a full night's sleep or a short nap, the same feeling can exist. Many solutions exist to combat this widespread problem.

Additional Sleep Time

The human body is programmed to wake up when enough sleep has been attained. If someone wakes up feeling groggy, he or she can simply roll over and fall asleep again. Most people, however, do not have enough time to be governed by a biological clock. Additionally, the possibility exists that people who use this method can oversleep, resulting in a tired feeling and inefficient use of time.

Third Party Help

Another way to have a refreshed feeling in the morning is to be gently woken up by a third party. For example, many mothers wake their children each morning. Conversations that sleepy people have upon waking can get their brains working, helping to reduce morning grogginess. However, many lack the luxury of a third party to wake them on a daily basis.

Conventional Alarm Clocks or Clock Radios

Many people wake up each morning to the sound of an alarm clock or a clock radio. These devices wake the user at a preset time with a loud noise. Clock radios are more effective than conventional alarm clocks because the music or speech that is played over the radio can stimulate the brain. Unfortunately, hearing any loud noise in the middle of deep sleep is not a very pleasant way to wake up in the morning and often results in grogginess and irritability.

Light

One of the main factors in controlling the human body clock is light. Light signals the brain that it is daytime and that it is time to awaken and be alert. Alone, moderate light is usually not enough of a trigger for someone whose body desires more sleep. After waking up via some other method, lights can help alleviate morning grogginess. People afflicted with seasonal affective disorder (SAD) have especially strong reactions to light.

Hypnosis

Hypnosis is one of the more interesting ways of ensuring that someone wakes up feeling refreshed. Essentially, the hypnotist places a hypnotic suggestion in the mind of the hypnotized person. If that person would have normally felt groggy upon waking, the hypnotic suggestion overrides that feeling. Once again, drawbacks exist for this method. Firstly, not everyone can be hypnotized. Also, hypnotic suggestions are not permanent and must be reinforced periodically. The time and monetary cost of regular hypnosis sessions can be prohibitive for many people.

Caffeine

Many people find that they cannot function without at least one cup of caffeinated coffee each morning. Indeed, caffeine is a stimulant that can help people wake up in the morning or stay awake at night. Like other drugs, it has its drawbacks. People who consume too much caffeine can develop high blood pressure, increased heart rate, persistent jitteriness, or even become addicted. Caffeine has even been linked to osteoporosis and infertility in women. In practice, caffeine can be a convenient way to stay awake the night before an exam to study, but it should not be used as a long-term solution.

PROPOSED DESIGN SOLUTION

Our proposed solution is to build a portable unit that monitors brain waves and eye movement to determine the user's state of sleep. Waking the user only at specific points in the sleep cycle avoids disorientation upon waking up, or "sleep inertia". Sleep inertia is reduced when the user awakes while they are coming out of Stage 4, or "deep," but before they enter REM sleep. By not disturbing REM sleep, there is a benefit to those that need to be alert when awaking but cannot sleep until they are completely rested.

While both brain waves and eye movement have recognizable patterns during different cycles of sleep, correlating both signals gives a much more accurate measurement. Electro-encephalograph (EEG) and electro-oculograph (EOG) machines are standard equipment in hospitals but they are often bulky, complicated, and inaccessibly expensive. By building a small, portable device that monitors and recognizes pertinent signals, a relatively inexpensive and versatile alternative would exist.

The main constraints in completing this project are the limited resources with which we are working. While we have been given these four months to build and verify this device we are concurrently occupied in course study and research. Given this limited timeframe we can build a prototype and verify its operation on several test subjects. Since testing requires that the subject sleep for a significant amount of time, verification is likely to be an arduous task.

Given additional time and funding it is possible to develop this product into an alarm clock that learns the user's typical sleep patterns and uses this information together with the EEG and EOG to assure the alertness of the user upon waking up. With the current societal trend of sleep deprivation, this device would likely be helpful to anyone who wishes to feel better when they wake up from a much-needed rest.

SOURCES OF INFORMATION

Project research will involve several key sources of information. Such sources will include, but will not be limited to, sleep research literature, neurological research publications, medical instrumentation books, various Internet resources, electrical component specifications, and sleep behaviour experts.

Much of the statistics and data we need on sleep can be found in various books and publications devoted to the subject of sleep. The Internet is also a useful resource for obtaining information on sleep research and project implementation.

One expert who has been extremely helpful is Dr. Hal Weinberg from the SFU Kinesiology department. Dr. Weinberg specializes in brain systems information processing at the Brain Research Laboratory at Simon Fraser University. Some of his research has included sleep analysis and behaviour. Dr. Weinberg has already become an instrumental part of our project, providing us with feedback, use of lab facilities, helping us assess user safety, and introducing us to other contacts and sources of information.

Other contacts worthy of note include Dr. Ralph Mistlberger of the SFU Psychology department. Dr. Mistlberger specializes in circadian sleep rhythms and leads the Circadian Rhythms Lab at SFU. He has offered to provide us with additional feedback and insight into our project. A doctor of traditional Chinese medicine, Dr. Weidong Yu, has also offered assistance as a source of information and for product evaluation. Because Dr. Yu deals with insomnia patients, he has expressed great interest in our proposal.

Further information regarding the design, implementation, and useability of the product will be gathered from Dr. Andrew Rawicz and Steve Whitmore (the course instructors) as well as Jason Rothe and James Balfour (the course teaching assistants). Patents, both American and Canadian, have also been consulted. In addition, Greg Hall, a recent graduate of SFU engineering who has worked on a project that is in some ways similar to ours, has already provided us with technical assistance.

PROJECT FINANCES

Budget

Table 1 shows our preliminary budget for the portable brain wave monitoring system. All items are categorized according to their application. Each component has been overestimated by ~ 15% to ensure safer funding.

Table 1: Forecasted Development Costs

Equipment		Cost ($)
Bio-Medical	Electrodes	300
	Sensor Hat	120
	Skin Conditioners	20
	Cabling	10
Electronic Components	Amplifiers	20
	Microprocessor EVB	250
	LCD Screen	40
	Power Supply	40
	Miscellaneous Electronics	50
Hardware	Instrumentation Case	50
	Circuit Board	20
	User Interface Peripherals	30
Software	Microprocessor Development Tools	85
	Electronic Simulation Tools	100
Estimated Total		**1135**

Funding

Various sources for project financing are being explored. The team is in the process of applying for the Wighton Development Fund and the Engineering Science Student Endowment Fund. The Engineering Student Society offers the Endowment Fund solely for the purpose of student projects. The team is confident that funds will be awarded to this project due to the health benefits associated with it as well as a target consumer group consisting of people such as surgeons and pilots.

Alternate channels of funding include lobbying for donations from government officials (Burnaby MP and MLA) and also approaching local industry for financial support. Further possible sources include funds from various health foundations and health organizations that recognize sleep disorders. Additionally, each member of the group is willing to contribute the cash equivalent of a textbook (~$100) toward the course should the funds be required.

SCHEDULE

Table 2, the Gantt chart for our project, shows the amount of time we intend to devote to various tasks. Figure 3 shows the expected completion dates of project milestones.

Table 2: Gantt Chart

ID	Task Name	September				October					November				December			
		3	10	17	24	1	8	15	22	29	5	12	19	26	3	10	17	24
1	Project Proposal																	
2	First Progress Report																	
3	Functional Specifications																	
4	Design Specifications																	
5	Second Progress Report																	
6	Process Report																	
7																		
8	Feasability Study																	
9	Scientific Research																	
10	Funds Acquisition																	
11	Critical Parts Acquisition																	
12	Analog Front-End Development																	
13	EVB Experimentation																	
14	Firmware Development																	
15	User Interface Development																	
16	Alarm Clock Interface																	
17	Testing and Debugging																	
18	Web Site Development																	

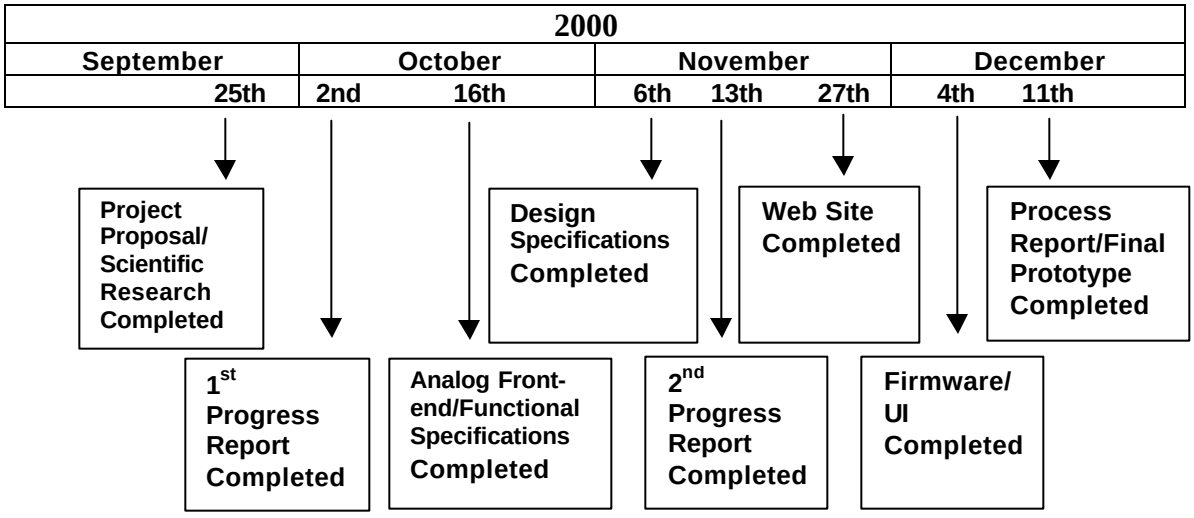


Figure 3: Project Milestone Chart

TEAM ORGANIZATION

Five innovative and talented engineering students comprise QND Medical Devices. David Lee, Stephen Liu, Hiten Mistry, Roch Ripley, and Matt Ward are all in their fourth year of study. Combined, the members of QND have completed 12 terms of work experience. Each team member's experiences and skills will contribute to the success of the company.

The corporate structure of QND Medical is designed to minimize conflict and maximize productivity while highlighting the strengths of the team members. Each team member possesses a title, but members are also expected to assist with jobs that lie outside their main role. Roch Ripley, President and Chief Executive Officer (CEO), is responsible for the overall success of the project. He monitors the project's progress and takes steps to ensure that it is carried to completion. Hiten Mistry, Chief Financial Officer (CFO), has budgeting and funds acquisition as two items in his portfolio. David Lee, Vice President of Operations, sets and evaluates deadlines and performs logistical duties. Stephen Liu, Vice President of Engineering, leads the team in the development of the hardware and software required to complete the project. Finally, as Vice President of Marketing, Matt Ward is in charge of market research, product direction, and interaction with external parties.

Weekly meetings serve as a formal discussion period for the company members. During the one-hour period, each team member gives a short progress report, and any other issues on the agenda are addressed. David Lee and Roch Ripley lead the meetings as chair and secretary. Frequent informal gatherings supplement the formal meeting times. In formal and informal scenarios, it is important for team members to express their own unique viewpoints.

The sheer quantity of work associated with the project requires that sub-projects be created and distributed among the members of the team. QND has decided that one group member will act as "Prime" for each sub-project, supported by other team members. Sub-projects will thus proceed more effectively under the direction of the Prime. A member will be Prime for only a few sub-projects so that no sub-project is neglected.

QND Medical Devices has the people with the intelligence, skills, and work ethic to successfully complete the project. Teamwork will undoubtedly prove very important in the success of the project. All in all, we believe our system of team organization will improve our chances of accomplishing our goal.

COMPANY PROFILE

Roch Ripley – President and Chief Executive Officer (CEO)
Roch is an Electronics Engineer in his fourth year at Simon Fraser University. He has had previous work-terms at Nortel Networks and PMC-Sierra and is familiar with PCB layout, high-speed board design, VHDL programming, and many types of lab equipment. While Roch's background in both analog and digital electronics is useful, he plays a more important role in that he helps to keep the team unified, focused, and motivated.

Hiten Mistry – Chief Financial Officer (CFO)
Hiten is a fourth year Electronics Engineering student with previous work experiences at VTech Engineering for the consumer electronics market. His technical skills are broad and range through a variety of hardware and software abilities including firmware, RF, and design of product test systems. Hiten's work experience has provided him with thorough troubleshooting and design skills, as well as the opportunity to absorb the development process of a consumer product from concept to market. These experiences will prove valuable to aid project management and in the development of product performance and reliability.

David Lee – Vice President of Operations
David is a fourth year Engineering Physics major with previous work experiences at Circon and iZ Technology. He is familiar with analog electrical layout and design, including the use of Orcad, MicroSim, PSpice, and Logicworks. David also has experience with micro-controller programming in assembly with the HC05, HC11 and HC12 microprocessors. One of his more useful attributes is his laboratory ability, including his ability to use the oscilloscope, DMM, waveform generator, FFT analyzer, and soldering iron. More important than his technical skills, however, are his abilities to organize group work, communicate, work with others, and do chops on his Gibson Les Paul Standard electric guitar.

Stephen Liu – Vice President of Engineering
When Stephen was 10 years old he took apart a train set. It has never run again. He has worked for large corporations (Nortel and Agilent) on three occasions, in opto-electronics, wireless, and test equipment. He has experience with a wide range of engineering tasks from surfing the WWW to C++ to FPGA design. When he has any free time he chooses to work.

Matt Ward – Vice President of Marketing
Matt has successfully completed work terms at three different companies. Work terms with Tantus Electronics, Nortel Networks, and Spectrum Signal Processing have required fusion of hardware and software skills while exhibiting leadership and team organizational abilities. Numerous project courses have served both as proving grounds for theoretical knowledge and as occasions for new learning. Matt's strong technical experience combined with his excellent communication skills, interpersonal abilities, and penchant for sleeping make him a perfect fit as QND's Vice President of Marketing.

CONCLUSION

QND Medical Devices was formed in order to help people feel alert and energetic after waking from sleep. We are a group of five students who grew tired of passing accidents early in the morning, hearing of passengers fearing for their safety in airplanes, and of being tired ourselves. Our system will allow anyone, but especially active professionals, make efficient use of their rest time so that they will be able to maintain a high level of focus.

Such a project poses a challenge for our team, but we believe that we have the necessary technical abilities and determination to see this project through to completion. By synchronizing an alarm clock with the body's own biological signals, we are working with the human body's own natural systems instead of against them as a regular alarm clock does.

We have identified a problem and our proposed solution has already generated interest from the experts we have consulted. Our Gantt and milestone charts illustrate our high level of organization and our belief that the project can be completed within the allotted time frame. Mark December 2000 on your calendar: It's bedtime.

REFERENCES

1. Dr. Hal Weinberg, Department of Kinesiology, Simon Fraser University

2. Dr. Ralph Mistlberger, Department of Psychology, Simon Fraser University

3. Dr. Weidong Yu, Doctor of Traditional Chinese Medicine

4. http://www.sleepfoundation.org/pressarchives/new_stats.html

5. http://abcnews.go.com/sections/auto/dailynews/too_tired_000505.html

6. Webb, Wilse B. *Biological Rhythms, Sleep, and Performance*. (1982) John Wiley & Sons, Inc.

7. Coren, Stanley. *Sleep Thieves*. (1996) The Free Press.

8. Geddes, L.A & Baker, L.E, *Principles of Applied Biomedical Instrumentation.* (1975) John Wiley & Sons, Inc.

9. UCLA Sleep Research Society, *Basics of Sleep Behaviour*. (1993).

10. Canadian Patent: #1315347

11. US Patents: #5928133
    #4238806