CALIFORNIA STATE SCIENCE FAIR
2005 PROJECT SUMMARY

Name(s)
Nathan Bales; Daniel Trubey

Project Number
S0701

Project Title
Detecting Radio Anomalies in the ULF to ELF Spectrum

Abstract

Objectives/Goals
We are trying to create a device that can detect radio anomalies in the radio frequency range of sub-1 Hz to 30 Hz.

Methods/Materials
We created the inductor coil using 37,000 feet of 30-gauge magnet wire. The #receiver# or signal-processing unit was made from schematics off of the ELFRAD web site. We wound the wire around a PVC pipe and inserted a mu-metal core to make it more sensitive. We record these signals through our coil into the #receiver# and then into our computer through an analogue to digital converter. If we can detect an event called a Schumann resonance then we were successful.

Results
We have made the coil and the receiver but have yet to successfully record with this set-up. We are working on a variety of little problems and should have it fixed by the time of the fair.

Conclusions/Discussion
By what we have seen so far and what we know of our coil, we believe that we will be able to successfully record the Schumann Resonances. We are working on getting our system up and running.

Summary Statement
We are trying to create a device that can detect radio anomalies in the radio frequency range of sub-1 Hz to 30 Hz.

Help Received
Bruce Mount from Hamilton Sundstrand helped with electrical engineering questions

CALIFORNIA STATE SCIENCE FAIR
2005 PROJECT SUMMARY

Name(s)

James B. Bonner, IV

Project Number

S0702

Project Title

Determining the Accuracy of an Ultrasonic Proximity Sensor vs. an IR Proximity Sensor using Autonomous Robots

Abstract

Objectives/Goals

The purpose of this experiment was to determine which type of proximity sensor, ultrasonic or infrared, is most accurate at detecting the presence of an object. The ability of proximity sensors to detect the presence of objects allows the ability of envisioning a foreign and dynamic surrounding without possessing the sense of sight. Therefore, proximity sensors can be used to replace the nonfunctioning eyes that burden the blind or to assist in the autonomous navigation of robots.

Methods/Materials

To test this problem, several objects, each varying in size, shape, and dimension, were placed in front of an autonomous robot, equipped with either the ultrasonic proximity sensor or the infrared proximity sensor. The object was placed at varying distances from the sensors to test the distance of each sensor#s sensing range. In addition, the sensors# output energy was emitted at different angles.

Results

Following the completion of testing each sensor#s accurateness at detecting the presence or absence of an object, the results indicated that the original hypothesis, which stated that the ultrasonic sensor would be the most accurate sensor in its ability of object detection, was supported.

Conclusions/Discussion

After conducting extensive research pertaining to electronic sensors and analyzing the experimental results, a probable explanation was postulated.

The infrared sensor experienced difficulty in detecting objects from the 30cm marks. This is most likely attributed to the large #dead spots# infrared sensors experience when sensing objects from far distances. The autonomous motion trials also support this inference. In the autonomous motion trails the robot equipped with the infrared proximity sensor stopped much later than the robot equipped with the ultrasonic proximity sensor, implying that the infrared sensor#s sensing range is shorter than that of the ultrasonic sensor.

Another flaw the infrared sensor possessed was its high susceptibility to ambient infrared light. In trial where the ambient infrared light circuit projected infrared light with a wavelength of 940nm, the IR receiver module mistook these received beams of infrared light as reflections of the emitted light beams. This data proves that infrared proximity sensors misread the absence of an object when the IR receiver module intercepts ambient beams of infrared light.

Summary Statement

This purpose of this project was to determine which type of proximity sensor, ultrasonic or infrared, is more accurate at detecting the presence of an object.

Help Received

No help was received during the execution of this science project.

CALIFORNIA STATE SCIENCE FAIR
2005 PROJECT SUMMARY

Name(s)
Scott M. Elder

Project Number
S0703

Project Title
Brewster's Angle Effect on GPS Multipath

Abstract

Objectives/Goals
Brewster's angle is typically associated with light. However, it also has an effect on GPS Radio Frequency (RF) signals. When a GPS navigation signal is reflected off a material, it will change from a right hand circular polarized to a left hand circular polarized signal at Brewster's angle. If the reflected signal reaches a GPS antenna, it can cancel out the real or direct GPS signal. This is called multipath and it can cause a position error in a GPS receiver. The problem is how to determine Brewster's angle at the GPS frequency and its effect on the GPS receiver. My hypothesis states "If I can create a controlled GPS multipath environment, then I can determine Brewster's angle and determine the effect on the Global Positioning System signals for different materials".

Methods/Materials
I first created a controlled multipath environment by mounting my GPS antenna on a board and pointed the antenna towards the WAAS POR Geostationary (GEO) satellite. This satellite supplies a GPS signal but is a GEO satellite so its orbital position to earth stays the same. Also, this signal is lower power than GPS signals so it will react more to multipath. I then used different surface materials to determine their effect on the GPS receiver operations.

Results
My board was the propagation environment and it was big enough to contain the first Fresnel zone from 10 degrees to 50 degrees with an antenna height of 4 inches. Placing the board in line with the POR signal created a controlled multipath environment and tilting the board at different angles resulted in different multipath signals being received by the GPS antenna.

Conclusions/Discussion
The multipath signal did result in a disruption of signal power as I increased the angle of the board. For each surface type tested there was a complete loss of signal at a specific angle. Although this angle was not Brewster's angle, it did correspond to Brewster's angle by subtracting 7 degrees. The 7 degree difference is attributed to the internal GPS processing techniques.

Summary Statement
I determined Brewster's angle at the Global Positioning System (GPS) L1 frequency and what its multipath effect was on the GPS receiver operations.

Help Received
Dad helped with the test fixture design.

CALIFORNIA STATE SCIENCE FAIR
2005 PROJECT SUMMARY

Name(s)

Evan M. Gates

Project Number

S0704

Project Title

Rubik's Cube Solving Robot, Year Two: Faster Algorithm, Graphical User Interface, and Vision

Abstract

Objectives/Goals

The goal was to write the software and create the hardware required to autonomously solve a Rubik's cube.

Methods/Materials

The physical Rubik's cube solver was made primarily out of Plexiglas. Stepper motors were used to turn the faces of the cube. All code was written in C or C++. For the second year, the Kociemba algorithm was implemented, which works in much the same way as the prior algorithm, using iterative deepening searches, except that it works through fewer nested subgroups, cutting down the number of moves needed to solve the cube. A Graphical User Interface (GUI) was also created which added ease of use to the robot. The use of cameras has been implemented to read the state of the cube, as opposed to "remembering" it. A color recognition scheme was devised, comparing red, green and blue (RGB) values of preset sample points. For the second year, the RGB values were converted to hue, saturation and value (HSV) values, and the sample points were input by the user.

Results

There was some trouble stopping the solver from jamming. This was fixed by making all turns clockwise and slightly overshooting the goal so that the cube would self correct if slightly misaligned. The Kociemba algorithm solved the cube in roughly half the time and half as many moves as the Thistlethwaite algorithm. The GUI worked nicely, making the robot much more user friendly. The cameras worked more consistently, but still not to a point at which they can be depended on.

Conclusions/Discussion

Although the goal was reached, the project can still be improved upon. The main area that could use improvement is the color recognition algorithm. The implementation of neural networks along with an edge detection algorithm would be optimal. Now that the Kociemba algorithm has been implemented, the next step would be God's algorithm, which is still an impossibility with modern computing power.

Summary Statement

During year two of the project the Rubik's Cube solving robot was refined to use a faster solving algorithm, a graphical user interface, and visual recognition.

Help Received

Father was programming mentor and helped format final report, Herbert Kociemba provided advice on visual recognition, Mother helped create project board.

CALIFORNIA STATE SCIENCE FAIR
2005 PROJECT SUMMARY

Name(s)
Ian R. Girard

Project Number
S0705

Project Title
Solar Hydrogen Fuel Cell Future

Abstract

Objectives/Goals
I designed and built a renewable hydrogen energy system. It consisted of a photovoltaic panel, an electrolyzer, a hydrogen storage system, and a proton exchange membrane fuel cell. I tested it to find its optimum operating conditions and energy conversion efficiency. The entire system was designed to be simple enough and cheap enough to build and test in a high school classroom for educational purposes.

Methods/Materials
I built almost all of the components in my garage from materials you can buy from a hardware store. I made changes in the design of the different parts of the system to try to make it work more efficiently. I manipulated air flow, cell compression, source of oxygen and type of proton exchange membrane to see how these variables affected the voltage and current output of the fuel cell. I also tested the electrolyzer to determine hydrogen and oxygen production rates.

Results
The efficiency of the solar panel averaged only 3% because it was operating at a low voltage and a high current which was very inefficient operating point for that particular panel. The energy efficiency of the electrolyzer was 41% which is about right when compared to industrial standards and considering the simplicity of the design. The maximum fuel cell efficiency was 10%. The source of oxygen and the compression had the most affect on the cell#s performance.

Conclusions/Discussion
Each stage of the system worked well, but at low efficiencies. I was able to optimize the output of the system by manipulating operating variables in the same way you would have to for commercial systems so this system would make a realistic teaching tool. If I was going to continue working on this I would use a different kind of photovoltaic panel that is designed to run an electrolyzer. This would have the most effect on the overall system efficiency. I would also change the design of the electrolyzer to prevent mixing of hydrogen and oxygen. I would also test to see the best way to keep the cell membrane moist so the fuel cell could run without constant care. This topic is very relevant because of the need to find an alternate energy source besides fossil fuels. Hydrogen is a likely candidate so it is important for students to at least have a basic knowledge of how a solar hydrogen energy system works.

Summary Statement
I designed, built and tested a simple solar hydrogen fuel cell system that can be used for educational purposes.

Help Received
I got advice on design and testing from the Schatz Hydrogen Energy Research Center. My dad supervised me when I was testing the system especially with handling the electrolyte. A lot of businesses donated or loaned the materials and testing equipment I used.

CALIFORNIA STATE SCIENCE FAIR
2005 PROJECT SUMMARY

Name(s)

Corie Holland, Jr.; Freeman C. Outlaw, III; Jose Partida, Jr.

Project Number

S0706

Project Title

Hydrogen Fuel Cells

Abstract

Objectives/Goals

The objective of the project was to conduct internet research, and laboratory experimentation to study the theoretical principles behind fuel cells, and study their practical applications in the real world.

Methods/Materials

Fuel cells were assembled and connected to solar modules, electrolysers, load measurement boxes, multimeters and other equipment to conduct the following experiments to determine the following:

a. Characteristic curve of a fuel cell.
b. Faraday efficiency and energy efficiency of the fuel cell.
c. Impact of catalyst concentration on the characteristic curve of the fuel cell.
d. Impact of gas input on the characteristic curve of the fuel cell.
e. Impact of total resistance on the characteristic curve of the fuel cell.

Results

Fuel cells have the following advantages in the development of a Hydrogen-based economy

a. Fuel cells are efficient.
b. Fuel cells are clean.
c. Fuel cells are quiet.
d. Fuel cells are modular.
e. Fuel cells are environmentally safe.

Conclusions/Discussion

As our demand for electrical power grows, and non-renewable sources of energy are getting depleted, there is a need to find new ways of meeting this demand safely and responsibly.

With the use of fuel cells and hydrogen technology, portable electrical power from renewable energy sources can be delivered cleanly, efficiently and sustainably.

Summary Statement

This project explores the use of fuel cells and hydrogen technology, to produce portable electrical power from renewable energy sources, cleanly, efficiently and sustainably.

Help Received

The project was conducted under the guidance of our Science Teacher, Mr. Avinderjit Bindra, using fuel cell components and equipment provided by a grant awarded by BP America and National Energy Development (NEED) Project.

CALIFORNIA STATE SCIENCE FAIR
2005 PROJECT SUMMARY

Name(s)

Asmita Kumar

Project Number

S0707

Project Title

New Organic Dye-Sensitized Photovoltaic Cell for Simultaneous Photon Energy Capture, Conversion, and Storage

Abstract

Objectives/Goals

To modify Grätzel type blackberry anthocyanin dye-sensitized photovoltaic cells and to improve the ability of the cell to simultaneously capture, convert, and store photon energy.

Methods/Materials

Grätzel type photovoltaic cells were made with ITO glass and KI/I electrolyte. Control cells had one electrode composed of a mesoporous titanium dioxide layer with absorbed blackberry anthocyanin dye and a graphite catalyst electrode. Modified cells included additional porous layers of silica gel on either or both control electrodes, the twin layers separated by tissue paper. Trial modifications also included carbon black or mixtures of carbon black and silica gel in layers on the control electrodes. Control and modified cells were tested for photovoltaic effect under halogen light and in darkness.

Results

All cells showed an ability to convert photon energy into electrical energy. After halogen light charging and storage in darkness, control cells showed energy supply with weak no load power of 2.25x10^-11 W/cm^2. The no load power of silica gel modified cells under similar dark conditions was 1.4x10^-9 W/cm^2, with maximum recorded power of 6x10^-8 W/cm^2 under load. Cells with carbon black layers showed a reversal of electrode potential in light and dark conditions.

Conclusions/Discussion

Organic dye-sensitized photovoltaic cells can capture, convert, and store photon energy. The storage capacity of standard Grätzel type photovoltaic cells is low as indicated by power under no load. This poor storage is attributed to the low amount of electrolyte and to the absence of sufficient dielectric material in the standard cell. The power capacity can be increased by modifying a standard cell using mesoporous silica gel layers on both electrodes with a porous paper separator. This modification potentially increases the amount of electrolyte and the amount of dielectric material in the cell, leading to improved storage capacity.

Summary Statement

The overall energy conversion and storage performance of organic blackberry dye-sensitized photovoltaic cells was improved by increasing electrolyte containment and capacitance through additional porous dielectric layers.

Help Received

Dad helped with heating of samples in kiln and provided supervision. Michael Reidy of Hartford Glass provided free glass, electrolyte, and titania. Sorbent Technologies provided free silica gel.

CALIFORNIA STATE SCIENCE FAIR
2005 PROJECT SUMMARY

Name(s)
Vinhcent H. Le

Project Number
S0708

Project Title
The Effect of Varying Parabolic Reflectors on the Amplification of the Signal to Noise Ratio of 802.11g Devices

Abstract

Objectives/Goals
To determine the effect if any, varying the width of Linear Locus Parabolic Reflectors have on the amplification of the signal to noise ratio of an 802.11 wireless signal.

Methods/Materials
Materials:
Aluminum Sheet Metal, Ruler, Styrofoam, Electrical Tape, Scissors
Razorblade, Knife, Wireless Router, Wireless Laptop, Netstumbler Wireless Fidelity Tester, Stopwatch, Parabolic Template

Methods:
1.) Using the parabolic template make 3 sizes of reflectors
2.) Using the template cut styrofoam support braces according to template dimensions
3.) Tape the aluminum metal onto sytrofoam support
4.) Attach finished reflectors to a wirelss router
5.) Use netstumbler in order to test signal to noise ratio

Results
Avgs. Group 1 Group 2 Group 3 Group 4
Trial 1 -45.86 -29.71 -29.86 -29.86
Trial 2 -51.71 -30.29 -31.14 -28.43
Trial 3 -50.57 -25.43 -31.43 -35.14
(Units for numbers is db)

Conclusions/Discussion
Upon the completion of this experiment the hypothesis was proven correct. It could be seen that an 802.11g antenna used in conjunction with a 16.5 cm parabolic reflector would boost the signal to noise ratio of a wireless signal the most. Without the use of the parabolic reflectors the signal to noise ratio of the control group averaged about -49.38 dB. The 12.5 cm parabolic reflector group boosted the signal the least with an average SNR reading of -31.14 dB, in comparison the signal to noise ratio of the 14.5 cm parabolic reflectors had an average signal to noise ratio of about -30.81dB. Group 2 which was the 16.5 cm parabolic reflector group boosted the signal to noise ratio by close to 21 dB and had an average signal to noise ratio of -28.48 dB. So the experiment supports the idea that the greater surface area a parabolic reflector has the better it will perform. Group 2 had the largest surface area and performed the best and the

Summary Statement
Finding effect parabolic reflectors have on wireless internet signal quality.

Help Received

CALIFORNIA STATE SCIENCE FAIR
2005 PROJECT SUMMARY

Name(s)
Noel L. Lopez

Project Number
S0709

Project Title
A Revolution in Electrostatic Motors

Abstract

Objectives/Goals
This project involves various stages and fields including Engineering/Mechanics, self-taught "C-Windows" Computer Programming, Electronics, and Mathematics. My primary goal is to improve the power electrostatic motors can transfer to demonstrate their usefulness and utilize the million to billion kilowatts of electrostatic charge our atmosphere contains. Existing designs are weak and impractical. I decided to build my own Computer Numeric Controlled (CNC) Router to cut precision models and compare my results to the strongest existing version, the Corona Discharge Motor, developed and tested by Professor Oleg D. Jefimenko and graduate students in the 1970's.

Methods/Materials
I started this research after believing I invented a new electric motor. Although I did not create the Electrostatic Motor, I decided to continue the historic efforts of scientists such as Benjamin Franklin and Professor Jefimenko. Last year I tested my first working designs, powered using an 18,000 Volt transformer. I measured output in Watts by having each motor pull a 5-gram weight. The established Corona Motor performed best.
This year I wrote C-Language programs (without shortcuts) for my CNC Router and testing. I designed, built, cut, drilled, and soldered every aspect of the Router System. For the Regional Science Fair I still had to build versions of my aluminum cylinder rotor by hand to compare with last year's models. I am constructing precision models of my successful Aluminum Cylinder Motor along with additional designs. I also plan to measure Voltage and Amperage and design a tower to harness the atmosphere's energy.

Results
In last year's tests, the Corona Motor exhibited the most power, at 0.98 mW. This year, two series of test runs with hand-built models proved that my optimized Aluminum Cylinder Motor effectively produces 2.6 mW, over twice the power of the Corona Discharge Motor.

Conclusions/Discussion
Tests of precision models with rows of brushes surrounding their rotors should yield similarly successful results. Unlike my hand-cut models using only 2 brushes, this should greatly improve power, as Jefimenko demonstrated with his 4-in. Corona motor containing 40 brushes that produced 1/10 hp.
I am confident the aluminum cylinder design, along with my tower concept and other ideas I have yet to test, will help meet the world's rising energy requirements and create "A Revolution in Electrostatic Motors".

Summary Statement
I have developed an electrostatic motor that has tested more powerful than existing designs, and has a potential for accessing a new alternative energy source.

Help Received
Plastic, metal, and funds donated by local companies and individuals; younger brother and mother provided minor assistance; Oleg D. Jefimenko provided some background information.

CALIFORNIA STATE SCIENCE FAIR
2005 PROJECT SUMMARY

Name(s)
James (Jiajun) Luo

Project Number
S0710

Project Title
Comparison of the Efficiency of Gauss and Rail Guns

Abstract

Objectives/Goals
One of the most interesting and useful applications of magnetism is to accelerate objects at tremendous velocities using magnetic accelerators. The two most are the Gauss Gun and Rail Gun. However, there has been no actual comparison of the efficiency of these two guns, only blind amplification by various institutions. Thus, the goal of my project is to determine which accelerator is actually more efficient, and in what scenarios and environments, to put an end to blind amplification.

Methods/Materials
I constructed the Gauss Gun by using a plastic 12.75-inch long tube, copper coils, and electric receivers. I constructed the Rail Gun using wood and copper tape as the rails, and used a solid-state magnet as a boost for the magnetic field. I used a power source that provided 10 amperes at 40 volts, and I also constructed a graphite switch to efficiently connect the circuit. To fire the accelerators, I quickly completed the circuit using the switch and then disconnected it. I conducted five trials each for the two guns using projectiles of the same dimensions (a copper and a metallic one). Then, I calculated the velocity in meters per second by using mathematic equations for the two guns.

Results
Through experimentation, I discovered that the Gauss Gun allows projectiles to launch projectiles at higher speeds and farther distances when the guns are smaller. The average distance for the Gauss Gun was 245 cm. The Rail Gun's average distance was 52 cm. The theoretical velocities for the accelerators also confirmed my experimental results. However, through analysis of the equations and various difficulties during experimentation with the Gauss Gun, I found that when the launchers are increased in size, the Rail Gun becomes more pragmatically efficient than the Gauss Gun because of physical properties.

Conclusions/Discussion
I concluded that the Gauss Gun is better for small-scale purposes while the Rail Gun is better for larger scale purposes. This is due to the effect of length on the velocity and distance, heat generation, and extreme inconsistency with the Gauss Gun. Although these accelerators are already more promising than most other launching mechanisms, the reason why they are not used currently is because of the aforementioned temporary difficulties with the Gauss Gun, the rail erosion of the Rail Gun, and not knowing which is more efficient.

Summary Statement
The focus of my project is to compare efficiencies of the accelerators to put an end to blind amplification and allow for the advancement of these promising launching mechanisms.

Help Received
Seung Jung helped measure distance; Used lab equipment at California State University Los Angeles under the supervision of Professor/Doctor Oscar Bernal.

CALIFORNIA STATE SCIENCE FAIR
2005 PROJECT SUMMARY

Name(s)
Guanxiong Mao; Maxwell Radin; Daniel Ram

Project Number
S0711

Project Title
Digital Telescope Utilizing Tomography

Abstract

Objectives/Goals
The purpose of the project was to construct a prototype of a digital tomographic telescope that could capture images of targets as far as one hundred feet away as an inexpensive alternative to telescopes that use lenses and mirrors.

Methods/Materials
The mechanism consisted of an illuminated target, a rotating disk with a slit in it, and a light sensing unit that recorded the intensity of light passing through the slit as the disk moved. A series of complex computer programs processed the data using several algorithms based on linear algebra to produce an image.

Results
The prototype was able to image simple shapes as well as complex patterns of geometric arrangements.

Conclusions/Discussion
The project demonstrated that telescopic tomography can be used to capture images digitally. Theoretically, the imaging power can be increased by increasing the size and precision of the apparatus. This technology could be applied to many fields, such as astronomy, topography, and military intelligence.

Summary Statement
The aim of the project was to build a digital telescope that uses tomography instead of lenses or mirrors.

Help Received
Father (Lon Radin) helped construct electronics and operate the mechanical components

CALIFORNIA STATE SCIENCE FAIR
2005 PROJECT SUMMARY

Name(s)
Vasco H. Morais

Project Number
S0712

Project Title
The Effect of Temperature on PEM Hydrogen Fuel Cell Efficiency

Abstract

Objectives/Goals
My hypothesis was: If the temperature of a proton exchange membrane (PEM) hydrogen fuel cell were increased in the range of 9°C to 40°C, then electrical output in voltage (as a measure of efficiency) would increase as well (a direct relationship).

Methods/Materials
A PEM separates the protons and electrons in hydrogen atoms, freeing the electrons to travel via a circuit generating electricity for electromagnetic applications, emitting no waste or by-products other than heat and water vapor.

For the experiment, the fuel cell was stored in the freezer until its temperature dropped to 9°C. A hydrogen tank was attached to the fuel cell and a multimeter was attached to the electrodes on the fuel cell, displaying the voltage. I recorded the voltage for each degree as the temperature rose from 9°C to room temperature (23°C). I then used a blow dryer to increase the temperature to 40°C and recorded the voltage for each degree as the temperature decreased from 40°C to room temperature (23°C).

Results
My hypothesis was refuted. My results displayed an indirect linear relationship.

Conclusions/Discussion
I found the 9°C to be the optimum temperature for maximum efficiency. Electrical applications using fuel cells would not be running at optimal efficiency at room temperature.

Summary Statement
The experiment tested the effect of temperature on voltage output of a PEM (Proton-Exchange Membrane) hydrogen fuel cell.

Help Received
I was assisted by my father in obtaining the materials, my science teacher helped develop the experimental procedures, and my parents helped edit my report. It took two people to run the experiment, so while my dad read the data values aloud, I recorded the data.

CALIFORNIA STATE SCIENCE FAIR
2005 PROJECT SUMMARY

Name(s)
Linnea L. Motts

Project Number
S0713

Project Title
The Influence of Periodic Structure of Colloidal Crystals on Indium Tin Oxide using Optical Gradient Forces

Abstract

Objectives/Goals
The experiment investigated whether plasmon oscillation of Ag plasmons with an ideal resonance frequency of 410nm would diverge more of the normally nondiverged Heaviside energy flow, free flowing EM energy from a dipole that usually does not interact with anything to any significance and is thus wasted. By oscillating the Ag plasmons, more EM energy is diverged onto the particles which are attached to an ITO substrate used as an electrode.

Methods/Materials
Using a UV light source with a gradient, colloidal silver plasmons were deposited in an ordered array on ITO film, which was later used as an electrode in a colloidal battery with a silver colloid electrolyte. The colloidal battery consisted of a magnetic field, electric field, and a UV light source all perpendicular to each other. Three UV light sources were tested - UV LED, UV lamp, and a 409 nm laser each with different wavelengths. Once the Ag colloids are deposited onto the ITO film, they are refered to as Ag plasmons.

Results
The data supported the hypothesis in that the battery configuration Ag colloids on ITO film deposited in an ordered array resulted in the greatest power output of the electrodes tested. The results were extremely promising in that with all three light sources, there was a percent increase in power output of about four hundred percent. To increase power output and efficiency, the colloids or surface plasmons must be arranged in a very ordered array to minimize random movement and consequent power loss. Consequently, the experiment supports the ability to diverge more Heaviside energy onto Ag plasmons, thus creating a "super battery" that has a greater power output than would a battery without the oscillation of the Ag plasmons.

Conclusions/Discussion
From the experiment, it is safely concluded that the fabrication of the electrodes is very significant to the power output of the colloidal battery. With more sophisticated technology available, the experiment would undoubtedly produce much more impressive results. The experiment also showed that the colloidal battery has some storage capabilities; hence, the colloidal battery could also be considered a wet cell storage device. The plasmon oscillation could also be used in conjunction with a PV cell. Instead of merely converting light energy into electrical energy, a PV cell with plasmon oscillation could potentially store charge generated from light energy.

Summary Statement
The experiment investigated whether more energy can be diverged onto Ag surface plasmons on electrodes in a battery through plasmon resonance frequency.

Help Received
Father provided materials used in experiment.

CALIFORNIA STATE SCIENCE FAIR
2005 PROJECT SUMMARY

Name(s)
Stephanie N. Phillips

Project Number
S0714

Project Title
A Study Using Different Concentrations of a Ferrofluid to Model the Effectiveness of E-Ink in Electronic Paper

Abstract

Objectives/Goals
The purpose of this experiment is to determine the ratio between the oil and the electrically charged particles in electronic paper.

Methods/Materials
The ferrofluid dilution with greatest amount of ferrofluid and the least amount of added oil was expected to attract the greatest amount of iron particles to the magnet.
The amount of ferrofluid attracted to a magnet will be used to determine how concentrated the electrically charged particles should be in e-paper.
A magnet was rolled under each glass ball, filled with an oil/ferrofluid mixture. When the ferrofluid had stopped settling, the magnetic liquid at the bottom of the ball and some of the surrounding water were extracted. Because the two liquids are immiscible, the total amount of ferrofluid in the graduated cylinder was recorded as the approximate amount of magnetic liquid attracted to the magnets.

Results
The results indicated that the hypothesis was basically correct. The amount of ferrofluid attracted to the bottom of the balls by magnets was negatively proportional to its dilution. The balls of the first set were filled with 0.80 ml water, 1.00 ml ferrofluid and no oil. The average amount of ferrofluid attracted was 0.99 ml.
2nd Set (0.80 ml ferrofluid and 0.20 ml oil): 0.99 ml
3rd Set (0.50 ml ferrofluid and 0.50 ml oil): 0.37 ml
4th Set (0.20 ml ferrofluid and 0.80 ml oil): 0.20 ml

Conclusions/Discussion
These results may have occurred because the concentration of iron filaments in the fluid is greater without added oil. However, the ferrofluid/oil mixture had a tendency to bubble, giving the appearance of a greater volume than ferrofluid alone. Lessening the concentration of electronically polarized ink or particles, relative to magnetic fluids in this experiment, would be beneficial to E-paper's design. Without significantly losing visual quality, a small dilution of the ink would be more cost efficient.

Summary Statement
The purpose of this experiment is to determine the concentration of the electrically charged particles in electronic paper using ferrofluid as a model.

Help Received
Parents financed the experiment; Mother helped clean beakers after each trial; Ms. Susan Hinton sent sample of Gyricon SmartPaper.

CALIFORNIA STATE SCIENCE FAIR
2005 PROJECT SUMMARY

Name(s)
Arjan S. Puniani

Project Number
S0715

Project Title
Energy Conversion in the Internal Combustible Engine via Thermopiles: Waste Heat to Electrical Energy

Abstract

Objectives/Goals
Automobiles are notorious for their fuel inefficiency, utilizing only 13% of the total amount of fuel for locomotion, while 62% is lost as the engine itself is incapable of harnessing the tremendous force released from igniting gasoline and compressed oxygen. The remaining 25% is consumed for the coolant and alternator. My project utilizes thermocouples, which are devices for measuring temperatures, consisting of two dissimilar metals that are electrically joined at one end. When one junction is hotter than the other, a thermal electromotive force is produced that is roughly proportional to the difference in temperature between the hot and cold junctions. I used these thermocouples to convert that waste heat emission into useable, electrical energy. My hypothesis states that this may very well be a possibility to the improvement of fuel efficiency in automobiles.

Methods/Materials
After wiring the thermocouples in a series to achieve an accumulative voltage output, also known as a thermopile, I secured the conversion tool with fiberglass insulation on the muffler. I then extended the range of the thermopile from underneath the Pontiac Firebird (model automobile) with copper wiring to keep track of the engine temperature from the dashboard. A voltmeter measured the voltage output and a thermo-gun was used to determine the temperature of the muffler. I then recorded both numerical values.

Results
The initial results were quite straightforward: the higher the temperature, the higher the voltage output, indicating a positive correlation. However, as the experimentation progressed, high muffler readings were paired with lower voltage output in comparison to other trials. As the difference between the reference and measuring junctions decreased, the voltage negatively correlated.

Conclusions/Discussion
The plausible mechanism explaining this inconsistency is the lack of ambient air to create a high enough difference for maximum voltage output. However, the purpose of the experiment--to determine the possibility of harvesting electrical energy from waste heat of the automobile--was suggested true. Future application of these results includes actual, calculated fuel efficiency and multiple thermopiles in critical heat locations.

Summary Statement
The purpose of my experiment is to propose a possible solution of automobile fuel inefficiency by converting the waste heat emitted from the internal combustible engine into useable electrical energy.

Help Received
Mr. Bob Gatzman provided the testing environment and model, as well as the measurment tools; Mr. Wayne Garabedian provided invaluable insight to board design and layout; my parents, Trilok and Navjit, provided the monetary funds for the board and other supplies

CALIFORNIA STATE SCIENCE FAIR
2005 PROJECT SUMMARY

Name(s)
Christopher F. Weyant

Project Number
S0716

Project Title
Improving the Performance of Proton Exchange Membrane (PEM) Fuel Cells through Design Modifications

Abstract

Objectives/Goals
My objective is to improve the performance of Proton Exchange Membrane (PEM) Fuel Cells. The ideal thermodynamic voltage limit on PEM fuel cell performance is approximately 1.23 Volts. Activation, ohmic, and mass transport losses in fuel cells lead to reductions in voltage as loads are attached to the electrodes and current is drawn.

Methods/Materials
I modified the flow plate/anode of a fuel cell from a kit by changing the size of the holes in the anode flow plate. I also added flow channels with various other geometries (e.g., parallel or inter-digitated patterns with various channel depths and widths). I varied the load on the cell by adding resistors with a range of resistances to the external electrical circuit, and measured the resulting voltages and currents. I drew I-V and Tafel plots for each design. I also used a 2-D fluid mechanics approximation of flow in a channel to model concentration losses along the flow channels.

Results
The linearity of the Tafel plots based on the Butler-Volmer equation shows that the initial voltage losses resulting from current increases are largely activation losses. My results for the different flow plate hole sizes show that the greater the total hole perimeters there is in a flow plate, the lower the activation losses and the better the fuel cell performance (less reduction in voltage for any level of current). Although experiments with alternative flow channel designs are continuing, initial results suggest that smaller flow channels reduce both activation and mass transport losses.

Conclusions/Discussion
I used electro-chemistry and fluid mechanics laws governing fuel cell performance to try to predict the performance of the fuel cell kit as I modified it. I also used existing theoretical and experimental results in picking my designs. Through this process I was able to substantially improve the measured performance of a PEM fuel cell kit by making design modifications.

Summary Statement
I improved the performance of a PEM fuel cell through design modifications.

Help Received
Mr. Tim Holme, a graduate student at Stanford University, provided me with feedback and references.