

PROJECT:
GLUV

(Great Lakes Underwater Vehicle)

CODE NAME:
DEEP PURPLE

(aka "Smoke on the Water")

The Purple Gang:

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Alpena High School, Alpena MI

ABSTRACT

Alpena, Michigan, a rural city located 250 miles (402 km) north of Detroit, with a population of 10,000 is proud to be sending a team of its youth to the 4th Annual ROV Competition for High School and College Students.

Twelve students from Alpena High School developed an underwater remotely operated vehicle. This vehicle was built and designed to perform three specific underwater tasks as stated in the “Mission Specs” designated by Marine Advanced Technology Education as part of their ROV competition. These tasks include closing an underwater oil valve, reconnecting a broken fiber optics line, and adding on an attachment to the Hubble telescope.

The team’s acronym is GLUV (pronounced glove), which stands for Great Lakes Underwater Vehicle. Team members range in age from fourteen to eighteen years.

DESIGN RATIONALE

Frame:

Our first concern in the construction of the underwater remotely operated vehicle this year was to design a structure large enough to complete the challenge of the assigned tasks but stay within the limits stated in the design specifications with special emphasis being placed on both stability and maneuverability.

We started the year with a great amount of optimism and energy. We were starting early enough that we thought that would be able to build two completely separate models, have several “sea trials” and then decide, as a team, which vehicle we would like to enter into competition. In hindsight the quote “What fools these mortals be...” by Shakespeare comes to mind.

From the beginning, there were two separate camps of thought: one took on a traditionalistic design approach, and the other a more minimalistic approach. Our traditionalists decided to build their ROV with a 1/4-inch (.635 cm) CPVC pipe in the tried and true box shape. It’s dimensions were approximately 40 cm x 50 cm, with it being slightly taller than it was wide. The initial concern (brought up by the minimalists) was that with these dimensions, it would lack the stability needed to perform the tasks put forth in the competition specs. The traditionalists responded by drilling holes into the pipe so that it would fill up with water at a uniform rate, thus reducing the amount of instability it had while submerged. However, this made the structure extremely heavier. So heavy in fact that the vertical lift motors were unable to propel the craft. After several attempts were made to lighten the structure, the final version of the frame was in no way similar to the beginning structure. It was under half the size of the original. Serious doubts were raised at that point regarding whether or not this version would be able to physically perform the arduous underwater tasks.

The minimalists built their ROV frame with $\frac{3}{4}$ inch (1.905 cm) PVC pipe. It started out as four pieces of pipe connected by 90-degree PVC elbows. To this basic frame they added six legs made out of the same $\frac{3}{4}$ in (1.905 cm) PVC with thoughts of adding to their own stability. Their next concern was what type of sub frame they would need to mount their various apparatus used to complete the tasks. This took some guessing on the part of the team. When this part was initially being designed there was only speculation on what our tasks might be. A simple sub frame in the shape of a box was decided upon. The feeling was that it would be best to keep it as simple as possible and that it would be easier to make adjustments as needed at a later point.

Next came the initial in-water testing of the minimalist's creation. The traditionalists had already seen their design shot down and were almost looking forward to the failure of the second model, perhaps just to gloat just a tad. The design proved to be stable, with very little roll and yaw present, in the beginning. After the first few minutes however the telltale sign of bubbles started appearing, throwing the vehicle off-pitch. At this point the team was faced with a decision; to drill holes into the structure to let the water fill in the pipes at a constant rate, or to make the craft waterproof. Learning from the other group's mistakes, it was decided to reseal all joints and connections.

Retrieval:

When the mission challenges were posted, the focus shifted to how to be able to hold onto a variety of objects from the surface and let them go underwater. Again, our main objective was to keep it as simple as possible. There were several ideas of building a complex robotic arm that would be controlled by hydraulics and rotated on servomotors. After two weeks of research and development the idea was abandoned and we were back to the drawing board. The story of how the next idea came about is a bit bizarre. Our mentor and her daughter (also a MATE ROV

alumnus) were having a dueling match with salad tongs during the Thanksgiving holiday (we know, they're weird). After several bruises were incurred they were told to knock it off and get back to making the salad. At this point they discussed the next mission scenario and what needed to be done. The salad tong arm was born. To the salad tongs an electromagnet made out of a metal rod and wrapped with copper wire would be added to keep the tongs in the closed position. When the power was turned off, the spring loaded action of the salad tongs would move them apart, thus letting go of the items that would be placed between them.

Problems arose when trying to build the electromagnet that would hold the salad tongs together. The basic principle of an electromagnet is a simple one. When DC power is applied to a coil wrapped around a metal core, the core is magnetized and an electromagnet is produced. We chose copper wire for our electromagnet since it is one of the best conducting wires due to its free electrons. The core was a 3/8th inch (0.953 cm) by two-inch (3.08 cm) bolt with nuts and washers on either end. Everything was going along swimmingly until we started wrapping the wire. To get the amount of power needed to keep the salad tongs closed we required a fair amount of wire wrappings around the metal core. Keeping the wires tightly wound proved difficult, and we were also unable to get the amount of power needed. The team was sold on the idea of an electromagnet, but we needed to go back to the drawing board to figure out how to make one strong enough. On one very helpful Internet web site the very first sentence provided us with the answer we needed. It stated "An electromagnet, also known as a solenoid....." (<http://howstuffworks.com>). Eureka! We had solenoids!

Nestled in the back of one of the cupboards in the physics lab were six solenoids whose previous life consisted as a part of a now defunct class called Principles of Technology. We

modified one of these solenoids to fit what we wanted to do with it. These modifications included waterproofing and having another “plunger” with a longer shaft made.

Propulsion:

Building on previous years experience we decided to keep our propulsion system similar to what was used in the past. Modified bilge pump motors that have the capacity of pumping 500 gallons (approximately 1895 liters) of water per hour is used to power our ROV. There are a total of four motors attached to the ROV. Two are mounted horizontally for forward, reverse and right and left turning. The remaining two motors are mounted vertically in order to provide enough power to submerge and bring the ROV back to the surface. It was rationalized that since our ROV would be just negatively buoyant (floating just under the surface of the water at rest), that we would need the most thrust to reach the mock-ups of the three different mission scenarios. Also, with the added weight of the solenoid (0.35 kilograms) we would need the extra thrust to return to the surface.

We chose bilge pump over other types of motors because of the fact that they were already waterproof. Last year’s experiments with different types of motors and waterproof housings turned out to be expensive in both money and time.

The new innovation for this year was to break the bilge pump casing down to the point where the shaft of the motor was accessible. Once this was accomplished we designed a coupler that could be attached to the shaft and a 1 ¾ -inch (4.44 cm) right and left turning brass propeller. We believed this process would give us greater propulsion than the traditional, unmodified, and ungainly bilge pump than had been used in the past. Upon testing, our hypothesis was proven to be true. Adding the propeller to the bilge pumps motors did increase our rate of propulsion. The

vertical lift motors worked beautifully, we would easily be able to submerge and return to the surface.

Another improvement was that we chose bilge pumps that would be easily mounted through the PVC frame with the use of 2-inch (3.08 cm) bolts and nuts. The motors lock onto the mounting system with an easy twist. This provides for easy removal and replacement of motors if needed.

The motors were initially controlled through a 12-volt variable speed controller. We believed that by doing so, the motors would no longer have to run at full power at all times, which would give the driver more control over how fast each propeller would be turning.

However, during our tests, it was found that the variable controllers were no accurate. Given the load put on the motors, the controllers were generally either sluggish or completely unresponsive in some cases. We changed the control at the last minute to double pull double throw switches.

Tether Management:

The final step in building our ROV was finalizing and stabilizing the tether. Due to lessons previously learned regarding tether management, we tried to use the minimum amount of wiring possible with the smallest gauge of wire. We started our research by going to a local shop that rebuilds motors for our industrial community. We were shown various charts that would enable us to calculate the smallest gauge wire we could use while not losing too much power through voltage drop. It was calculated that 18-gauge speaker wire would work well for our purposes. This gauge of wire was also very flexible which would allow us to turn tightly enough so the ROV wouldn't get bound up in its own tether.

We were also aware that the cord needed to be buoyant so as not to weigh down the ROV. “Fun Noodles” (purchased at a local toy store) spaced evenly along the length of the tether served the purpose of flotation. Alpena is lucky enough to be the home of the first fresh-water marine sanctuary. When we return home from competition we plan on assembling the team and videotaping several shipwrecks with our ROV and therefore the longer tether will come in handy.

Navigation

The one area that we did not alter from the previous years was our underwater camera. Since the inception of MATE’s underwater ROV competition we have used the *Intellicam Black and White Underwater Camera*. This camera proved to be extremely hardy, durable and inexpensive. The camera was so hardy that we are still using the camera from our first year of competition in Florida. To this camera we will be incorporating another *Intellicam*. One camera will be used for driving the ROV and the second will be placed to more closely view the receptacle for the uplink portal.

CHALLENGES

One of the first challenges we had to face was our own inexperience and naiveté. At the beginning we felt that we could easily create an ROV to fit the specifications within a matter of months. Technically, this was true, but we forgot about how the dynamics of a large group work. The group was comprised of twelve students ranging in age from fourteen to eighteen years of age. Many were new faces and the first few organizational meetings took the form of a social gathering more than a plan-of-attack session. There were also personal schedules to accommodate. There were dental appointments, doctor appointments, practices for various sports, and of course the all-important job. There were also the seasonal attacks of head colds, influenza, and even a case of mono nucleosis. There were some team meetings when only two or three people would show up. The team had problems with getting things done in a timely manner.

After Christmas Break our mentor brought up what had happened to last year's team. Their behavior at the beginning of the year was very much like ours was. They procrastinated and treated work time as if it was some social club they were attending. The few people that did do work weren't able to do it all. As a result, they did not even come close to completing construction on their ROV. Alpena High School did not have a team competing in the national ROV competition for the first time since its inception. This was the motivation that we needed. We all wanted to see what a national competition would be like, we wanted to represent our school, and we wanted to travel to Houston. It was now time to get serious.

One of the more technical challenges that we faced was our lack of knowledge in a variety of aspects needed to design and build a working underwater vehicle. For many on our team this was the first time that they had even touched a power tool. It was also made readily

apparent how precisely we needed to measure. “Give or take a quarter inch” no longer fits into our vocabulary. We now realize that our measurements need to be exact as possible, with as little error as possible; hence our team motto “Measure twice, drill once.”

Another part of our knowledge that needed help was our vocabulary. Fuses, amps, volts, schematic, buoyancy, tether, and drag were all part of a language we knew nothing about. For instance, one of our team members, who shall remain nameless (read Josh), was pronouncing bilge pumps as “billage pumps” (billage as in village). After months of corrections from the team and mentor, Josh finally pronounces it correctly. That was one of our easier difficulties to overcome. The team members literally had a lot to learn in order to figure what they needed to know so that the ROV would work. There were times when members of the team were just downright scared of making an electrical connection, thinking that the whole thing would blow up. After assurances and back-up checks by Mrs. Spain we became more confident in what we were doing. Our ignorance may have been a challenge this year, but with the average age of our team being so young, it will be a benefit to us next year.

TROUBLE SHOOTING TECHNIQUES

The techniques that we used were to discuss the design, attempt to build it and then test it. If we failed, we either modified or completely redesigned, depending on the severity of the flaw. Mrs. Spain's physics classroom was used as our building and parts test center. At this location we were able to access multi-meters, soldering irons, batteries, tools, and the all-important duct tape.

This year it was decided that we would splurge on our own ability to test the ROV more fully without having to pack everything up and leave the classroom. For \$196.00 the team purchased a 396-gallon (1499 liters) galvanized steel livestock-watering trough that had a 6-foot diameter (1.83 meters) and a depth of 2 ½ feet (0.76 meters). This trough was proudly placed in the back of the physics classroom. From this purchase the team also learned a bit of chemistry. After the first week of having the tank filled with tap water, it became apparent that some pool cleaning supplies would be needed.

With our trough in place we started testing. The camera was tested in the dark, the motors in the trough, and the arm's multiple discussions and drawings, on the board. Once everything was found to be working, we attached them to our model and field-tested it first in our own beloved trough and then in Alpena County's plaza pool, which is, fortunately, attached to the high school. Once in the pool we were able to observe problems that arose due to the deeper water provided in the pool.

IMPROVEMENTS AND LESSONS LEARNED

Even though this will be the third year that our team has participated, we still have a great deal to learn. Next year, our team will need to strive to be more organized and begin preparations earlier. We have all learned that things get done when deadlines are set, and reinforced! The returning members of the team will be able to help and guide next year's team members and pass along information gained from this year's experiences.

One of the areas of improvement that will need to be addressed in the future is the propulsion system. Our current method of propulsion is sufficient, but there is always room for improvement. One of the ideas we would like to explore is the use of rotating servomotors that we would be able to use as trimming mechanisms. While not practical with this year's designs (or our abilities) we believe that with this system in place we would no longer be bound to the idea that we would need a separate motor for vertical movement, thus cutting down the diameter of the tether, the weight, and the bulkiness of the ROV. Plus the ultimate goal of our group is to build something that closely resembles "Little Herc", with his maneuverability and stamina.

Another idea that we are currently trying to incorporate into our design for this year's competition is using five strand telephone wire for our tether. We believe this would make for a lighter and more flexible tether. What we need to calculate before implementation is whether the wire can withstand the amount of voltage and current that would be required to power our ROV.

ACKNOWLEDGEMENTS

Team G.L.U.V. would like to acknowledge our mentor, Kristen Spain, Alpena High School physics teacher. Without her there would be no team GLUV. When we consider how much of her own time she has given to this project, and us, we are humbled as a group to realize that she thinks so much of us and help us with what we're trying to accomplish. She was the driving force behind team GLUV, making sure we kept on task and got our work done.

Another person that we must thank is Cathy Green from Thunder Bay National Marine Sanctuary and Underwater Preserve. She has put in countless hours in organizing and planning Michigan's first regional competition to be held May 7, 2005 right in our own backyards. Cathy has shared her knowledge and has enlightened us all to the amazing field of underwater preservation and research.

Our parents have also played an important role in our ability to compete. Putting up with us constantly talking about our project (even though they probably didn't have a clue as to what we were talking about), shuffling us back and forth after school and the loan of some of their ideas has truly helped make this team what it is, an extended family. One father in particular, Dave Fisher, has given countless hours and has shown great patience with taking our team members under his wing and showing us how to work together to achieve our common goal.

We have also had some generous supporters that have helped to make all of this happen. Even though Alpena's economy continues to be in a rather dire position, several local businesses and individuals found the ability to support something that they strongly believed in: the youth of Alpena. These businesses included Basic Communications, Alpena Glass, Bank of Alpena, Independent Bank, Creative Creations, and Alpena County Plaza Pool.

We would also like to take this opportunity to thank Marine Advanced Technology Education and Jill Zande. They have opened up new horizons to many students who would not otherwise get the chance to learn about educational and vocational opportunities within the marine exploration field.

Lastly, we would like to thank the individual members of our group. We all gave many hours of our time, had to deal with significant others who became jealous of all the time we were spending together, dealt with people who thought we were nerds, dealt with short tempers, and agonizing headaches. And because of all the shared experiences we've had, it has made us stronger. Thank you one and all for making this possible.

Diving Deeper.....The Hubble Space Telescope

The Hubble Space Telescope, put into orbit in 1990, will stop operating and eventually tumble back to earth sometime after 2007 (<http://www.newsinfo.nd.edu>) without some type of intervention. Hubble has produced amazing glimpses of what lies beyond our own cluttered view of the universe.

The fate of Hubble became a great concern when space shuttle Columbia disintegrated upon re-entry into the atmosphere over Texas. Without a viable space shuttle program there was no way that Hubble could be serviced. There is now renewed hope for the Hubble due to breakthrough technology being developed at Goddard Space Flight Center, located in Maryland (The Alpena News, April 28, 2005). Engineers there are running experiments in order to see if they can design an unmanned remotely operated vehicle that will be able to charge the Hubble's battery packs and take care of other maintenance issues facing the fifteen year-old craft.

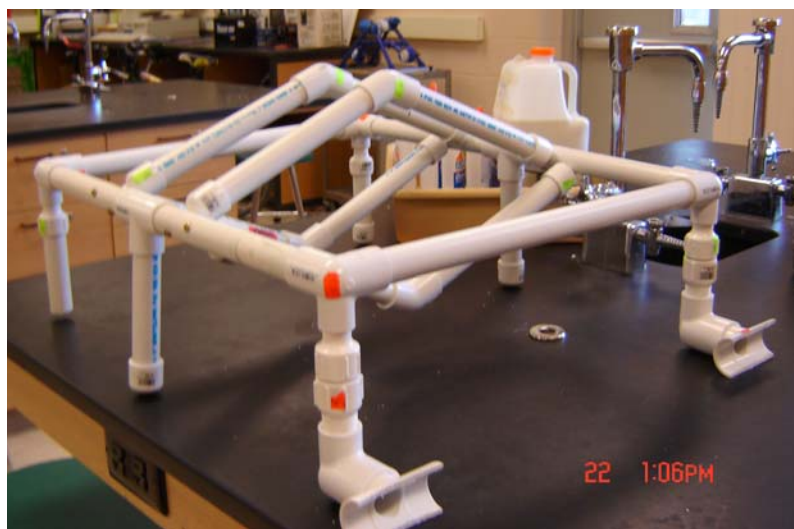
All of this new research and development into groundbreaking technology comes with a substantial price tag. It has been estimated that it may easily exceed a billion dollars (<http://www.spaceref.com>). This may seem like a great of money but when considering the benefits this technology would bring it would be well worth it in the long run. Not only will this technology keep the Hubble from becoming so much space dust upon entering the earth's atmosphere, it will also allow future unmanned space travel. We will be able to travel further than man has ever traveled before. It will also prevent tragedies the likes of which the family and friends the victims of the space shuttle crews of Challenger and Columbia had to endure.



Our in-room testing pool.

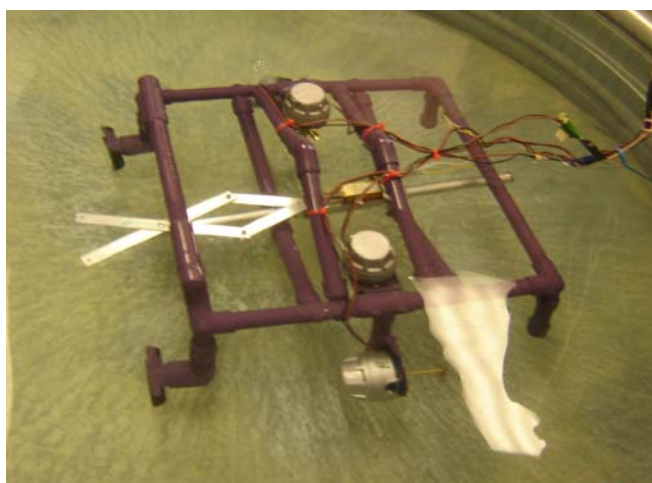


The 'traditional' point of view .

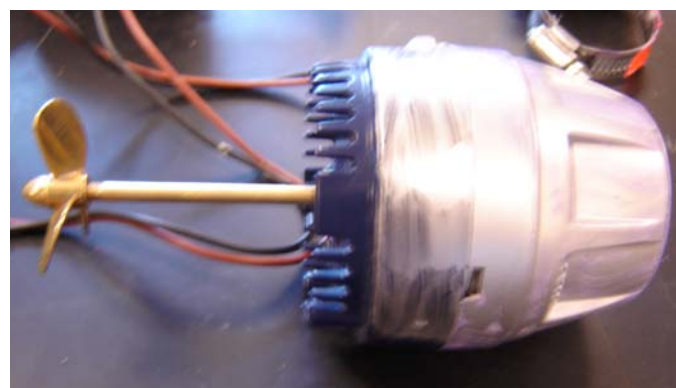


vs.

"Minimal" point of view.

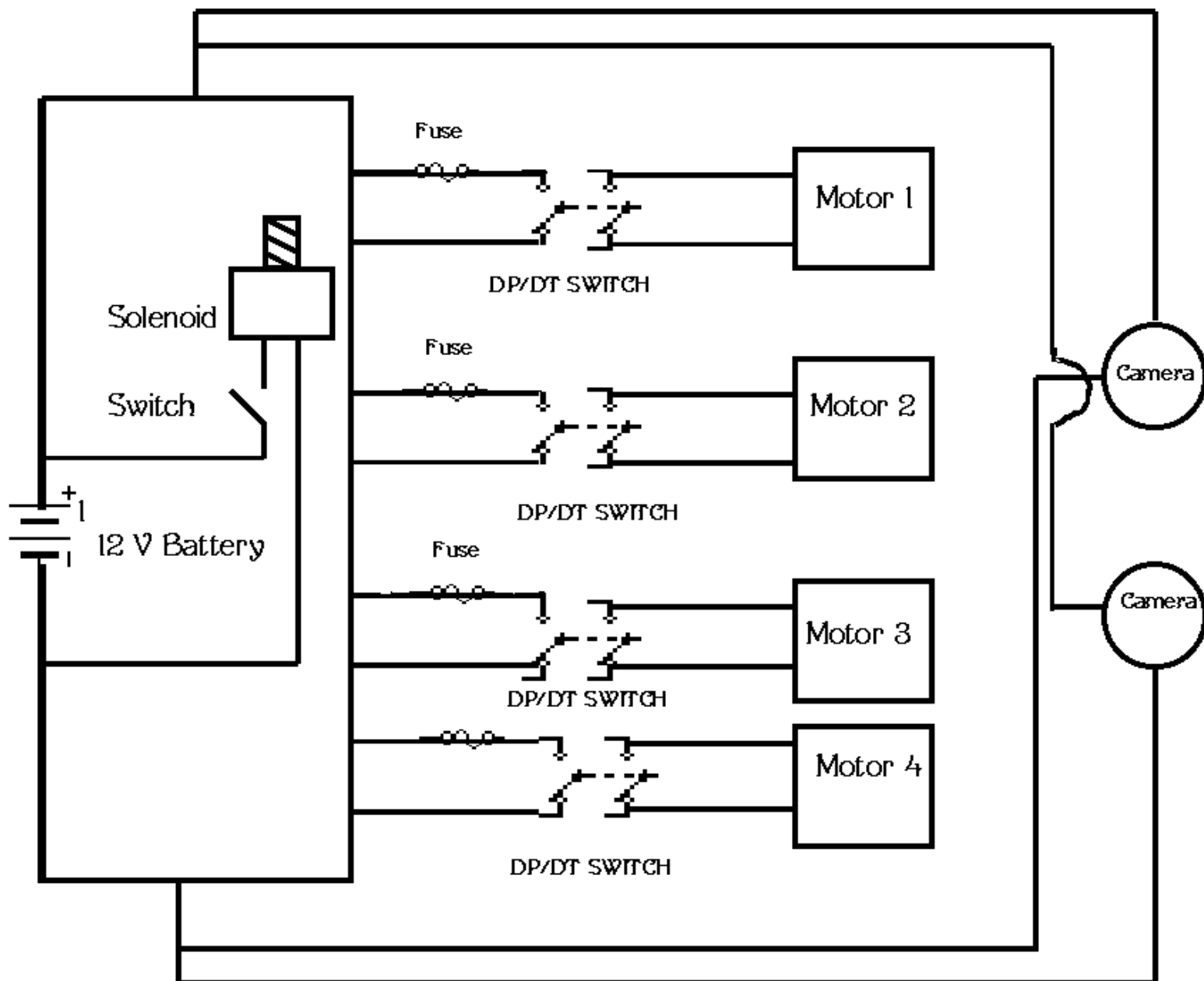


Deep Purple in action.



Close up of our propulsion system.

ELECTRICAL SCHEMATIC
"DEEP PURPLE"



STARTING BALANCE
\$998.21

Cash Donations	Amount
Basic Communications	\$ 100.00
Bank of Alpena	\$ 50.00
Independent Bank	\$ 50.00
Alpena Glass	\$ 50.00
Total	\$ 250.00
<u>New Balance</u>	
\$1,248.21	

Donated Supplies	
Alpena County Plaza Pool	Pool Time
Creative Creations	Part Manufacturing

Expenditures	Description	Cost
Tractor Supply Store	Water trough	\$ 196.00
Tower Hobbies	Propellers	\$ 71.95
Tower Hobbies	Motor Speed Contro	\$ 139.73
Home Depot	PVC/Fittings/Parts	\$ 52.06
WalMart	Scrapbook Material	\$ 65.85
WalMart	Team Shirts	\$ 83.43
WalMart	Paint/Brushes/Glue	\$ 24.97
RadioShack	2 Way Video Select	\$ 20.33
Total		(\$654.29)

Additional Funding

Thunder Bay National Marine Sanctuary & Underwater Preser	Build Money	\$ 500.00
Thunder Bay National Marine Sanctuary & Underwater Preserve	Travel Stipend	\$ 1,500.00
MATE	Travel Stipend	\$ 1,500.00
TOTAL		\$ 3,500.00

Total Balance
\$4,093.92