Great Lakes Underwater Vehicle
2006

Featuring

Mini Murphy

Mentors	Team Members	
Kristen Spain	Jennifer Brousseau	(Class of 2007)
Patrick Pokorski	Nichole McCafferty	(Class of 2007)
Bailey Bowen	Adam Nowak	(Class of 2006)
	Josh Oliver	(Class of 2007)
	Ross Pokorski	(Class of 2008)
	Eric Rosenberg	(Class of 2006)
	Jorden Seck	(Class of 2007)
	Ben Wedge	(Class of 2006)

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ABSTRACT

Great Lakes Underwater Vehicle (GLUV) is comprised of a group of nine students from Alpena High School in northeastern lower Michigan that set out in the fall of 2005 to build and test an underwater remotely operated vehicle (ROV). This ROV, named "Mini Murphy", has been designed to perform several operations that would be vital in the maintenance of an ocean observation system.

The first task Mini Murphy was designed to perform is the completion of a central node which would involve transporting instrumentation packages, placing the package in the correct location, accessing control panels located on the pack, and replacing or connecting a power/communications cable in the appropriate port.

An instrument package containing data related to sea conditions is the focus of the second task that Mini Murphy was designed for. Mini Murphy will be able to trigger an acoustic release transponder so that the instrument package attached to it will be set free and then be collected for repair.

Mini Murphy will complete these tasks efficiently with the aide of one 12-volt battery located on deck, a battery operated air compressor, and two TV monitors.

DESIGN RATIONAL

FRAME

The team chose to use chlorinated poly vinyl chloride (CPVC) as the material for the frame of Mini Murphy. This decision was reached with an emphasis on the cost effectiveness and the availability of the material. The abundance of different types and configurations of connectors also gave us the ability to be flexible in our design. With slight modifications to these connectors, we were able to make a solid frame from which to attach all of the components the ROV needed to perform the mission tasks.

PROPULSION

One of the most economical and practical decisions that we made this year involved our propulsion system. Our propulsion system is comprised of four Mayfair bilge pump replacement cartridges. These cartridges are each outfitted with homemade adaptors that attach to the shaft of the bilge pumps at one end and connect to a brass 4.445 cm three-blade propeller on the other (please see figure 1). For the left and right motors we chose bilge pumps that are capable of moving 2839 liters of water per hour. Based upon our design of the ROV, these two motors are able to create enough thrust to move the ROV in forward and reverse efficiently.

Figure 1: Propulsion

The two remaining bilge pumps are rated to move 3785 liters per hour and are used for vertical propulsion. These two motors, with the aide of the buoyancy system, create enough thrust to move the ROV vertically under the different loads required throughout the competition tasks.

PERIPHERAL MANIPULATORS

Two additional features of Mini Murphy were designed with the mission tasks first and foremost in our minds. The first is what we refer to as the pin puller. The pin puller does just what the name implies; it pulls the pin that holds the top of the electronics module underneath Mini Murphy (please see figure 2). The actual mechanism that does the pulling is a bilge pump motor rated at 1440 liters per hour. The shaft of the bilge pump is attached to a piece of high tensile strength string that is also attached to a pin on the other end. When power is applied to the motor the string is wound around the shaft until the pin is pulled free of the PVC mechanism allowing the electronics module to be released.

Figure 2: Pin pulling mechanism

Another feature that makes Mini Murphy able to perform the competition tasks is an arm mechanism. The arm mechanism is based upon the mechanical advantages found in the simple machines of screws and hinges. A bilge pump replacement cartridge is attached to a 5 mm threaded rod of rebar by means of an adaptor. This piece of rebar is then threaded through a piece of aluminum which has a hinge attached to either side. These hinges are then attached to the gripping portion of our arm (please see figure 3). When power is applied to the bilge pump in the forward direction, the arm opens; when power is applied in reverse, the arm closes. Two lock nuts are placed on the threaded rod of rebar so that the hinges will not be allowed to go past their point of retraction.

Figure 3: Arm mechanism

CONTROL SYSTEM

It was a team goal to improve the control systems of our ROV this year. Due to a last minute mistake (see CHALLENGES), we now have two feasible, interchangeable controllers for the ROV.

Our first control unit utilizes a salvaged Nintendo 64 controller for the switching of two salvaged radio control transmitters (please see figure 4). The receivers of the radio control module are interfaced through a digital matrix, which controls a 3 H-bridged Mosfet switching module transistor. The 3H-bridged Mosfet also receives a pulse width modulated signal via the digital matrix from the control unit. These signals control the motion of Mini Murphy. Pulse width modulation and radio control is sent to the motor switching unit by way of a four-conductor cable from the topside control unit.

Figure 4: Control Unit 1

The second controller is a replica of controllers that we have used in the past with a proven track record (please see figure 5). The main control module is comprised of three double pull/double throw switches with center-off position; one for vertical motors, and one each for both the left and right motors. These switches control the forward/reverse and vertical motion of the ROV; it has proven to be a reliable control system.

Figure 5: Control Unit 2

Each of the systems described above is used in conjunction with the control systems for the pin pulling motor (Task 1) and the motor that manipulates the arm (Task 1 and 2). A single pull/single throw switch controls the pin puller motor, which is interfaced to one of the radio control transmitters (please see figure 5). The arm control utilizes a double pull/double throw switch with center-off position. This allows the reversal of polarity of the motor to open or close the arm in small increments and is hard wired directly to the motor by means of an extra two-conductor cable ran down to the ROV. Both of these switches are housed in a separate control unit.

BUOYANCY

One of our most improved elements of this year's ROV is the buoyancy system. After encountering difficulties last year in regard to buoyancy (see LESSON LEARNED) we needed to develop a "fool proof" method for being able to change our buoyancy under a variety of circumstances. In short, we had found that we were not able to replicate the pressure present in the Neutral Buoyancy Lab. Therefore we built a system that would work in a variety of conditions.

The system consists of a 7.50 cm inside diameter 4-way PVC cross with threaded ends. The cross has been drilled so that a 1.7 cm diameter hose can be attached to it at the center of the top. The ends of the cross are capped with screw on valve plugs. These plugs each have a 0.4 cm hole drilled into the bottoms. These holes allow the water to be pushed out of the 4-way cross by a twelve volt DC battery operated air compressor. With the screw on caps we are also capable of removing one or more caps to lessen the amount of buoyancy applied to the ROV (please see figure 6).

Figure 6: Buoyancy

TROUBLE SHOOTING TECHNIQUES

Many of our components were modified greatly during the progression from design to completion of Mini Murphy. We began our design process by mapping out what the ROV needed to accomplish. Then we divided into sub groups based upon individual interests. Each sub group came back with their finding as to which method to use to create the components needed. Many hours of research and reflection from past competitions were utilized before making our final decisions.

Even after researching there were many components that needed to be field-tested in order to assess our theories. Originally, our propellers were inexpensive plastic model boat propellers. After testing we found that they were able to produce about 2 Newtons of forward thrust; this would not enable us to operate our ROV the way it was intended. Next we tested the 4.445 cm three-bladed brass propellers. These propellers were judged to fit our needs by producing a forward thrust of 6 Newtons.

The arm mechanism also went through several modifications before becoming a part of Mini Murphy. Initially the arm was made up of a solenoid assemble and plunger. When the power was turned on, the plunger would pull into the solenoid, closing the arm; with the power off, the arm would open by a spring mechanism. The drawbacks of this system were that the arm did not open very wide, and it was temperamental. If the plunger was too far out of the solenoid, it didn't have enough power to pull it back in, therefore not closing the arm. We struggled through many modifications trying to make it function consistently before abandoning the idea and starting anew.

LESSON LEARNED/SKILLS GAINED

After competing and winning our 2005 regional competition in a 3-meter deep pool we made no real adjustments to our ROV before traveling 30 hours by van to Houston, TX. During our first day practice session we should have been able to spot the error of our ways, but we were too caught up in our surroundings to notice our ROV wasn't functioning properly at any depth over 3 meters.

The next day our first attempt at the mission failed miserably. We had not adjusted our buoyancy to accommodate the increase in pressure associated with the Neutral Buoyancy Lab. We had forgotten Archimedes teachings that pressure increases with depth. Our old buoyancy system consisted of commercially available Fun Noodles™ taped to the frame of the ROV. We learned that while inexpensive and easy to use, Fun Noodles™ are not a dependable means of buoyancy. To our dismay it was discovered that Fun Noodles™ loose all of their buoyancy at any point beyond 3 meters, thus earning them the warning "Not to be used as a flotation device." We should have followed the directions on their packaging!

Another hard lesson learned that came at the end of this year was that it is always best to have someone check your wiring connections before applying power to any electrical component of the ROV (please see CHALLENGES). A simple once-over from another team member would have taken only minutes to accomplish, but would have saved days of rebuilding a new controller and a great deal of stress by our mentor.

CHALLENGES

One of the challenges GLUV has faced and continues to face is our lack of a “sophisticated” control system for the ROV. This year we began by researching different types of controllers, with an emphasis on not using a pre-manufactured control system.

A miscommunication in wiring procedure lead to the demise of the new and improved control system. The controls were fried with competition a week away. Parts needed to be reordered and were not guaranteed to be delivered in time for competition. A new control system needed to be designed and wired immediately.

With the deadline approaching ever so quickly, double pull/double throw switches, speaker wire, and in-line fuse panels were salvaged from previous years attempts. These recovered parts were then assembled to form a new controller, albeit one far less technologically advanced than the original. Through perseverance the team was able to transition smoothly from one controller to the other with a limited amount of pool time before competition.

FUTURE IMPROVEMENTS

One aspect of the ROV that we have not altered since the beginning of the competition is the material we use for the frame. Up to this point we have used PVC or CPVC for five generations of ROV's. The advantages of the availability and cost may be outweighed by its inability to easily change its configuration in order to adapt to new additions without having to completely rebuild the frame. We would also like to take out the worry of whether all joints have been sealed for water tightness.

One of the materials the team will pursue and research is lightweight aluminum for next year's competition. It is readily available in this area, we have a state-of-the-art welding lab at Alpena High School, and aluminum is environmentally friendly. We believe this material will alleviate our inability to add components on during the testing process and will give us a greater freedom of design.

ACKNOWLEDGEMENTS

What we have accomplished this year would not have been possible without the driving forces of our mentors and parents. Our mentors; Kristen Spain, Patrick Pokorski, and Bailey Bowen kept us focused and on task (not an easy task!) When we needed questions answered about wiring, we knew we could turn to Mr. Nowak. His knowledge and patience were always in abundance. Our parents were our constant cheerleaders. Even when we didn't

have faith in ourselves, our parents believed in what we could accomplish and us.

The support of our community has been a humbling experience. Alpena and the surrounding areas have endured great economic hardships for several years, but our community still stands behind educational enrichment programs. It is with their help that we are able to afford the opportunities that MATE provides us at national competition. Our corporate sponsors include: LaFarge North America, Alpena Optimists, Alpena Public Schools, Presque Isle Electric & Gas, WalMart and Hillman Power.

Lastly we need to acknowledge our two biggest supporters; Thunderbay National Marine Sanctuary & Underwater Preserve and Marine Advanced Technology Education. Each year these two entities have supported us through monetary donations. More importantly they have challenged us to learn, create, work as a team, and expand our horizons.

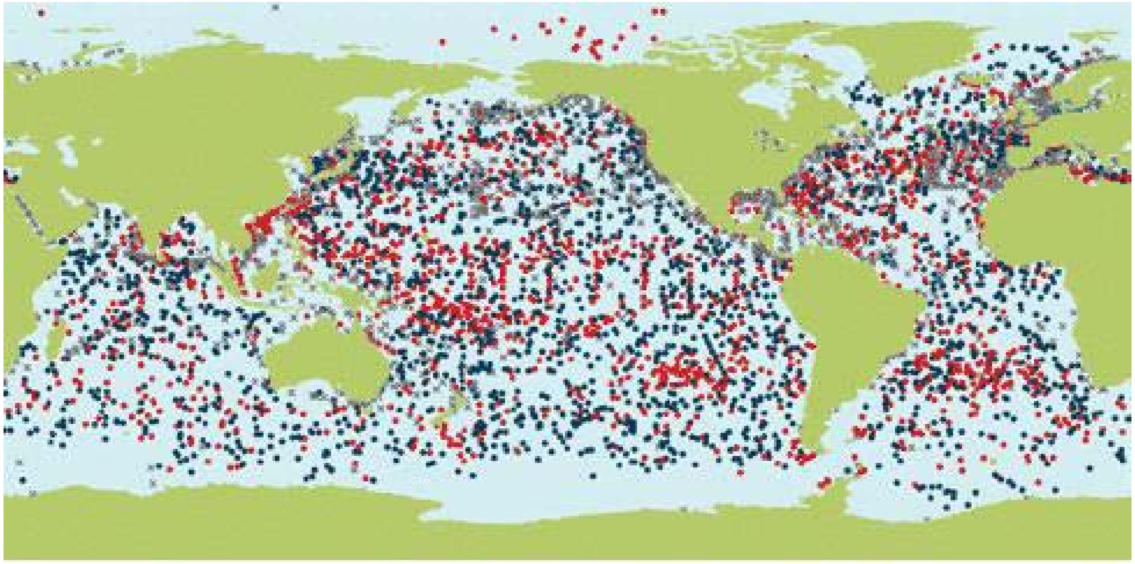
OCEAN OBSERVING SYSTEMS

Ocean observing systems are of vital importance to humankind's everyday life. These systems are able to map and monitor seismic and biological activities that are not easily observable. Systems such as the Global Ocean Observing System (GOOS) can be used to predict weather, describe and forecast the state of the ocean, and improve management of marine and coastal ecosystems.

One of the most intriguing benefits of this system is its effect on predicting natural disasters. The implications surrounding the implementation of GOOS will be astounding. Imagine what the last 2 years could have been like if GOOS had been fully in place. Meteorologists could have saved thousands of lives if only they were able to detect the tsunami that struck Indonesia in time to evacuate ocean-side towns and villages. Also, imagine if the path that hurricane Katrina took could have been more accurately foretold. Not only would the loss of life been reduced, but perhaps residents of the gulf states could have had enough time to take irreplaceable personal mementos, such as photographs and heirlooms with them.

In order for GOOS to reach its full potential it will take the cooperation of all coastal governments to become a truly global observation system. This will mean political issues will need to be put aside. All must cooperate in order to benefit humankind.

Sources:
www.oceansatlast.com
www.ndbe.noaa.gov
www.dod.nnic.in



In situ marine observing platforms, January 2006

Total observations: 5814

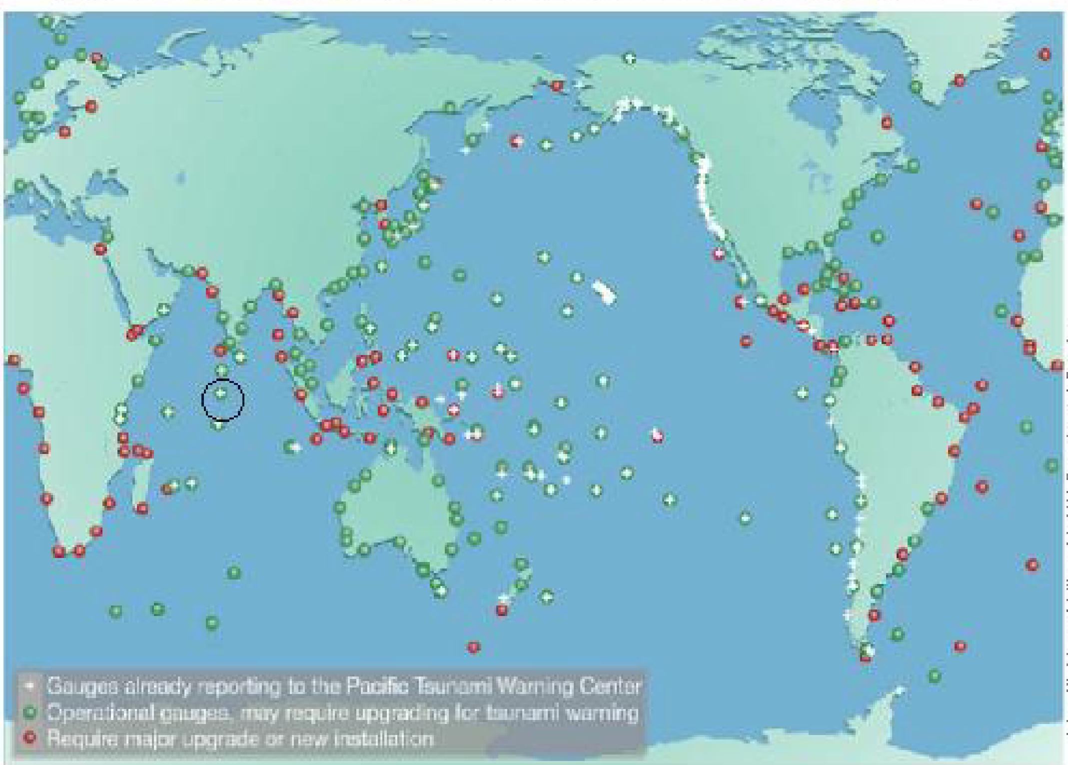
- BATHY (mainly XBTs) (49, 1350)
- SHIP (VOS ships & some moorings) (2089, 128122)
- TESAC (mainly Argo floats) (2032, 16378)
- BUOY (drifting & moored buoys) (1613, 219840)
- TEMP SHIP (ASAP ships) (22, 88)
- TRACKOB (mainly TSG) (9, 8782)

(platforms reporting on GTS, last position during the month; in brackets: platforms, observations).

Note: Data received from GTS at JCOMMOPS via Météo-France

Tide gauge observation network GLOSS

A Global Tsunami Water Level Network based on the GLOSS Core Network



Merrifield and Kilonski, UH Sea Level Center

2006 GLUV BUDGET		$190.00
STARTING BALANCE		

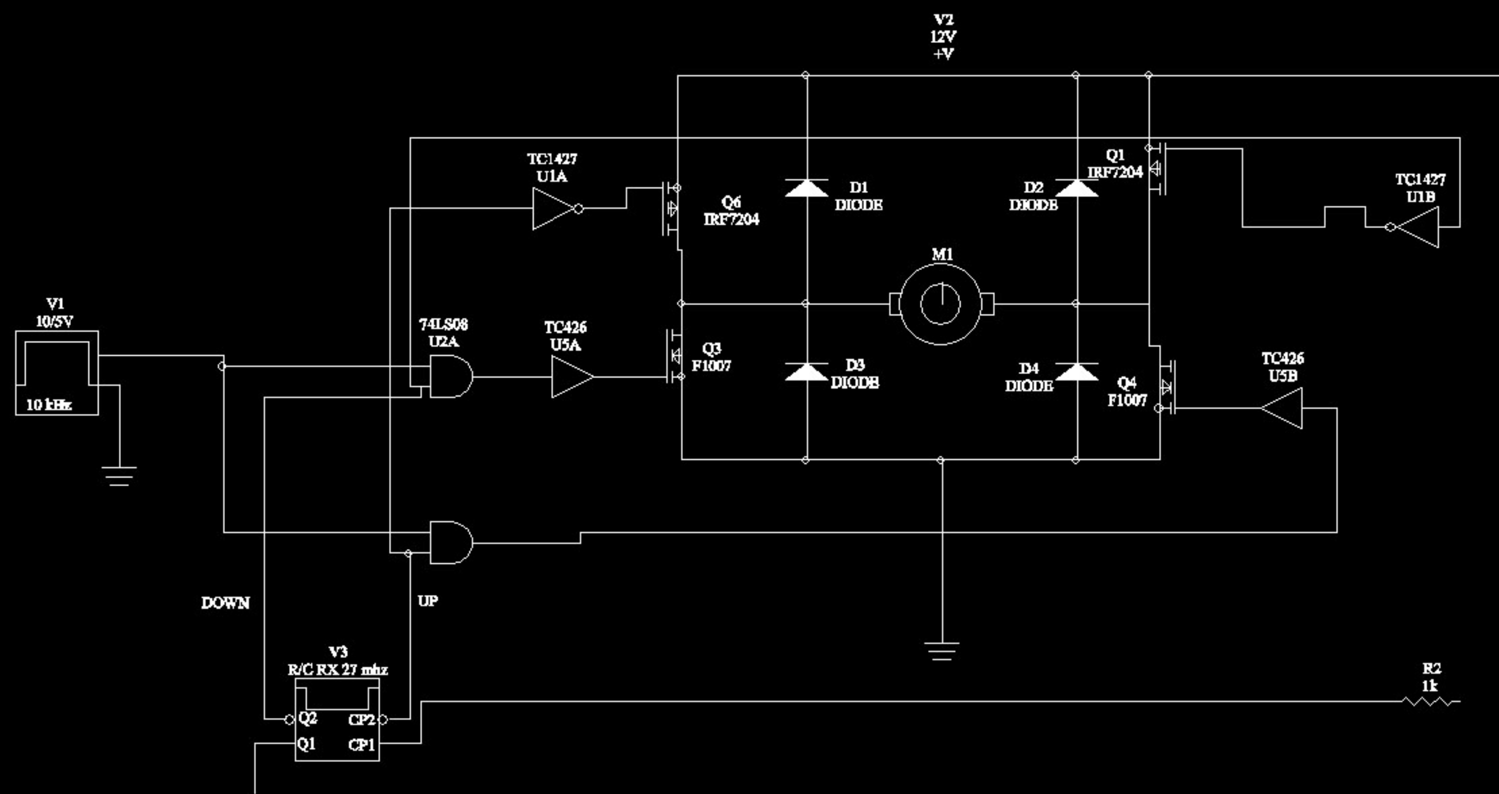
Monetary Donations	Amount	
Marine Advanced Technology Education	$1,000.00	
ThunderBay Naitonal Marine Sanctuary & Underwater Preserve	$ 500.00	
Community Foundation of Northeast Michigan	$ 500.00	
Hillman Power	$ 100.00	
Alpena Optimists	$ 350.00	
Presque Isle Electric & Gas	$ 750.00	
LaFarge Corporation	$ 250.00	
Total	**$3,450.00**	**$ 3,640.00**

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

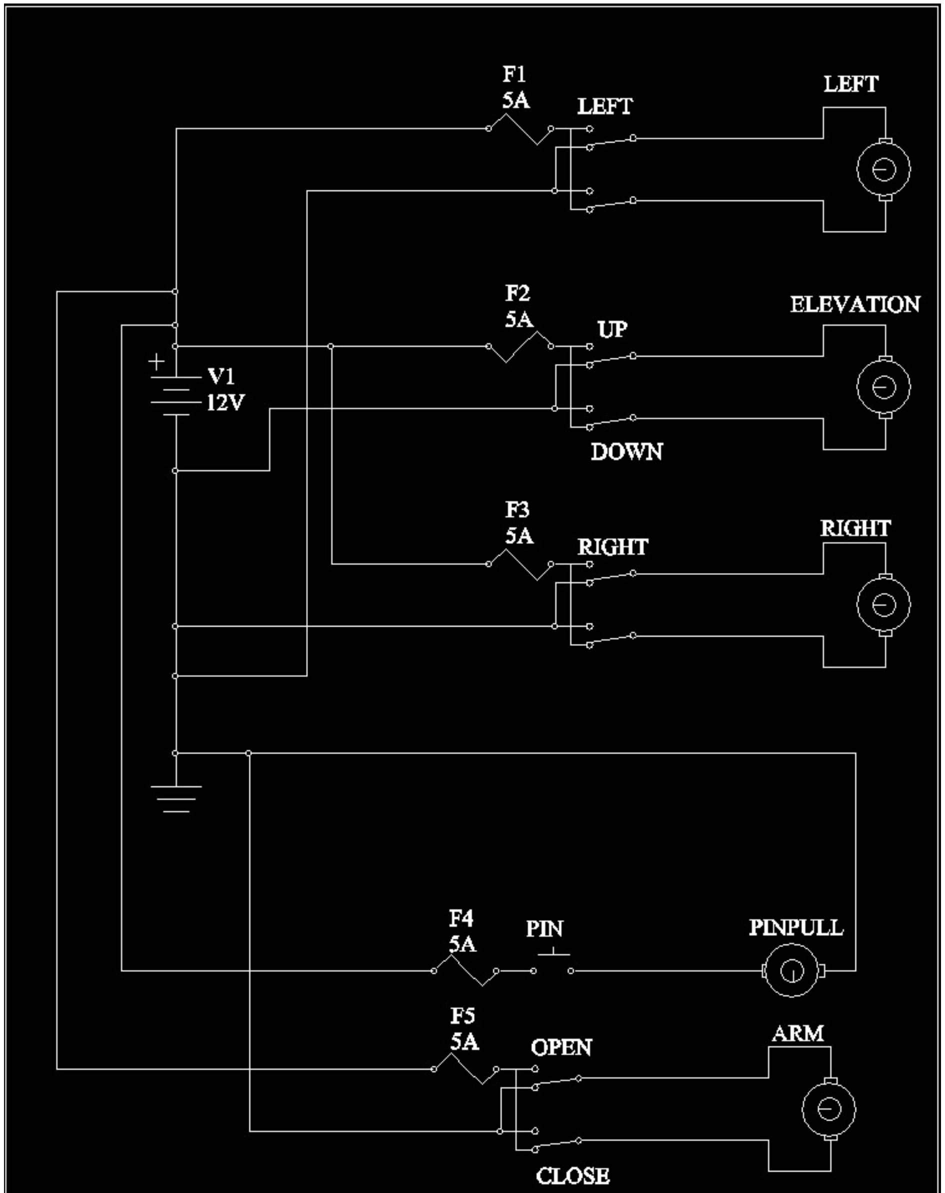
EXPENDITURES

Description	Cost
PVC/Fittings/Parts	$ 52.06
Propellers	$ 71.95
Bilge Pump Replacement Cartridges	$ 210.89
Safety Equipment	$ 26.49
U Bolts/Fasteners	$ 16.07
Electronic Components/Switches	$ 191.77
Paint/Brushes/Glue	$ 24.97
TOTAL FOR ROV	**$ 594.20**

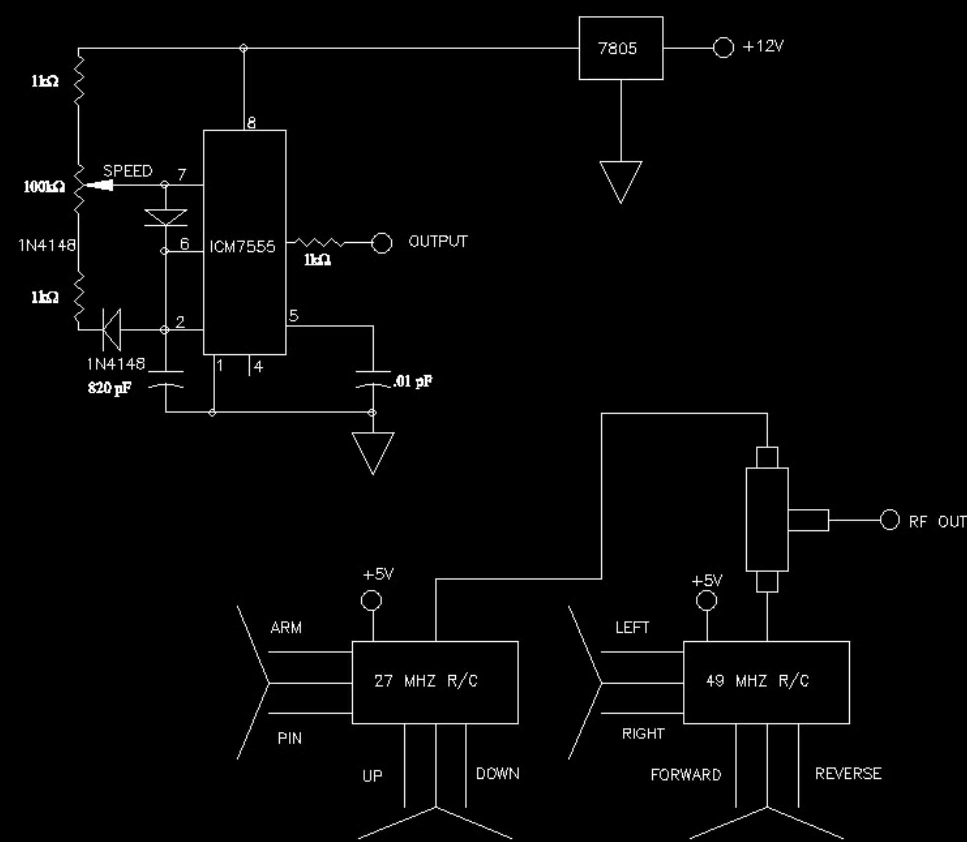
BALANCE	**$ 3,045.80**



ROV - BLACK BOX	ENGINEERING CLUB	CP1778	T&I 377	SCALE:	#2



MINI MURPH	ENGINEERING CLUB	CP1778	T&I 377	SCALE:1:1	#3



ROV CONTROLLER - GREY BOX	ENGINEERING CLUB	CP1778	T&I 377	SCALE:1:1	#1