

## 6.0 Wiring the Switches

There are three thrusters on the ROV. Two control the forward and reverse movement and can also be used to manipulate the ROV's direction. One is for vertical (up and down) movement. Each thruster is controlled by a separate switch. Three switches are incorporated into the controller. One switch controls the port thruster, one the starboard thruster, and one the vertical (up/down) movement. The switches are called double pole, double throw (DPDT), center moment off. The double throw means that if you push the switch in one direction the system will be turned "on", when the switch is returned to the center position it will be "off". If you pull the switch back in the other direction, the system will be turned "on". Again, when the switch is returned to the center position it will be turned "off". In this case, the switch needs to be forcibly pushed one way or another. If there is no force on the switch, it will automatically return to the center "off" position, that is why it is called "Center Moment Off". The double-pole means that if you push the switch "up" the motor will spin in one direction, if the switch is pulled "down", in the opposite direction, the motor will spin in the opposite direction. In the case of the thrusters, if both port and starboard switches are pushed forward, the ROV will move forward. If both are pulled back, the ROV will move in reverse. If just the port thruster is engaged without the starboard the ROV will make a lazy turn to starboard. If the starboard switch is pushed forward, the ROV will make a slow turn to port. Sharp turns can be made by pushing one switch forward and the other in reverse. If the port engine is pushed forward, and the starboard engine in reverse, the ROV will turn to sharply starboard. Conversely, if the starboard switch is pushed forward and the port one pulled back, the ROV will turn sharply to port. Note that there is no way to vary the speed of the port and starboard thrusters. They are either "on" or "off". In the "on" position, they are at full strength.

In advanced systems, the vertical thruster may have a different switch system and a way to vary the power that is delivered to it. In the system presented here, the switch is a DPDT center off. If you push it "up", it will stay on until the switch is physically returned to the center. If it is pulled "back", the thruster will turn "on" until the switch is physically moved to the center. There is no "automatic" turn off if pressure is taken off of the switch. In some cases a "potentiometer" may be installed that allows the power to the thruster to be varied from slow to fast by turning a knob.

When operating the ROV the control box has three switches, two for horizontal movement and one for vertical movement. With two hands, it is difficult to operate three switches simultaneously. In addition, without speed control, the vertical movement of the ROV is either full speed, or stop. The ROV either dives or rises quickly to the surface. There is no way to keep the ROV at a single depth. This early problem can be resolved by installing a potentiometer, or "volume" switch that allows the speed of the vertical thruster to be controlled. If the operator would like the ROV to dive, they "pull" the switch into the down position and rotate the speed control switch clockwise until it descends. By applying a little downward movement to the slightly, positively buoyant ROV the vehicle will be neutrally buoyant. The ROV will stay at the depth selected by

the Operator as long as necessary. When the mission is finished and the ROV needs to be recovered, the operator can move the switch to the “off” position and the ROV will float upwards. The potentiometer switch applicable to this ROV has not yet been identified.

### Wiring DPDT Switches

Figure 6.1 shows three views of a Double Pole, Double Throw switch that is rated for 3 amps. One of the reasons this switch was chosen because its action, or “throw” does not take much force to actuate. The switches are also relatively inexpensive costing less than \$1 each.



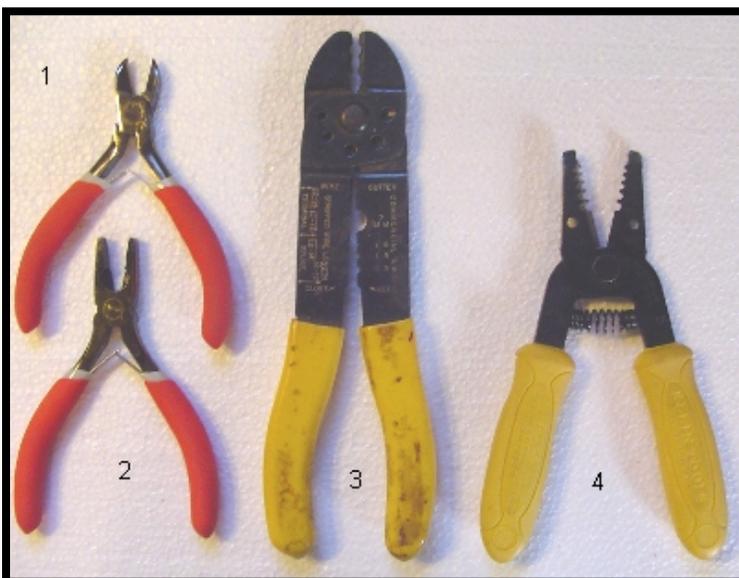
Figure 6.1 shows three views of the same switch. Note the six posts of the switch back in the left and center view. Each of the six posts will receive a specific wire. The right-most view shows the toggle that actuates the switch when it is pushed up or down.

Figure 6.1: 3 views of the same switch



The gold colored annulus, or ring, around the silver switch is threaded so that you can fasten it to the handheld controller device (Figure 6.2). Each controller will have three of these switches, one for each thruster.

Figure 6.2: A good view of the switch



The tools needed to connect the wires to the switch (Figure 6.3). Diagonal cutters (1) for cutting the wire, flat jaw pliers (2) for holding the wire pieces, a crimping tool (3) for securing the connectors to the wire ends, and wire strippers (4) for removing the insulation from the wire ends (Figure 6.3).

Figure 6.3: Tools for this step.

## ROVs in a Bucket – Building an Underwater Robot

Each switch will require the preparation of six connecting wires to control the thruster. 18 gauge, color coded, stranded wire, has been selected to connect the thrusters with the switch and the power source (Figure 6.4 and 6.5). Stranded wire works well because it is easier to twist and bend. The wire colors are red, black, and green. The following wire colors and lengths are needed for each switch.

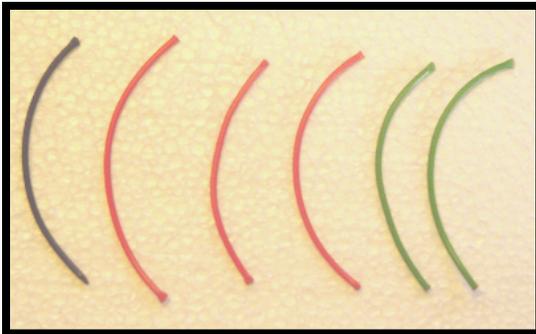


----- Figure 6.4



Figure 6.5 -----

Figure 4 & 5: Recommended 18 gauge, stranded wire, in green, red, and black



3" red – thruster direction need 2  
3" green – thruster direction need 2  
3" red – power need 1  
3" black – power need 1

Figure 6.6: The six wire pieces needed for the switches.



About 3/8" of an inch of insulation needs to be stripped from one end of the wire and 1/2" from the other end. Because of the small size of the wire pieces this can be a little tricky. Grasp a wire piece with the flat jaw pliers (2) with one hand and place the jaws of the wire stripper (4) about 3/8" from the piece end. Squeeze the strippers and pull towards the wire end (Figure 6.7). The goal is to remove the insulation from the wire without cutting the wire strands (Figure 6.8).

Figure 6.7: Stripping the wire ends by holding one end with pliers.

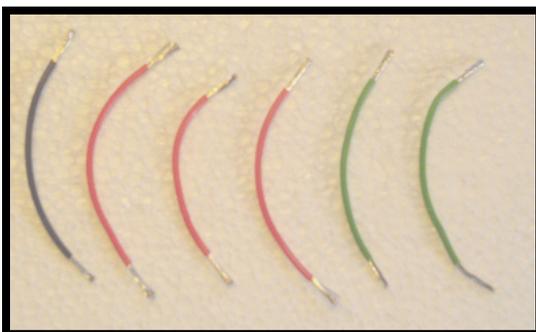
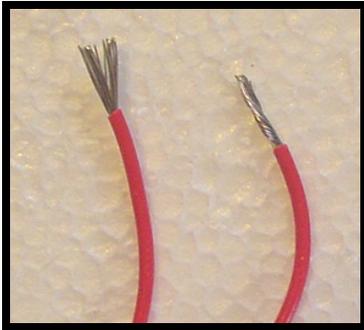


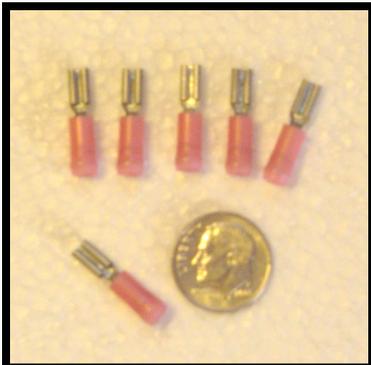
Figure 6.8: The wire ends are ready to receive the connectors to they can be attached to the switch.



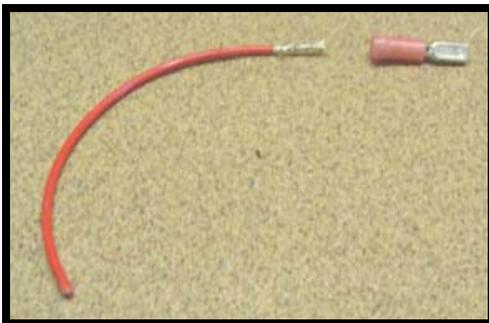
**Figure 6.9:** Before the connectors are attached, grasp the wire ends between your fingers and twist the stranded wire. The ends should not have any frayed ends. In Figure 6.9 you see the wire before (left) and after (right) the twisting.



Get six (6) female quick disconnect vinyl insulated connectors ready to attach to the wire ends (Figure 6.10 and 6.10b). These connectors should be able to accept 18-22 gauge wire. The idea here is that the female end of the connectors fit snugly onto the switch posts..



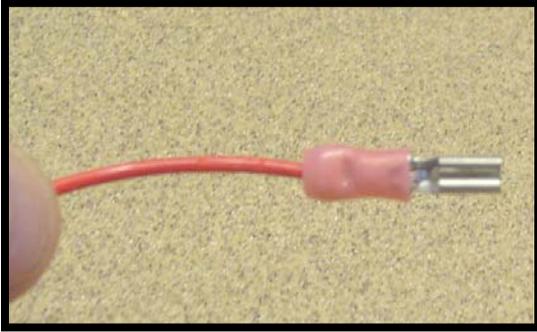
**Figure 6.10 & 6.10b:** The quick disconnects enable the wires to be attached to the switches without the need for soldering.



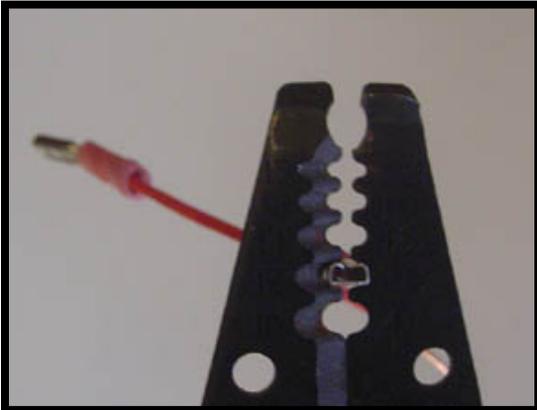
**Figure 6.11:** Slide the connector over the twisted wire end.



**Figure 6.12:** Hold the insulated part of the wire connector in the jaws of the crimping tool. Squeeze the insulation until the insulation is pinched. Do not apply too much pressure or the connector will break.



**Figure 6.13:** Pinch the insulator in two locations. The wire should be securely attached to the connector.



**Figure 6.14:** The connector end that attaches to the switch post is too wide. It will fall off of the switch if attached without following this step. The attachment end needs to be squeezed a bit to narrow the opening of the connecting end. Hold the connector firmly between the stripper (tool 4) and squeeze lightly... read that.. it says squeeze lightly, or gently. With the slightest squeeze, you'll feel a mechanical "snap" when you push the wire onto the switch post.



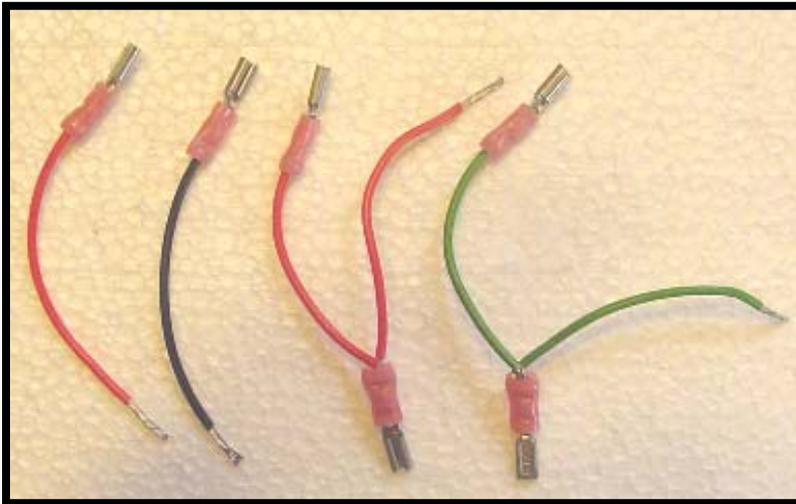
**Figure 6.15:** View of switch posts for connections.

Note the six posts on the backside of the switch (Figure 6.15). Also note that the switch has a metal label with different text on each side. When the wires are attached make sure that the same color wires are attached on the same side of the switch. Keeping the wire pattern the same will keep the thruster spin direction consistent when they are attached.



After the connector has been adjusted with the gentle squeeze, it should require a small amount of force to slide it over the post (Figure 6.16).

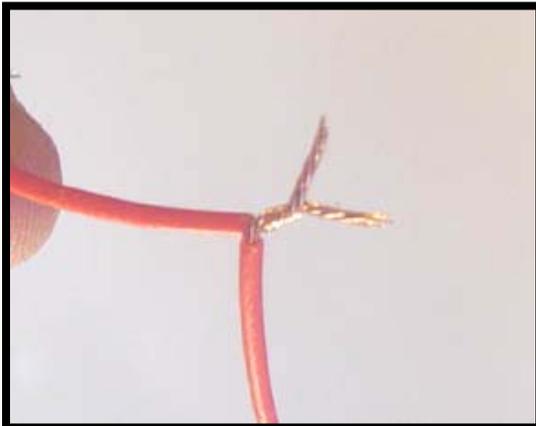
**Figure 6.16:** Making the Connection



There are four sets of wires with six connectors that need to be prepared (Figure 6.17).

1. red for power
2. black for ground
3. red “forked”, two ends with connectors, one end bear.
4. green “forked”, two ends with connectors, one end bear.

**Figure 6.17:** The sets of wires that make the switch



This is how to prepare the “forked” wire sets.

Take two of the red wires and twist two of the stripped ends together. Twist it until it looks like “one wire” (Figure 6.18).

**Figure 6.18:** Connecting the wire ends.



Slip the connected end into a connector and crimp it (Figure 6.19). This will bind the two wires securely. Attach another connector to one of the other bare wire ends. Don't worry about the other bare end. It will be connected to the tether wire. Do the same for the green wire. Now we should have the four sets of wires as pictured in Figure 6.17.

**Figure 6.19: Crimping the connector**

### **Attaching the wire to the switch posts.**

Three switches are used to control the ROV. Each switch controls an individual thruster. One controls the left horizontal thruster and one the right horizontal thruster. The third switch controls the vertical thruster.

The thruster can be powered in two directions. For the horizontal thrusters that would be forward and reverse. For the vertical thruster that allows the ROV to rise or sink in the water that would be “up” and “down”. The switches used to control the ROV movement are termed Double Pole – Double Throw (DPDT).

A Double Pole – Double Throw switch is off when the toggle is in the center of the switch (Position Off) (Figure 6.20). When the toggle is pushed in one direction (up), the thruster will turn in one direction (On-F). When the toggle is pulled in the other direction (down) the thruster will turn in the opposite direction (On-R).



**Position: On-F**



**Position: Off**



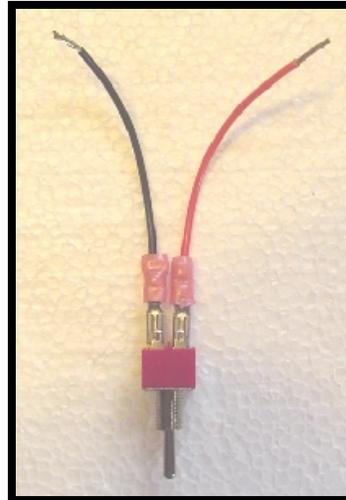
**Position: On-R**

**Figure 6.20: The three positions for the DPDT switches powering the thrusters.**

Prepare and attach the red and black wires to the center posts. See the figure below and note the red and black boxes that show the posts where these wires should be affixed (Figure 6.21 & 6.22).

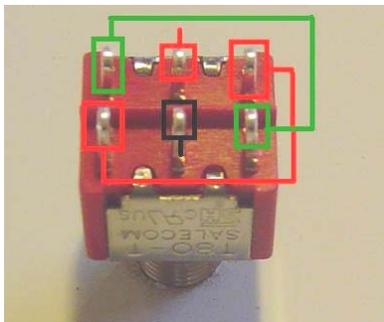


**Figure 6.21:** Attachment posts for the power wires which are red and black.



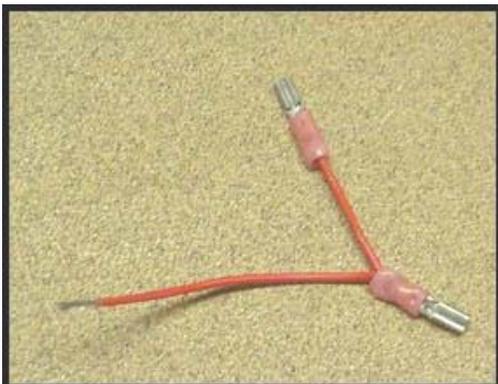
**Figure 6.22:** Power wires attached

The two sets of “forked” wires are now needed to complete this switch. The wires will be attached to the switch back in the following pattern.



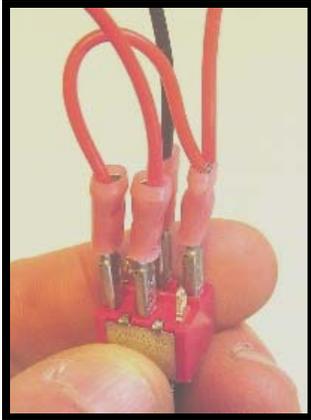
The middle posts are occupied by the black and red power wires. The red “forked” wires will be attached diagonally to the outside corners of the switch. The green “forked” wires will be attached to the other side (Figure 6.23).

**Figure 6.23:** Position for “forked wires” will occupy posts on opposite corners of the switch.



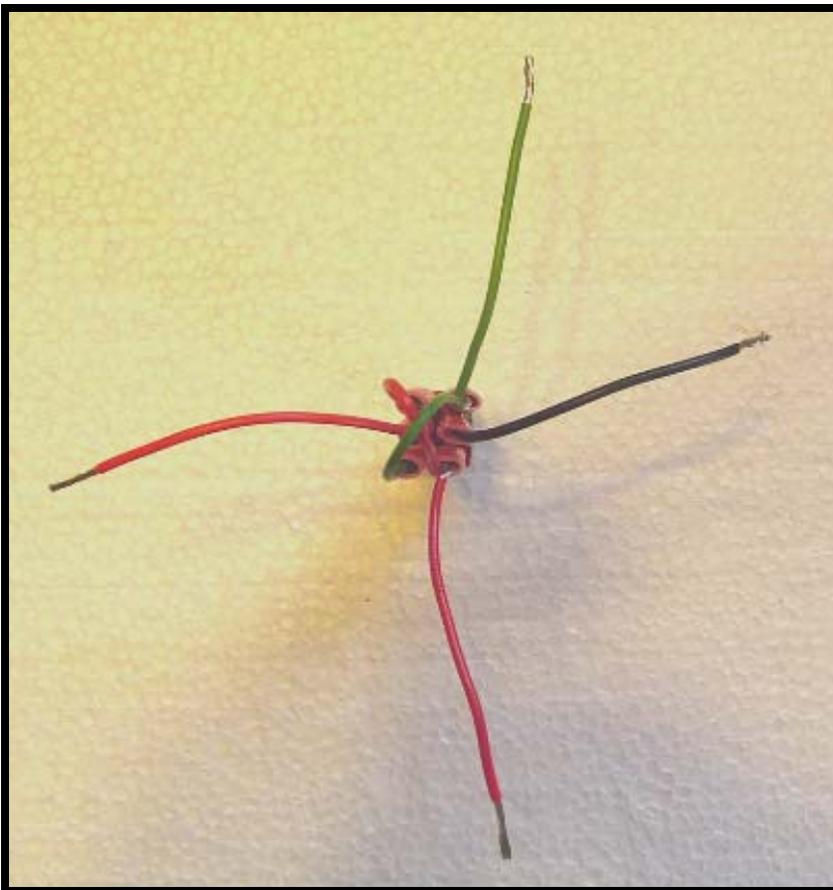
Take the red “forked” wire, crimp the connectors slightly, and attach them to opposite, outside posts of the switch (Figure 6.24).

**Figure 6.24:** “Forked” wires for corner post attachment.



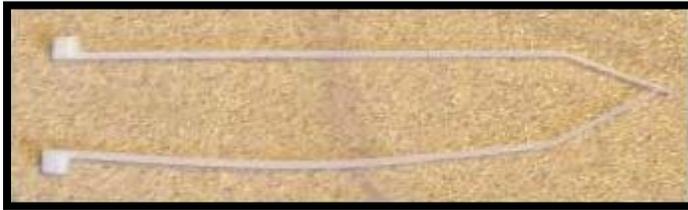
Be certain that the red wires are attached to the outside posts, so that they are “diagonal” to each other (Figure 6.25). By placing the wire connectors on the switch in this position the thrusters will reverse direction when the switch toggle position is changed from one end to the other. Now gather the green “forked” wire set. Attach the green wires to the other outside posts. The red and green wires should cross, diagonally.

**Figure 6.25:** “Forked” wires attached to the corner posts.



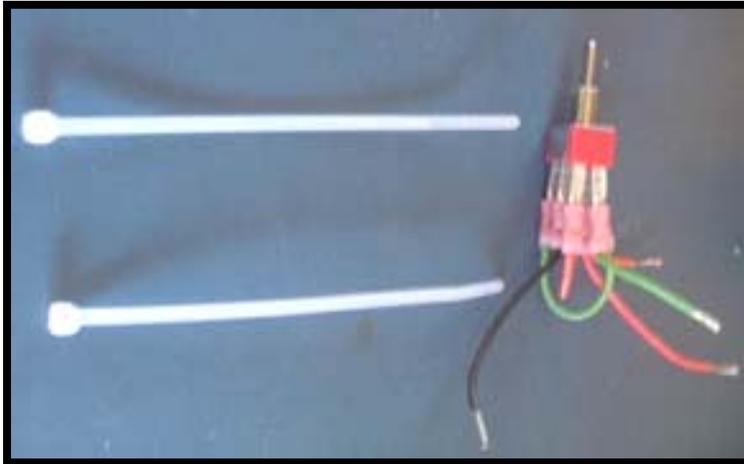
**Figure 6.26:** This image shows how the forked wires (red and green) are crossed.

The green and red “forked” wires are attached to opposite corners of the DPDT switch (Figure 6.26). The Red and Black wires that are positioned pointing to the left and right, respectively, are attached to the center posts of the switch back. Because of the slight “crimping” of the connectors the wires are pretty securely attached to the switch. With continued handling by the ROV operator it is wise to secure the switch connectors using additional materials.



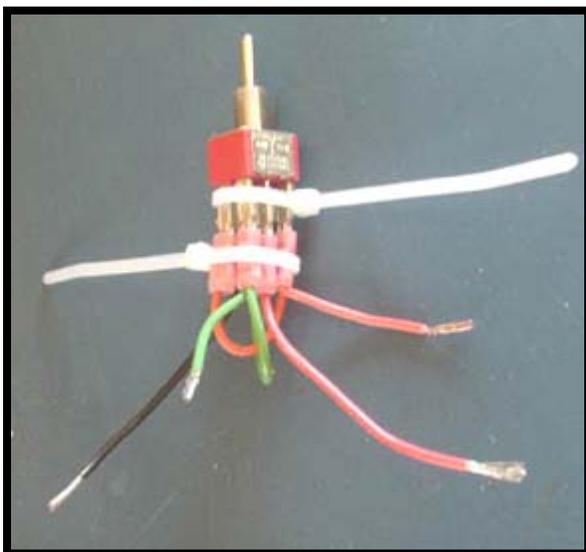
**Figure 6.27:** 4" plastic cable ties

To do this use small plastic tie wraps (Figure 6.27). These are 4" long. When one end is inserted in the slot end and pulled through the ribbed plastic tightens.



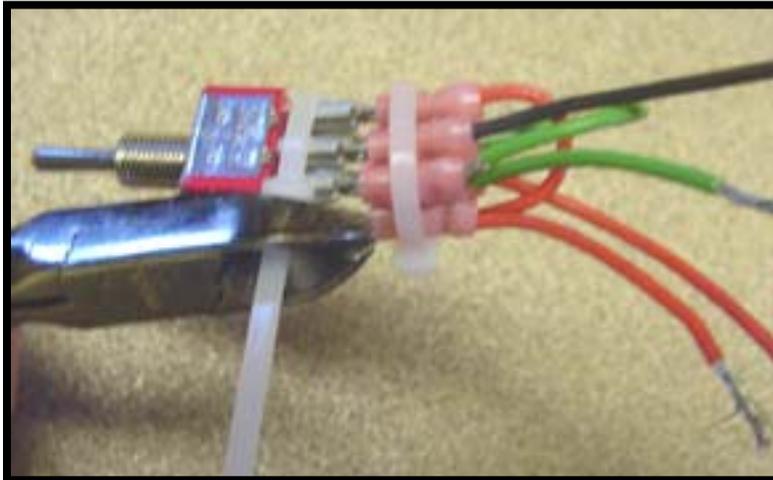
**Figure 6.28:** cable ties to secure the wires on the switch posts.

Take the two tie wraps and use them to help secure the connectors to the post (Figure 6.28). This will also help the connectors from getting loose and creating a short circuit with the neighboring connector posts.



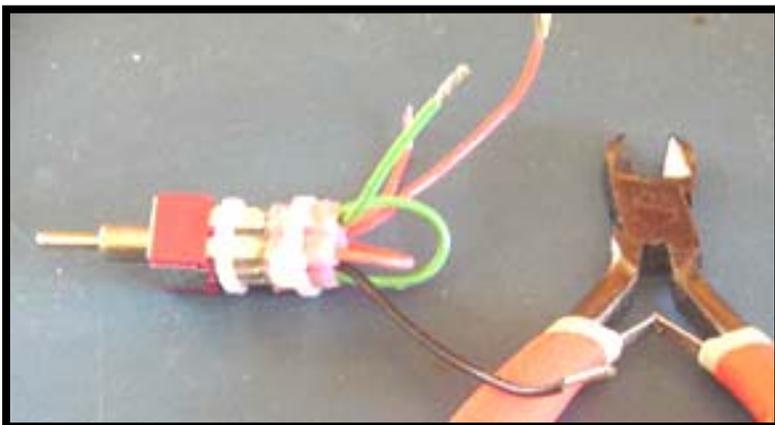
**Figure 6.29:** One cable tie around the connections and one around the insulators.

Put one of the tie wraps around the six connectors where they attach to the switch posts. This will help keep them from falling off of the post during operation. Put the second tie wrap around the insulation joints of the connectors. Pull both of the tie wraps snug, but don't over tighten them (Figure 6.29).



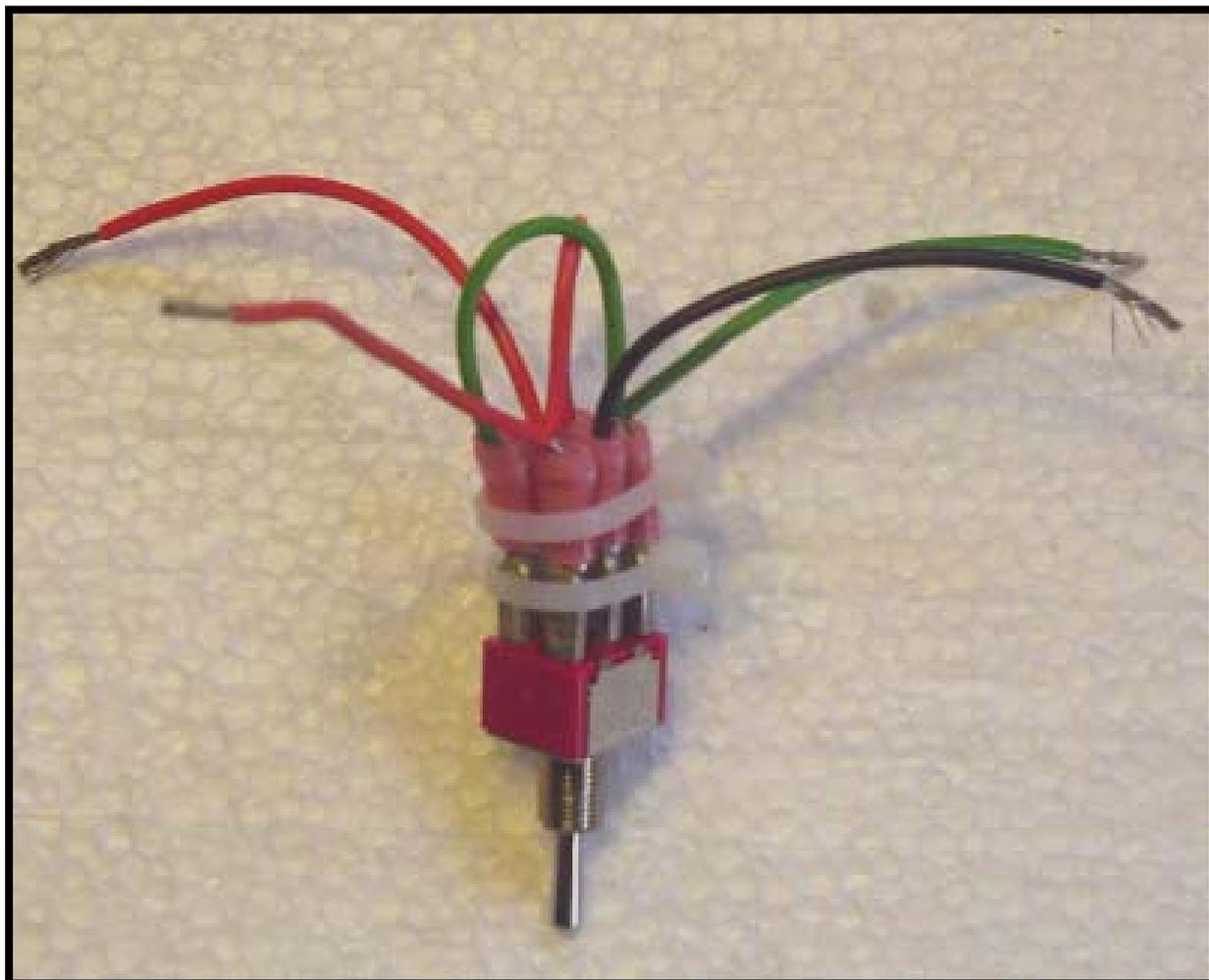
Use the diagonal cutters (tool 1 from the tool picture) to trim the two tie wraps. Place the flat end of the cutter against the tie wrap “buckle” and squeeze the handle until the tie wrap piece is cut (Figure 6.30). Do the same for the second tie wrap.

**Figure 6.30:** Trimming the cable ties.



The switch is ready for installation (Figure 6.31). Three wired switches are needed to build the ROV control box..

**Figure 6.31:** One of three finished switches needed for a controller box.



**Figure 6.32:** A completed switch ready for installation into the controller jar.

This is the completed switch (**Figure 32**). Three of these switches will be installed into the controller “jar” and will send the information to the ROV thrusters allowing it to move forward and back, left and right, and up and down.