

# Homebuilt Dive Lights

By Brent Schermerhorn  
bnscherm@bnsengineering.com  
[www.bnsengineering.com](http://www.bnsengineering.com)

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First of let me point out that this is not to be interpreted as "plans" or a cookie-cutter approach that will work for everyone in all situations, or for the tools that you have on hand. Also, many of the ideas and construction techniques described here are not solely my ideas, but a collection of the tips and tricks that I have learned along the way from many people. Most notably "Padipro" who can be regularly found on [www.scubaboard.com](http://www.scubaboard.com) and from various individuals on the yahoo group "HIDDivelights". That said, from this page you should be able to build yourself a reliable dive light using hand tools, and materials found at the local hardware store.

## Proceed at your own risk!

### HID, Halogen, or LED?

I recommend a Halogen dive light as a first project. HID lights are more finicky, and costly than Halogen, and require more difficult engineering problems than the first time homebuilder will likely be ready for. This being said, HID bulbs and ballasts have dropped in price by about 50% from the time they were released making them more attractive to the homebuilder. Light Emitting Diode (LED) dive lights are a possibility, but it is difficult to predict whether a given LED configuration will have the light output or penetrating power that a diver will require.

Halogen bulbs come in a variety of low voltage styles that are suitable for dive lights. Many have a built in reflector for either flood light or spot light patterns. The most commonly used sizes are the MR16 and the smaller MR11. A 12 volt 30 to 50 Watt MR16 spot bulb is a good place to start and will work in nearly all diving situations, and can be found at all hardware stores. (**See Figure 1**). Spotlight variations are less readily available in hardware stores but are easily found online.



Figure 1: MR16 bulb without integral lens. [www.mcmaster.com](http://www.mcmaster.com)

### **The Batteries:**

The second thing you should consider in designing a dive light is the voltage and capacity of the battery pack that you wish to build. Ultimately these variables will dictate the size, and shape of the canister that will be needed. Rechargeable batteries come in four different types suitable for diving, two of which have become obsolete. Sealed Lead Acid (SLA) and Nickel Cadmium (NiCad) were used in the first dive lights, but have been outdated by newer technologies that have no "memory" effect. The two remaining options are Nickel Metal Hydride (NiMH) and Lithium Ion (Lith). Lithium batteries have the highest charge density, meaning they will last the longest for their size, but require special controller boards to monitor the charging rate, and voltage of each cell individually. In "over current" charging situations, Lith batteries have the tendency to rapidly, and irreversibly disassemble themselves (read explode). Lithium batteries are the best battery out there, as reflected by their higher price. The simpler solution (KISS) for the first time builder is NiMH which will still require special attention when charging, but low cost "smart chargers" are available for as little as \$15. NiMH cells generally considered for dive lights are the size "C" and size "D" with size "D" offering about twice the milliamp hours (mAh) charge capacity of the smaller "C" size. The mAh hour rating is based on the optimal discharge rate and temperature for the cell, and should be considered as theoretical (especially from Chinese manufacturers). 10000 mAh indicates that the cell should be able to output 5 Amp for 2 Hours or one Amp for 10 hours, etc.

NiMH cells generally have a nominal voltage of 1.2 V, and therefore if using the 12V MR16 bulb we will need 10 cells, and for this example we will use the larger D size cells.

The cells will need to be soldered together, and this can be done with a high wattage soldering iron. Instructions for this procedure can be found online from many RC enthusiasts' websites such as <http://www.dynamolectrics.com/How%20To.aspx>. The basic concept is to use two wooden dowels taped together as a fixture to hold the cells inline to assure a straight stack. I recommend a configuration of three columns of three cells each with the tenth cell placed horizontally across the top of three columns with the whole thing encapsulated in heat shrink (**See Figure 2**). Many connectors could be used, but I've had most of my experience with the Tamiya style connector often used with RC models. (**See Figure 3**) The charger, cells, connectors, and heat shrink can be purchased from [www.batteryspace.com](http://www.batteryspace.com).



Figure 2: Assembled C-Size and D-size battery packs. Three columns of three with tenth cell horizontal.



Figure 3: Tamiya female RC connector.

### **The Canister:**

Professional canisters are often made from solid pieces of expensive plastics such as Delrin, and are bored out on a lathe. For the homebuilder these techniques and materials are often out of the question. As a replacement I recommend everyone's favorite schedule 40 PVC. PVC is durable, moisture resistant, cheap, and easy to "form". The low melting temp allows a homebuilder to easily form the PVC, but also makes it a pain to machine as it is prone to melting which leaves burrs.

The primary consideration in selecting the diameter of pipe, wall thickness, and length is to accommodate the battery pack that you plan to use in your light. Heavier gauges will undoubtedly hold up to higher pressures at depth, and allow easier installation of the latches for attaching the lid. However, these pipes are often difficult to find and cost much more than standard schedule 40 pipe, which I've had down to 150 ft without any problems. For the ten "D" cell example project in the three-column configuration 3" pipe is a near perfect fit. To determine which size pipe will fit your battery configuration you will need to find the inner diameter. There are various charts that can be found online that give O.D. and I.D. for different size tubing.

The bottom of the canister can be sealed in a variety of ways. Undoubtedly, the first thing that will come to mind for the first time homebuilder is a standard 3" end cap. The problem with these end caps is that they tend to be big, bulky, and tend to prohibit the canister from being mounted cleanly. Another solution is to seal the bottom of the canister with "flat stock" PVC that can easily be made from a section of that 3" schedule 40 that you all ready purchased. This flat stock can also be used later in building the lid. The flat stock is made by cutting the pipe on one side lengthwise. The pipe is then placed in a 400F oven on a baking sheet for five minutes. The pipe will then become very rubbery and it can be flattened out on the ground and left to cool with a board weighted with a scuba tank flattening it to the ground. A hard, cold, smooth surface like a basement floor works the best.

With the PVC now cooled, and the "flat stock" in hand you can trace out the bottom of the 3" pipe canister on the flat stock, and then cut it out with a saw. Preferably, a bandsaw works best, but scroll saws and reciprocating saws have also been used with success. I've found that it is easiest to do a rough cut of the disk leaving about 1/8" around the diameter. The disk can then be glued to the bottom of the canister with PVC cement (make sure to use PVC cleaner as well). A stack of books atop the canister will help hold the bottom on tight. After this has cured I like to pour a little PVC cement in the bottom of the canister and roll it around to ensure a watertight seal on the inside. After everything has cured the last 1/8" of the disk can be sanded, ground, Dremeled, or cut off so that it is perfectly flush with the rest of the canister (**See Figure 4**). Make sure the top (open end) of the canister has been cut square, and sand it with fine grit paper to ensure a very smooth finish, as this is where the o-ring will seal.



Figure 4: Cemented on end cap, sanded flush with bottom of the canister.

#### **The Lid:**

Professional lids are made from clear plastics such as Polycarbonate so that you can see into the canister while it is sealed and to see if it is dry. Polycarbonate is VERY difficult to get in small quantities with the thickness that we would need. It can be done however, with a router table with a square ended bit to cut away a portion of the polycarbonate that will fit inside the canister after a circle has been cut from the plastic stock.

The easier way is to make the lid in the same fashion as the bottom of the canister with either 2,3 or 4 PVC disks cut from the "flat stock" and cemented together. You'll need as a minimum one disk with a diameter the same as the outside of the canister, and one disk with a diameter that just barely fits into the canister. The better option is to use two of each thickness and sandwich the four disks together with PVC cement in a vice. I like to glue the two of each diameter together first, and then use a scrap of pipe to ensure that the two different diameter stacks are centered on each other by placing the smaller stack just barely in the end of the pipe for alignment. (See **Figure 5**)

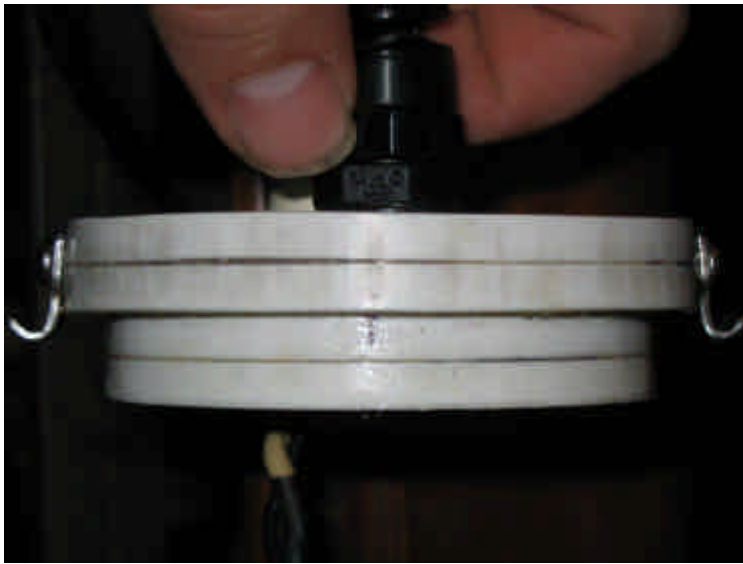


Figure 5: Four PVC “flat stock” disks cemented together.

The lid will be held to the top of the canister by latches (discussed later) and sealed with a silicone greased o-ring face seal. What has worked for me on 3" pipe canisters is 1/4" Buna-M o-rings with a 3.5" outer diameter and a 3" inner diameter. These o-rings can be ordered from [www.air-oil.com](http://www.air-oil.com) or from <http://www.mcmaster.com> (THE store for homebuilders). Alternatively, o-rings of this material and thickness can be found at many local hardware stores for replacement on under sink inline water filters. The diameter will probably not be correct, but the o-rings can be cut and reattached with a drop of super glue on the end to make the perfect size o-ring. (See **Figure 6**)

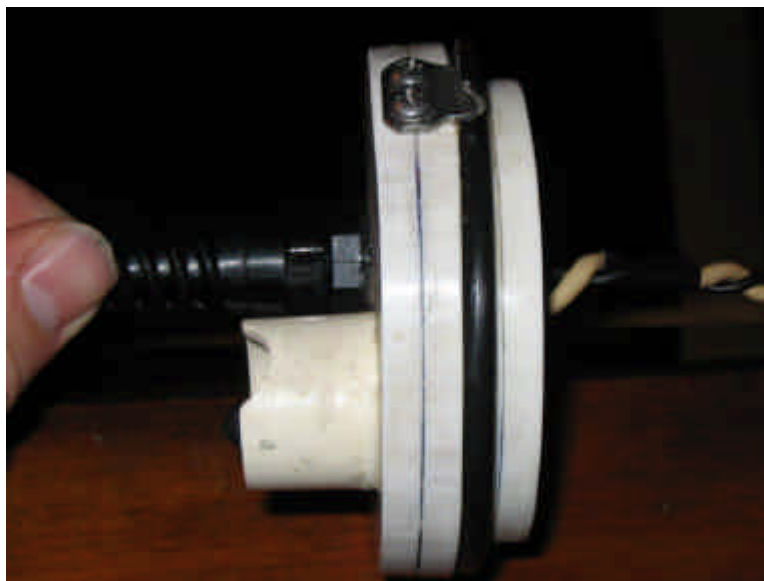


Figure 6: PVC lid with face seal o-ring installed.

### **The Cable:**

People obsess over finding the "holy grail" of dive light cable shelling out big bucks for special marine wire. These types of cable do not use paper fillers to make them round, but are instead made with over-molded rubberized plastics. The theory being that if you were to nick the paper filled cord on a metal wreck that it would somehow saturate the entire length of paper filler, and then flood the canister. For me locating this type of cable at \$5/foot does not appear to be worth the time or effort. Rubber coated landscape cable can be found at good local hardware stores for less than a buck a foot, and can be replaced yearly at the slightest sign of abrasion. This landscape cable is referred to as SJOOW and an appropriate size would be 16 gauge 2 wire (16/2 SJOOW).

(See Figure 7)



Figure 7: 16/2 SJOOW water resistant cable.

### **The Cable Gland:**

How do you get the cable into the canister and into the lighthouse without letting water into the canister? Cable Glands. Cable glands are generally threaded on two ends with a tapered pipe thread pattern (NPT). One end will screw into the lid, and the other end contains a rubber grommet through which the cable passes and is then compressed and sealed with a special nut. Cable glands come with strain relief and without strain relief to reduce fatigue on the cable at the gland. Either will work, but after using each I recommend the version without the strain relief since it just seems to get in the way.

Another concern is the cable gland material. You'll want a metal not prone to corrosion, possible solutions include stainless steel, nickel plated brass, and aluminum. For the price and performance the nickel plated brass works extremely well (this is same material used in the first stage of regulators). With the 16/2 SJOOW cable, a good size gland is McMaster-Carr part #6907K12 which fits .16-.31" cable with 3/8" NPT threads.

(See Figure 8)

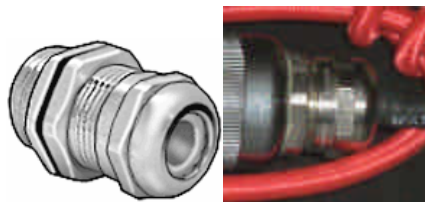


Figure 8: 3/8" Nickel Plated Brass cable gland. [www.mcmaster.com](http://www.mcmaster.com)



### **Cable Gland Placement:**

The cable gland can be installed in the lid by drilling a hole slightly smaller than the cable gland and tapping the hole with a 3/8" NPT pipe tap, if you have one available. Otherwise the metal threads of the gland should be able to cut their way into the softer PVC with some effort.

I've yet to achieve the perfect o-ring, tapped hole, cable gland seal, and as a result after testing I usually remove the cable gland, coat the threads with epoxy (I prefer JB Weld), and then reinsert the cable gland permanently.

### **The Latches:**

The latches needed to secure the lid are draw/catch type compression latches that lock so that the latch cannot be inadvertently knocked off during a dive. There is one latch that works so well for this application it will be the only one that I discuss here. They are made of SS by Nielson Sessions, and can be purchased from [www.salvodiving.com](http://www.salvodiving.com) They are relatively expensive at \$10 a piece but I HIGHLY recommend spending the money here, you'll need two (make sure to pick up the corresponding catches when you order). (See Figure 9)



Figure 9: Nielson Session locking compression latch and catch. [www.salvodiving.com](http://www.salvodiving.com)



**Latch Placement:**

To accurately attach the latches to the canister first make a template with a strip of paper. Cut and tape a strip of paper to the outside of the canister and mark where the paper overlaps. Take off the paper and measure the circumference of the canister and make a second mark at the halfway point. This will ensure that your latches are placed directly opposite each other, and therefore the lid will go on in either orientation. Mark the canister/ lid, and install the catches to the lid first using SS sheet metal screws (McMaster [#92470A108](#) for the lid [#92470A107](#) for the latches). With the lid, o-ring, and catches installed on the canister, position the latches on the canister with the draw portion sticking perpendicularly out from the canister. This will ensure that when the latches are closed the proper amount of tension is applied to the o-ring. (See **Figure 10**)



Figure 10: Proper latch orientation.

### The Switch:

The switch needed to switch the light on and off at depth is a single pole single throw (SPST) toggle switch. The longer the length of the toggle, and length of the threaded "through wall" portion the better. The toggle switch will need to be sealed with a switch boot, which is a rubber nipple that threads down over the toggle and seals itself against the lid. (See **Figure 11**) If the boot is too big and the toggle too short you may get into a situation where the water pressure compresses the rubber against the toggle to such a degree that the switch is inoperable. Bottom line, the longer the length of the toggle the better. The switch can be mounted off center on the inside of the lid by drilling a hole through all four layers of the lid and then drilling progressive holes around the through-hole so that the body of the switch is recessed far enough into the lid that the toggle extends through the top (See **Figure 12**). Alternatively, using a Dremel and a sanding bit like an end-mill, material can be removed to accommodate the switch. The switch is then held in place and sealed with the boot from the outside. A switch protector can be made from a small piece of PVC to help protect the switch from being damaged. (See **Figure 13**)



Figure 11: Toggle switch and boot. [www.salvodiving.com](http://www.salvodiving.com)



Figure 12: Bottom of lid bored out for switch.



Figure 13: Installed switch with protector.

Switches and boots can be ordered online from electronics distributors such as [www.digikey.com](http://www.digikey.com). However, the most convenient place I've found these parts together is the local Ace Hardware which carries these parts under their brand name, and should be available at all of their stores.

Another switching option is to place a magnetic reed switch in the lighthouse using some derivation of the circuit below. When a magnet in the lighthouse handle is oriented in the correct position the reed switch will close and generate a field in the MOSFET and allow current to flow through the bulb. (See Figure 14)

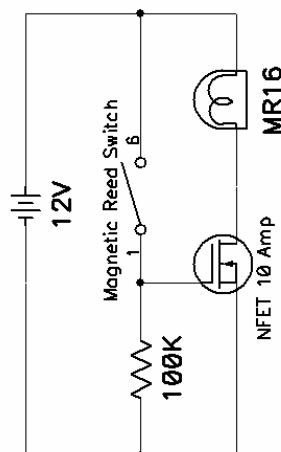


Figure 14: Magnetic switching circuit

### The Lighthouse:

The homebuilder's bread and butter lighthouse is made with a modified C cell Maglite. To build this style lighthouse you need a three C cell Maglite, a Dremel, and JB Weld epoxy. Start by unscrewing the entire bulbous reflector assembly just forward of the switch. The remaining battery cylinder with the switch needs to be cut .5" behind the switch, and the threaded portion with the switch-hole can then be discarded. The next step is to take the bulbous reflector assembly, remove and discard the reflector, and the internal guts. The threads at the base (small end) of the reflector need to be ground down with a Dremel so that the remaining portion of the battery compartment can be pressed into the reflector housing. Once a snug fit is achieved these two parts can be JB welded together. (See Figure 15) I recommend the standard JB Weld that sets in about 10 mins, and not the "Kwik" version, even though the standard stuff can take up to a week to fully cure (The Kwik Version never seems to fully harden).



Figure 15: Assembled lighthouse JB welded together without switch hole.

The lighthouse will also need a cable gland to allow the cable to pass through the end. The end cap of the light head can be removed and drilled out to accept the cable gland (same as was used in the lid). It may be possible to tap this portion and achieve an o-ring seal, but the easier way is to again just use the JB Weld on the inside of the end cap.

A MR16 pin connector base should be able to be found at a local lighting store which includes two lead wires and a small ceramic base which should be soldered to the end of the cable. Other online vendors may have the socket available, but in the worst case scenario an \$8 landscape light from Home Depot can be scavenged or maybe one of the neighbors wouldn't notice a missing landscape light... ;) (See Figure 16)



Figure 16: MR16 bulb connected to ceramic base

The MR16 bulb should be a near perfect fit into the reflector housing side of the lighthouse. There are many variances in the MR16 bulbs made by different manufacturers. Most notably is that some come with their own glass lenses, and others do not. Either will work, but it is important to find one that will fit fully within the reflector housing and not protrude past the end of the threaded portion for the bezel. I've sanded the circumference of some bulbs that I especially liked to get them to fit, but with mixed results. If the bulb protrudes even a fraction of a millimeter from the housing the pressure on the Maglite's lens will press down on the bulb and eventually crack it. (See **Figure 17 and 18**)



Figure 17: MR16 bulb inside of reflector assembly.



Figure 18: The MR16 bulb must be completely below the top of the threads.

### **The Lens:**

The Maglite comes with a flimsy acrylic lens. This lens will not to the pressure or the heat generated by the halogen bulb. Maglite, and other manufacturers, makes replacement glass lens for their flashlights that are generally sold for law enforcement. These lenses can be found from stores that sell police equipment including some military surplus stores. With the standard Maglite reflector removed, these lenses will no longer be thick enough to produce a watertight seal. The lenses need to be 1/8" thick with a 2 1/8" diameter. To achieve this thickness two glass lenses can be stacked on top of each other as long as they are not then too thick for the bezel to seal properly. **(See Figure 19)** A better solution would be to have a glass shop custom cut the lens for you, and may be less expensive than stacking two lenses.



Figure 19: Double glass Maglite lenses seated atop MR16 bulb.



Getting the bezel to seal properly with the lens and without putting any pressure onto the bulb is one of biggest challenges to getting the lighthouse to work properly, and will require some in water testing to verify a good seal. Make sure to lube all of the threads liberally to help facilitate sealing. (See Figure 20)



Figure 20: Sealed lighthouse ready for in water testing.

### **TESTING!!!:**

At this point you should have something that resembles a dive light. It would be a very good idea to test the canister, and lighthouse, on a dive or two without the battery or bulb in place to make sure that there are no leaks. The canister will be buoyant without a battery pack inside so put a weight inside before you dive. Do not rely on this light for open water diving until you have thoroughly tested it (don't even think about overhead environments), and always carry at least one backup, two is better. If diving in fresh water the dive light will almost always continue to work with a flooded canister or lighthouse, but may lead to corrosion in the future. Dry everything out after a leak as soon as possible to help prevent corrosion.

Condensation may fog the lens of the lighthouse on some dives, especially those in colder water. After completely drying the inside of the lighthouse with warm air (low heat hairdryer) the lighthouse should be purged of the warm humid air with cold dry air prior to sealing. A very good source of cold dry air would be from those near empty scuba tanks in the corner of the garage that you've been meaning to get filled.

### **Finishing Touches:**

The first thing you'll want for the lamp is a way to attach it to your gear. Most people do this by attaching it to their waist belt. This can be achieved with two hose clamps and a



loop made of piece of two inch nylon webbing. The other option is to attach it to your backplate/BC with a SS quick link and hose clamp D-rings which can be purchased online from [www.reefscuba.com](http://www.reefscuba.com).

The other thing you will likely want is a handle for the lighthead so that you can mount the light to the backside of your hand so that you are free to use your fingers. These types of handles are often called “Goodman” handles and can be made by cutting out three half circles of PVC flat stock and cementing them together. A 1.25” hole can be drilled in this piece to snugly accept the shaft of the lighthead. Two smaller holes can be drilled along the flat edge of the handle and bungee cord tied through the holes to hold it against your hand. In the picture below I’ve used a single piece of grey PVC round stock to make the handle, but the same thing can be accomplished by laminating three sheets together. (See **Figure 21**)

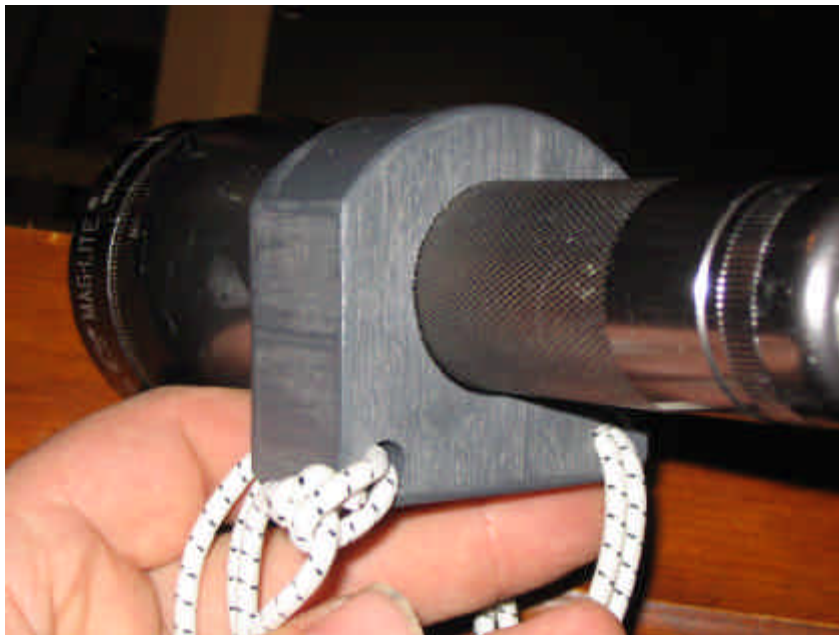


Figure 21: PVC lighthead handle.

If you went the reed switch route the base of the handle can be drilled out to accept a magnet. As the lighthead is turned within the handle the magnet will orient with the reed switch in the lighthead and turn on the light.

## Appendix

(Feel free to email me an appendix to this article with your own tips/tricks, and I'll update this section. [bnscherm@bnsengineering.com](mailto:bnscherm@bnsengineering.com))

### Appendix A:

You can cover blemishes on your canister by using a piece of large diameter heat shrink; similar to what you used on your battery pack. [www.batteryspace.com](http://www.batteryspace.com) sells heavy-duty rubber heat shrink that is very tough, and a nice matte black color. It is relatively easy to install, you just have to be careful to avoid heating your canister too much. To install mine I brought a large pot of water to a boil, positioned the shrink-wrap on the canister and used pliers to dip the canister into the water. I did not completely submerge the canister I just brought it to the highest point on the heat shrink. I then used the bottom of the pot to flatten the heat shrink on the bottom of the canister. The whole process should be done very quickly to avoid raising the temp of the canister itself to the point where it would deform. This was a quick and cheap way to cover some imperfections on the bottom of my canister, and as an added bonus it adds a professional looking touch. (See **Figure 22, 23, and 24**)



Figure 22: Heat shrink covered light. Note this light uses the magnetic reed switch, and does not require a switch on top of the lid.



Figure 23: PVC round stock turned on a lathe to make a custom lid.



Figure 24: A magnet is mounted inside the PVC handle to activate the reed switch inside the lighthouse.

-Eric Bauer  
esbauer68@comcast.net

**Parts:**

- [www.batteryspace.com](http://www.batteryspace.com) - Batteries, connectors, heatshrink, chargers.
- [www.mcmaster.com](http://www.mcmaster.com) - Cable glands, o-rings, switches, boots, cable, bulbs, etc.
- [www.reefscuba.com](http://www.reefscuba.com) - Clips, fasteners, webbing
- [www.salvodiving.com](http://www.salvodiving.com) - Latches. Expensive battery packs, switches, connectors and canisters.
- [www.digikey.com](http://www.digikey.com) - Switches, MOSFETs, Reed switches, connectors.
- [www.air-oil.com](http://www.air-oil.com) - Any size o-ring you can think of...