55 Watt
Flowing Gas
CO_2 Laser Tube Kit

Assembly/Operation Instructions:

Disclaimer:

The laser described herein is a Class IV laser device and is *Extremely Dangerous*. The laser will instantly ignite clothing, wood, paper, plastics, and many other common items and will *Seriously Burn Flesh, Including Eyes*. Care must be taken to avoid S*erious Injury* and/or *Blindness*. Always operate this and any other high power laser in an environment free of flammable materials, children, pets, spectators, etc. Always use Infrared Eye Protection Goggles when operating this laser. Failure to due so may result in *Permanent Blindness*. This laser uses *Lethal High Voltages*. Care must be taken when working with the power supply. Failure to do so may result in *Serious Injury or Death*.

Builder and/or User Assumes All Risks!
By assembling this laser kit, or by using the information contained in this manual to build, repair, or otherwise work with lasers or other high voltage devices of any kind, Y*ou Do So At Your Own Risk.*

These lasers do not comply with the Federal regulations (21 CFR Subchapter J) as administered by the Center for Devices and Radiological Health. Purchaser acknowledges that it is their responsibility to obtain compliance with all CDRH and other applicable domestic and/or international safety standards.

Table of Contents:

KIT CONTENTS:

The contents of the package should include:

1ea Instruction Manual (This Manual)
1ea Zinc Selenide (ZnSe) Output Coupler
1ea Enhanced Gold Rear Miror
1ea Pyrex® Glass Cooling Jacket
1ea Pyrex® Glass Bore Tube
1ea Machined Brass Adjustable Mirror Cell
3ea 3MM X .35 Pitch - Adjusting Screws
1ea Machined Brass End Cap
2ea Machined Nylon Bore Supports
2ea Large O-Rings
2ea Small O-Rings
1ea Formed Anode
1ea Anode Attachment Screw
1ea Anode Attachment Washer
1ea Anode Attachment Nut
2ea HV Wire Connection Clips
1ea Machined Stainless Steel Cathode
1ea Cathode Support Spring
1ea Cathode Retainer Washer
2ea Phenolic Mirror Insulators
2ea Brass Coolant Fittings
2ea Brass Gas Fittings
2ea Packages of 1/4”ID x 3/8”OD Water/Gas Hookup Tubing (20ft each)
1ea 20ft Length of High Voltage Hookup Wire
1ea Epoxy Adhesive System
1ea Tube - Silicone Adhesive
1ea Injection Syringe
4ea Adhesive Mixing Cups
4ea Adhesive Mixing Sticks

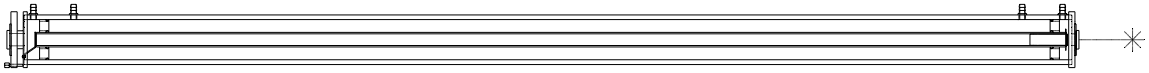
REQUIRED TOOLS:

You will need the following items in order to build this kit:

Suitable Clean and Flat Workspace
Oil Free Dish Detergent (The Kind Without Moisturizers)
Paper Towels
Cotton Swabs
Cleaner Degreaser such as MEK (Methyl Ethyl Ketone) or Acetone
Bore Cleaning Rod (A De-Greased Gun Cleaning Rod or Equivalent)
Lint Free Bore Cleaning Patches
Single Edge Razor Blade
X-Acto Knife
Masking Tape
Small Helium Neon or Diode Laser for optical alignment
Adjustable Mount for HeNe/Diode Laser
Compressed Air (Can of Compressed Gas Used for Camera Lens Cleaning)
Insulated Handle - Nut Driver with 3/16” or 5mm Socket
Flat Nose Pliers
Needle Nose Pliers
Small Phillips Screw Driver
320 Grit Sandpaper

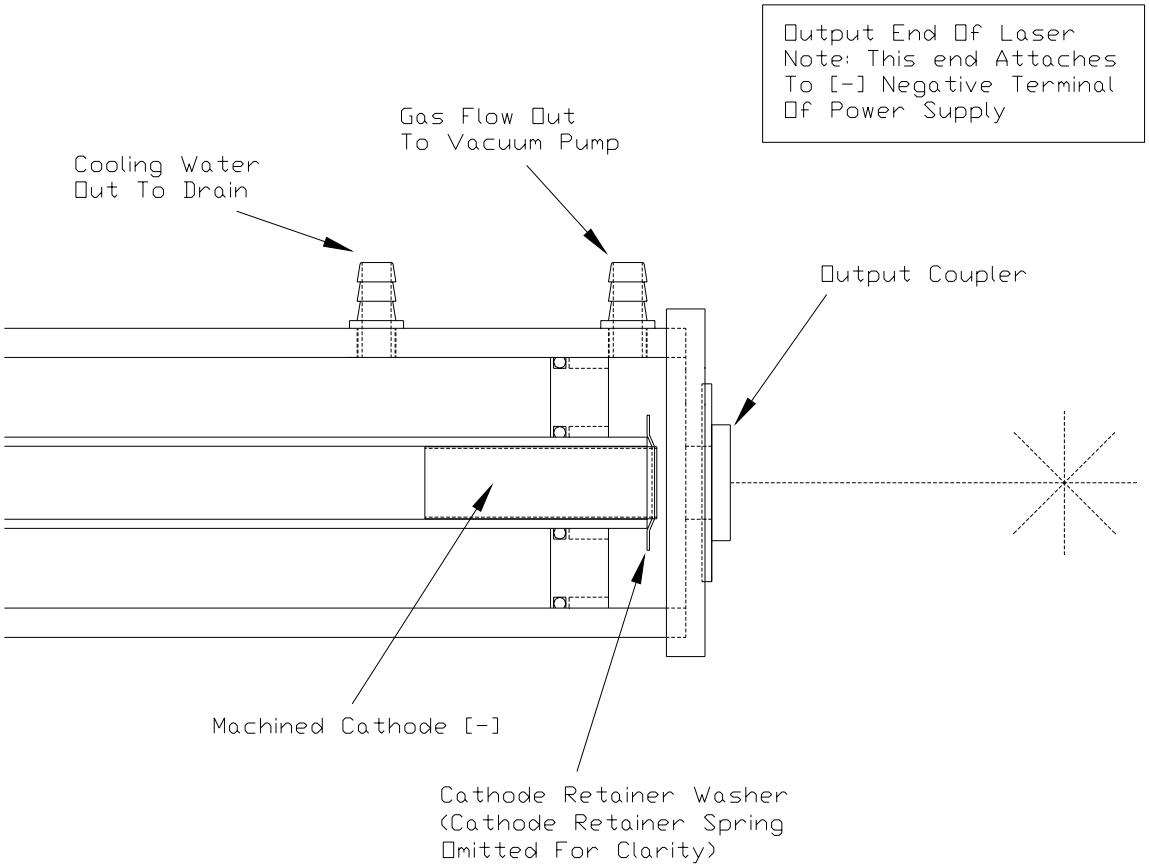
Tube Drawings:

Overall View:



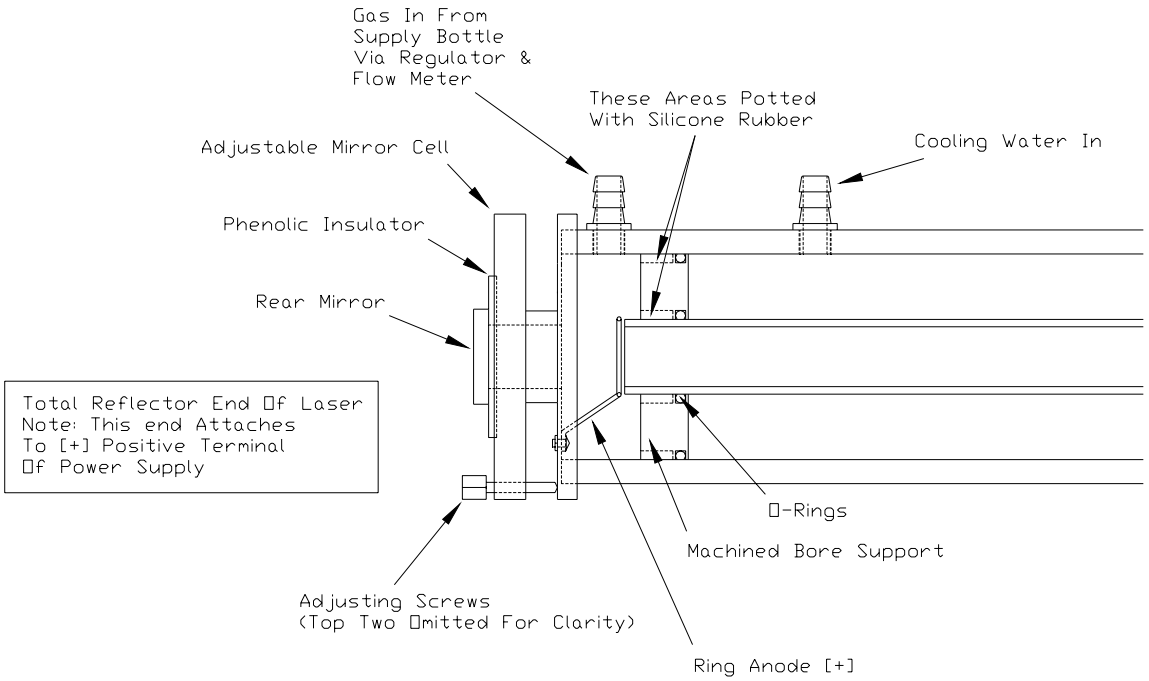
Output End:

This is the non adjustable Output Coupler end of the tube. This is the CATHODE [-] end of the tube. Note tubular cathode inserted inside of bore. A spring (Not Shown) holds the cathode into the bore and provides electrical connection to end cap.



Total Reflector End:

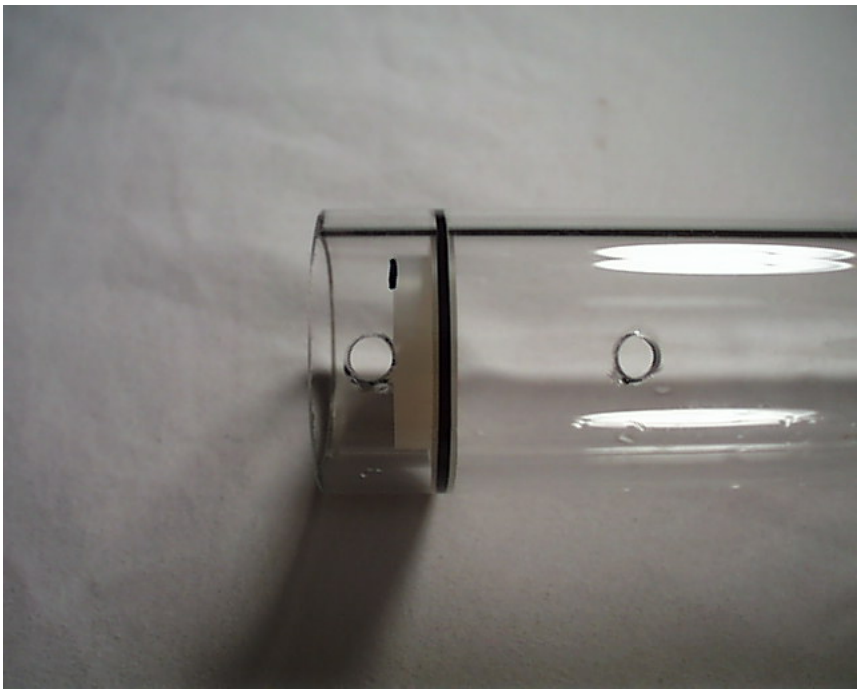
Adjustable, Total Reflector end. Only one adjusting screw shown for clarity. Adjusting screws are ultra fine thread (73 thread per inch). This is the ANODE [+] End of the tube. Note Ring Style Anode near end of bore.



TUBE ASSEMBLY:

1) Remove all items from packing and inspect for damage and or missing parts. Refer to Kit Contents on page 3.
2) Study the Tube Drawings on pages 5 and 6 to familiarize yourself with the parts.
3) Clean and de-grease all Glass Tubing, Brass Fittings, Brass Adjustable Mirror Cell, Brass End Cap, and Nylon Bore Mounts using soapy water. Be sure to use a dish soap that has no moisturizers in it. Rinse well with warm water, then dry all parts thoroughly. Use compressed air if available to help dry the parts.
4) Insert the o-rings into their grooves in the machined Nylon Bore Mounts. See drawings.
5) Using the supplied drawing as a guide, insert one of the nylon bore mounts into one end of the cooling jacket. Align the mount so as to be the correct spacing for the output end of the tube. Note that on the output end of the laser the nylon bore mount is only pushed in far enough to be flush with the edge of the hole for the gas fitting (Approximately ½" or 12.7mm from outside edge of nylon mount to the outside edge of the cooling jacket). Wet the inside of the jacket and the o-ring so that it will slide in without binding.

   IMPORTANT: Be careful to orient the Nylon Mount so that the o-ring faces in toward the center of the tube.



6) Slide the remaining Nylon Bore Mount onto the Bore Tube. Slide the mount onto the end of the tube that is fire polished, not the sharp cut end, and work it all the way down to the other end of the tube. Use water on the o-ring to facilitate easy movement.

7) Insert the polished end of the bore tube down into the cooling jacket. At the other end pass a pen or pencil through the bore mount and use it to align the incoming bore tube. Push the bore tube through the bore mount while at the same time inserting the opposite bore mount into the cooling jacket. Use as much plain water as is needed to keep the o-rings lubricated while moving everything into position.

8) When properly inserted, the bore tube and mounts should look like the drawings on pages 5 and 6.
NOTE: At the output end, be sure that the bore tube is inserted exactly ¼" or 6.3 mm into the cooling jacket, and that the bore mount is just in far enough as to not block the gas passage. See the following picture.

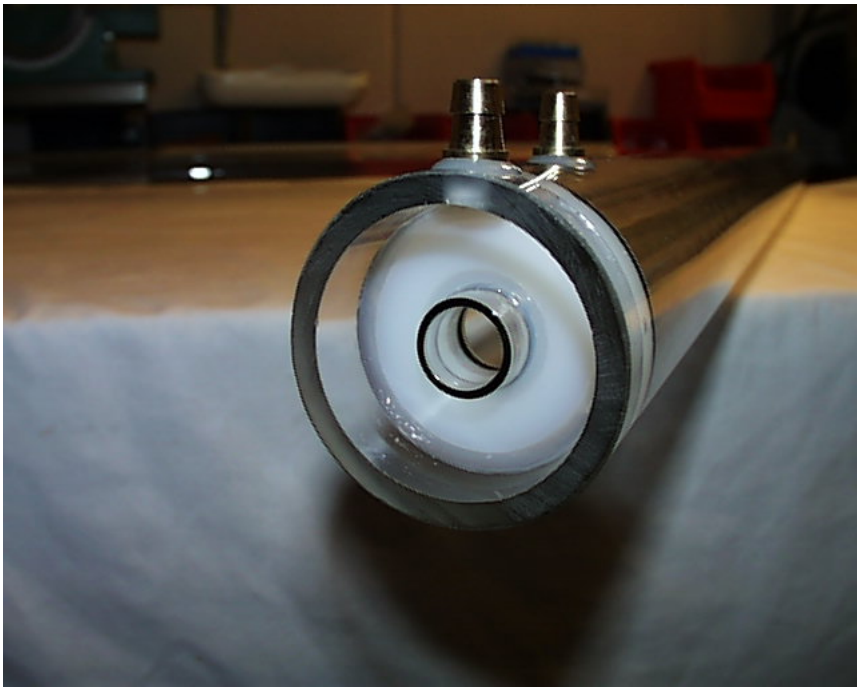
At the total reflector end, the bore tube should be inserted exactly ½" or 12.7 mm into the cooling jacket, and the bore mount should be inserted 5/8" or 15.8 mm. It is very important that the bore protrudes a minimum of 1/8" or 3.2 mm from the Nylon bore support at this end.

9) When you are sure of the alignment positions and have the bore supports square with the tube, clean the ends of the tube again with soapy water and a soft brush. Be sure to rinse well with warm water.

10) Dry the ends of the tube thoroughly by either letting air dry, or using compressed air if available. Ensure all moisture is removed from the recessed areas where the silicone will be injected.

11) Remove the plunger from the supplied syringe and inject the syringe full of silicone from the supplied tube. Do this in one motion forcing the air from the syringe as the silicone moves up inside. Avoid getting any air bubbles into the syringe. Insert the plunger into the rear of the syringe and expel any air that may be in the tip.

12) Use the syringe to fill the two grooves in each bore mount. Be sure to insert the tip of the syringe all the way to the bottom of the slot, and move slowly all the way around being sure to fill the entire groove as you go. Excess silicone can be wiped away using your finger tip.

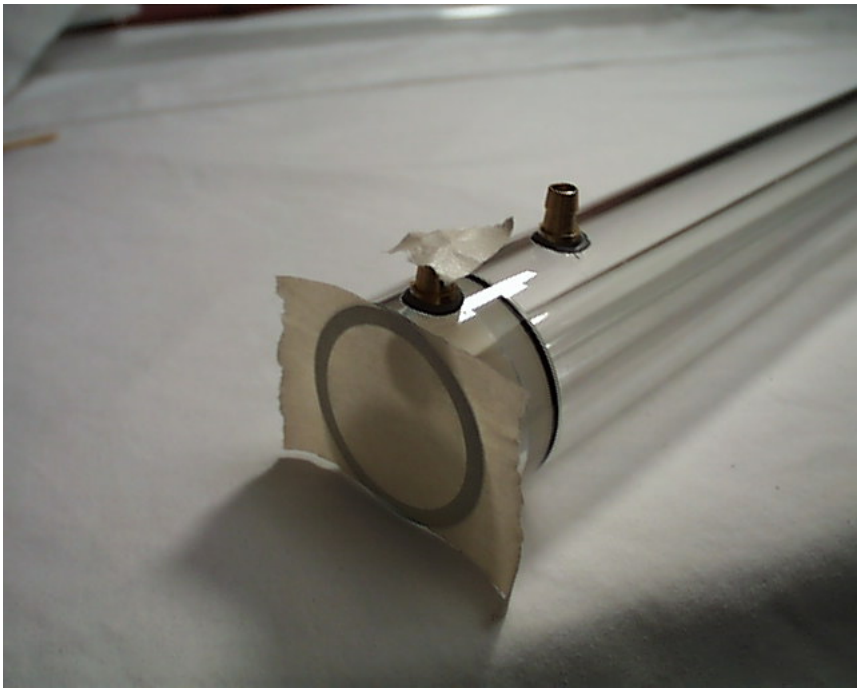


13) Repeat with opposite end of tube and then set aside to dry.

IMPORTANT: Allow silicone to air dry for 48 Hours before proceeding to install the end caps. If the ends are installed too soon, the silicone will not cure completely and the bore mounts could come loose while under a vacuum.

14) After the silicone has dried completely, use the single edge razor blade to remove any excess from the inner wall of the tube, then clean the inside of the tube with MEK or Acetone to remove any silicone residue.
15) Use a clean rod of sufficient length to pass several lint free cleaning patches soaked in MEK through the bore tube. Repeat process until all foreign matter is removed from inside of bore.
16) Wipe the ends of the cooling jacket with a clean cloth or paper towel soaked in MEK or Acetone to ensure that any oil or grease reside has been removed in preparation for gluing the ends in place.
17) Use compressed air to remove any dust from the ends of the tube where the bore supports are installed. Also use compressed air to blast any remaining dust from the inside of the bore tube. Inspect by holding up to a lamp and sighting down the inside. The tube should be clean and dust free. When completely cleaned and all

dust particles are removed, tape the ends of the tube off with masking tape to prevent any foreign matter from entering the tube.



NOTE: It is very important to ensure that all particles of lint and dust have been removed from the tube and the cavities at the ends. Failure to do so will result in the particles being vaporized when the tube is ionized, and could cause damage to the coatings of the mirrors, therefore reducing the life of the tube. Clean the tube well and use plenty of compressed air.

18) Mix up equal amounts of the supplied liquid steel epoxy using a supplied mixing cup and stirring stick. Be sure to dispense equal amounts of the resin and hardener.

19) Apply a generous portion of the epoxy to the bottom section of each brass fitting using a tooth pick, then rotate the fittings down into the holes in the cooling jacket allowing the epoxy to work into the joint and forming a nice fillet at the top. Allow the epoxy to cure for 8 hours.

20) Attach the Ring Anode to the Adjustable Brass End using the supplied screw, washer and nut. Slide the washer onto the screw, then insert through the anode, and then pass through the hole in the brass plate. Hold the screw in place and then apply a small amount of liquid steel epoxy over and around the threads where they come out the back side. Then use needle node pliers to position the nut in place and tighten the screw. Ensure that the Hoop Anode is exactly centered on the hole before tightening all the way. It may be necessary to adjust the hoop slightly by bending it with pliers until it is aligned square.

21) Trial fit the Adjustable Brass End onto the cooling jacket to ensure that the Anode attached in the previous step does not interfere with the glass. If it does, loosen the screw and slide the Anode in further, then re-tighten and align as described above. When satisfied, set aside to dry for several hours and continue with the next step.

22) Clean the two Phenolic Insulating Disks using MEK or Acetone to remove any grease.
23) Use a piece of 320 sandpaper on a flat surface such as a glass plate and carefully sand each side of each Phenolic insulator to insure that the surface is flat, and to remove the glossy sheen. When finished clean the insulators again to remove dust.
24) Mix up equal amounts of the supplied liquid steel epoxy using a supplied mixing cup and stirring stick. Be sure to dispense equal amounts of the resin and hardener.
25) Use a tooth pick to spread a very thin rim of epoxy around the inner edge of each insulator.

26) Note that in the following step the arrow on the output coupler faces toward the insulator.

Remove the two optics from their protective packaging and apply one optic to each insulator being sure to align them exactly over the center of the hole. (Arrow on OC faces toward the glue). Avoid any sliding of the optic which will spear the glue on the optical surface, just ensure that the optic is well centered on the phenolic washer before contacting the glue, and then press down firmly to spread the epoxy evenly. The rear mirror can be handled and pressed on directly, just avoid touching the optical surface. The

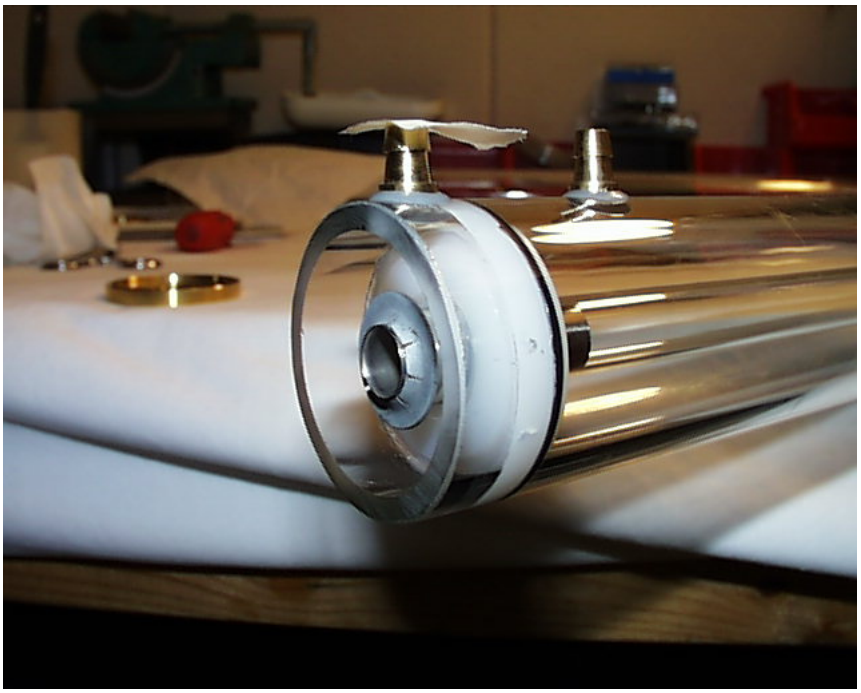
Output Coupler however should only be handled by it's edges. When ready to press down on the output coupler use the supplied tissue it was wrapped in to cover the outer surface, and apply pressure through the tissue. That way you will not scratch or smudge the optic. Allow the epoxy to dry for 8 hours.

27) Clean both of the brass ends thoroughly using MEK or Acetone and then allow to dry. Use some compressed air if available.
28) Mix up another small amount of the liquid steel epoxy and apply a thin bead all the way around the face of the recess on the outside edge of the "ADJUSTABLE" brass cell only. This is the area where the Phenolic insulating washer sits.

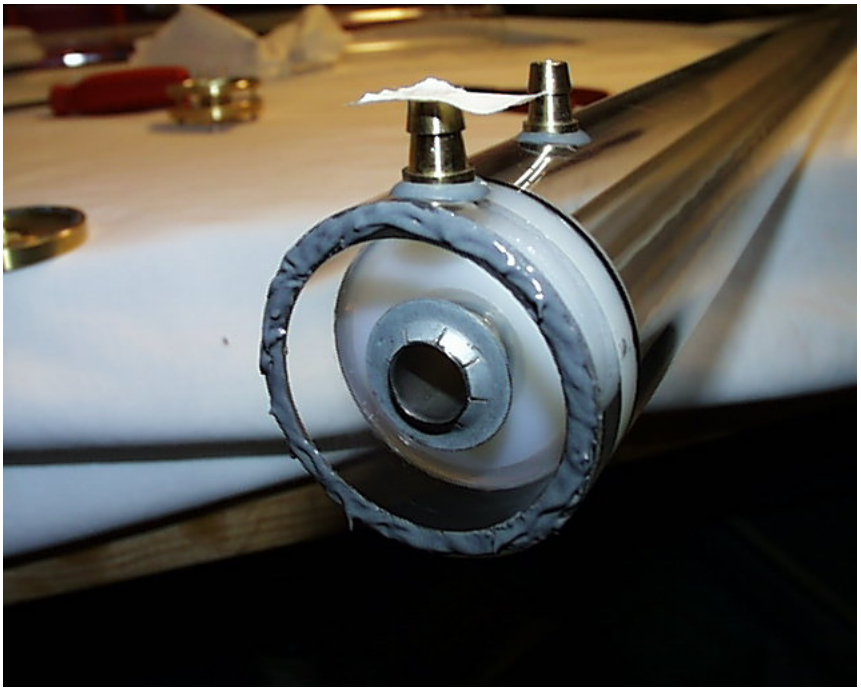
29) Insert the “Rear Mirror” along with its Phenolic Insulator into this “Adjustable Rear Cell” and press well into place rotating to spread the epoxy in a very thin layer, then set aside to dry for several hours. **DO NOT GLUE THE OUTPUT COUPLER TO THE OTHER BRASS END AT THIS TIME.**

30) Insert the machined Stainless Steel Cathode into the Output End of the Bore Tube.

NOTE: Be sure to do this at the output end of the tube. Output end has bore tube about ¼" or 6.3 mm from from end of cooling jacket. See Drawings/picture.



31) Mix up another batch of epoxy and apply a thin layer to the Output End of the glass cooling jacket.

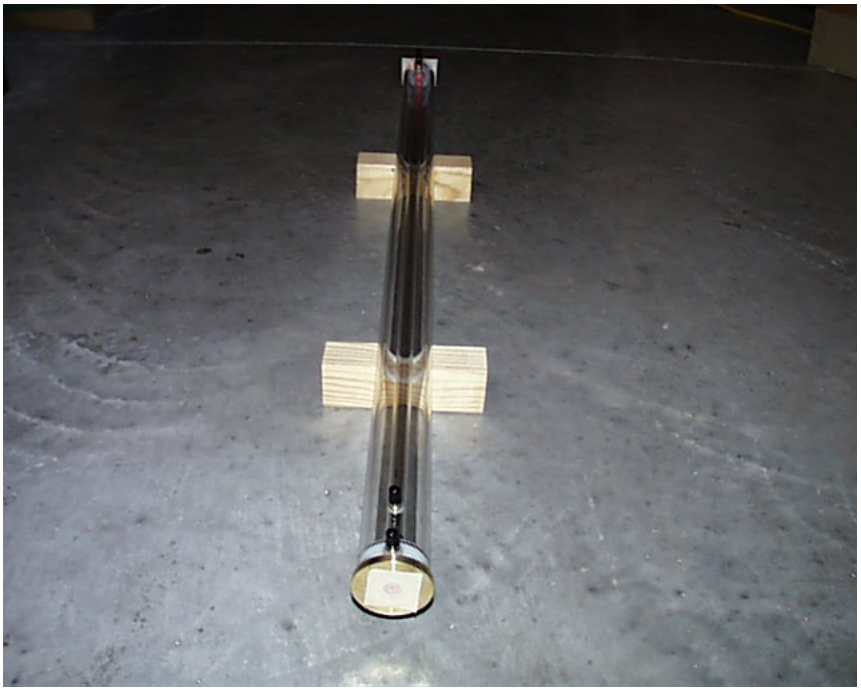


32) Stand the tube upright and place the Cathode Retainer Spring onto the Cathode. Wide section goes toward the Cathode.

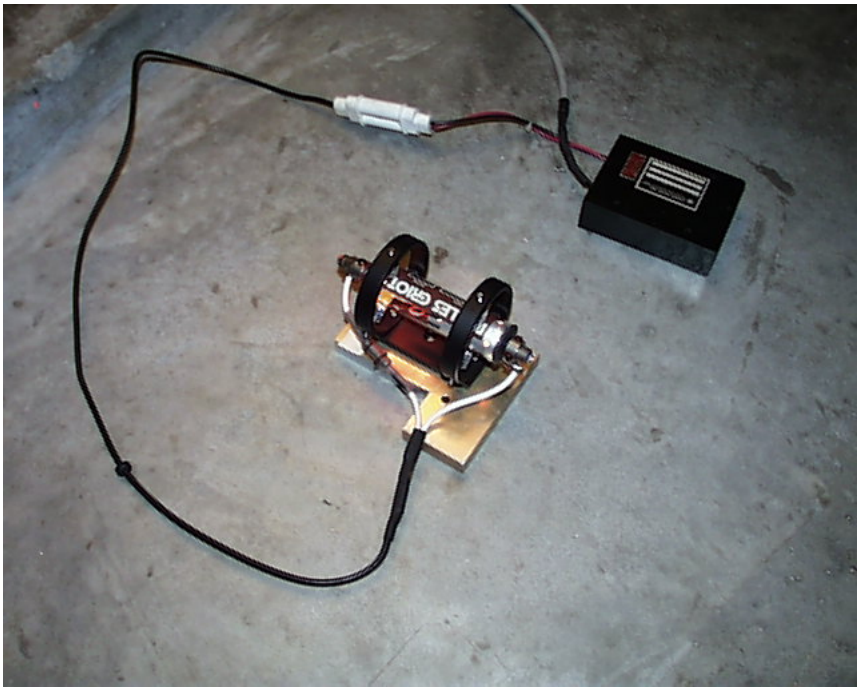
33) Apply a small amount of the epoxy around the inside edge of the lip on the Non Adjustable Brass end.

34) Press the brass end onto the glass with a twisting motion being sure to align the spring into the groove in the brass. After assembled, stand up in a vertical position so that the weight of the tube can keep the spring compressed and keep the end cap on tight. Allow to dry for 8 hours.

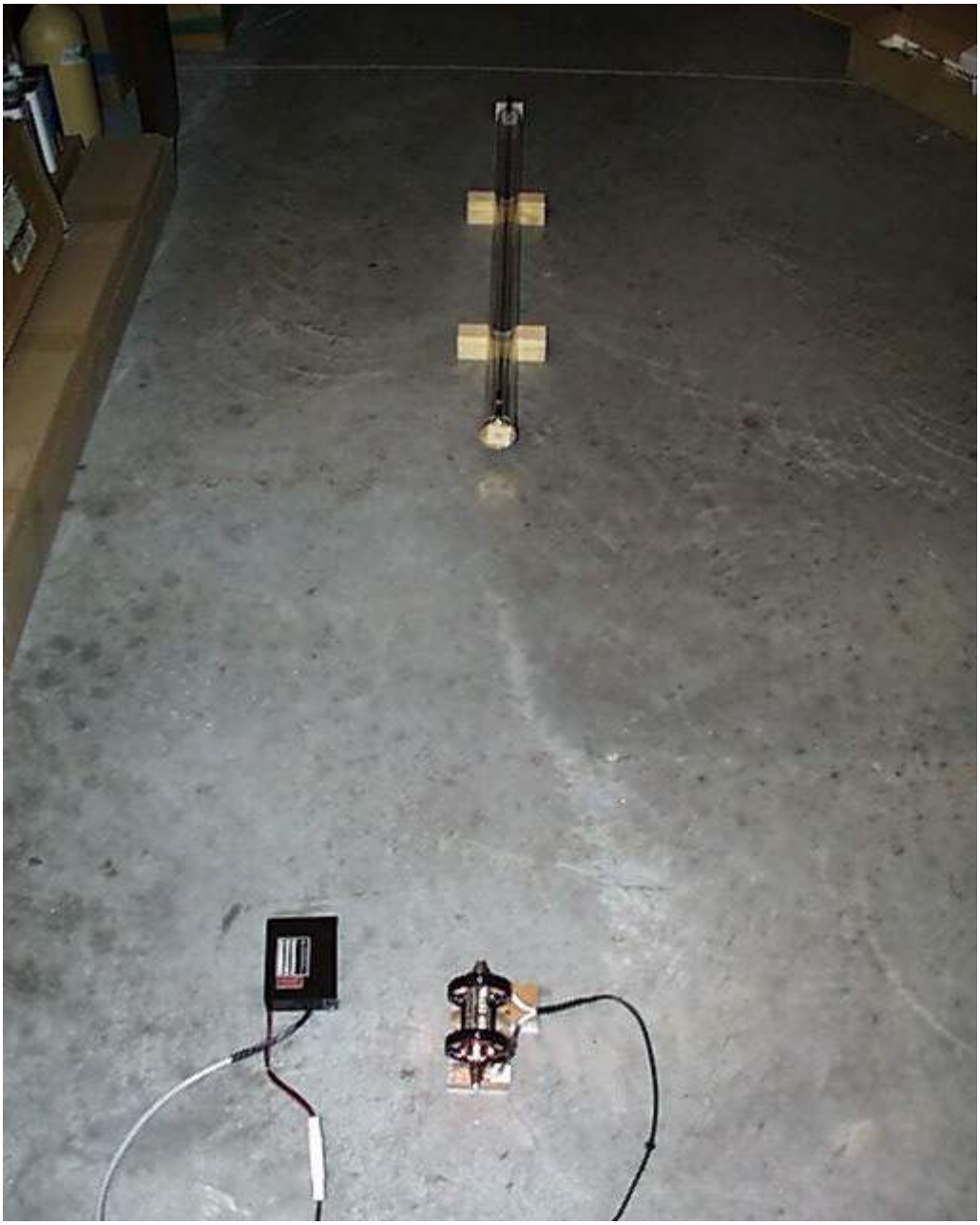
35) Next we will install the Output Coupler onto the front of the tube but first we must set up the alignment laser. We will install the Output Coupler first since it must be aligned to the bore of the tube using a Helium Neon or Diode Laser. You will need an appropriate cradle to hold the laser tube in a horizontal position. One can be fashioned easily from a couple of pieces of wood with cutouts for the tube to sit in. It would be best to line the inside of this cradle with a thin foam gasket tape so as to keep the tube from sliding.



36) Next you will need a means of carefully adjusting your Helium Neon (HeNe) or Diode alignment laser while holding it at the same height off the work surface as the bore of the CO2 Laser. For a Helium Neon (HeNe) laser, an adjustable finder-scope mount from a telescope works well. Whatever you use to hold the alignment laser, it should have non skid feet at the bottom to avoid inadvertent movement.



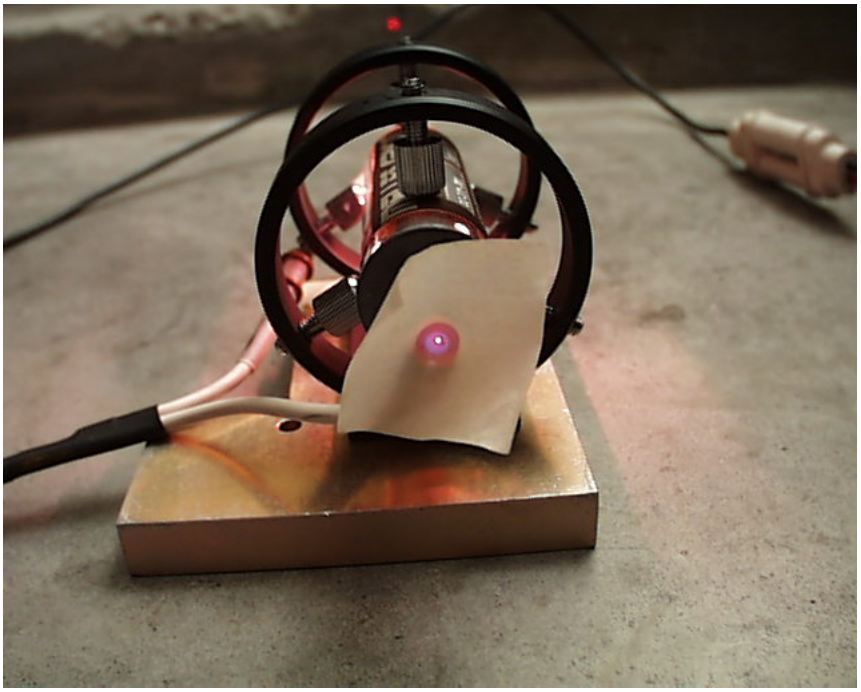
37) After you have the above items sorted out, place the two lasers on a hard flat and stable surface about 5 ft (1.5 meters) apart with the beam from the alignment laser facing the Output End of the CO2 Laser.



38) Use a piece of masking tape with a tiny hole punched in it to cover the front of the alignment laser. Align the tape so that the beam is coming through the center of the small hole. The hole should be roughly the same size as the beam and centered on the beam.

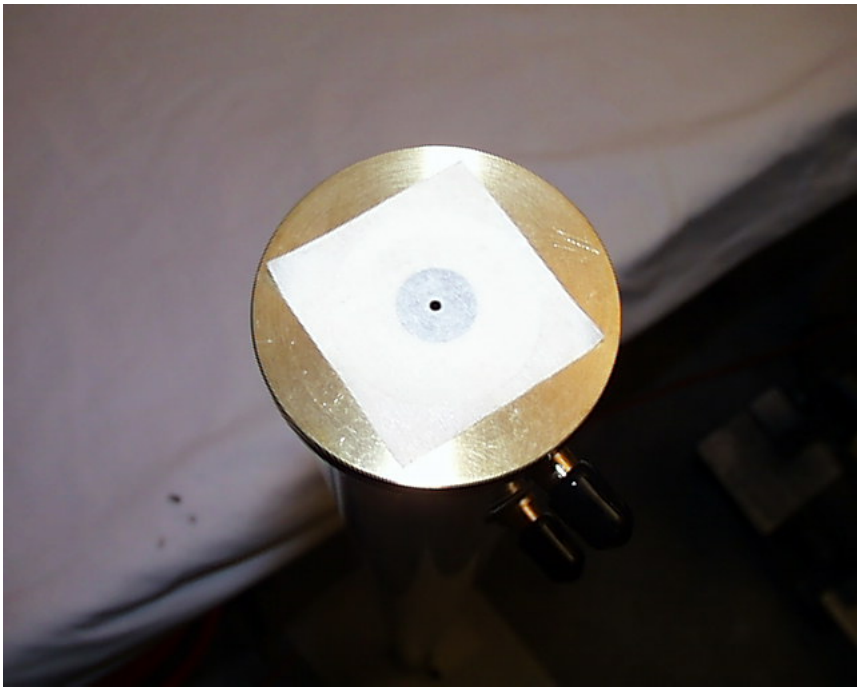
NOTE: To make a nice clean round hole in the tape, hold a thick needle with pliers over a burner or flame. When the needle gets red hot, use it to burn a perfect round hole in the

center of the masking tape. This keeps the beam quality better and it is easier to make the alignment.

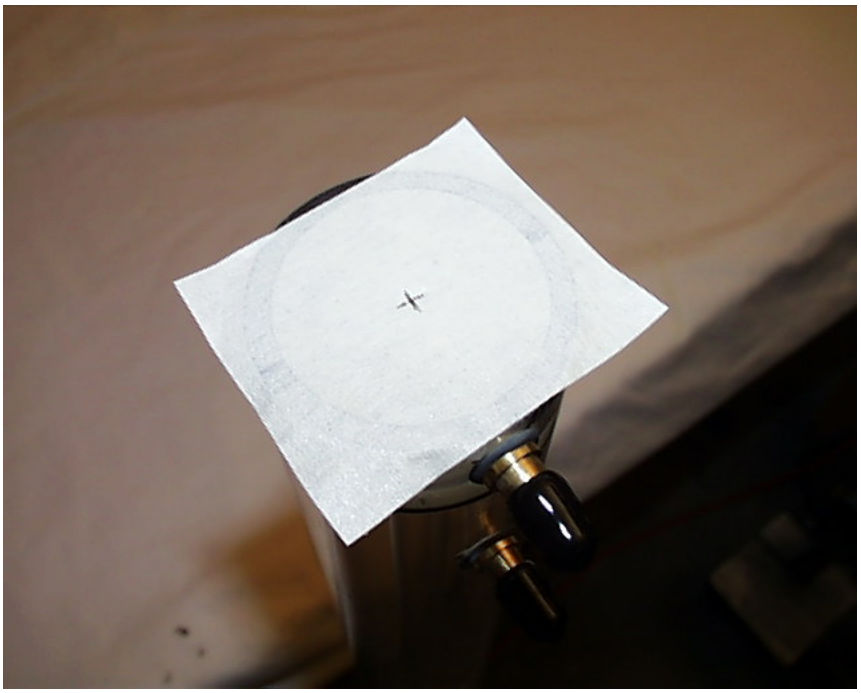


39) Take another piece of masking tape with a tiny hole (~2mm) punched in it's center (See above technique), and apply it over the hole in the center of the Brass End Cap, at the output end of the tube. The hole in the tape should be aligned as precisely as possible with the center of the bore.

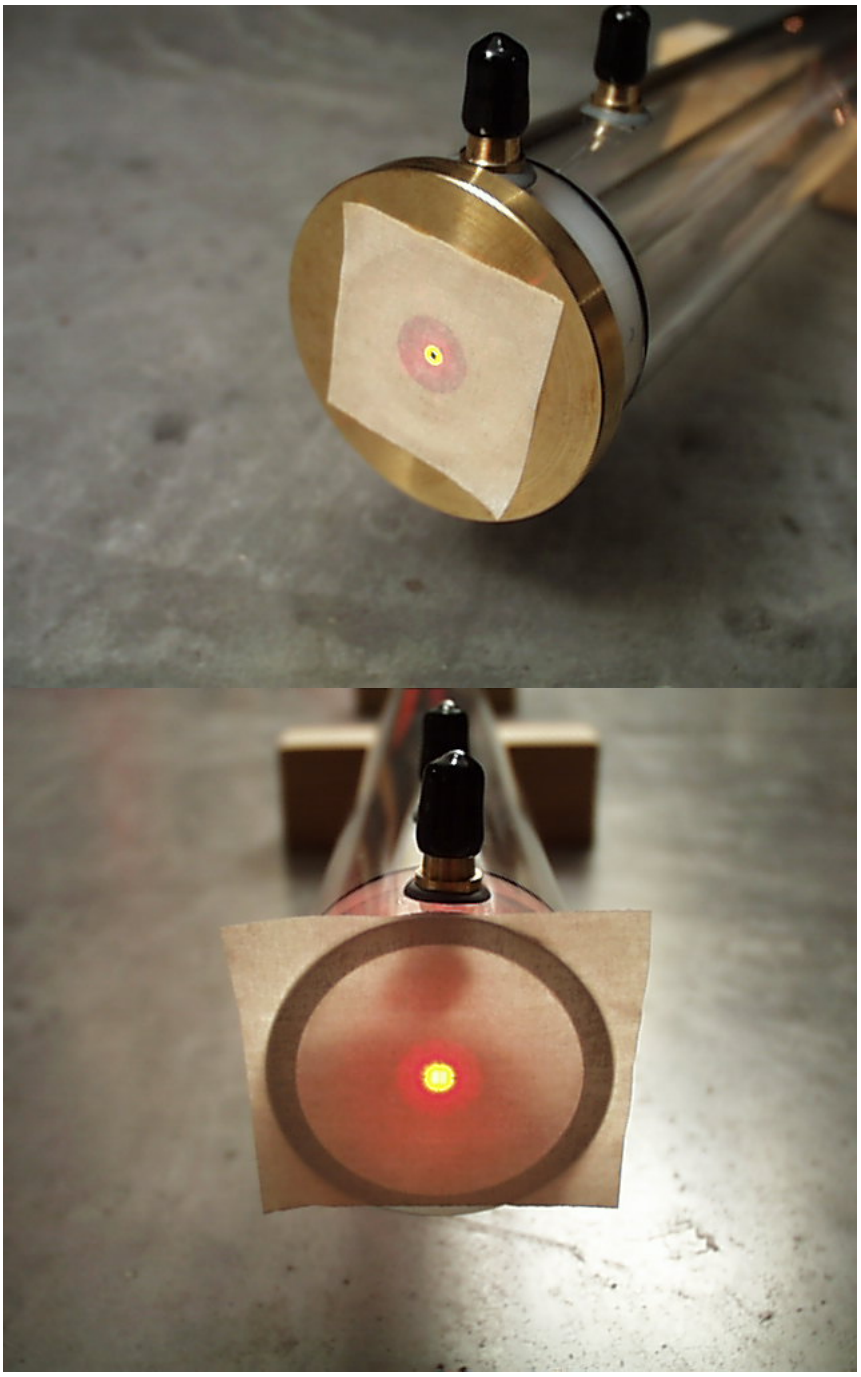
IMPORTANT: This is a very important step. Take time to ensure that the hole is aligned exactly in the center of the bore.



40) Take a third piece of masking tape and apply at the rear end of the CO2 Laser. This piece of tape should not have a hole in it but just cover the end of the tube. Use a ruler to mark a small X at the exact center of the tube on this piece of tape, but do not make a hole in this one.



41) Carefully align the HeNe laser so that the beam is exactly centered on the small hole in the tape at the front of the CO2 Laser, and then passes down the length of the CO2 Laser Tube and strikes the last piece of masking tape exactly in the center of the bore where you marked an X. What you should now have is the HeNe laser beam aligned so that it passes directly through the exact center of the CO2 Laser bore tube.



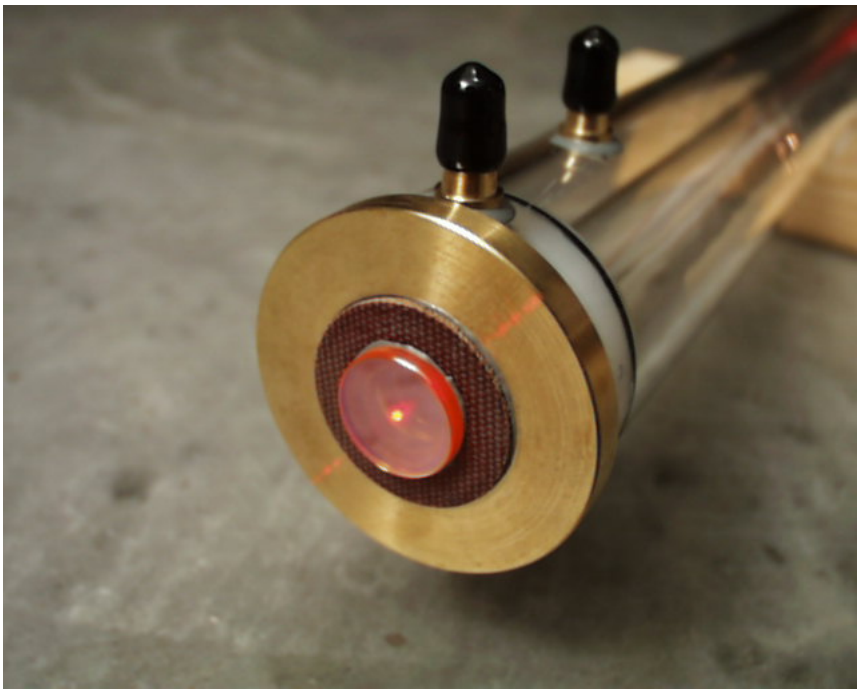
42) Carefully remove the masking tape from the Output End of the CO2 Laser tube being very careful not to move the tube and destroy your alignment. Do not remove the tape from the HeNe laser or the rear end of the CO2 Laser.

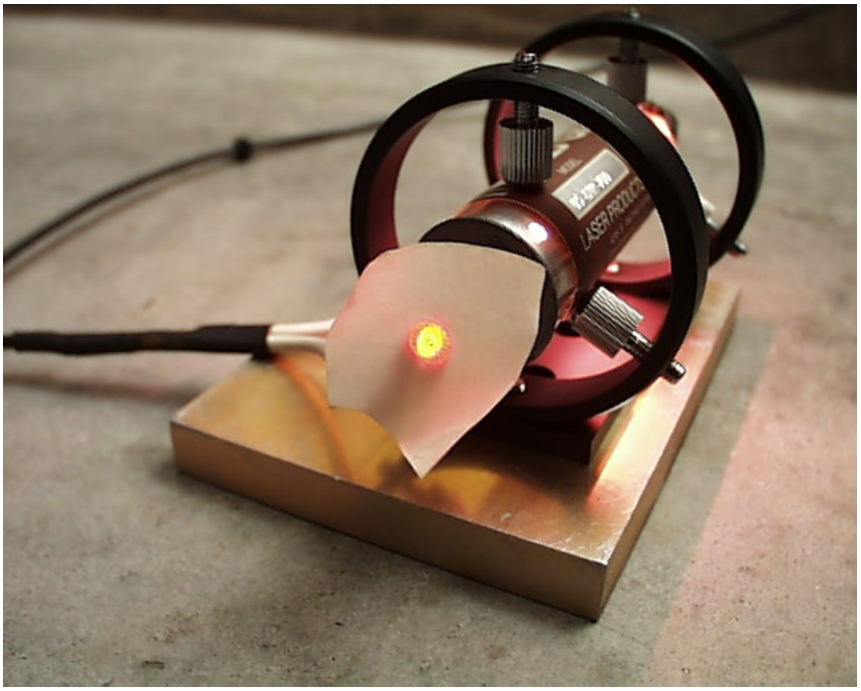
43) Carefully trial fit the Output Coupler with its Phenolic washer onto the front of the CO2 Laser and note the position of the reflected beam back onto the HeNe Laser. Be sure to do this very carefully so as not to bump the laser out of alignment with the HeNe. The reflected beam should strike the masking tape at the front of the HeNe Laser somewhere close to the aperture. Rotate the optic to achieve the closest possible return to the center of the HeNe. This will probably not be a perfect return, but should be within ½" of the center of the HeNe mirror. Make an alignment mark with a pen or marker so that the washer can be returned to this orientation again.

44) Ensure that the inside of the output coupler is dust free and has not been touched. It should not have any grease, oil, dust etc. on it. If needed clean the OC with compressed air to remove any dust/lint, then use a clean cotton swap dipped in pure MEK to carefully clean the optic. When satisfied mix up a small amount of the liquid steel epoxy and apply a thin bead around the Phenolic washer.

45) Carefully press the OC into the recess on the front of the Brass end without moving the laser tube in any way which could destroy your alignment. Rotate the optic so that your alignment marks line up once again. Now carefully seat the optic into position while watching the reflected beam on the HeNe Laser. Position the Output Coupler so that the reflected beam is returned exactly at the center of the HeNe Laser where the tape has the small hole. The thick liquid steel epoxy will hold the optic in this position until cured and will not sag. Just ensure the alignment is correct, then allow 8 hours to cure without being touched or moved.

IMPORTANT: Take your time and perform this step carefully. If this optic is not aligned with a fair amount of care, it will cause beam propagation to take place at an angle instead of straight down the center of your bore tube. This can cause beam distortion, undesired TEM output modes, loss of power, or all of the above.





46) After the previous step has been allowed to cure for 8 hours, we can now attach the Rear Adjustable Brass Mount with optic into place. First ensure that the gold mirror is clean and has no dust or lint on it. If needed give it a blast of clean dry compressed air. Also ensure that the anode ring is aligned parallel with the brass plate and that it is centered on the brass plate and will not block any of the beam path through center hole. Mix up another portion of the liquid steel epoxy and apply a thin layer to the Rear End of the glass cooling jacket just as you did on step 31 for the output end.

47) Apply a thin ring of epoxy around the inside edge of the brass lip, and then push the brass cell onto the rear of the cooling jacket with a twisting motion being sure to seat it fully against the glass. Turn the cell so that the anode attachment screw is opposite of the water and gas nipples.

48) Stand the tube upright and allow the final glue joint to dry for 8 hours.
49) Tube construction completed.

OPTICAL ALIGNMENT:

After assembly of the laser tube it is necessary to carefully align the rear optic so that laser output will commence. This is a critical step and should be done slowly and carefully.

1) Setup the CO2 Laser and the alignment laser again just as you did in steps 35, 36, 37 and 38 of the last section.
2) Place the two lasers on a hard flat and stable surface about 5 ft (1.5 meters) apart with the beam from the alignment laser facing the Output Coupler (partially transparent) end of the CO2 Laser.
3) Use a piece of masking tape with a tiny hole punched in it to cover the front of the alignment laser. Align the tape so that the beam is coming through the center of the small hole. The hole should be roughly the same size as the beam and centered on the beam. **Use the technique described in step 38 to make the hole in the tape.**

   NOTE: Do Not Apply Tape to the output coupler.

4) Align the Co2 Laser so that the beam from the HeNe Laser strikes the center of the Output Coupler (As close as possible by visible means), and then reflects back centered around the hole in the piece of tape on the alignment (HeNe) laser.
5) Use a 3/16” Nut Driver and turn the three adjustment screws clockwise until the tip just contacts the brass plate, then turn each screw an additional ½ turn to apply positive tension to the plate.

   CATUTION DO NOT OVER TIGHTEN
   Turn each screw only ½ turn past first contact.

6) Now adjust the three adjusting screws on the Brass Adjustable Mirror Cell using a nut driver until the reflection of the rear mirror is centered on the hole in the tape attached to the HeNe laser. Initially, turn the required screws clockwise until the beam is reflected near center. After that you can turn any of the screws either direction to achieve perfect alignment. This guarantees that there will always be positive tension against the screws. You will notice that as the reflection approaches center, it will become several reflections in a row. As you approach center, it will look like concentric rings. Continue adjusting until all of these

concentric rings are exactly centered on the small hole where the HeNe beam comes through.

7) This concludes the rough alignment process. Final alignment for full power output will be done while the laser is running **(Please Read Dangers Regarding Mirror Alignment While Laser Is Operating in the Final Optical Alignment section)**. Handle the tube cautiously from this point on so as to preserve your alignment.

FINAL OPTICAL ALIGNMENT:

DANGER!

Risk Of Death By Electrocution!!!!
In the following steps you will be making adjustments to the laser while it is in operation. The ends of the laser tube are at high voltage potential (Typically 16 KV). Never touch the ends of the laser tube or come within 2" (5cm) of the end caps or adjusting screws while in operation. Serious injury or death may result. Use only a WELL INSULATED adjusting wrench to touch the adjusting screws. Hold the insulated wrench by the tip end of the handle and keep away from the metal portion of the wrench by at least 2" (5cm). Use only one hand to hold the adjusting wrench. Keep your other hand in your pocket for safety. Always wear Infrared Eye Protection Goggles when the laser is running.

THIS IS A DANGEROUS OPERATION AND IS DONE AT YOUR OWN RISK!

BE SAFE…

1) We will assume that the laser is running and that you have gone through the "Operating Instructions" already. Position the brick beam stop in front of the laser and power up the laser in the normal manner described in the Operation Section of this manual. The

brick should immediately begin to heat white hot. . If not, refer to the “Laser Operation” section and ensure that you are running with the proper **Gas Flow Rate, Tube Pressure,** and **Discharge Current**. These items have a huge effect on laser output. If those items appear to be in order and you still have no output, perform the “Optical Alignment” process again very carefully with the HeNe laser and then return to this step.

2) All alignment changes will be made to the Rear Mirror only. The output coupler has already been permanently aligned so that it is perpendicular to the center line of the bore tube (Provided you followed steps 35 - 45 in the Tube Assembly Section) and will cause the beam to propagate down the center of the bore. We will make changes to the rear mirror and tune it to the front mirror for full output.
3) Using a **Very Well Insulated** 3/16” Nut Driver **(SEE CAUTIONS ABOVE)**, make tiny adjustments to the three adjusting screws of the rear mirror one by one. Adjust one until maximum brightness is seen on the target, and then move on to the next screw.
4) Repeat this process until the output is at maximum. Practice will enable you to perform this entire process in only a minute or so. After alignment, avoid jarring the tube or bumping the adjusting plate.
5) After the laser is powered off and the power supply disconnected, you may wish to add a small dab of red lacquer paint to each adjusting screw to lock them in position. Clean the threads first with a small soft brush dipped in MEK or Acetone to remove the oil residue then apply the paint with a narrow brush and let dry.

THE POWER SUPPLY:

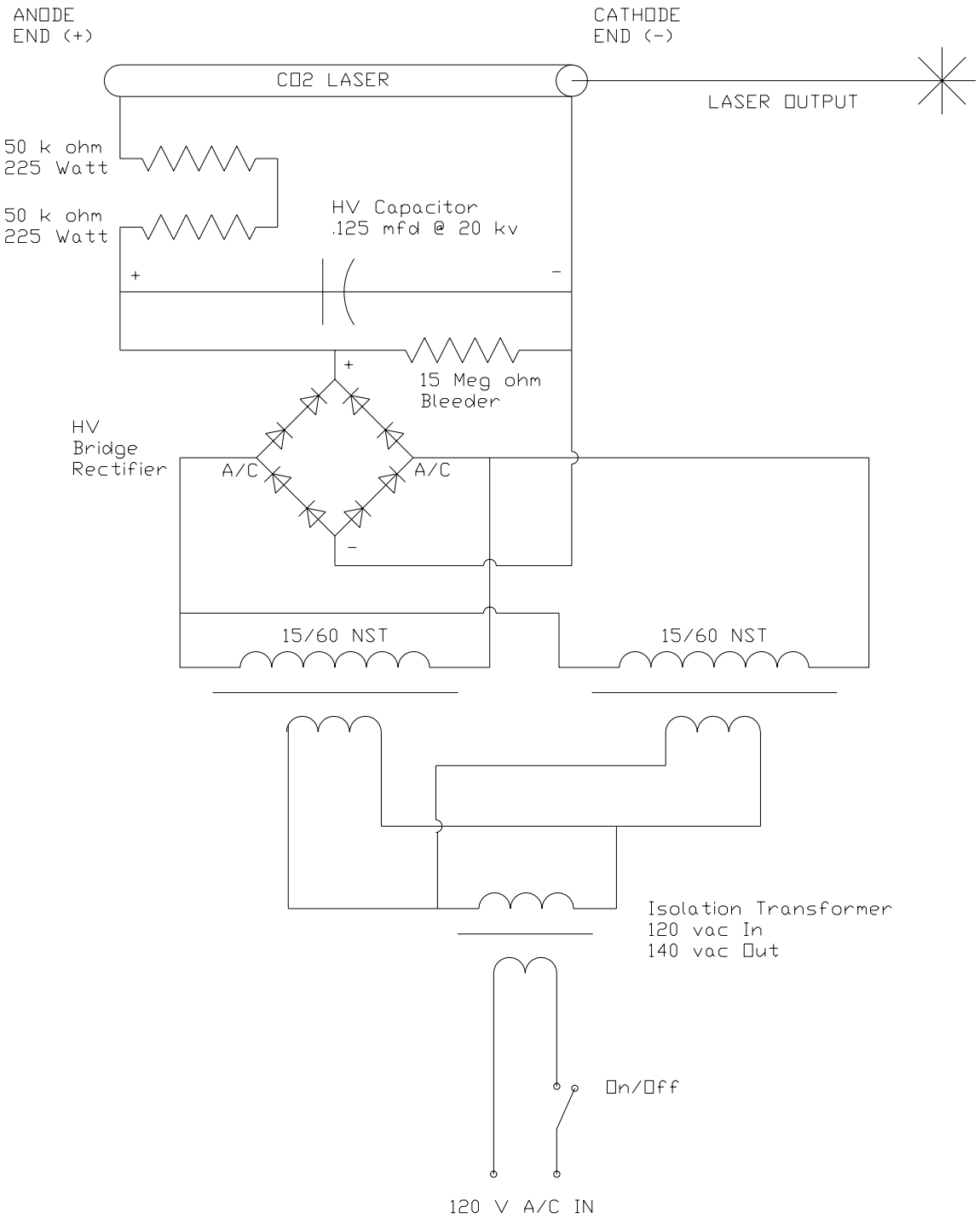
NOTE:
Do Not Use an A/C power supply to run this tube or overheating of the anode will occur which will destroy the tube. The power supply for this tube must be of the D/C (Direct Current) Type. The basic description and circuit diagram is shown below. It would be wise of the builder to completely enclose all of the high voltage components for safety reasons.

The design uses two 15,000 Volt Neon Sign Transformers rated at 60 ma. Commonly referred to as a 15/60 NST. The two transformers are running in-phase, and are connected in parallel. A single Line Isolation Transformer wired to produce 140 volts output powers the two neon transformers. This front end boost gives approximately 18 kv output from the neon transformers and is necessary to strike the tube at operating pressure. The Isolation transformer is typically multi tapped with four or eight posts on each side. The posts are labeled 0, 104, 110 and 120. The input side is connected between the 0 and 104 taps, and the output side is pulled off at the 0 and 120 taps. This gives around 140 volts on the output which is then fed to the neon transformers. A high voltage bridge rectifier is used to convert the output of the HV neon transformers to unfiltered D/C. The output from the Full Wave Bridge Rectifier is then connected to a 15,000 Volt @ .125mfd Capacitor for smoothing. The laser tube is powered from the smoothing capacitor and has two 50k ohm @ 225 Watt resistors in Series with the tube for current limiting. A 15 meg ohm bleeder resistor is connected across the capacitor to bleed off the high voltage after shut down.

The parts list is as follows:

1ea	Line Isolation Transformer rated @ 1800 Watts, multi tapped with 0, 104, 110 and 120 taps.
2ea	15 kv @ 60 ma Neon Sign Transformers
1ea	.125 mfd @ 15 kv High Voltage Capacitor
2ea	50 k ohm @ 225 Watt Resistors
8ea	High Voltage Diodes rated at: 15 kv PIV (Peak Inverse Voltage) and 100 ma Average Forward Current
1ea	15 Meg Ohm Resistor Rated @ 15 Watts
1ea	Power Switch rated 120 Volt @ 15 amp
AR	High Voltage Wire rated at 20 kv or higher
AR	Misc Connectors

Power Supply Schematic:



If you are planning to use the laser for CNC cutting or engraving, then the smoothing capacitor should be used to remove the 60 hz output. However,

for those on a budget, the capacitor may be omitted. You must still use the Bridge rectifier and ballast resistors. Note that without the capacitor, output power will be reduced and the output will be pulsed at 120 hz. The pulsed output is no good for cutting as it just makes a nice dashed line.

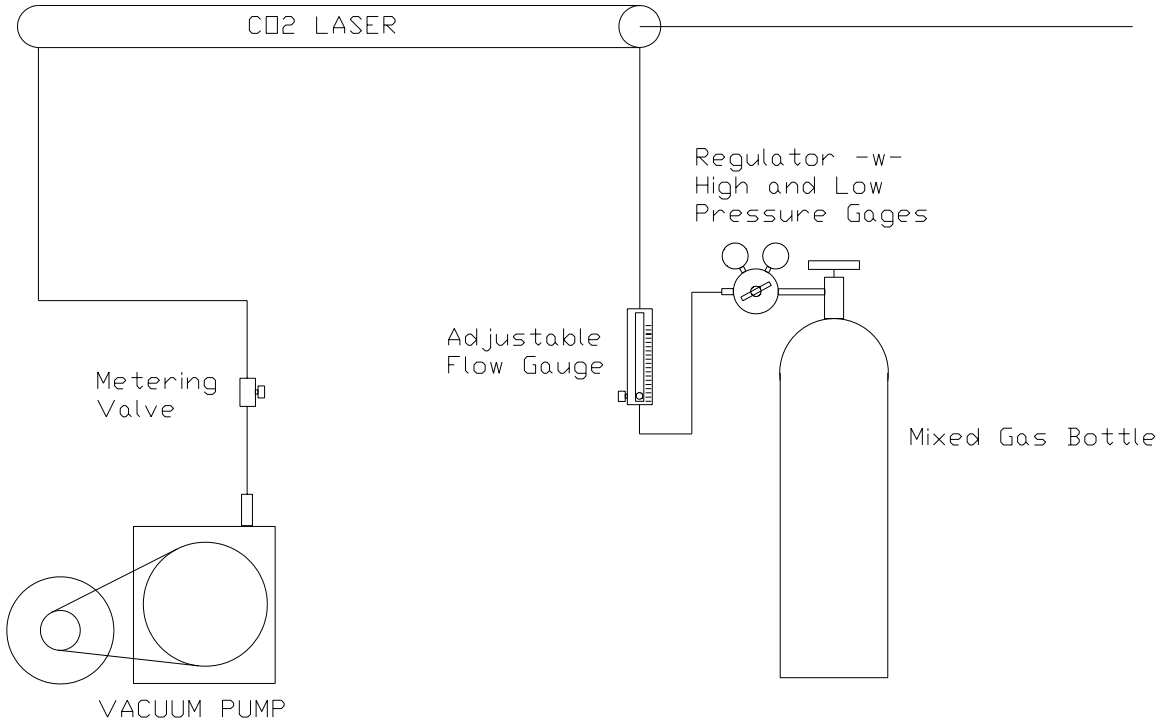
THE GAS/VACUUM SYSTEM:

For the gas supply you will need a suitable high pressure bottle of CO2 Laser Mix (Mixture 9.5% CO2, 13.5 % N2, and 77 % HE), a regulator for same with both high and low pressure gauges, and an adjustable flow meter that has a scale of at least 0 to 4 Liters Per minute. All of these items can be purchased from any good welding supply shop. Some can even mix the gases on site, but most will send out your bottle for filling to the required mixture. Be sure to also ask if they have generic CO2 Laser Mix. Sometimes they carry CO2 Mix on hand that is very close to the percentages above and should be used if available. If they do not have any pre-mix, just have the bottle filled according to the percentage above.

For the Vacuum side you will need a suitable pump, and a metering valve to adjust flow. There are several ways you can go for a pump. If you can find a used refrigeration compressor that is in good working order from an old freezer or refrigerator, that will work. Just cut the copper lines off near the compressor and hook the laser tube to the suction side of the compressor. The other type of unit you could use is a portable vacuum pump as used by air conditioning repair technicians. They use these to evacuate your A/C system of air before re-charging the system with freon. The last and best type of vacuum pump to use is a scientific grade unit. The top two types will work fine for most applications. If you buy a commercial unit, get a pump that is rated for 1 Micron Torr ultimate vacuum, and 140 liters/minute pumping speed or greater.

Below is a diagram of the gas and vacuum hookup.

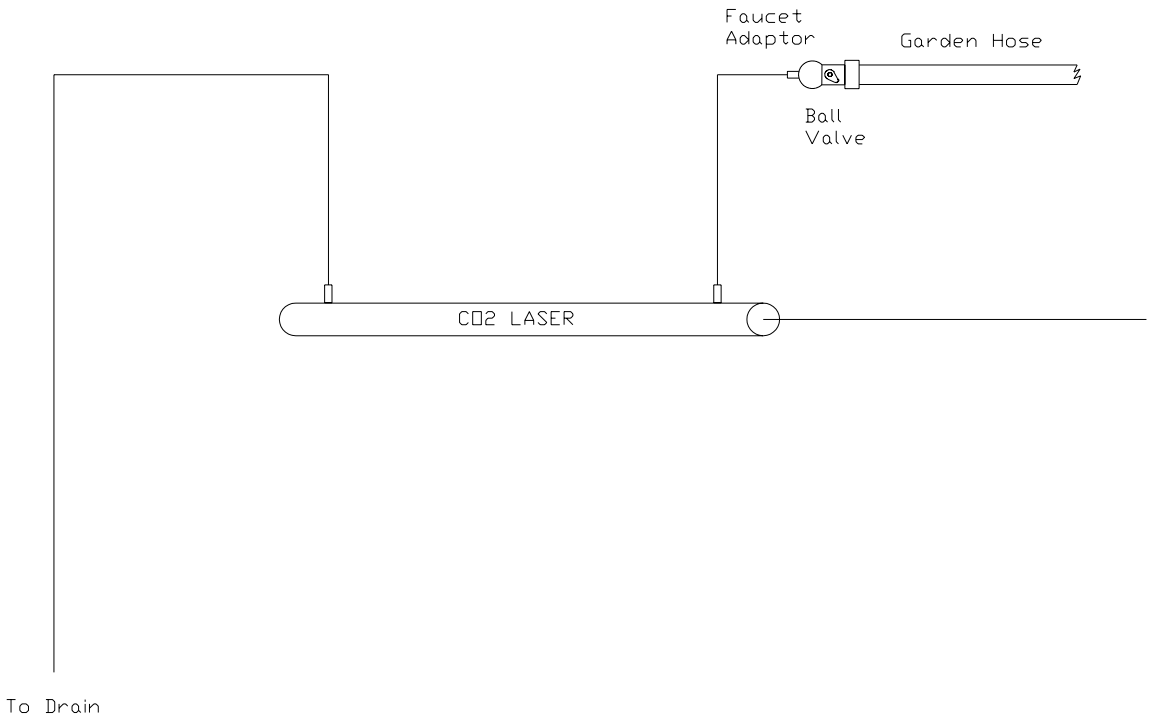
GAS/VACUUM HOOKUP DIAGRAM:



THE COOLING SYSTEM:

The cooling system is the simplest of all. Simply flow tap water from your sink or garden hose through the laser cooling jacket, and discard the discharge. If using a garden hose, go to your nearest garden shop and get a ball valve for the end of the hose. Cost is around $3.00. To attach the ball valve to the small tubing supplied in the kit, buy a rubber fitting that is normally used for attaching a water filter to your kitchen faucet. The small tubing should be a near perfect fit into the rubber adaptor, and the other end can be pushed onto the ball valve. The whole thing will cost under $10.00

Here is a diagram.

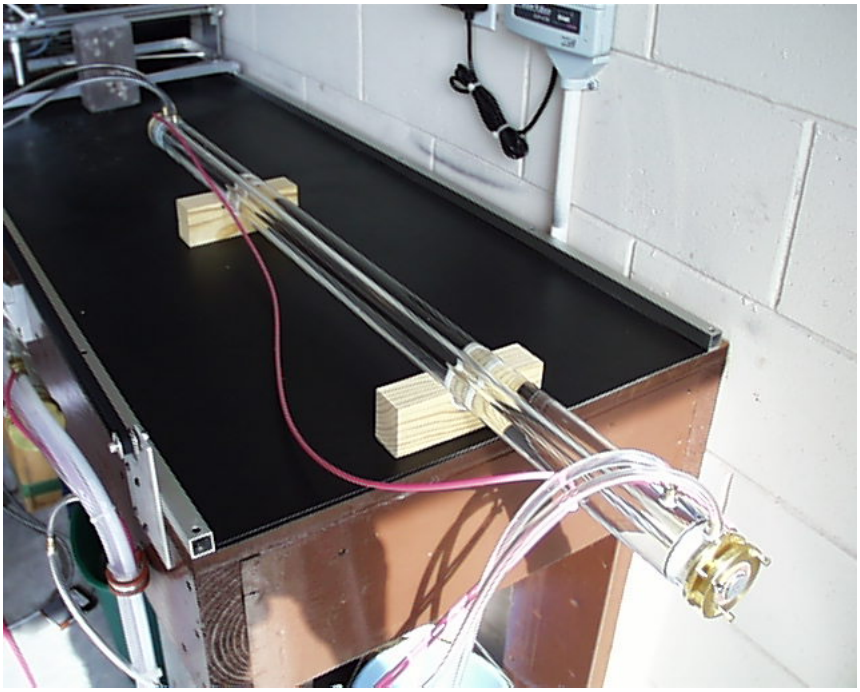


LASER OPERATION:

Now the fun part. You will now assemble the laser tube with the power supply, vacuum system, gas system, and cooling system.

Ensure that the area you will use to operate your laser is free of flammable materials, children, pets, and any unauthorized personnel. **NOTE: Always wear Infrared Eye Protection Goggles when the laser is running.**

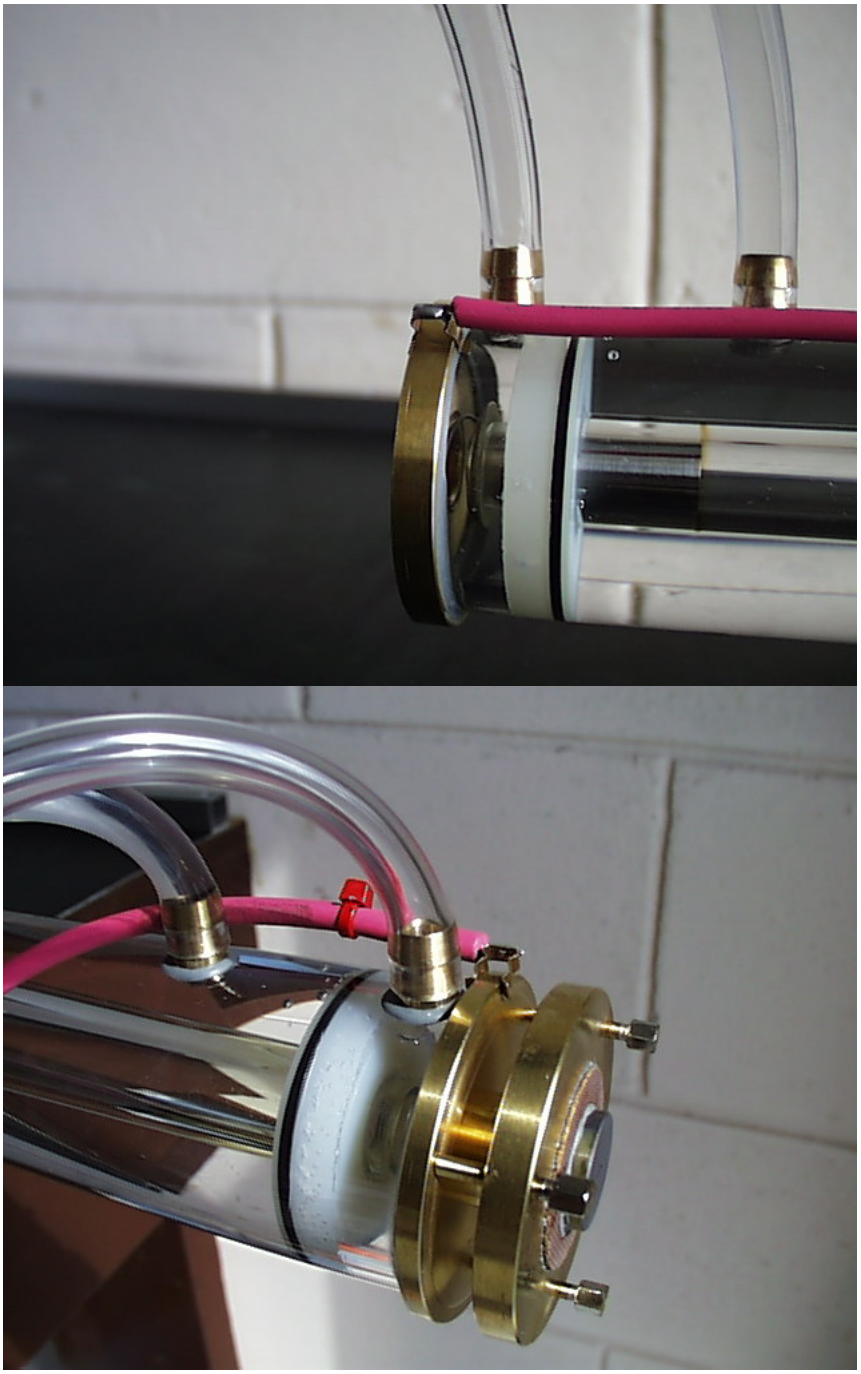
1) Using the provided tubing, hook up the cooling water supply to the innermost coolant fittings located on the outer glass tube. Refer to the drawings on pages 5 and 6, and diagram on page 40.



2) Using the other roll of supplied tubing, hook up the gas and vacuum lines to your vacuum pump and gas supply. Refer to the drawings on pages 5 and 6, and the connection diagram on page 39.
3) Use the supplied high voltage wire to hook up your power supply to the tube. The wires attach to the edge of the brass lip with the

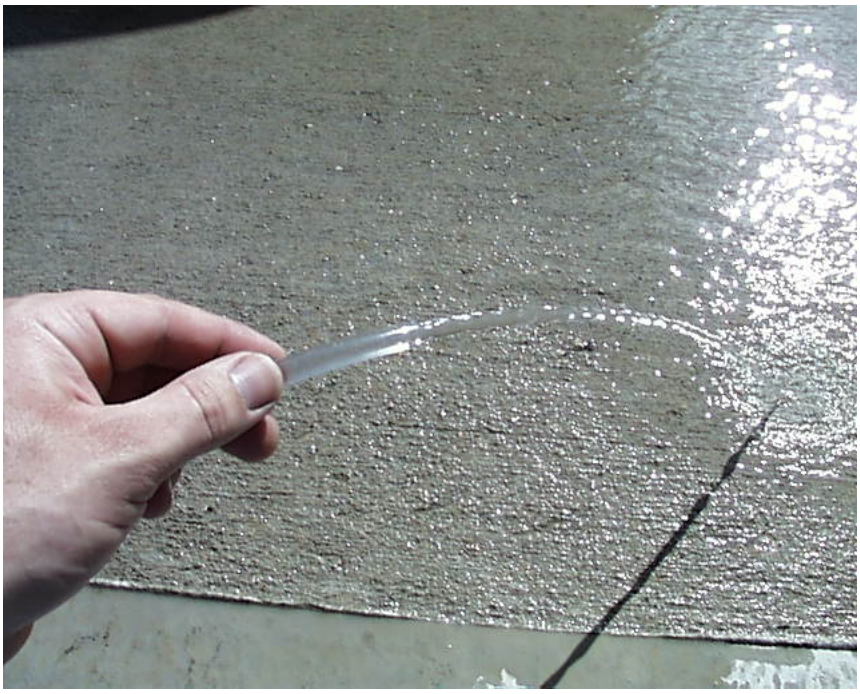
clips supplied. Ensure that the **(-) Negative** side of the power supply hooks up to the **Output** end of the tube. The **(+) Positive** side of the power supply attaches to the **Rear Total Reflector** end of the tube. In the picture, the positive lead wire has been identified by the wire tie.

NOTE: Ensure that the connection polarity is correct, or overheating will destroy the tube.

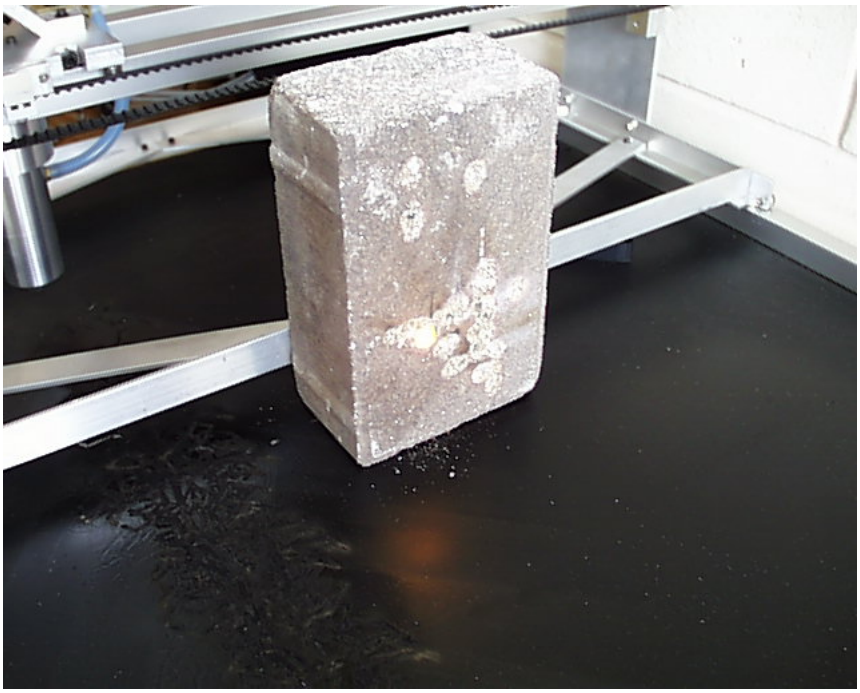


4) Fill the cooling jacket with tap water by slowly opening the ball valve. As the tube fills, tip it so that all air is removed via the overflow line. After the tube is filled with water, set the flow rate to about 2 – 3 liters per minute.

WARNING: Never operate the laser without flowing tap water for cooling.



5) Place an adequate beam-stop in the path of the laser about 3’ (1meter) beyond the output end of the laser. A red fire brick works well.



6) Next turn on the vacuum pump and open the metering valve all the way.

7) On the Gas Cylinder, ensure that the gas regulator knob is screwed all the way OUT, so it will not allow any gas to pass to the low-pressure side as the main high-pressure gas valve is opened. Open the high pressure valve at the top of the gas cylinder and check the pressure of the bottle. A fresh bottle will have around 2000 PSI.

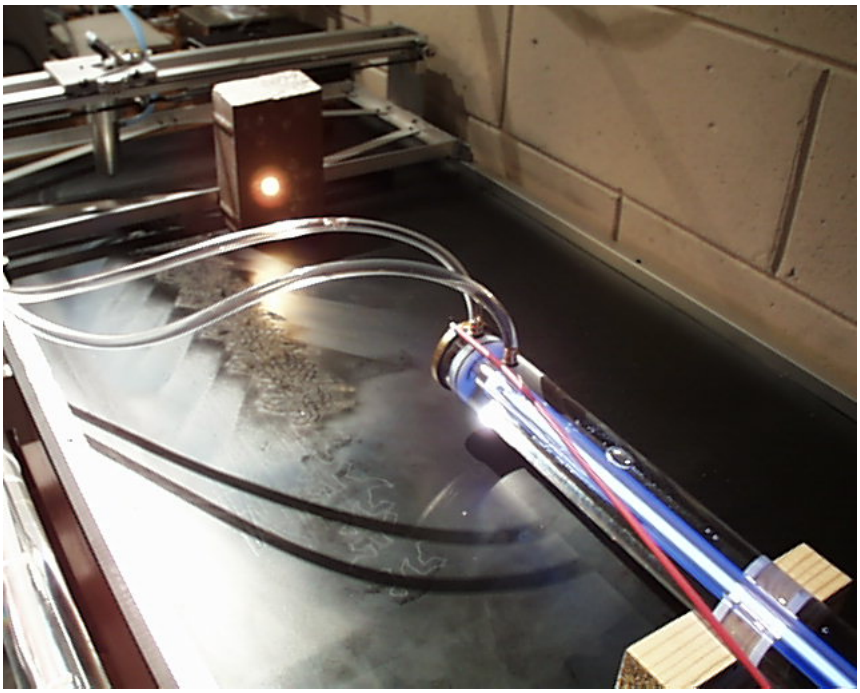
8) Ensure that the flow control valve on the gas flow meter is CLOSED.

IMPORTANT: This is a very important step. You should never allow the inside of the laser tube to become pressurized.

9) Now turn the gas regulator knob clockwise until you get around 10 PSI indicated on the low pressure gauge of the gas regulator. This will be the pressure in the line between the regulator output, and the flow meter, which is STILL CLOSED.

10) Next crack open the valve on the flow meter slowly until you begin to see a flow indicated by the rising ball. The rate of flow that you will use for maximum output will depend on the type and flow rating of your vacuum pump. 2 liters/minute are typical but for initial tests, start with about 1 liter/minute of flow.

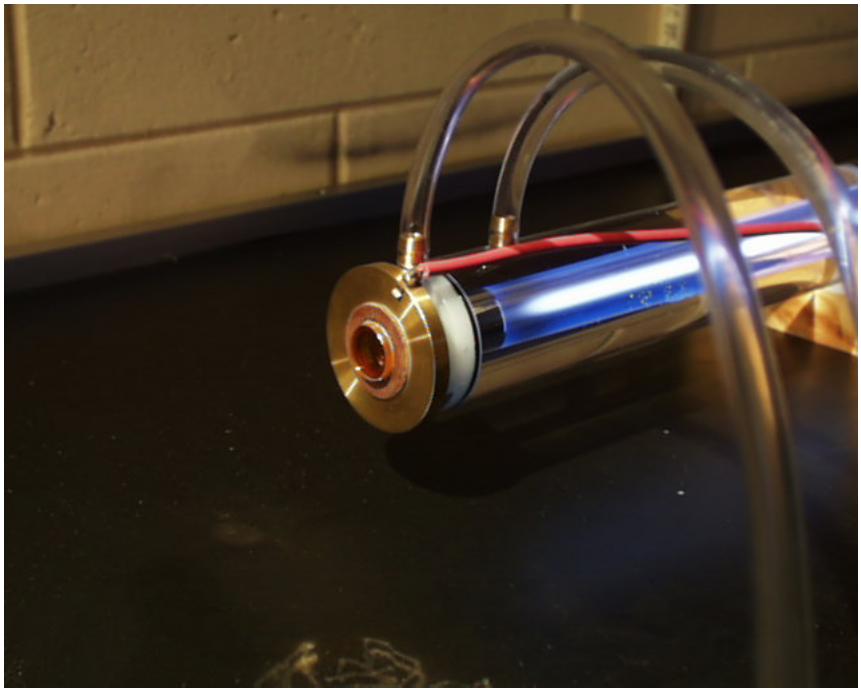
11) Next switch on the high voltage and you should immediately see a purple-blue discharge in the tube. If no discharge occurs, the gas pressure may be too high inside of the tube and you will need to reduce the flow rate slightly until the tube ionizes.

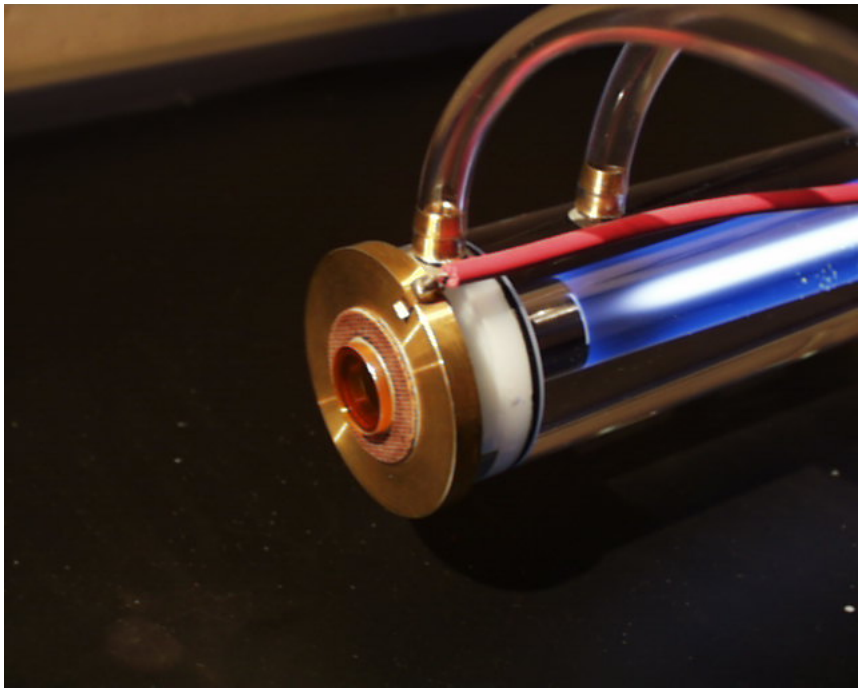


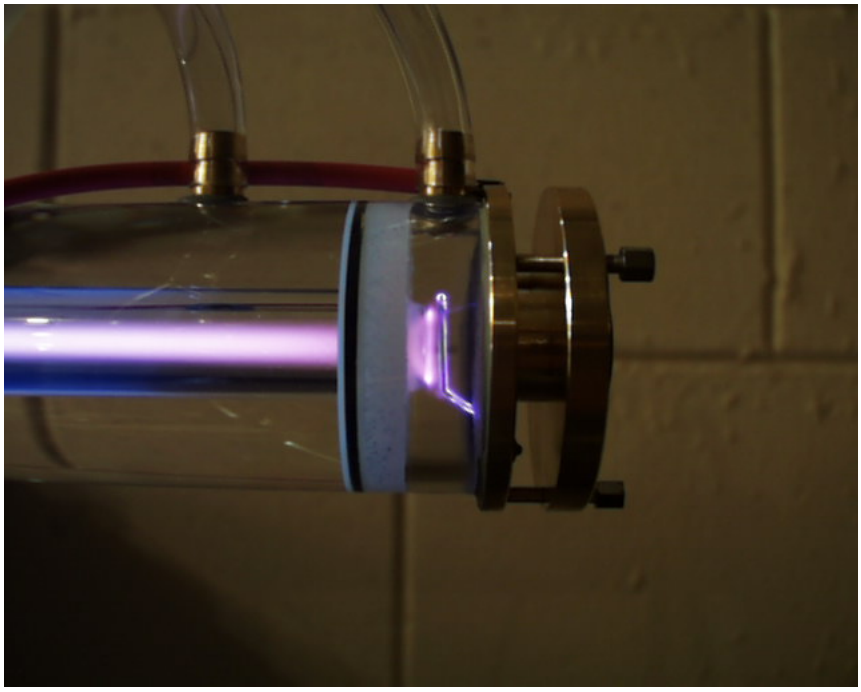
12) Once the tube is ionized, adjust the gas flow slowly for maximum output of the beam as indicated on the brick beam stop. As stated above this will vary depending on the flow volume of the vacuum pump you are using but the flow rate will generally be between 1 and 2.5 liters per minute.
13) Once the exact flow rate has been found that enables maximum laser output, you can leave the flow meter adjusted to this setting and add a shutoff valve between the output from the regulator and the input of the flow meter. This way you can shut off the gas without changing the flow settings each time.
14) When shutting the laser down, turn off high voltage first, then the gas supply, then the vacuum system, and finally the cooling water last.
15) When starting the laser up, use the exact opposite routine. Water first, then vacuum, then gas, then high voltage last.
16) After "tweaking" the output by adjusting the gas pressure as described above, Go to the "FINAL OPTICAL ALIGNMENT" section on page # 24 and perform the final tweaking of the tube for maximum power.

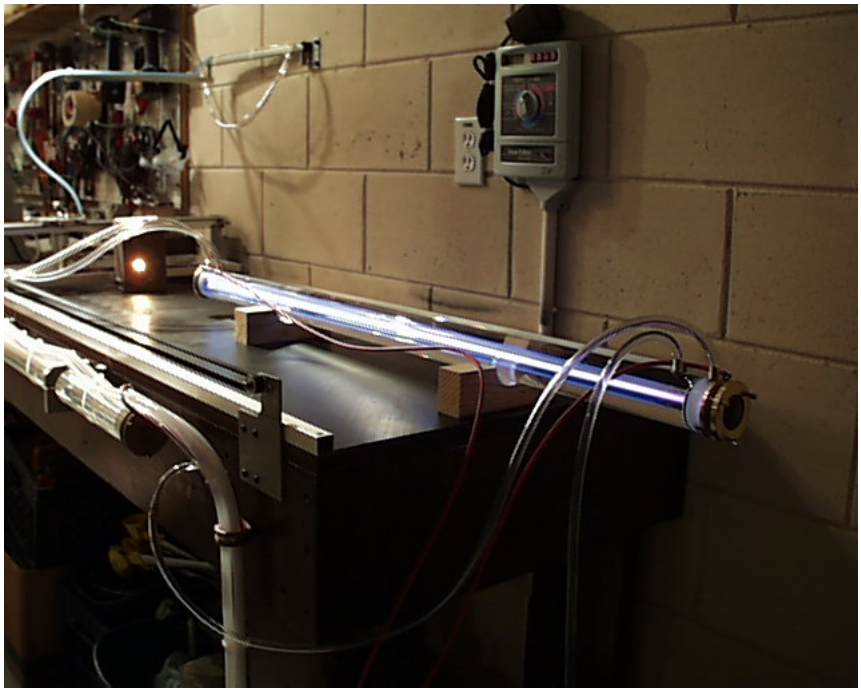
Have Fun And Be Safe!

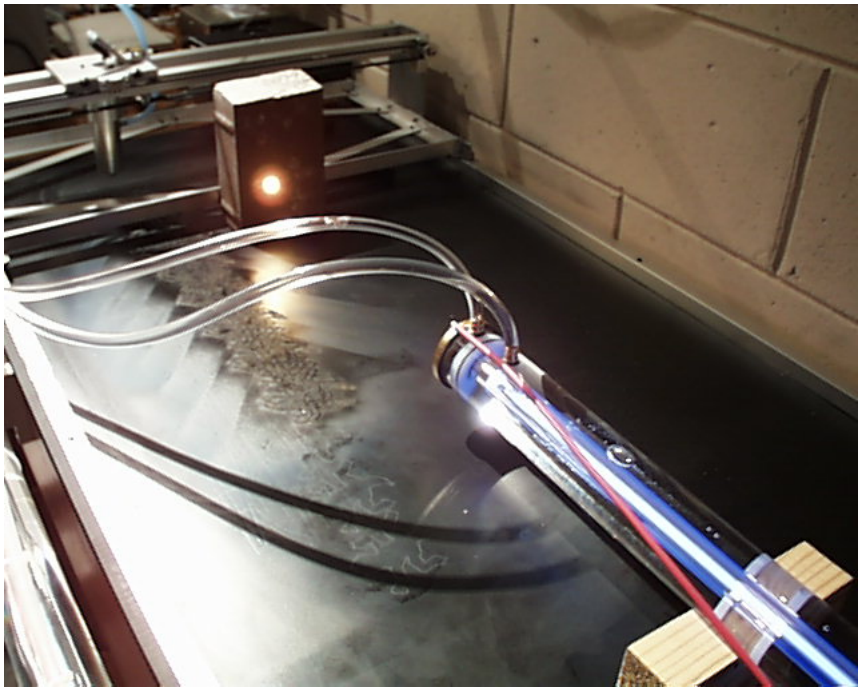
Here are a few operational photos.

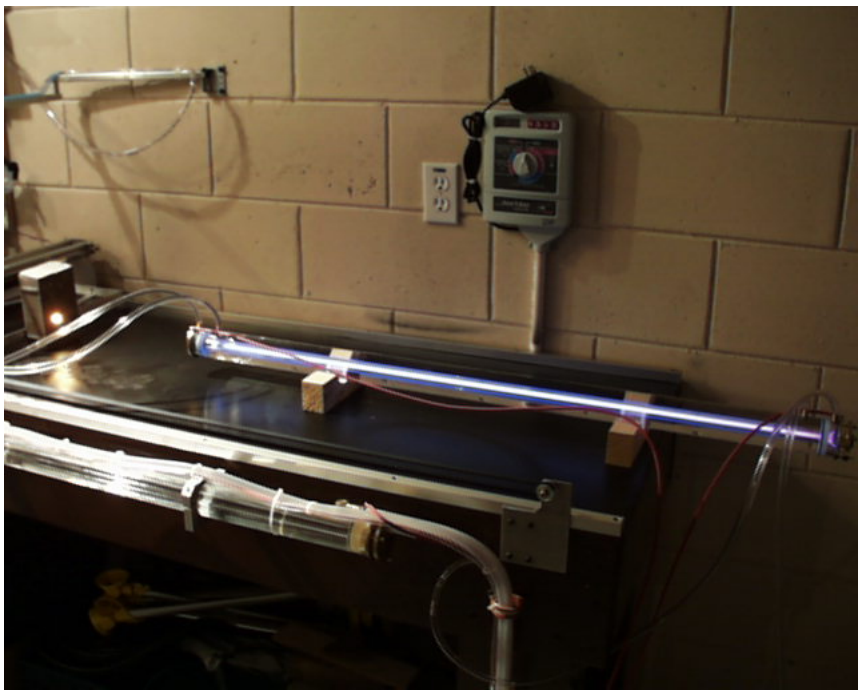












TUBE SPECIFICATIONS:

Rated Power Output:	55 Watts
Typical Power Output:	60 Watts
Beam Mode:	TEM 01
*Effective Beam Diameter:	5.2 mm
Length of Discharge:	1016 mm
Length or Resonator:	1080 mm
Overall Tube Length:	1097 mm
Bore Diameter:	12mm
Bore Tube Material:	Pyrex® Glass
Cooling Jacket Diameter:	51mm
Cooling Jacket Material:	Pyrex® Glass

Rear Mirror (HR): .75” x .120” x 5 Meter Radius Enhanced Gold
Output Coupler (OC): ZnSe .75” x .120” x 85% Reflectance, Plano Plano
Cooling: Flowing Tap Water @ 3 Liters/Minute
Gas Mix: 9.5 % CO2 - 13.5% Nitrogen - 77% Helium
Gas Flow Rate: 1 – 3 Liters/Minute (Varies with vacuum pump used)

Optimum Gas Pressure:	8 Torr
Power Supply Requirement:	15KV DC @ 35ma
Optimum Current:	35 ma
**Tube Weight:	3 lbs

* (using the 1/e2 criteria)
** (No Coolant)

55 Watt Flowing Gas CO2 Laser
PN: ETI-055K

Parts/Materials Specifications:

The following components/compounds must be procured/manufactured prior to starting the assembly process.

Part# ETI-ANODE1
1ea Required
The ring style Anode is formed from a piece of .034 stainless steel wire. This wire is commonly used in Mig Welders and can be found at almost any store that sells welding supplies. Form the wire as per the drawing on sheet 1.

Part# ETI-BORESUPP1
2ea Required
The Bore Supports are machined from solid 2” Natural Nylon Round Bar as per the drawing on sheet 2.

Part# ETI-BORE1
1ea Required
The Bore Tube is a standard size (15mm OD, 12mm ID) piece of Neon Sign Tubing. Procure it from any Neon Shop in a 48” length. The tube should be cut to exactly 41.5” using a diamond wet saw. Fire polish one end and leave the other end un-polished. See drawing on sheet 3.

Part# ETI-CATH1
1ea Required
The Cathode is machined from a piece of ½” Stainless Steel Tubing. The tubing should have a .028 wall thickness. After turning the outside down the inside should already be the correct size. See the drawing on sheet 4.

Part# ETI-FTNG1
4ea Required
The water and gas Fittings are machined from solid brass stock. Alternately, they may be made by modifying several brass fittings used to splice ¼” ID plastic tubing together. See the drawing on sheet 5.

Part# ETI-INS1
2ea Required
The Phenolic Insulators are simply Phenolic washers with a 1.25” OD and .625” ID. They should be available in near or exactly this size. See the drawing on sheet 6.

Part# ETI-JACKET1
1ea Required
The Cooling Jacket is cut to exactly 42.25” using a diamond wet saw. It is cut from a length of 2” Heavy-Wall Pyrex® Glass. Do not use any other type of glass. Only Low Expansion Pyrex® should be used. This item should be ordered from a scientific house and you should get it pre-cut to length. Be sure to specify “MINIMUM OVAL” when ordering otherwise the o-rings may not seal correctly. The four holes are drilled using a .25” Diamond hole saw in the drill press. Use lots of water while drilling and be sure not to press too hard when approaching the bottom of the cut as it will cause a chip on the inside of the glass. See the drawing on sheet 7.

Part# ETI-OC85
1ea Required
The Output Coupler is made from Zinc Selenide. It is .75” Diameter by .120” thick. It has an 85% reflectivity and is Plano/Plano or optically flat on both sides.

Part# ETI-TR5
1ea Required
The Total Reflector is made of a Silicon Wafer and coated with Enhanced Copper. It is .75” Diameter by .120” thick. It has a 5 Meter Radius of curvature.

Part# ETI-OCCELL1
1ea Required
The Front Mirror cell is machined from 2 1/2” diameter Brass Round Bar. Note the .050 wide by .030 deep groove on the inside edge which holds the Cathode Retainer Spring in place. See the drawing on sheet 9.

Part# ETI-REARCELL1
1ea Required
The Rear Adjustable Mirror Cell is machined from 2 1/2” diameter Brass Round Bar. Bore the ½” hole and machine the 1.26” x .02” recess first, then reverse the piece and machine the channel in the center. Machine the .125” recess where it connects to the glass of the Cooling Jacket last. See the drawing on sheet 10.

Part# ETI-ADJSCREW1
3ea Required
The three adjusting screws are made from .115” OD brass rod. Insert the rod into the lathe chuck leaving about 1.5” protruding and run the lathe on its lowest speed. Thread the rod up to the chuck using a 3mm x .35 pitch Die. Then machine the taper at one end before cutting the piece to length at 7/8”. Repeat process for others. Use 3/16” brass hex stock for the screw heads drilled out to .118”. Solder the hex heads onto the adjusting screws with a torch using paste flux and plumbers solder. See the drawing on sheet 11.

Part# ETI-SPR1
1ea Required
The Cathode Retainer Spring is cut from a spring commonly found in a D-Sized battery holder. See the drawing on sheet 12.

Part# ETI-WSHR1
1ea Required
The Cathode Retainer Washer can be found at a hardware store almost ready to use. They are zinc plated steel retainers and are commonly used on drive shafts and as wheel retainers. Find one made for a 7/16” shaft and machine out the center to .462”. The retainer is then pressed 1/16” onto the Cathode using the tailstock of the lathe. See the drawing on sheet 13.

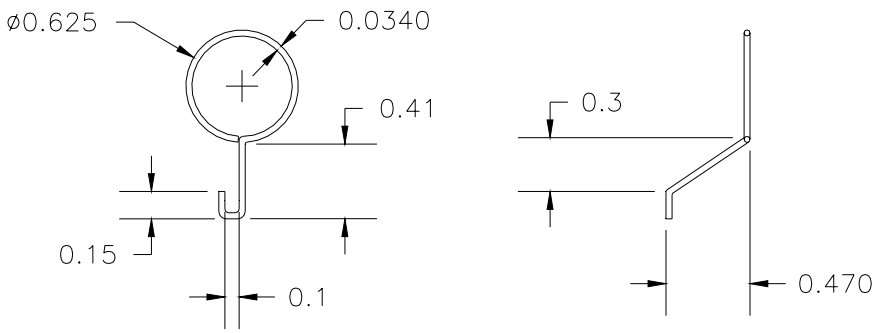
Part# ETI-ORING1
2ea Required
Large Black O-Ring used on outside edge of the Nylon Bore Tube Support. Found at the hardware store in plumbing section. 1.5” OD x .080 thick.

Part# ETI-ORING2
2ea Required
Small Black O-Ring used on inside edge of the Nylon Bore Tube Support. Found at the hardware store in plumbing section. .75” OD x .080 thick.

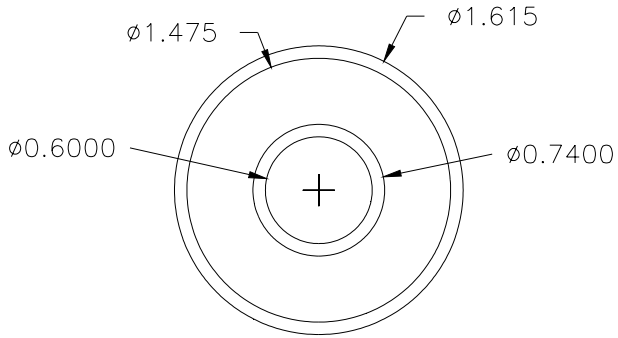
Part# ETI-SCREWSET1
1ea Required
.080 x .25” Screw, Nut & Washer used to attach the Anode to the Adjustable Rear Mirror Cell.

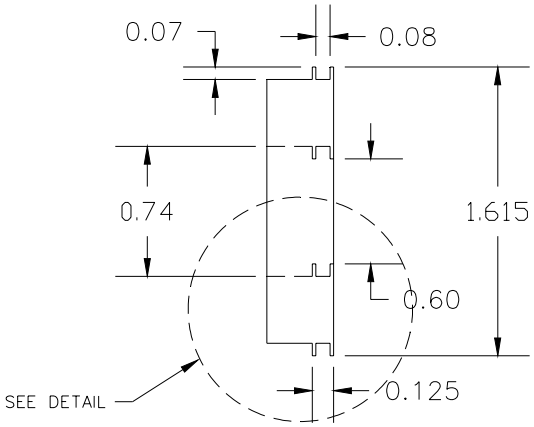
Part# ETI-STEPOX1
1ea Required
The adhesive used for the majority of the assembly process is a two part mix Liquid Steel Epoxy commonly marketed by the trade name JB WELD™.

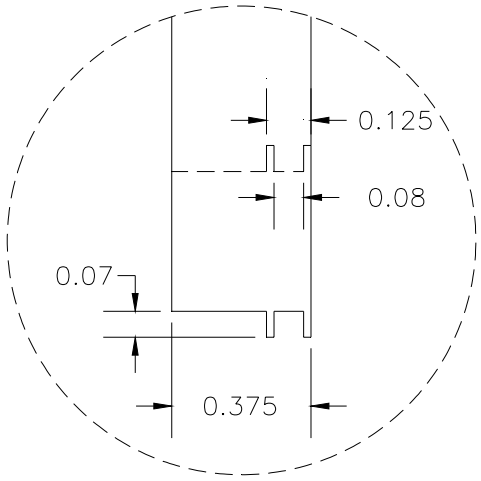
Part# ETI-SILICON1
1ea Required
The Nylon Bore Tube Supports are adhered to the glass using a tube of RTV Silicone Rubber. Either the clear or white variety may be used. Ensure that what you purchase is 100% pure silicone.



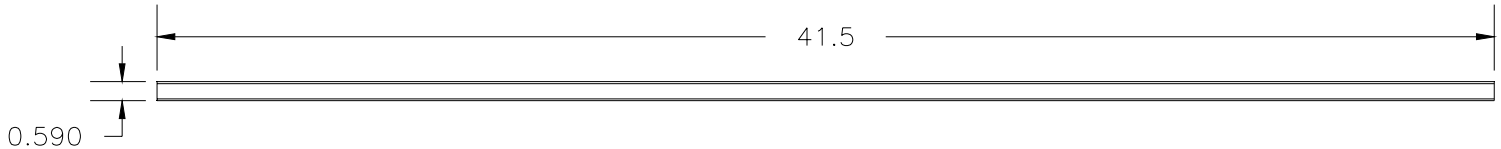
PART NAME:			MATERIAL SPECIFICATION:	
ANODE			.034 STAINLESS STEEL WIRE	
SIZE	PART NO.	QTY REQUIRED.	DWG NO.	REV
A	ETI-ANODE1	1	1	A
SCALE 1 : 1	DRAWN BY: R.C.	DATE: 02/15/02	SHEET 1 OF 13	





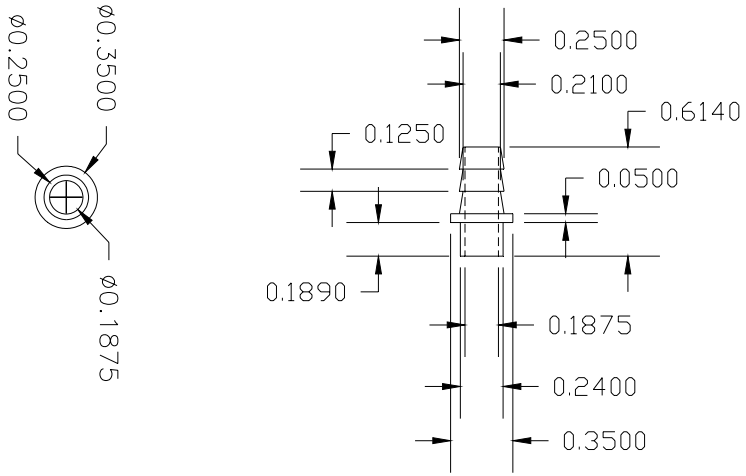


PART NAME: BORE TUBE SUPPORT			MATERIAL SPECIFICATION: NATURAL NYLON	
SIZE A	PART NO. ETI–BORESUPP1	QTY REQUIRED. 2	DWG NO. 2	REV A
SCALE 1 : 1	DRAWN BY: R.C.	DATE: 02/15/02	SHEET 2 OF 13	

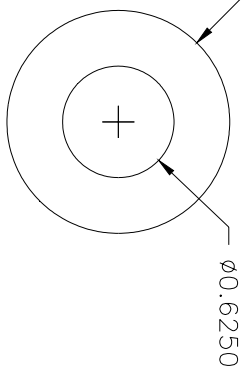


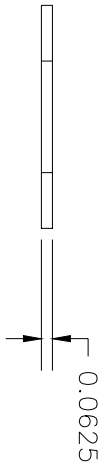
PART NAME: BORE TUBE			MATERIAL SPECIFICATION: STD. NEON SIGN GLASS	
SIZE A	PART NO. ETI-BORE1	QTY REQUIRED. 1	DWG NO. 3	REV A
SCALE 1 : 1	DRAWN BY: R.C.	DATE: 02/15/02	SHEET 3 OF 13	

PART NAME: CATHODE			MATERIAL SPECIFICATION: STAINLESS STEEL	
SIZE A	PART NO. ETI-CATH1	QTY REQUIRED. 1	DWG NO. 4	REV A
SCALE 1 : 1	DRAWN BY: R.C.	DATE: 02/15/02	SHEET 4 OF 13	

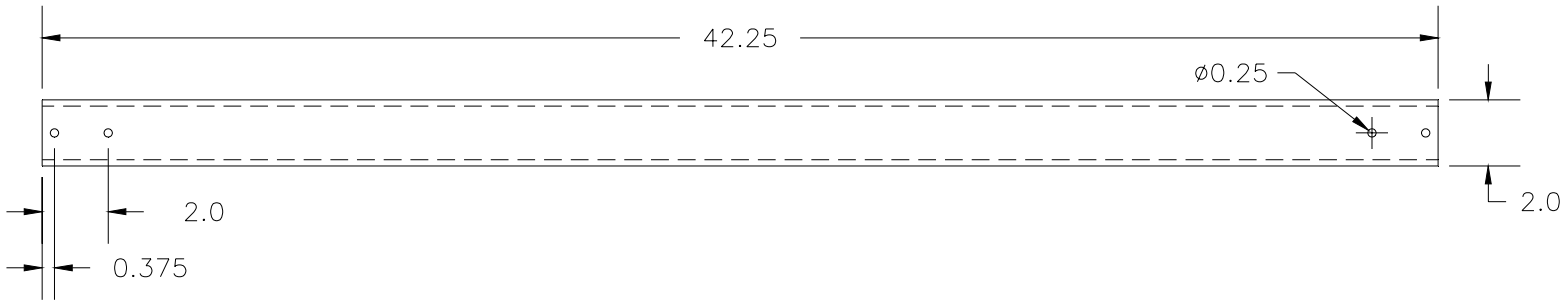


PART NAME: FITTING			MATERIAL SPECIFICATION: BRASS	
SIZE A	PART NO. ETI–FTNG1	QTY REQUIRED. 4	DWG NO. 5	REV A
SCALE 1 : 1	DRAWN BY: R.C.	DATE: 02/15/02	SHEET 5 OF 13	

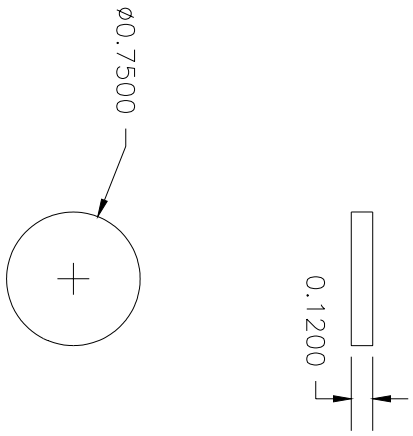




PART NAME: PHENOLIC INSULATOR			MATERIAL SPECIFICATION: PHENOLIC	
SIZE A	PART NO. ETI-INS1	QTY REQUIRED. 2	DWG NO. 6	REV A
SCALE 1 : 1	DRAWN BY: R.C.	DATE: 02/15/02	SHEET 6 OF 13	



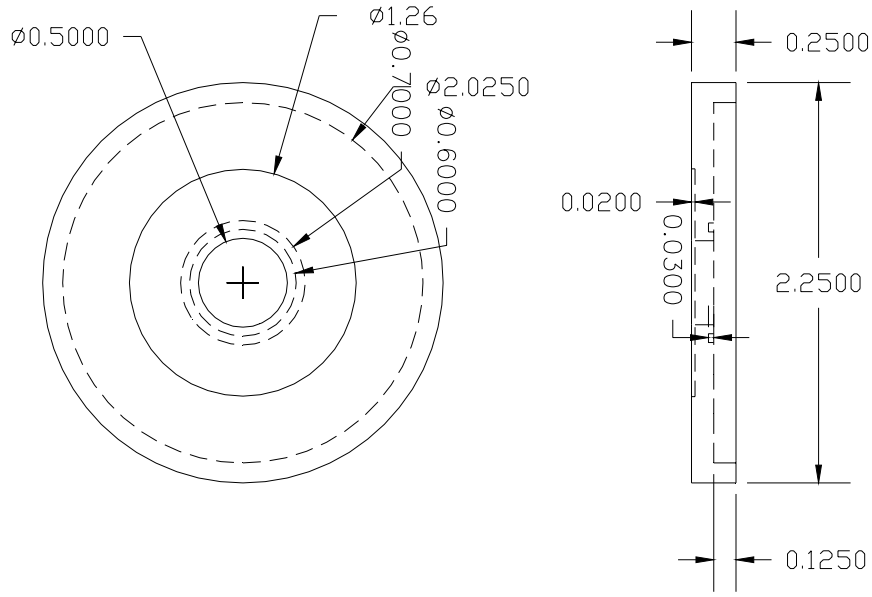
PART NAME:			MATERIAL SPECIFICATION:	
COOLING JACKET			LOW EXPANSION PYREX GLASS 2" Dia x .189" (Heavy Wall) REQUEST "MINIMUM OVAL"	
SIZE A	PART NO. ETI-JACKET1	QTY REQUIRED. 1	DWG NO. 7	REV A
SCALE 1 : 1	DRAWN BY: R.C.	DATE: 02/15/02	SHEET 7 OF 13	



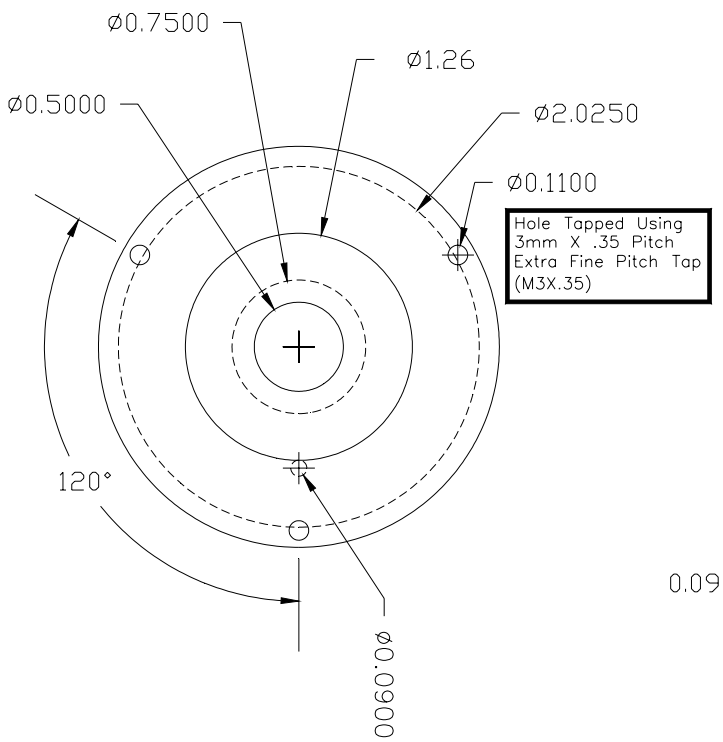
OUTPUT COUPLER = .75" X .120" ZINC SELENIDE PLANO/PLANO 85% REFLECTIVITY

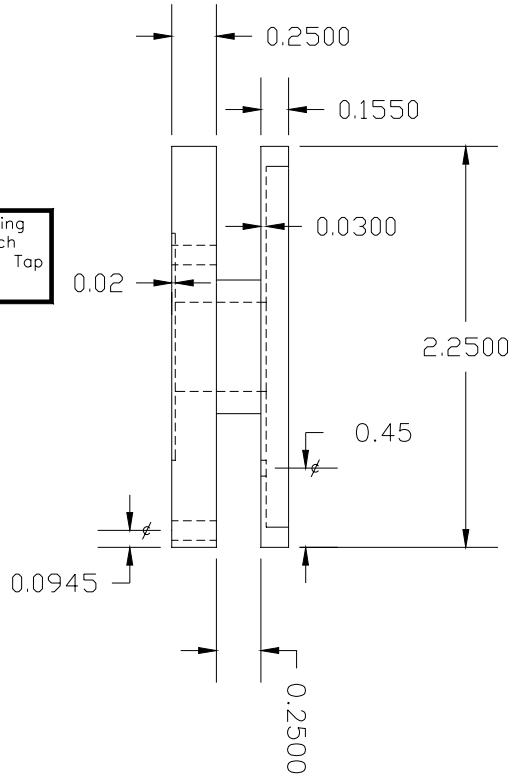
TOTAL REFLECTOR = .75" X .120" SILICON, ENHANCED COPPER COATED, 5 METER RADIUS

PART NAME:			MATERIAL SPECIFICATION:	
MIRROR/OUTPUT COUPLER			MIRROR – COPPER COATED SILICON O.C. – DIELECTRIC COATED ZnSe	
SIZE A	PART NO. ETI–OC85, ETI–TR5	QTY REQUIRED. 1 of each	DWG NO. 8	REV A
SCALE 1 : 1	DRAWN BY: R.C.		DATE: 02/15/02	SHEET 8 of 13

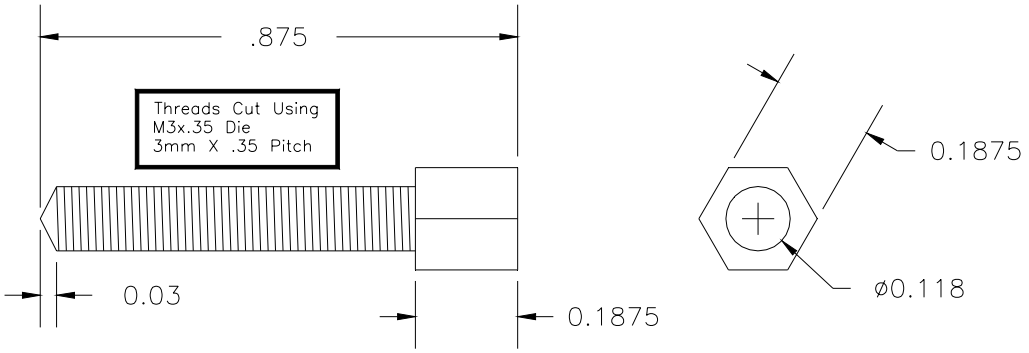


PART NAME: FRONT MIRROR CELL			MATERIAL SPECIFICATION: BRASS	
SIZE A	PART NO. ETI-OCCELL1	QTY REQUIRED. 1	DWG NO. 9	REV A
SCALE 1 : 1	DRAWN BY: R.C.		DATE: 02/15/02	SHEET 9 of 13

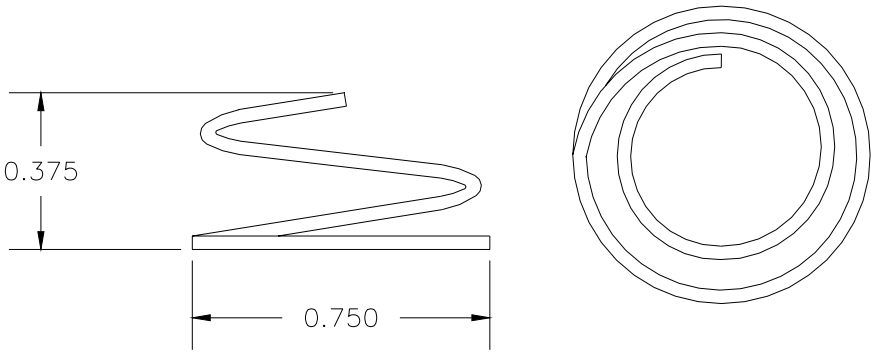




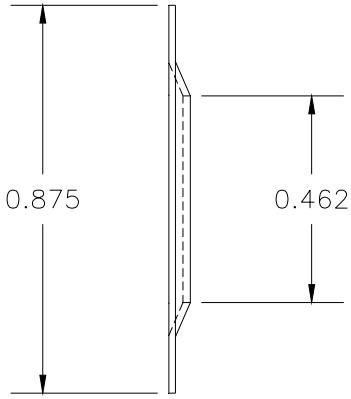
PART NAME: ADJUSTABLE REAR MIRROR CELL			MATERIAL SPECIFICATION: BRASS	
SIZE A	PART NO. ETI-REARCELL1	QTY REQUIRED. 1	DWG NO. 10	REV A
SCALE 1 : 1	DRAWN BY: R.C.		DATE: 02/15/02	SHEET 10 of 13

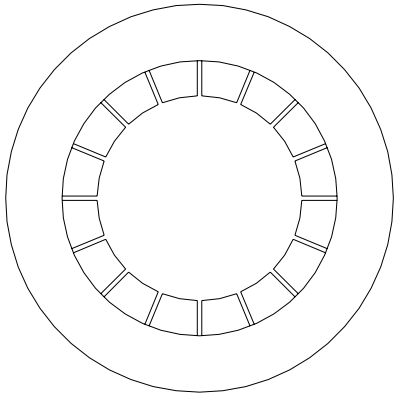


PART NAME: ADJUSTING SCREWS			MATERIAL SPECIFICATION: BRASS	
SIZE A	PART NO. ETI–ADJSCREW1	QTY REQUIRED. 3	DWG NO. 11	REV A
SCALE 1 : 1	DRAWN BY: R.C.		DATE: 02/15/02	SHEET 11 of 13



PART NAME:			MATERIAL SPECIFICATION:	
CATHODE RETAINER SPRING			.034 SPRING STEEL WIRE	
SIZE	PART NO.	QTY REQUIRED.	DWG NO.	REV
A	ETI-SPR1	1	12	A
SCALE 1 : 1	DRAWN BY: R.C.	DATE: 02/15/02	SHEET 12 OF 13	





PART NAME:			MATERIAL SPECIFICATION:	
CATHODE RETAINER WASHER			ZINC PLATED STEEL	
SIZE	PART NO.	QTY REQUIRED.	DWG NO.	REV
A	ETI-WSHR1	1	13	A
SCALE 1 : 1	DRAWN BY: R.C.	DATE: 02/15/02	SHEET 13 of 13	