35 Watt
Flowing Gas
CO2 Laser Tube Kit

Model# ET035S
Serial#_____

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 eye protection 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 buy 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.*

Table of Contents:

KIT CONTENTS:

The contents of the package should include:

1ea Zinc Selenide (ZnSe) Output Coupler
1ea Enhanced Gold Rear Miror
1ea Pyrex® Glass Cooling Jacket
1ea Pyrex® Glass Bore Tube
2ea Machined Aluminum End Caps
2ea Machined Teflon® Mirror Adjusting Plates
2ea Stainless Steel Electrodes
2ea Coolant Fittings (Flared)
2ea Gas Fittings (Machined)
2ea Mirror Adjustment O-Rings
6ea 2x56 Adjusting Screws
6ea #2 Washers
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 Insulated Allen Wrench
1ea 2 Hour Cure Epoxy Resin
1ea 2 Hour Cure Epoxy Hardener
5ea Epoxy Mixing Cups
5ea Epoxy Mixing Sticks
3ea Epoxy Application Brushes
2ea Epoxy Injection Syringes

REQUIRED TOOLS:

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

Suitable Clean and Flat Workspace

Single Edge Razor Blade or X-acto Knife

Wire Cutters/Strippers

Paper Towels

Cleaner Degreaser such as MEK (Methyl Ethyl Ketone)

Small Helium Neon or Diode Laser for optical alignment

TUBE ASSEMBLY:

1) Remove all items from packing and inspect for damage and or missing parts.
2) Clean and de-grease all parts to be joined using MEK. This would include all fittings, aluminum end caps, and ends of glass tubes. Also clean the glass cooling jacket inside and out around the holes for the water fittings. This can be done using Q-Tips dipped in MEK.
3) Devise a way to hold the cooling jacket in a horizontal position elevated off the work surface at least 1" with the two holes facing downward.
4) Mix up a small amount of epoxy being careful to mix equal parts resin and hardener, and glue the two flared water fittings into the holes in the cooling jacket, inserted from the inside. Use a supplied brush to apply the epoxy to the flared end of the fittings first, before insertion into the tube. Use enough epoxy to ensure a good watertight seal. Rotate the fittings in the glass to ensure even distribution of the epoxy. When satisfied with alignment of the fittings, (they are straight, etc.) set the assembly aside to cure with the fittings facing straight down. SEE FIGURE # 1
5) Using the same mix of epoxy from step 4, glue the two machined gas fittings into their respective holes in the aluminum end caps. Again, apply the epoxy to the fitting only using the brush. Avoid using too much glue. Rotate the fittings into the end caps to ensure even distribution of the glue. Set the two end caps aside to dry with the gas fittings in a vertical position. SEE FIGURE # 2
6) Allow epoxy from steps 4 and 5 to cure for 4 hours before continuing.
7) Using the supplied sandpaper, rough up ½" (12mm) of the outside ends of the glass cooling jacket and bore tube. Do not sand any farther than ½" (12mm) from the ends or the scratches will not be covered by the end caps and they will detract from the looks of the tube. SEE FIGURE # 3
8) Clean the ends of the glass and the inside of the aluminum end caps one last time using MEK.
9) Ensure that your work surface is perfectly flat. Test that you can insert the glass cooling jacket into the aluminum end cap and then stand the unit strait up onto the end cap and that it will remain vertical without fear of falling over.

10) When satisfied with step 6, mix up enough epoxy to glue both the large cooling jacket and the smaller bore tube onto one of the aluminum end caps. We will only glue on one end at a time. Be sure to mix equal amounts of the epoxy.
11) Use the brush to coat ½" (12mm) of One End of the bore tube with epoxy. SEE FIGURE # 4
12) Stand the aluminum end cap upright on the work table with the machined groove for the o-ring facing down.
13) Insert the epoxy covered end of the bore tube into the center recess of the end cap with a twisting motion so as to distribute the epoxy evenly. Rotate the tube several times to work the glue in. SEE FIGURE # 5
14) Now coat ½" (12mm) of One End of the cooling jacket with epoxy. SEE FIGURE # 6
15) Slide the cooling jacket down over the bore tube with its epoxy covered end facing the aluminum end cap. Using a twisting motion, insert the cooling jacket down into the end cap and rotate a few turns to distribute the epoxy evenly. Carefully align the gas fitting with the water fitting. SEE FIGURE # 7
16) Now slide the second aluminum end cap (without any glue on it) onto the top of both glass tubes so as to hold them in perfect alignment while the bottom end dries. SEE FIGURE # 8
17) Let entire assembly stand for at least 6 hours while epoxy cures.
18) Flip entire assembly over and repeat procedure for the second end. This time however you will need to insert both tubes at the same time (obviously). Ensure that the end caps are aligned with each other and that the gas fittings are facing the same direction and aligned with the water fittings.
19) Let tube stand for at least 6 hours while epoxy cures.
20) Mix up about ½ oz (15ml) of epoxy.
21) After mixed thoroughly, draw the epoxy up into one of the supplied syringes.
22) With the laser tube standing in a vertical position near the edge of the work table, insert the tip of the syringe into the small hole in the end cap that passes into the water cavity. Insert the syringe with a twisting motion until it is tight in the hole. SEE FIGURE # 9
23) Slowly inject the epoxy into the end of the tube until it is level with the top edge of the aluminum cap. The resin will be around ½ " (12-13mm) deep. SEE FIGURE # 10

24) Leave the syringe in place and let stand for at least 6 hours.
25) After resin has cured, use a singe edged razor blade or x-acto knife to cut the syringe off flush with the aluminum and discard. SEE FIGURE # 11
26) Flip tube 180 degrees and repeat process with other end of tube. Allow to dry 6 hours, then cut off syringe as before.
27) You are almost done! We will now clean the bore of the tube before final assembly.
28) Find a clean rod of sufficient diameter and long enough to reach through the bore tube. A fiberglass or carbon fiber arrow shaft works well. A gun-cleaning rod may also be used as long as it is oil and grease free. Clean the rod well using MEK.
29) Using the rod, pass several "lint free" cleaning patches soaked in MEK through the bore. SEE FIGURE # 12
30) If available, also use a blast of clean dry air through the bore to ensure that any lint is removed.
31) Clean and de-grease the two formed electrodes using MEK.
32) Insert the electrodes into the tube with the wire connecting the two hoops on the bottom of the tube, opposite of the gas fittings. It may be necessary to push the electrode in at an angle to get it started as it is a close fit to the bore. A friction fit is used to hold the electrode in proper position. Use a clean blunt object (the supplied allen driver works well) to push the electrode in until the outermost hoop is "just" past the gas fitting. If looking straight down into the gas fitting, you should only see the outside edge of the electrode.

    SEE FIGURES # 13, 14, & 15

    CAUTION: Do not over insert the electrode. The outermost hoop must be in direct contact with the aluminum of the end cap. If over inserted into the glass bore, arcing will cause the glass to fracture.
33) Install the two 4x40 x ¼" allen head screws with #4 washers into the inside edge of each end cap. These are the high voltage attach points. SEE FIGURE # 16
34) Install an o-ring into the groove at each end of the tube.
35) Press the optics into the recess in the Teflon® adjusting plates. You can use the tissue that comes with the optics to press against so as not to smudge the optics. Note that the arrow marked on the edge of the output coupler faces toward the inside of the laser cavity and away from the adjusting plate. SEE FIGURE # 17

36) Attach the adjusting plates with optics to the laser using the supplied 2x56 allen head screws and #2 washers.
SEE FIGURE # 18

37) Tighten the screws so that the o-ring is compressed evenly about .0025" (.63mm) or so that the initial gap between adjusting plate and end cap has been reduced to half what it was at first contact.
SEE FIGURES # 19 & 20

38) This concludes the construction phase of the tube assembly.

TUBE ASSEMBLY PHOTOS:

Fig # 1

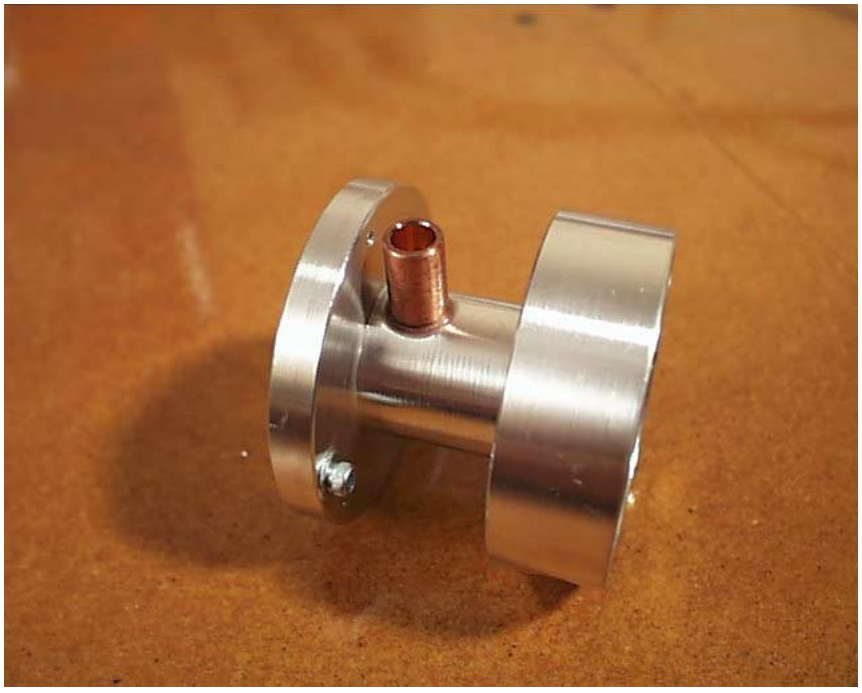


Fig # 2

Fig # 3

Fig # 4

Fig # 5

Fig # 6

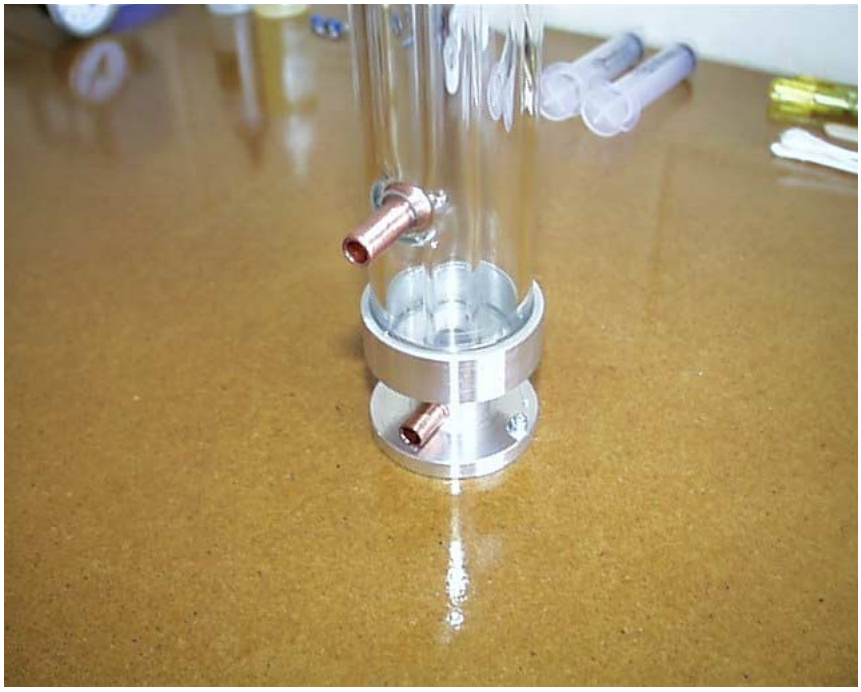


Fig # 7

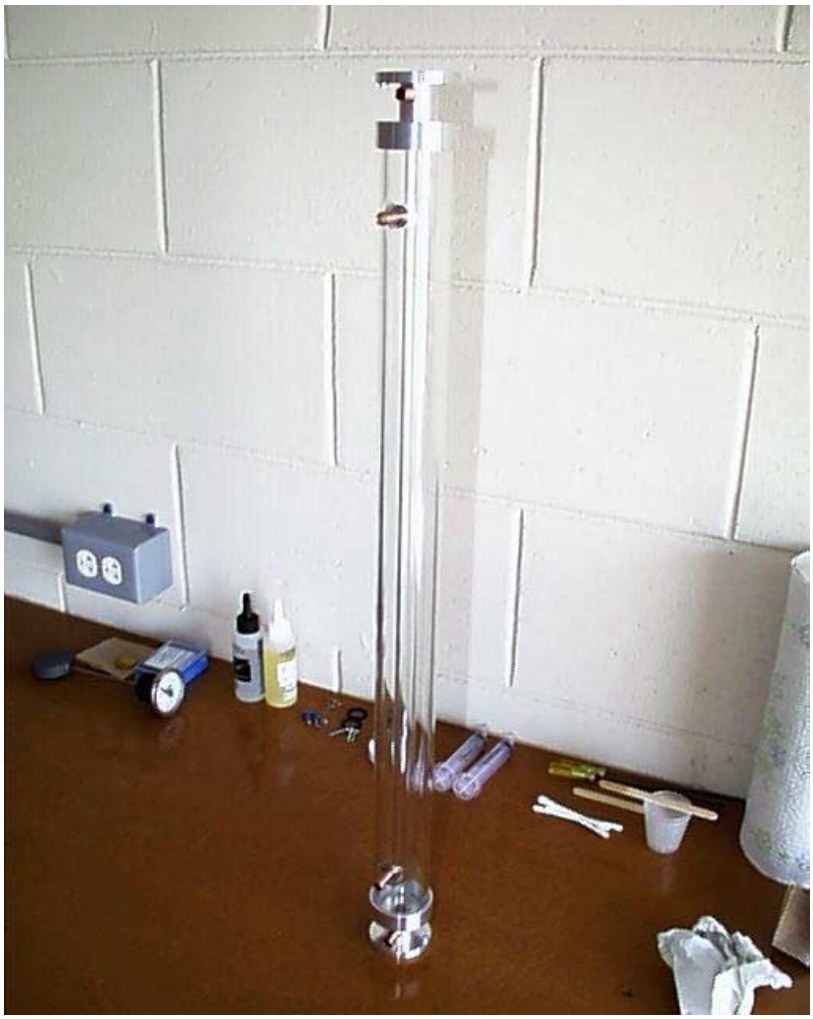


Fig # 8

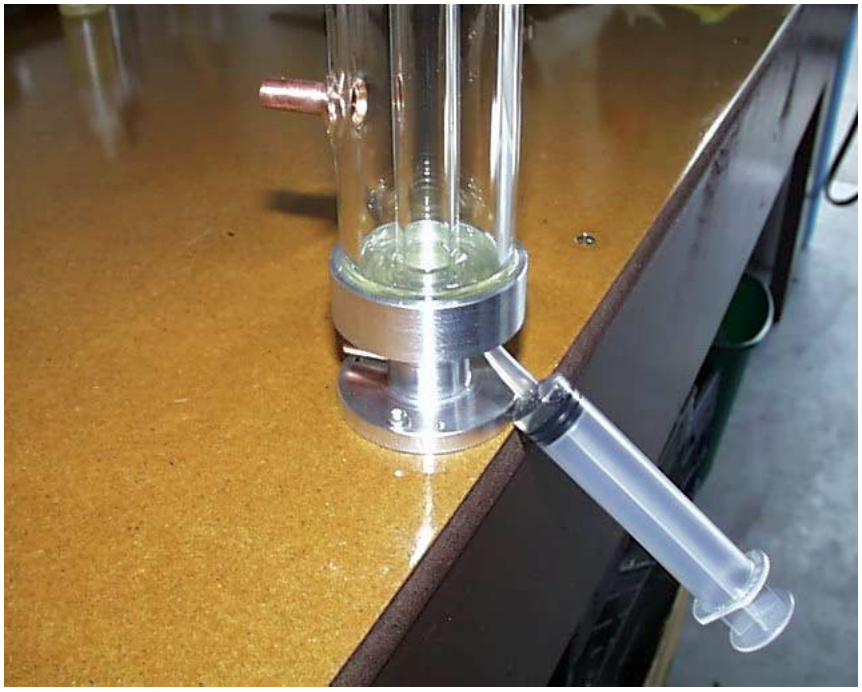


Fig # 9

Fig # 10

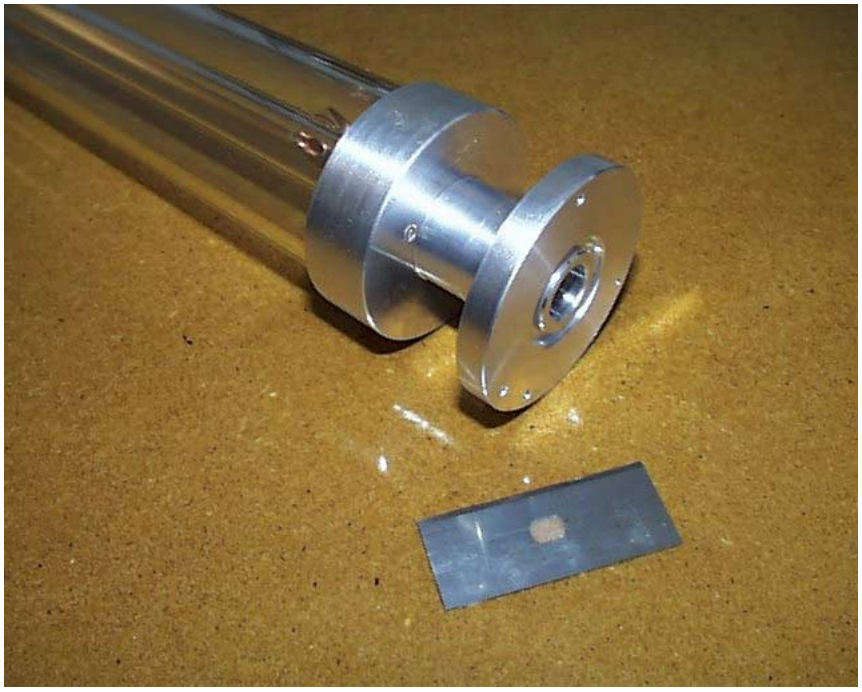


Fig # 11


Methyl Ethyl
Ketone
M.E.K.
Special-purpose thinner,
cleaner and remover
Metil Etil Cetona

Fig # 12

Fig # 13

Fig # 14

Fig # 15

Fig # 16

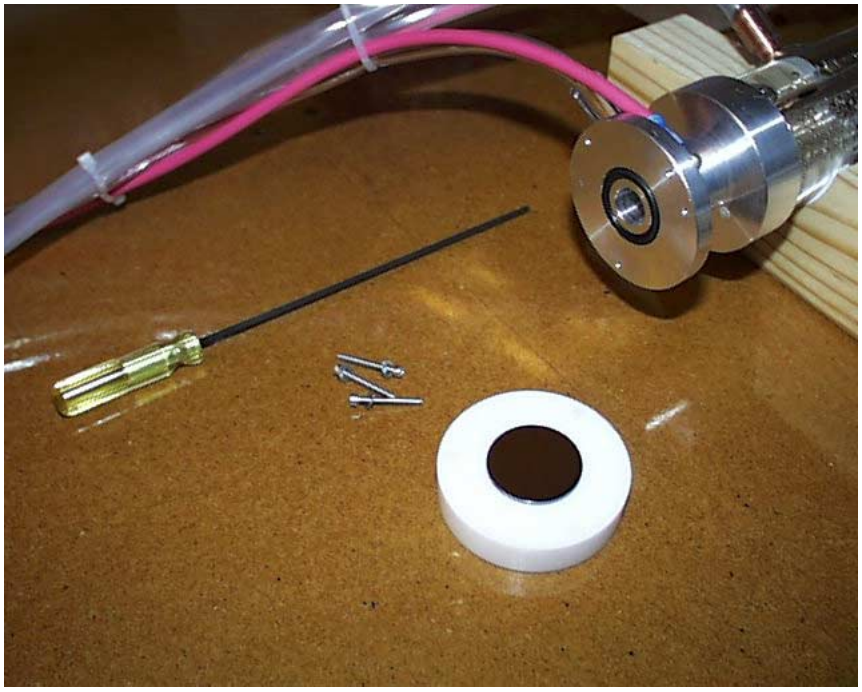


Fig # 17

Fig # 18

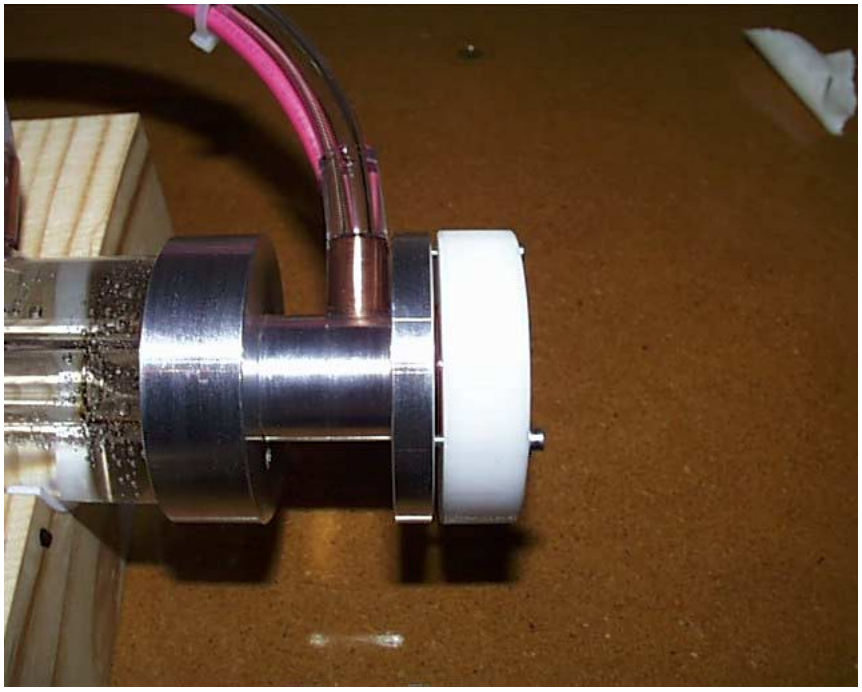


Fig # 19

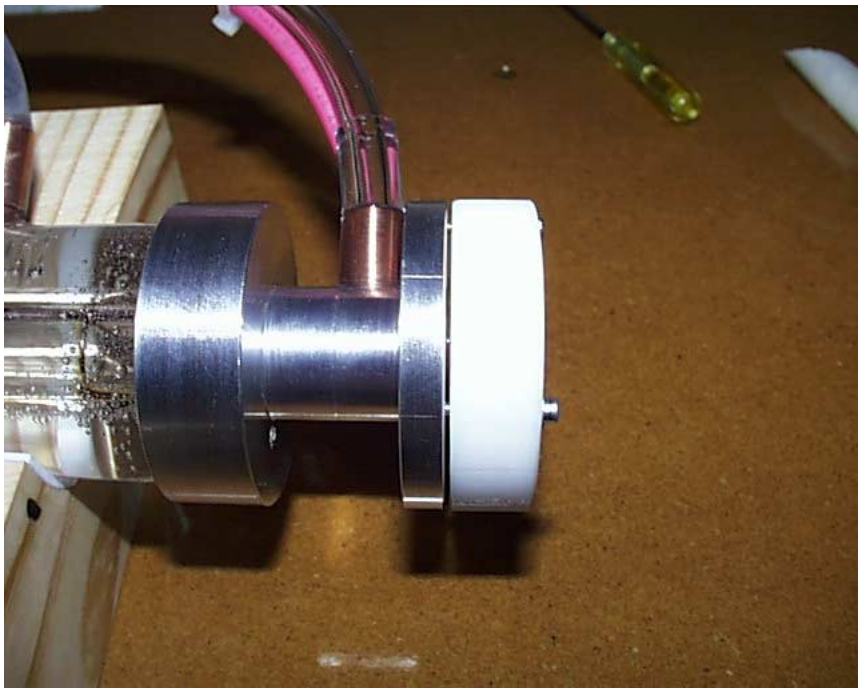


Fig # 20

OPTICAL ALIGNMENT:

After assembly of the laser tube it is necessary to carefully align the optics so that laser output will commence. This is a critical step and should be done slowly and carefully. A laser tube who's optics are not precisely aligned will only make a neat looking conversation piece and will not emit laser light at all.

1) 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.
2) 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.
3) 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 Coupler (partially transparent) end of the CO2 Laser. SEE FIGURE # 21
4) 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. SEE FIGURE # 22
5) Remove the optics and o-rings from both ends of the CO2 Laser. Leave the optics in their Teflon® adjusting plates and set aside where they will not collect dust.
6) Take another piece of masking tape with a tiny hole (~2mm) punched in it's center and apply it to the Output Coupler End of the CO2 Laser (the end facing the HeNe laser). The hole should be aligned as precisely as possible with the center of the bore.
7) Take a third piece of masking tape and apply to the Total Reflector end (farthest from HeNe) of the CO2 laser. This piece should not have a hole in it but just cover the end of the bore.

8) 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. What you should now have is the HeNe laser beam aligned so that it passes directly through the center of the CO2 Laser bore tube.
SEE FIGURES # 23, and 24

9) Carefully remove the masking tape from both ends 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.

10) Carefully put the o-rings back into their grooves on the end caps being sure not to move the tube in any way.

11) Install the output coupler (transparent lens) and adjusting plate back onto the laser at the end closest to the HeNe laser. Tighten the screws until the lens just contacts the o-ring and note the size of the gap between the end cap and adjusting plate. Tighten the screws further until the gap is about half what it was at first contact. This should compress the o-ring about .025" (.63mm). Remember to do this carefully to preserve your alignment.

12) Adjust the three screws until the reflected beam from the HeNe is directed straight back at the HeNe. Take your time and make careful adjustments, until the red spot being reflected by the CO2 laser is exactly centered around the small hole in the tape where the beam exits the HeNe. SEE FIGURE # 25

13) Install the mirror at the rear of the CO2 just as you did the output coupler. The o-ring should be compressed in the same manner.

14) Adjust the rear mirror until its reflection is centered on the hole in the tape attached to the HeNe laser just as you did with the output coupler. This time 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. I cannot show a picture of this as it looks just like Figure # 25 and the small rings do not show up.

15) This concludes the rough alignment process. Final alignment for full power output will be done while the laser is running. Handle the tube cautiously from this point on so as to preserve your alignment. Do not touch the adjusting plates when connecting

tubing and wire. It is ok to hold the tube by the aluminum end caps, just avoid bumping the adjusting plates or jarring the tube.

OPTICAL ALIGNMENT PHOTOS:

Figure # 21

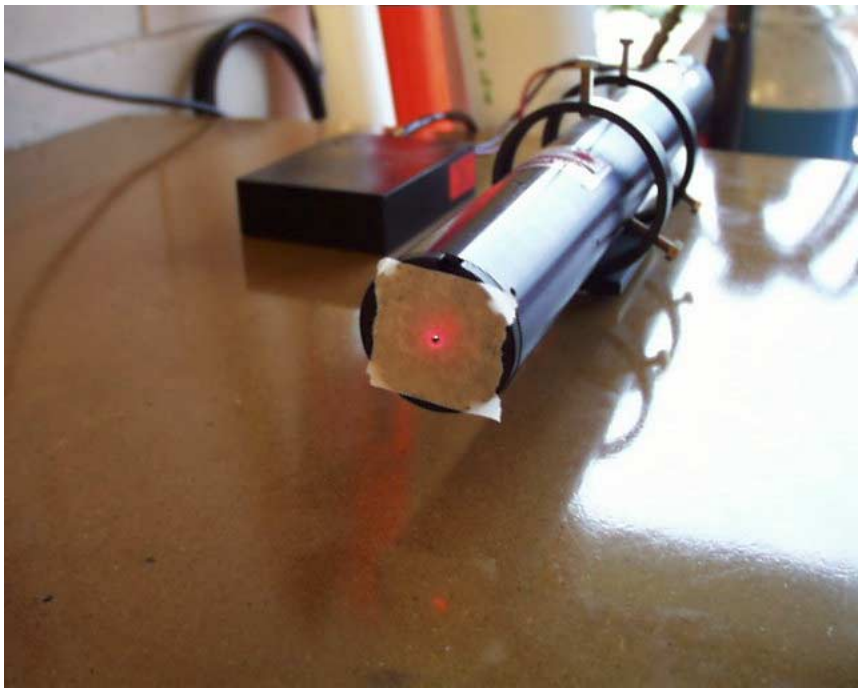


Figure # 22

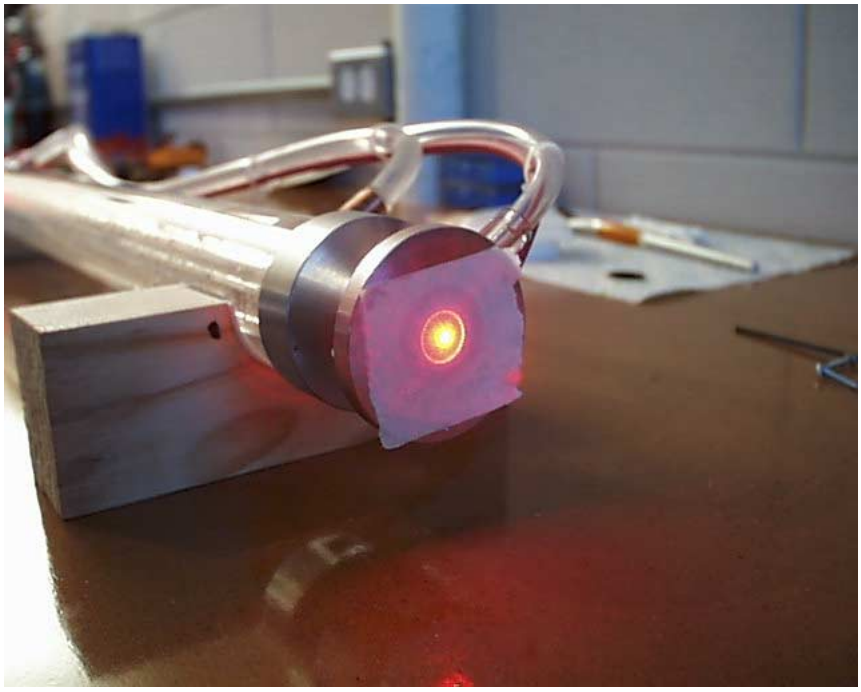


Figure # 23

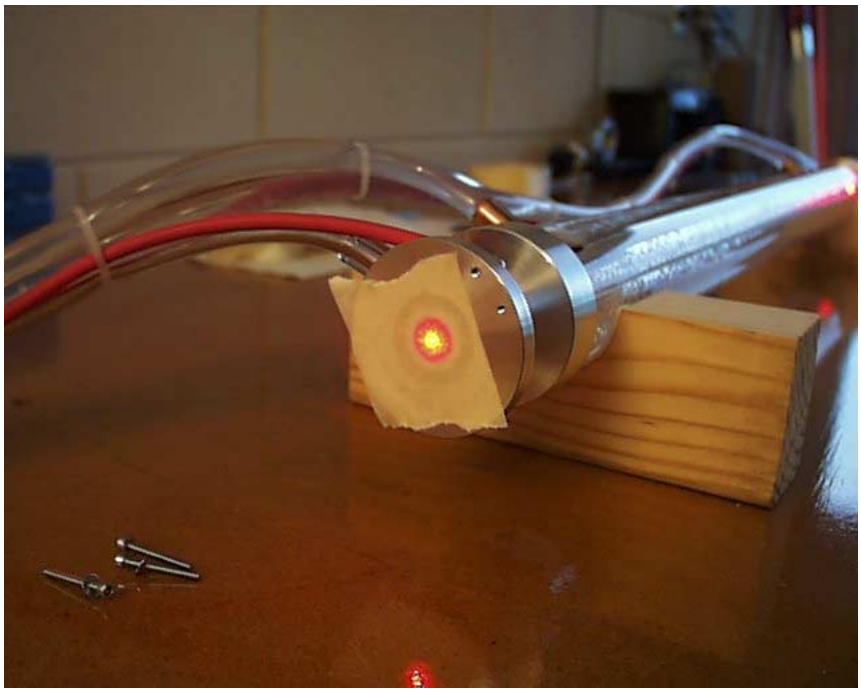


Figure # 24

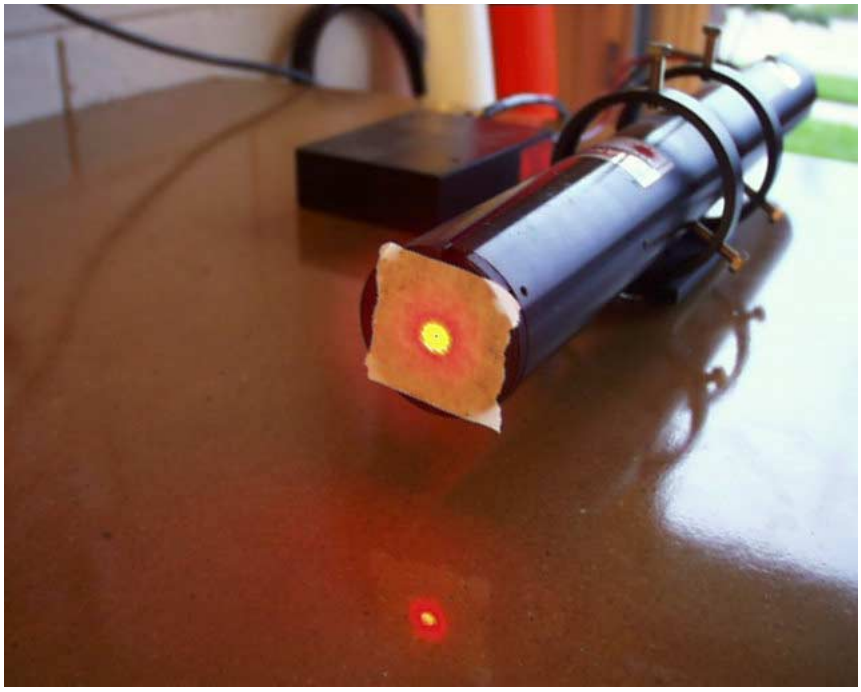


Figure # 25

FINAL OPTICAL ALIGNMENT:

These steps are to be performed while the laser is running. See the section on "LASER OPERATION" before performing these steps. You will need a beam-stop that heats quickly so that minor mirror changes can be seen immediately. A piece of wood that has been soaked in water works well. You will have a certain amount of time before it bursts into flames and causes you to move the wood to a new spot.

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. 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. In the event you were to accidentally touch the high voltage connection, you would not want your other hand to be grounded and cause current to flow across your chest. Always wear UV eye protection 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 wood block in front of the laser. It should begin to burn or smoke. 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 changes will be made to the **REAR MIRROR ONLY**. That is because the rear mirror is concave, and the front partial mirror or "Output Coupler" is flat. The output coupler has already been aligned so that it is perpendicular to the center line of the bore tube (Provided you followed steps 1-15 in the Optical Alignment section) and will cause the beam to propagate down the center of the bore. We do not want to change that. We will make changes to the **rear mirror only** and tune it to the front mirror for full output.

3) Using the insulated adjusting wrench provided **(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.

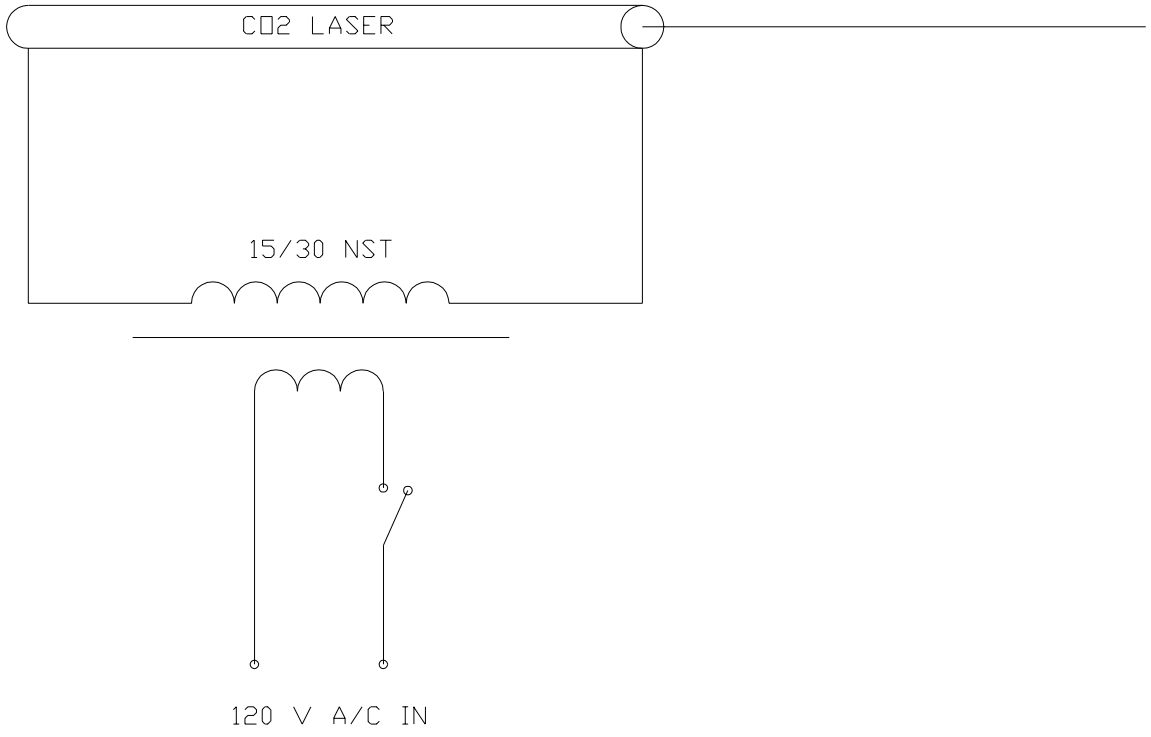
5) From time to time, minor tuning of the rear mirror may be required to achieve absolute maximum output. Avoid jarring the tube or bumping the adjusting plates.

THE POWER SUPPLY:

The power supply can be as simple or as complex as you wish to make it. I will list the options from least expensive/complicated to most expensive/complicated. Of course the better the power supply, the more power the tube will produce up to a point.

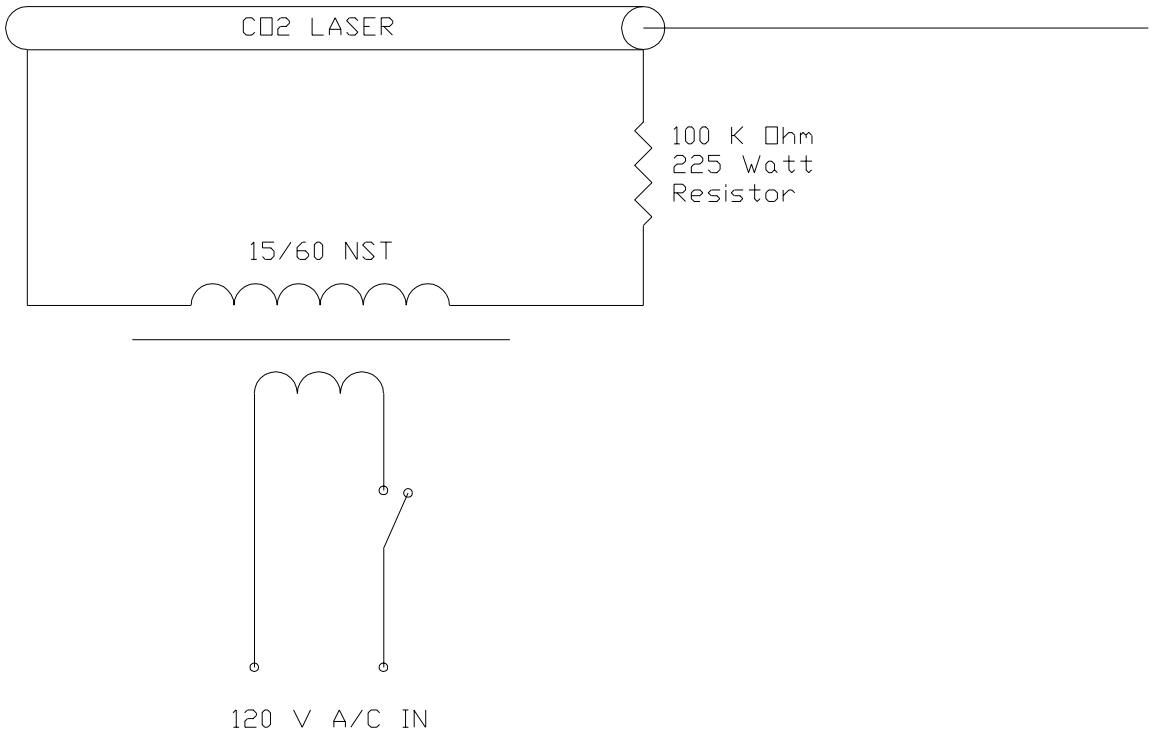
Option # 1

The simple power supply is a 15,000 Volt Neon Sign Transformer rated at 30 ma. Commonly referred to as a 15/30 NST. It's secondary output of 60 Hz A/C (Alternating Current) can be connected directly to the tube, and the primary (120vac) can be simply switched on and off. This option provides the least power output and is the least complex.



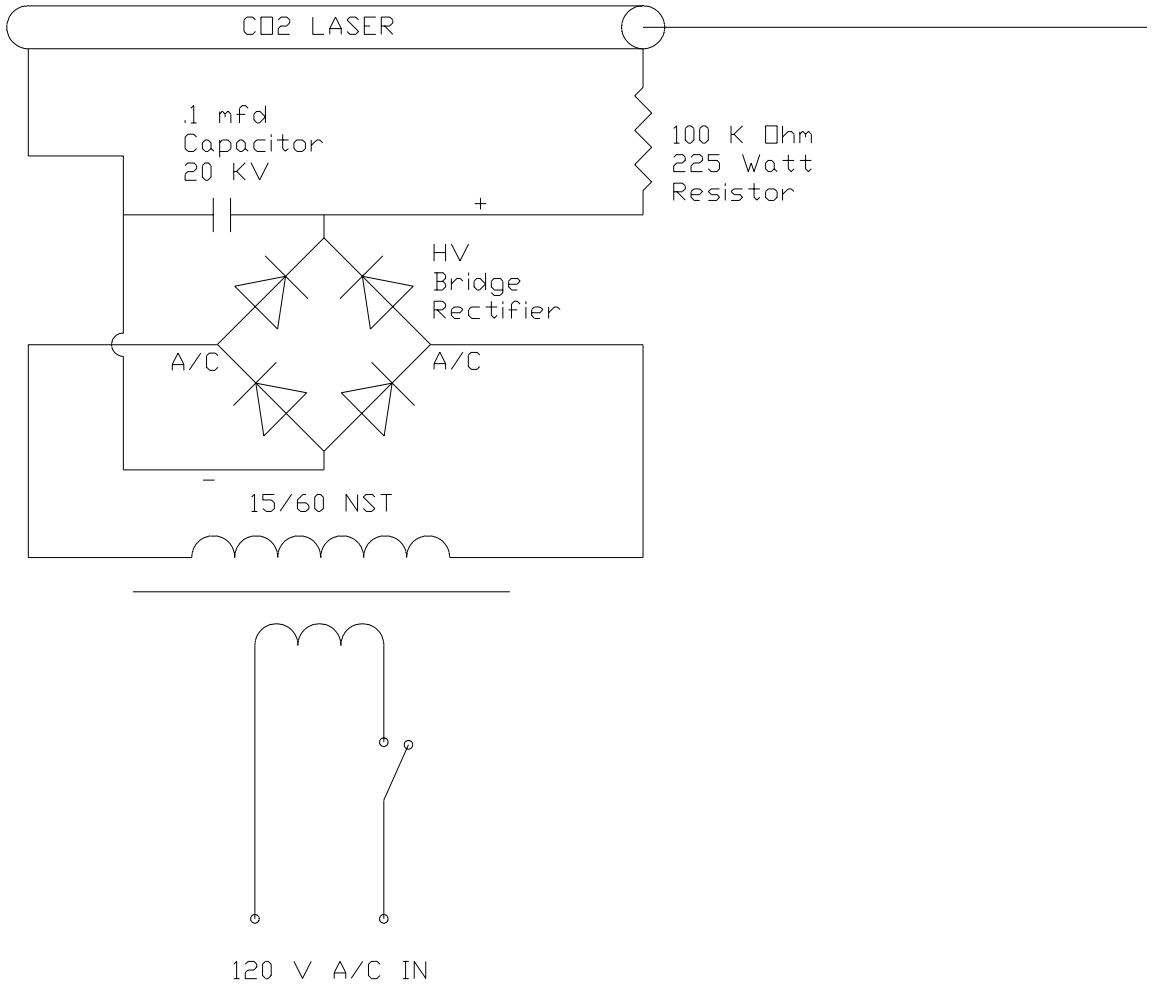
Option # 2

The intermediate power supply is a 15,000 Volt Neon Sign Transformer rated at 60 ma. Commonly referred to as a 15/60 NST. It is hooked up the same as # 1 except that a 100 K Ohm 225 Watt Resistor is placed in series between the tube and the secondary to provide current limiting. The resistor will require a fan to keep it cool for long run periods greater than 3-5 minutes at a time. This option provides greater power output, but since you are still running A/C, the output of the laser is pulsed at 120 hz, and will show up when cutting or engraving as a dashed line.



Option # 3

The best power supply option is a 15,000 Volt Neon Sign Transformer rated at 60 ma. Commonly referred to as a 15/60 NST. This time however you will use a high voltage bridge rectifier to convert the output of the NST to unfiltered D/C, then run it through a .1 mfd @ 20KV filter capacitor, and finally through the 100 K Ohm @ 225 Watt Resistor in series with the tube. For the rectifier use four high voltage diodes that are rated for 15,000 volt PIV (peak inverse voltage), and 100 ma average forward current arranged as shown in the drawing. This results in the maximum output power, as well as a smooth, ripple free beam which will cut evenly.



If you are planning to use the laser for CNC cutting or engraving, then option # 3 should be used. This will give the most power and a smooth discharge.

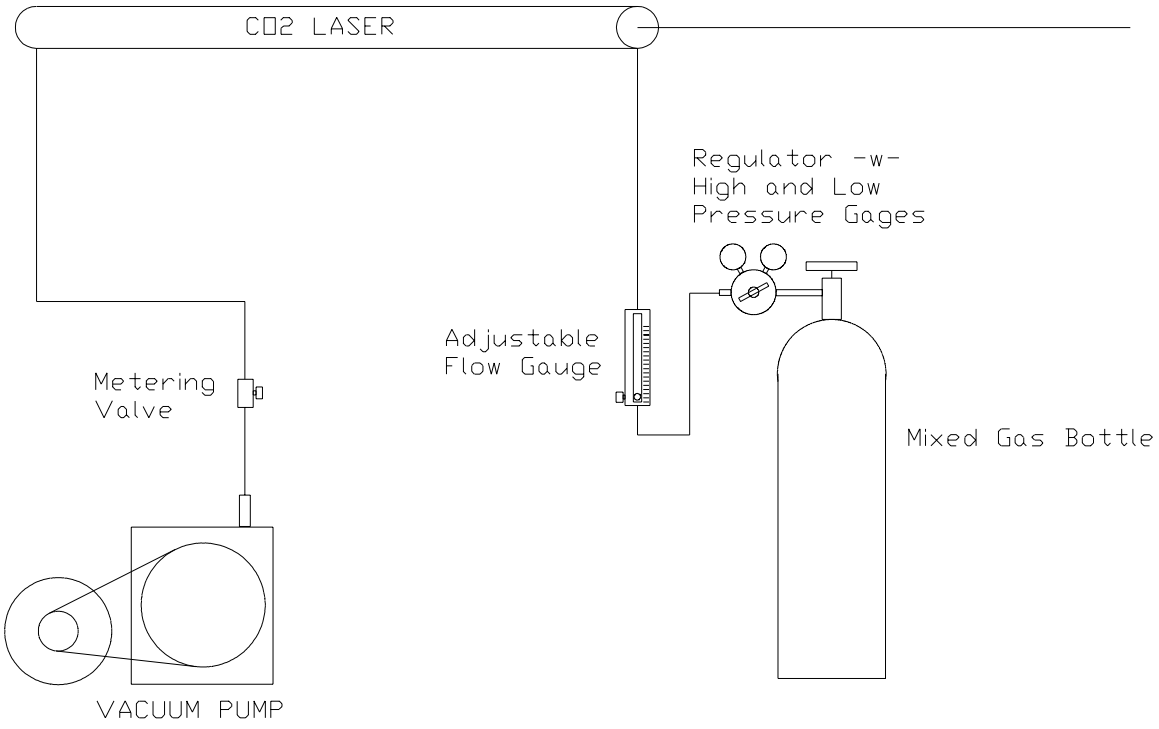
THE GAS/VACUUM SYSTEM:

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.

Below is a diagram of the gas and vacuum hookup.

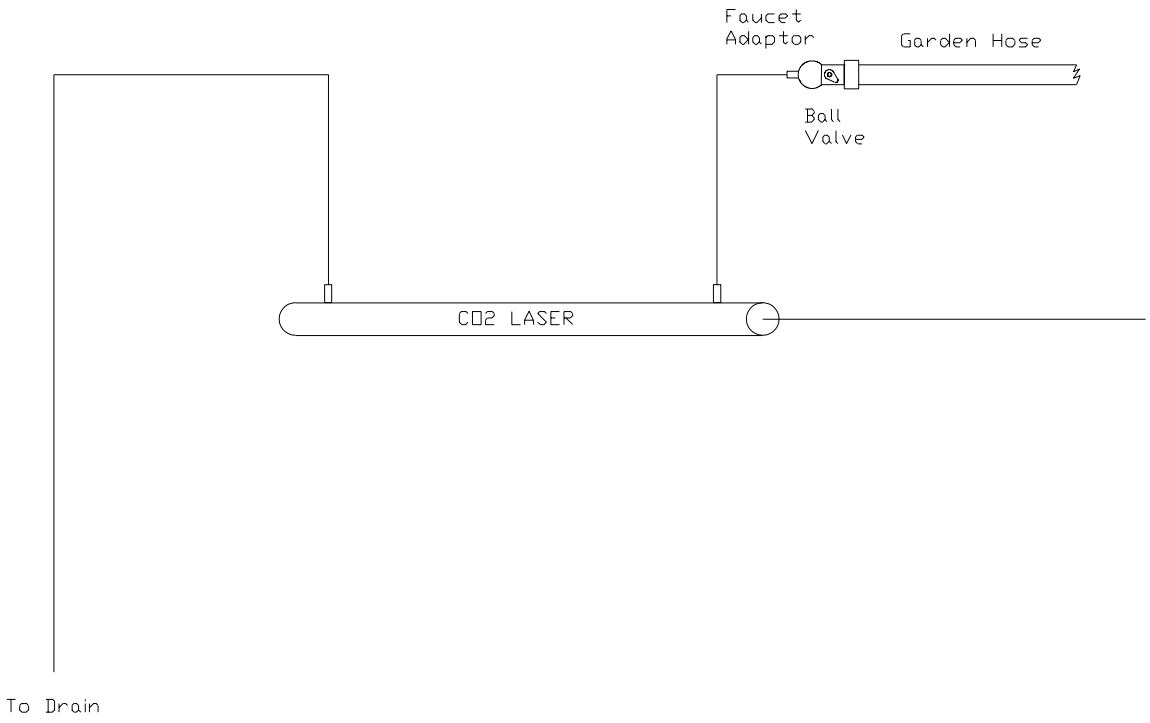
GAS/VACUUM HOOKUP DIAGRAM:



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 $2.00 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 $3.00

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.

1) Using the provided tubing, hook up the cooling water supply to the outer fittings located on the outer glass tube. Refer to the connection diagram on page 31.
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 connection diagram on page 30.
3) Use the supplied high voltage wire to hook up your power supply to the tube. The wires attach to the 4x40 allen head screws located at the inside edge of each aluminum end cap. Strip off about ½" (12mm) of insulation, form a loop and attach under the washer of the 4x40. Hook up the power supply as per the diagram on pages 26, 27, or 28 depending on which power supply option you chose to use.
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.
6) Next turn on the vacuum pump and open the metering valve all the way.
7) 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. This is very important. You should never allow the inside of the laser tube to become pressurized.
9) Now crank the gas regulator knob in 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. For initial tests, start with about 1 liter per 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 lights.
12) Once the tube is ionized, adjust the gas flow slowly for maximum output of the beam. This is generally a deep purple color at the gas connection end of the tube, that shifts to a lighter blue color as it approaches the vacuum pump end of the tube. 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. Use a piece of wood that has been soaked in water to watch the beam during these adjustments. The wood will give very quick indications of heat change. Of course you should always have a brick or piece of concrete behind the wood as your final beam-stop material.
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 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.

TUBE SPECIFICATIONS:

Maximum Power Output: (Using power supply option # 3) 35 Watts
Beam Mode TEM 00
Effective Beam Diameter (using the 1/e2 criteria): 5.6mm
Length of Discharge: 533 mm
Length or Resonator: 647 mm
Overall Tube Length: 673 mm
Bore Diameter: 11mm
Bore Tube Material: Pyrex® Glass
Cooling Jacket Diameter: 44mm
Cooling Jacket Material: Pyrex® Glass
Rear Mirror (HR): 1.0" x .120" x 10 Meter Radius Enhanced Gold
Output Coupler (OC): ZnSe 1.0" x .120" x 85% Reflectance, Plano Plano
Cooling: Flowing Tap Water
Coolant Flow Rate: 2 - 3 Liters Per Minute
Gas Mix: 9.5 % CO2 - 13.5% Nitrogen - 77% Helium
Gas Flow Rate: 2.5 LPM Minimum (Varies with vacuum pump used)
Optimum Gas Pressure: 8 Torr
Power Supply Requirement: 15KV @60ma Current Limited to 38ma
Optimum Current: 38 ma
Tube Weight (without coolant): 2 Lbs