

Laser Beam Alignment for Flying Optics

This tutorial is for assisting the laser machine maintenance person in aligning the laser beam. The most important thing about getting your laser machine to work correctly is to have the alignment correct. Doing the initial machine alignment can take as little as 15 minutes. A machine that has exceptional problems can take three hours to align the laser tube, brackets, mirrors, focal head, and lens.

This method is used by Ray Scott and should NOT be considered to be the only method or even considered as a professional method. This method works great so far and uses minimal tools. After a bit of reading and thinking about the procedure, a competent maintenance person should be able to complete the alignment.

Overview:

Alignment is done in steps. These steps are specifically in an order such that the total alignment gets done correctly. We expect that the laser tube excites properly, the mirrors are clean and free of damage, the lens is clean and in good condition. If the beam alignment is done right, then the machine will perform to top potential.

Materials:

Masking tape (2 inches wide) - The best masking tape (for this purpose) can be purchased at Harbor Freight. This tape has a low plastic content on the top surface and it has less adhesive on the bottom. It will be easier for the laser to leave a mark on the tape for us to see. The weak adhesive will not stick to the brackets permanently and is easy to reposition. The tape is also more paper and will be marked as brown/black burns.

Red Ink Pen - Used to mark the position of the laser marks. We can see the red ink through the thin tape. This tells us the original position and relates the position of the new laser mark. The idea is to make concentric laser marks.

Scissors - Used to cut the masking tape to the appropriate sizes.

Phillips-head screwdriver - Used to loosen/tighten the spring-loaded screws that tension the mirror brackets.

Finger nail Polish - Used to "lock" the screws into position after the alignment is done.

Denatured alcohol - For cleaning.

Small, Flat-head screwdriver - For removing the lens retaining nut.

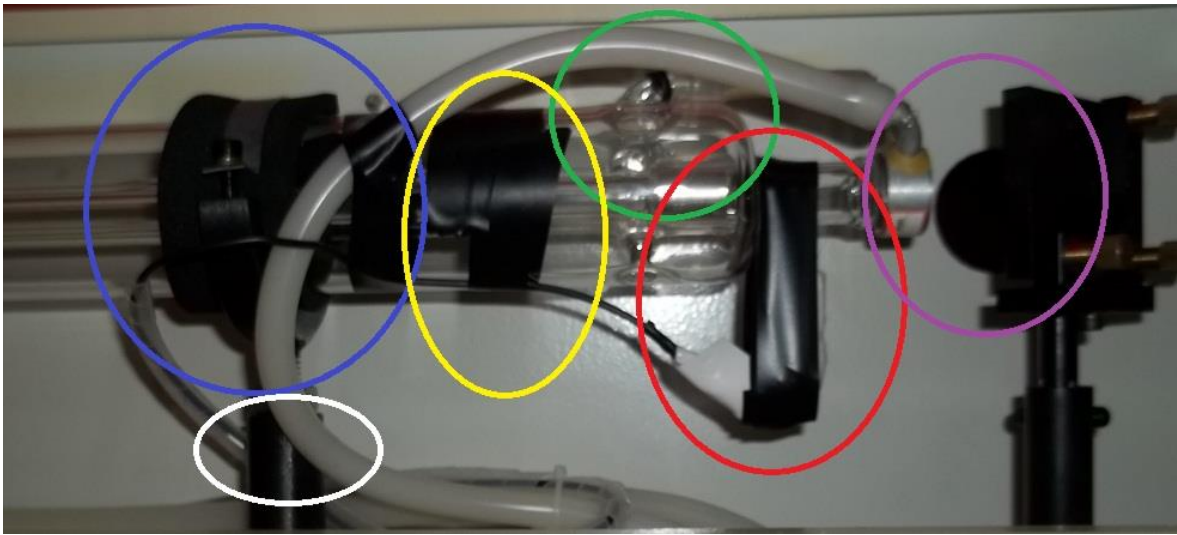
Knife - For cutting and marking.

Mirrors are named as first, second, and third according to how far they are from the laser tube. The first mirror is closest to the laser tube. The third mirror is directly above the focal lens.

Procedure:

Step 1 - Make sure the laser tube is installed correctly. The laser tube needs to be situated so that the laser beam exits and points into the first mirror. Allow about 1 inch between the end of the laser tube and the mirror bracket. Please look at the picture and notice this spacing under the PURPLE circle. It does not matter if the electrical connectors are rotated top or bottom, but make sure the electrical connectors will be safe from accidental pressure (the glass nipples are tender and easy to break). We have secured the electrical connectors with basic electrical tape (RED circle). The tape also acts as a strain relief (YELLOW circle) so the wire does not produce torque on the glass nipple.

Rotate the laser tube so that the coolant will automatically purge the air. The coolant should exit the glass chamber at the top right of the laser tube. Notice the coolant exits the cooling chamber of the glass (GREEN circle). Do not be so concerned about the orientation of the silicone tubes. You need to ensure the coolant will automatically exit the laser tube without leaving a bubble. The bubble will prevent any fluid from cooling the laser tube and output coupler lens. An overheated lens will become damaged and greatly reduce the output power. The laser tube would need to be replaced.



The mounting straps should be snug, but not overly tight. Excessive pressure could break the laser tube. The foam rubber pads (BLUE circle) are placed between the laser tube and the mounting brackets to absorb pressure and ensure an even pressure for holding the glass tube in place. Make sure that the "U" brackets are securely mounted. The base screws (under the WHITE circle) should be tight enough that the base does not move. There are set-screws that prevent the height adjustment from moving. These set screws must be tight. If the set screws are not tight, then the tube could move after alignment and waste the entire procedure.

Once the laser tube is installed, connect the high voltage wire and ground wire. This white silicone tape is the high voltage tape. It needs to be layered with thickness enough to prevent the High Voltage from sparking to the frame. Be VERY careful with this electrical connector. Breaking the glass nipple is NOT covered by warranty.



Step 2 - Close the doors. Turn the machine on. Make sure coolant is flowing. Move the Focal head to the top left of the machine. This puts all the mirrors at the closest locations. If you expect the laser alignment to be somewhat close, then it may be easy to place a small piece of wood under the air nozzle. Test that the laser tube excites (fully lights up for a moment) when the "Laser" button is pressed. This is also often said that the laser tube "fires". Now is a good time to check the menu configuration for what power percentage and how much time is set for the "Laser" pulse. For a 40 watt laser, the Laser power should

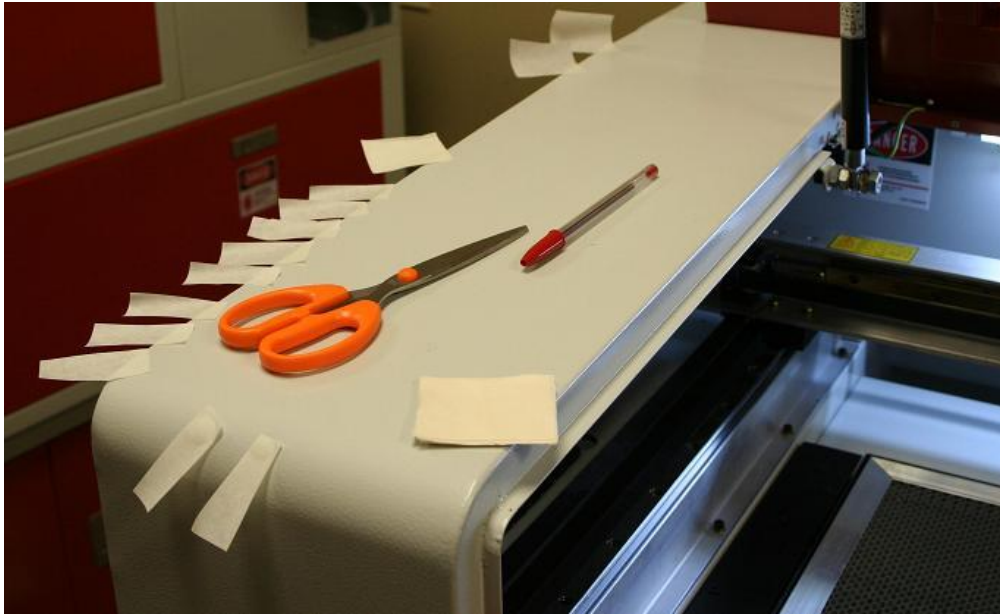
be set to 40 (percent) and the timing should be set to about 40mS (MilliSeconds). The laser should excite for about 16 watts for 40 MilliSeconds.



A damaged laser tube may not excite at all. A dying laser tube might produce a short flame at the end of the tube with RED wire. If the glass is cracked, then the tube should not excite. It is possible that the spark from the laser power supply could have burned a hole to the cooling chamber of the laser tube. The coolant passes through the bulkhead fitting as it exits the machine. This fitting protects from allowing the high voltage to pass through the coolant and onto the floor. If the laser tube excites correctly, then we can proceed with the alignment. If not, then call for technical help.

Step 3 - Use the scissors and tape to make a "target" and "cover-strips". The target is made by layering about 15 pieces of tape together. The resulting target board should be about 2x3 inches and 1/16th inch thick. The idea is that the laser pulse will not be able to pass through it. If the target is too thin, then the laser pulse could burn through or catch fire. If the laser burns through, then the fumes and laser heat could damage the mirror.

TIP *** I usually pull out tape of 10 inches and stick it to the laser machine. This makes it easy to align the tape on each layer. After I have several layers, then I cut it into three sections and stack them together. Use the scissors to cut the pieces of tape. Cut about 10 pieces at 1.5x2 inches. Cut about 20 pieces at 1x2 inches.



Step 4 - Inspect that the laser beam is going to hit the first mirror as the beam exits the laser tube. It would be difficult to adjust if the beam doesn't even hit the first mirror. The coolant should only be de-ionized water. The laser tube in this picture has anti-freeze in the mix. The coolant should NOT have any anti-freeze in it.. NONE!

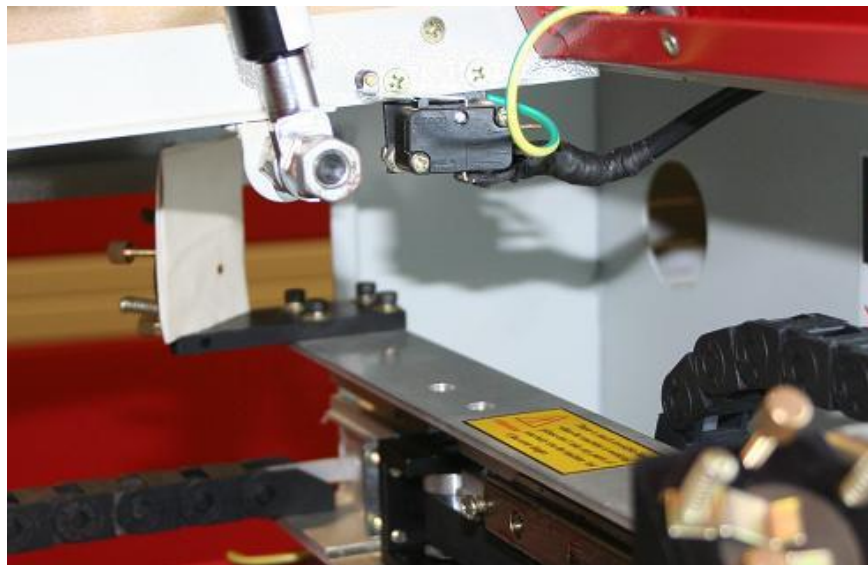


Step 5 - Place the target onto the mounting bracket of the second mirror. Notice that there are no screws protruding from the bracket and that the target does not actually stick to the mirror.

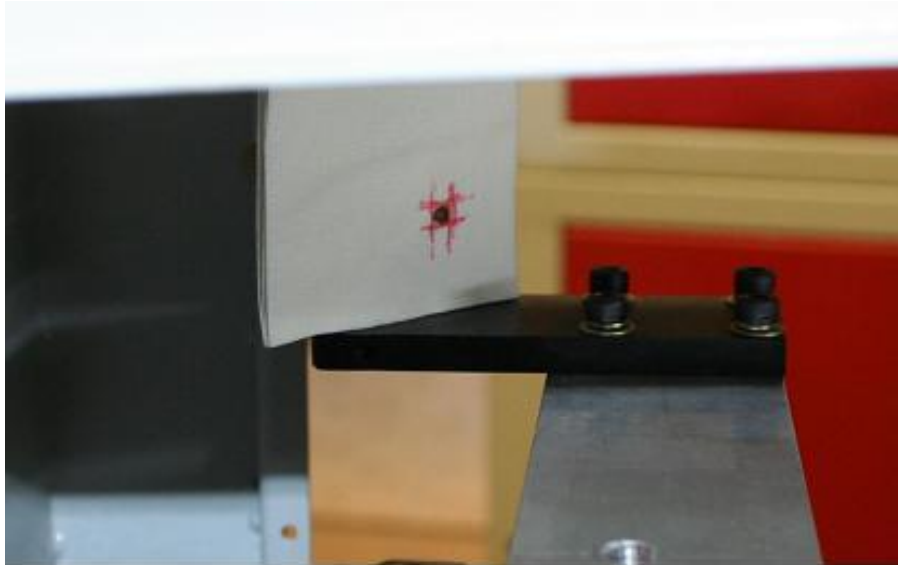


Step 6 - Use the operator control pad to move the gantry to the rear of the work space. This position is where the first and second mirrors are closest together.

Step 7 - Close all doors and press the "laser" button. Notice the mark that the laser makes on the target. You should press the "Laser" button just enough times that the new mark reveals a well defined oval. The oval shape is because the mirror is at 45 degrees angle off of the laser beam axis. The oval could be as small as 3/16 inch or as large as 1/2 inch. This depends on the laser tube power. Don't be scared if you see a flash of light or flame. It could be the paper vaporizing as it burns instantly from the laser heat. Make sure to observe if the tape catches fire. (Quickly put out the fire and make sure all the mirrors are clean.)



Step 8 - Now the laser has been made on the tape target. Move the gantry closer to the front of the machine. You need some space to get the ink pen in there. Use the red pen to mark the top, bottom, right, and left edges of the oval. The pen mark should look like a tic-tac-toe board that squeezes the oval. Make sure the pen mark is dark.

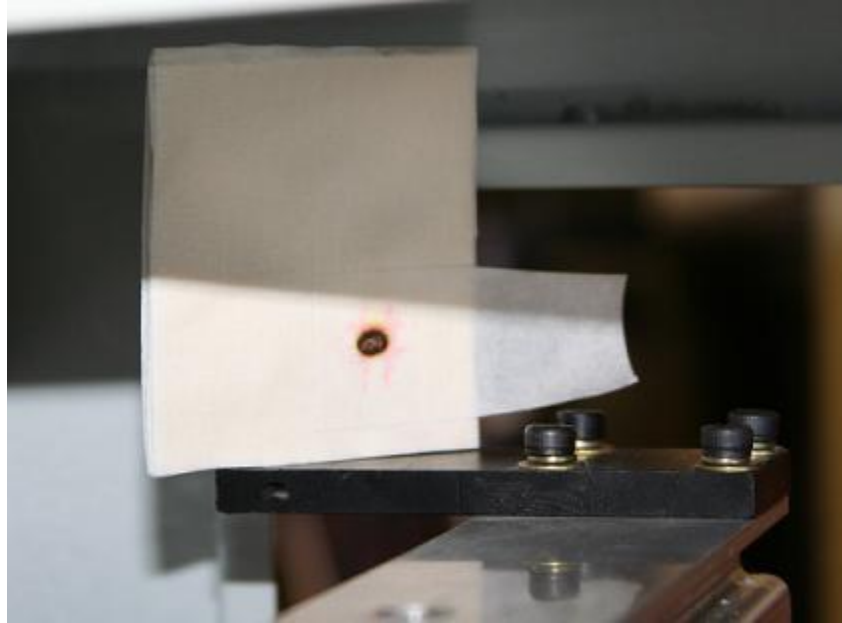


Step 9 - Place a small piece of tape over the red pen marks. This will allow you to see where the new laser mark is.



Step 10 - This is the odd step. If you think the alignment is already close, then you can move the gantry all the way to the front. If the alignment is considerably in error, then the laser beam may not be pointed onto the tape target at all. If the alignment is close, then the laser beam may land on top of the previous

mark. Move the gantry away from the first mirror. Close the doors. Press the "laser" button to produce a new circular laser mark.



Step 11 - Open the doors and observe where the new laser mark is located. Remember that the target (stack of tape) is located on the second mirror's mount. You will need to adjust the angle of the first mirror to make the laser beam land on the inside of the red pen markings. The red marks are made because it becomes difficult to distinguish the new laser marks from the old ones.

Step 12 - Adjust the first mirror angles to make the laser beam reflect onto the original mark. If the new mark is too high, then turn the top adjuster-screw clockwise. Make sure to only move the screw the slightest amount. I have seen that 1/16th of a turn could be too much adjustment. If the new laser mark is left of the target, then turn the bottom-left adjuster-screw clockwise. This will pivot the first mirror such to reflect the laser beam more to the right.



Step 13 - Now that you have made some adjustments to the mirror, we need to see what the results are. Remove the small piece of tape that covered the red pen mark. Replace the tape with a fresh piece of cover-strip tape. If the old piece of cover-strip tape has space available, then you could use an unburned section.



Step 14 - We are basically back at step 10. Close the doors. Press the "laser" button a few times to produce a new circular laser mark.



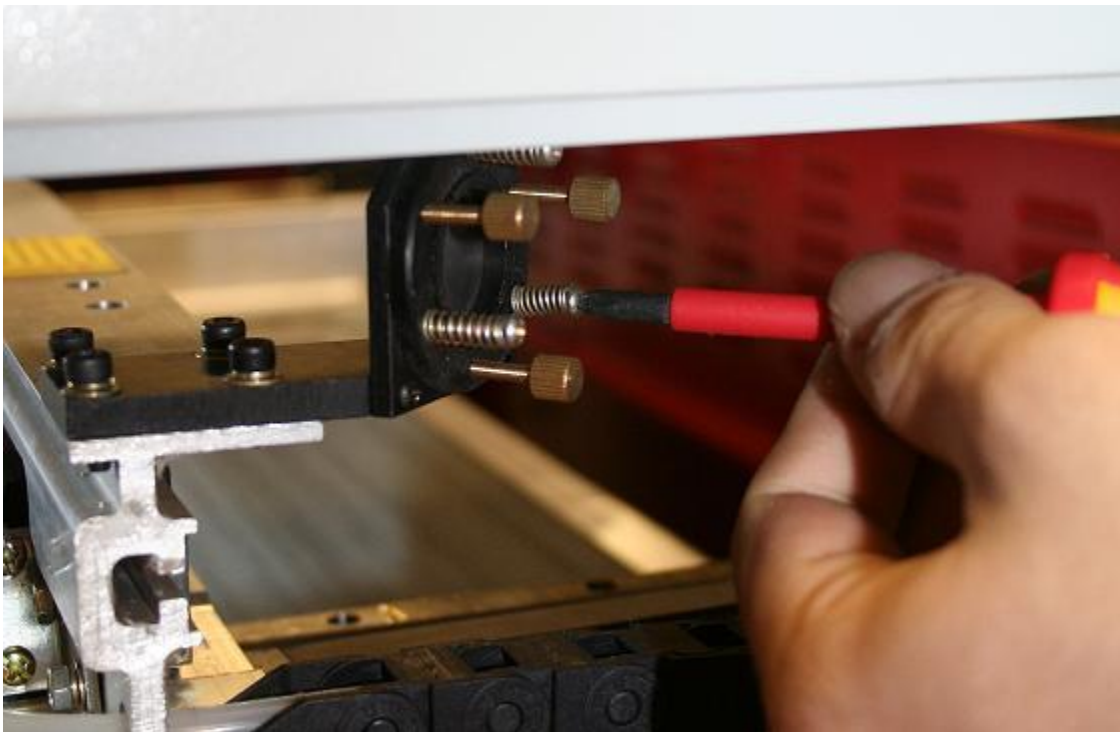
Step 15 - Continue to use steps 10 through 14 until the new laser spot is directly inside the red pen markings. This can be considered as a rough alignment phase. If the original mark(mirrors close together) and first test shot (mirrors apart) was within 1/4inch, then you do not need to go through another phase of step5-step14. If your alignment was already very close, then producing concentric marks will end this phase of the alignment.

Step 16 - The first axis is aligned. This axis isn't completely done until after we know that the laser beam is high enough to enter the focal tube correctly(slightly above center) and shifted out enough to enter the focal assembly on the center axis of that third mirror. This axis is in good condition for aligning the next

axis. We need to move the gantry to the center position while we align the gantry axis. Moving the gantry to center position averages any error coming from the first axis.

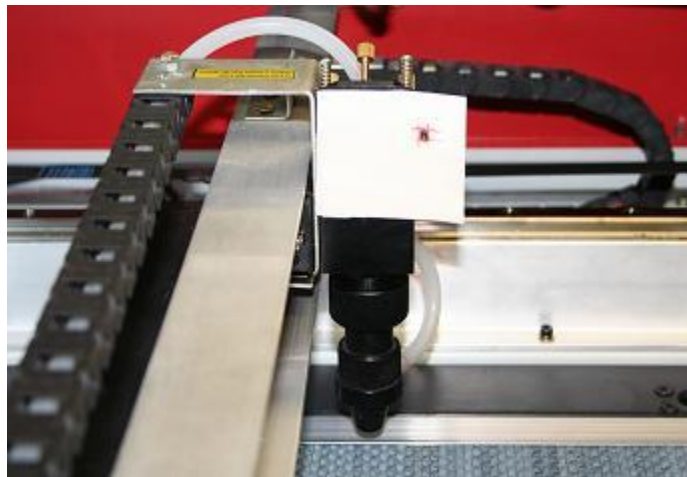


Step 17- There are three set screws that need to be tightened for the mirror on the left side of the gantry. Tighten these so the spring compresses as shown in the figure.





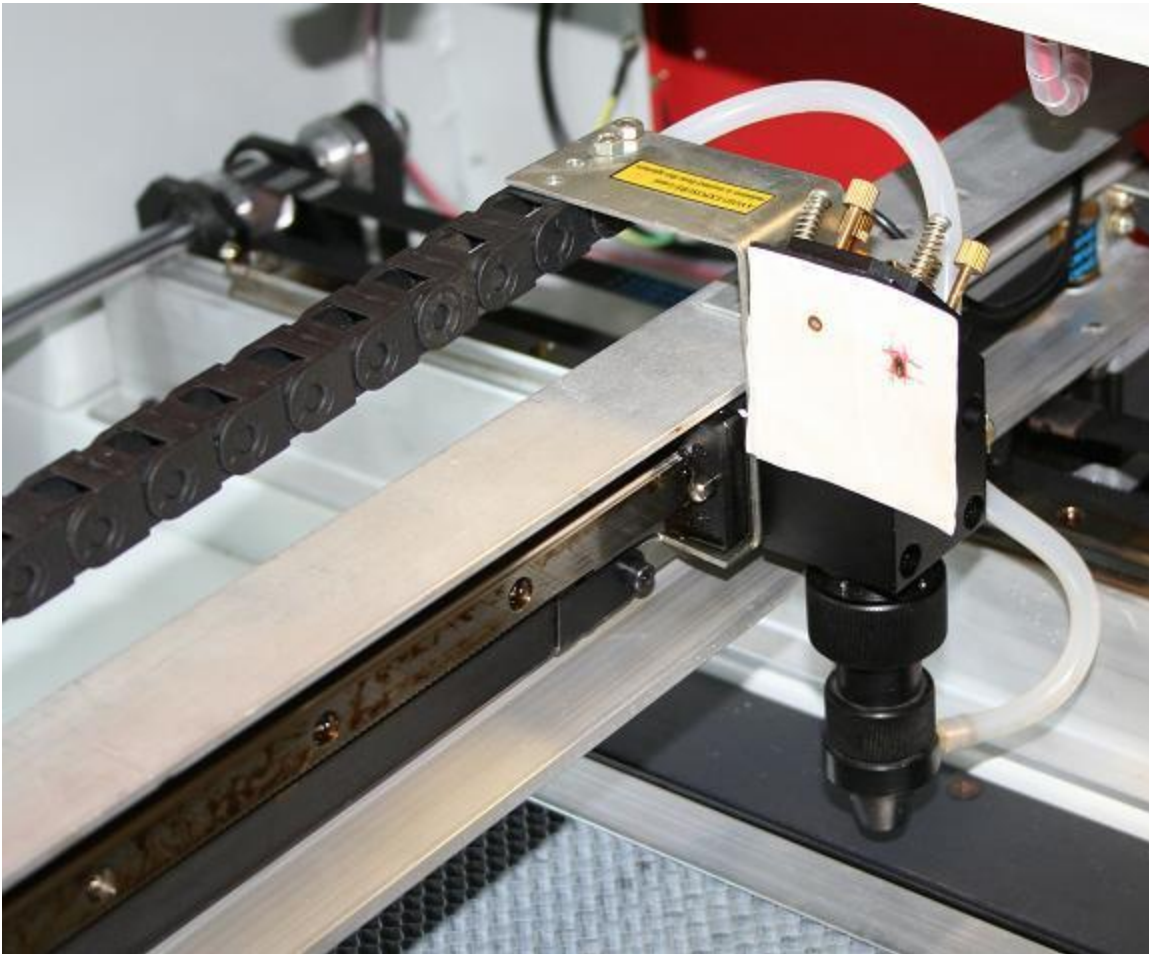
Step 18- Place the target on the third mirror located at the top of the focal head assembly.



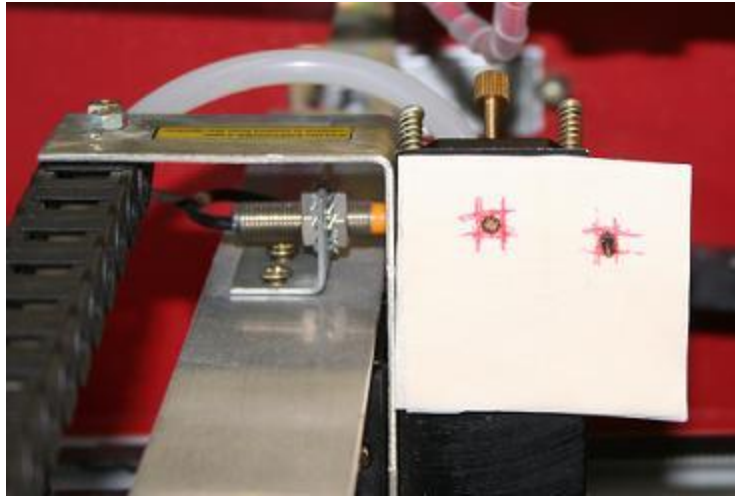
Step 19- Move the x-axis all the way to the left. Press the laser button a few times so that you have another dark circle



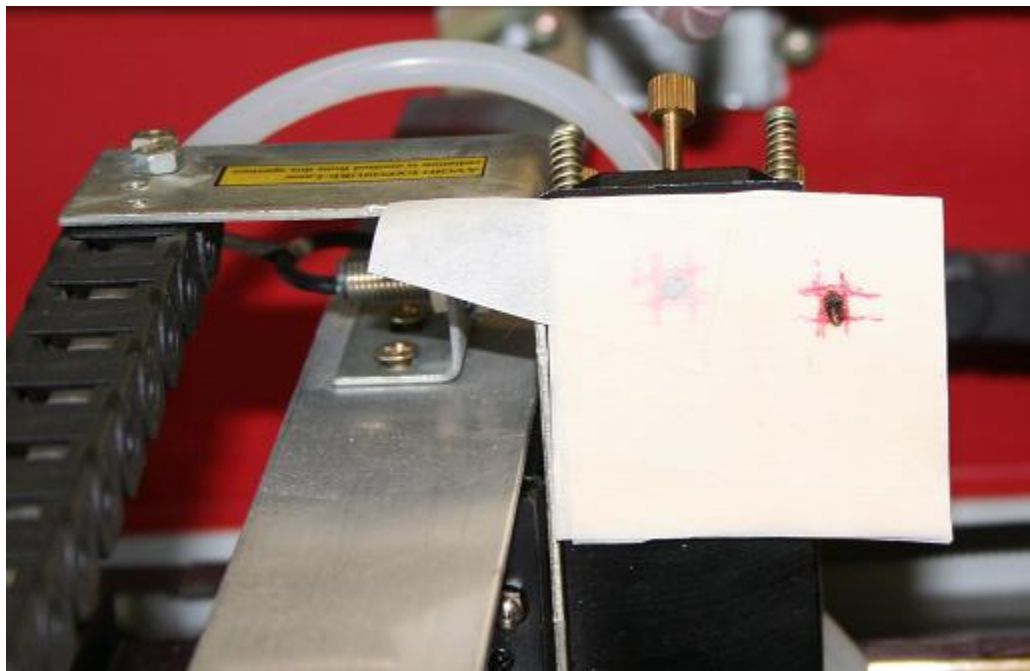
Step 20- Move the x-axis all the way to the right.



Step 21- With a bright pen, mark the pound sign around the circle that has been burned in the target.

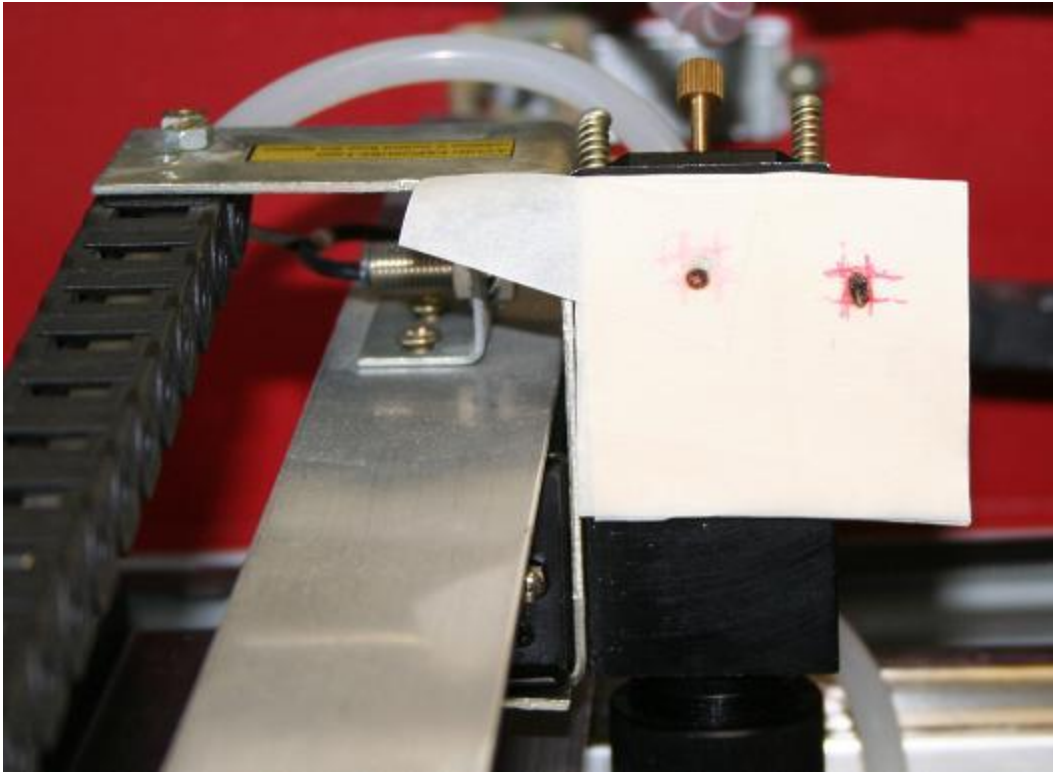


Step 22- Place a fresh piece of tape over the target where it was burned.

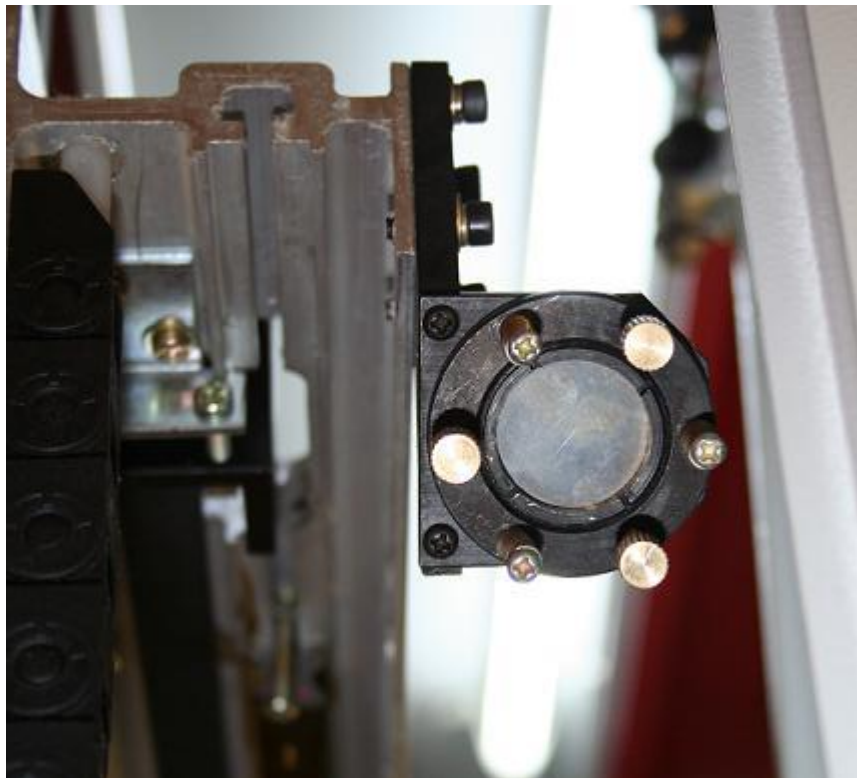


Step 23- Close lid and press the “Laser” button.

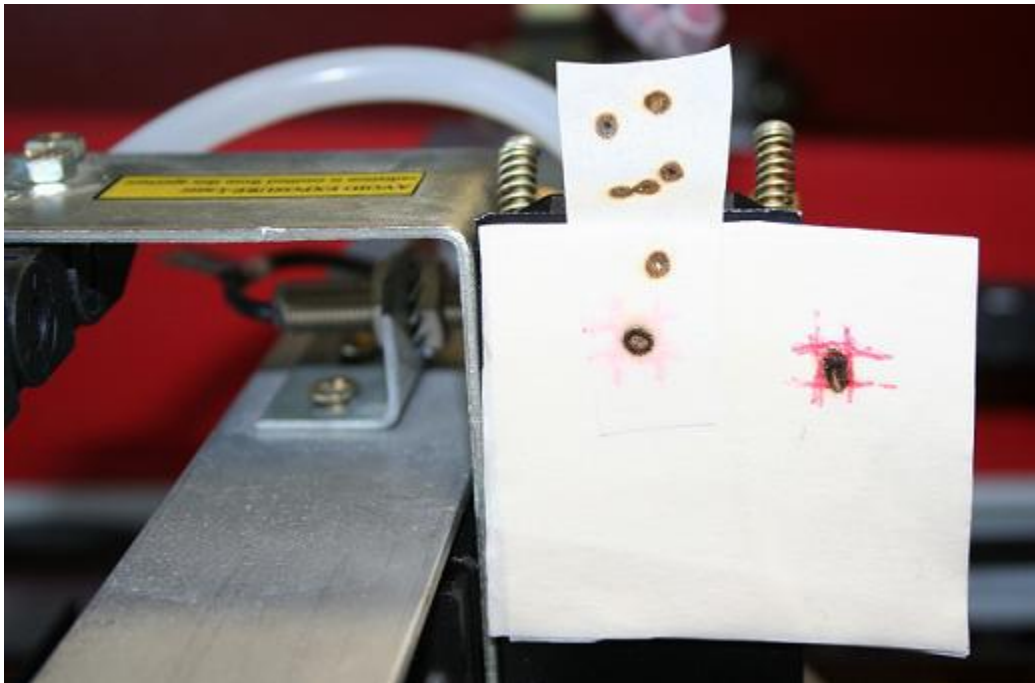
Step 24- Check the alignment.



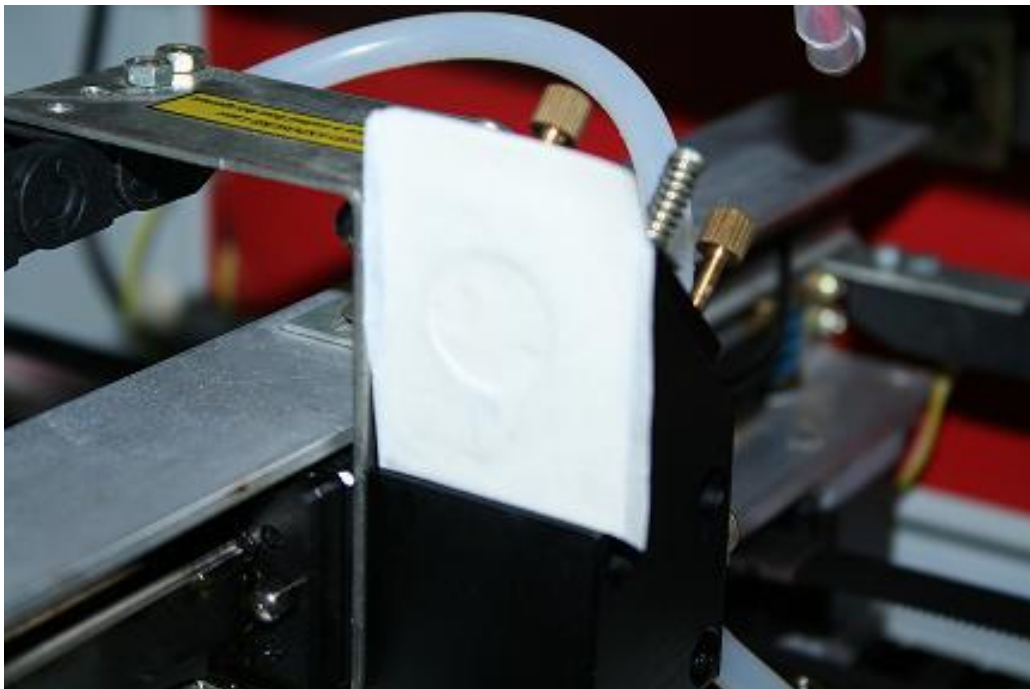
Step 25- There are three screws that can be tightened by hand on the mirror on the left of the gantry. These three screws will change the location of the beam on the target. If the spot is high but on center vertically tighten the bottom screw. If the spot is low but on center vertically tighten the top two screws. If the spot is low and to the left, tighten the top right screw. If the spot is low and to the right, tighten the top left screw. If the spot is high and to the right tighten the top left and bottom screw. If the spot is high and to the left tighten the top right and bottom screw. If the spot is on center horizontally but to the left, tighten the top right and bottom screws. If the spot is to the right tighten the top left and bottom screws.



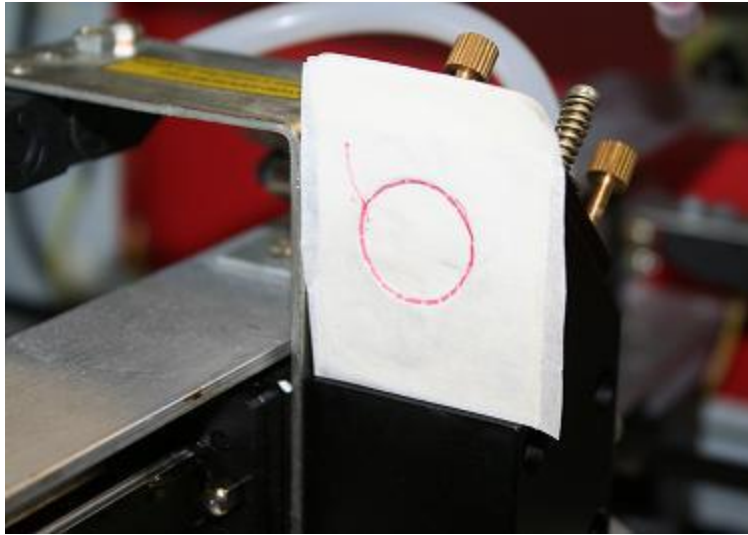
Step 26- Move the fresh tape so that you can see where the new laser spot will hit. Close the lid and press the laser button to see where the new spot landed. Repeat step 25 and 26 until the spots are concentric.



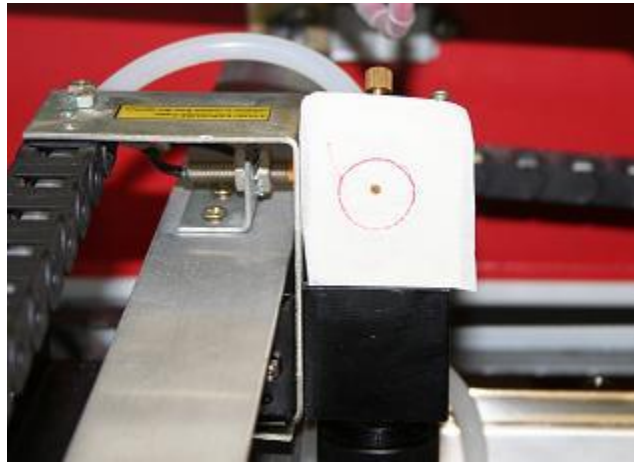
Step 27- Use a target of masking tape with three layers. Cover the hole at the top of the focal head entry. With your fingernail, locate the edges of the circular entry.



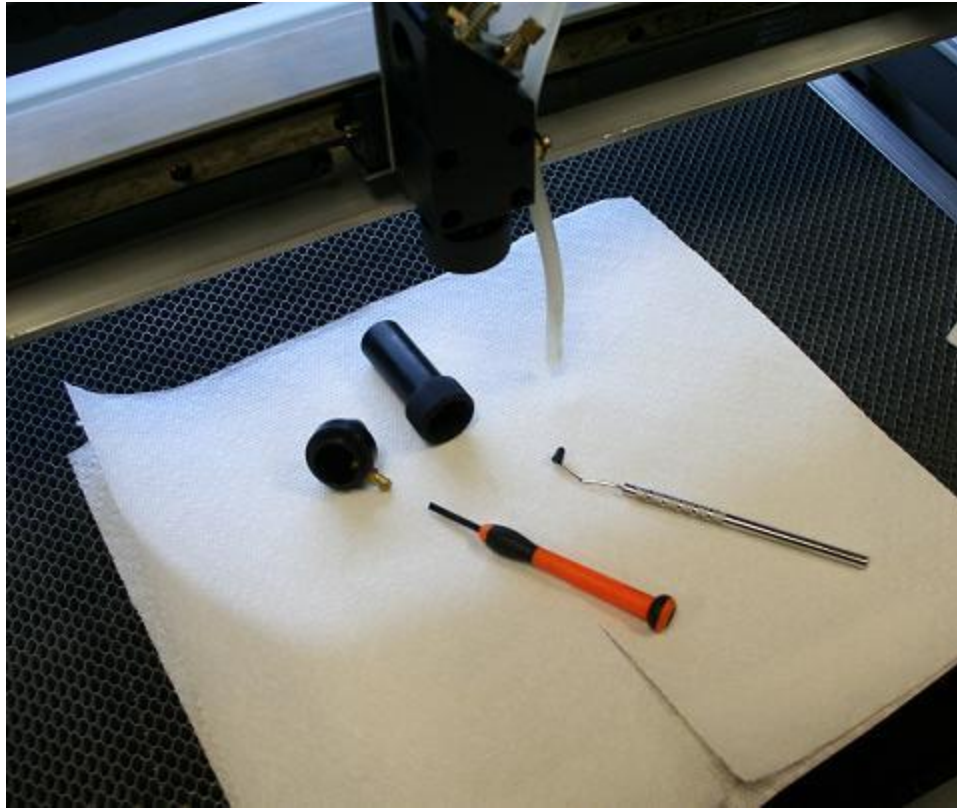
Step 28- With a pen, mark the location of the circle as shown in the figure.



Step 29- Move the x-axis to the center of the table. Close the lid and press the laser button once or twice. Check to see if the spot is high and centered as shown in the figure. If it is not, repeat steps 25 and 26 until the spot is as shown in the figure below.



step 30- Remove the focal tube from the focal head. Remove the air assist hose first. There is a knurled fitting that can be loosened by hand, loosen this and slide out the focal tube.



Step 31- Unscrew the top of the focal tube exposing the lens.



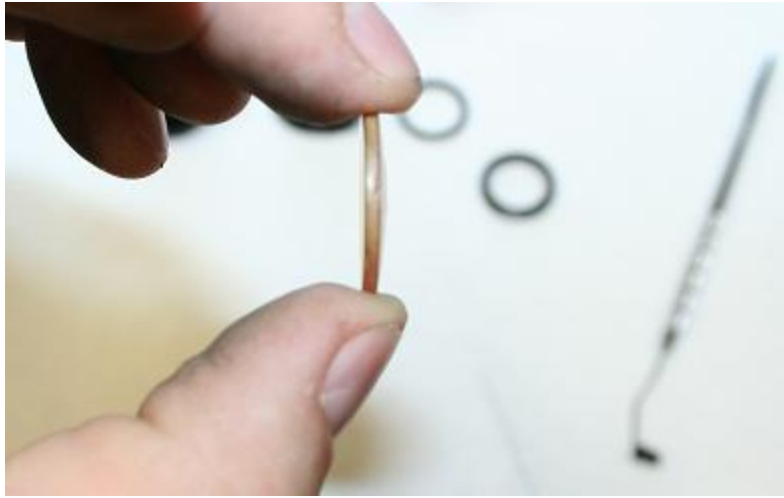
Step 32- There is a ring(Lens Nut) that holds the lens in place, this is screwed in. Being extremely careful. Hold a small flat-head screwdriver like a pencil. We don't want a small slip to make a big scratch in the lens. Loosen and remove this retention ring.



Step 33- There is a washer that absorbs abnormal pressures from cracking the lens. Remove the rubber washer. You can use a dental pick, toothpick, or needle. Again... Be careful to not scratch the lens.



Step 34- Remove the lens. Tip the focal tube upside down to dump the lens onto a soft towel. Inspect the lens for deposits and scratches. Use a fluffy q-tip and denatured alcohol for cleaning. Clean the lens by dripping the alcohol onto the lens and use the q-tip only to wipe the alcohol from puddling anywhere on the lens. Do not apply pressure or scrub in any way. Use the Q-Tip to transfer the alcohol to the lens. Make sure the lens is dry and clean.



Step35- Wipe the focal tube with a paper towel. Make sure the focal tube doesn't have any oil, water, or dirt inside it. Place the lens back in the focal tube with the curved section of the lens facing into the inside of the tube. The laser should hit the curve first, pass thru the lens, then exit the flat side of the lens.



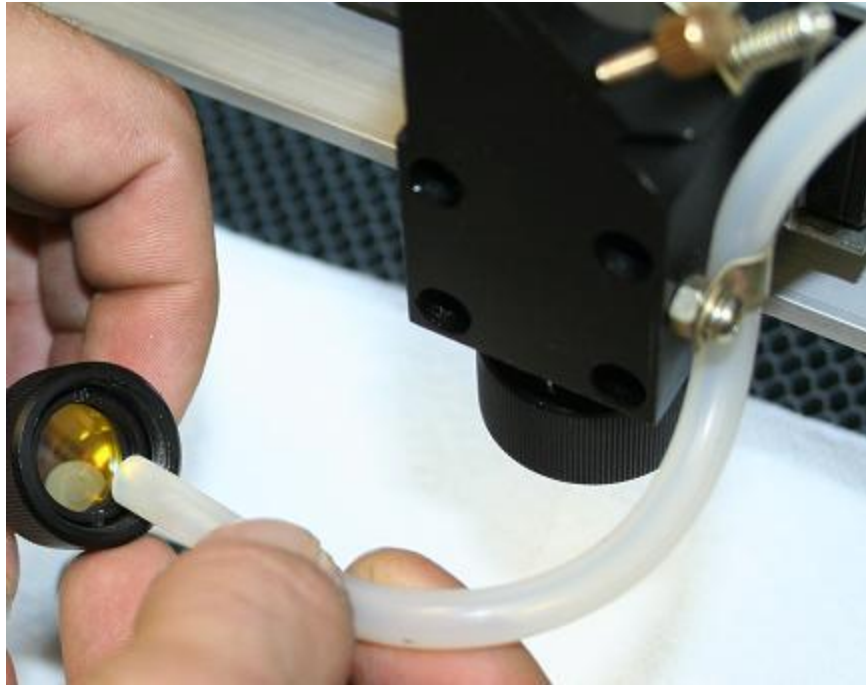
Step 36- Place the rubber washer back into the focal tube. This washer will protect the lens from too much pressure or pressure that is concentrated to one side.



Step 37- Put the retaining lens nut back and secure it in place snugly.



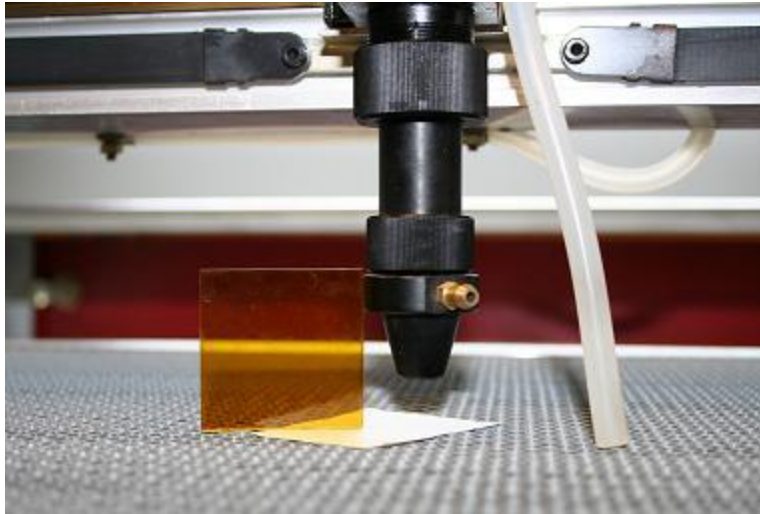
Step 38- Using the air assist, blow off any debris that may be contaminating the lens.



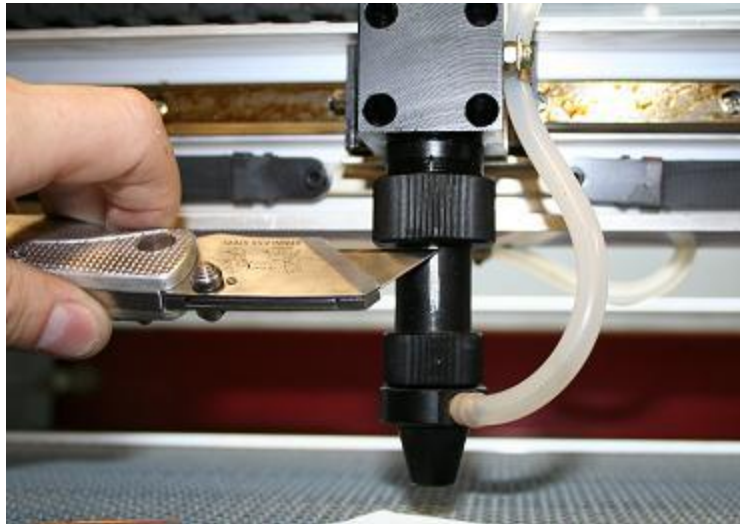
Step 39- Once the lens is clean, replace the top section of the focal tube.



Step 40- Move the Z-Axis table to the top position. Place the focal tube into the focal head far enough so that with the table at maximum height a single sheet of paper is in focus. Make sure the air assist inlet is facing the correct direction and not obstructing movement. Then tighten the knurled fitting so that the focal tube is snug. Place the air assist hose back onto the hose-barb fitting.



Step 41- Using a utility knife, mark the front of the focal tube and how deep it is placed into the focal head. This step will make cleaning your lens a faster process.



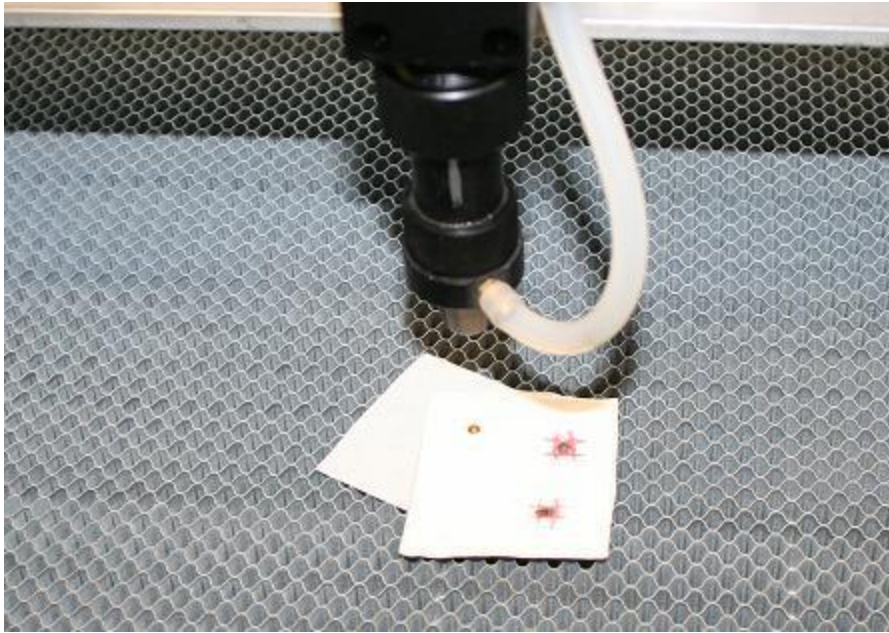
Step 42- Using the focal tool, move the table so that the machine is out of focus like shown in the picture. Place the masking tape target on the table under the focal tube.



Step 43- Tighten the set-screws on the focal head assembly until the springs are snug.



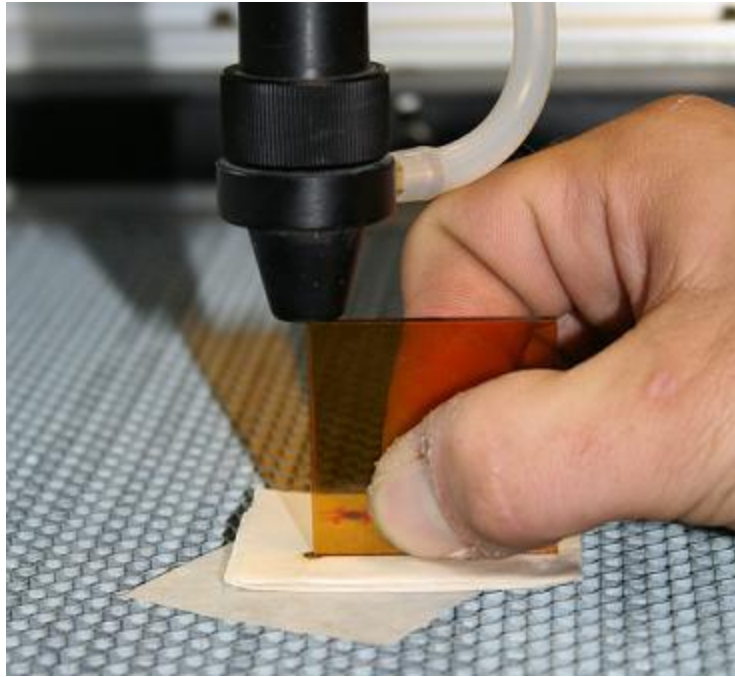
Step 44- Close the lid and press the laser button. The result should be a circular laser spot about 1/4 inch in diameter. Make sure the spot is dark and easily seen. If the laser spot is shaped like a cat-eye, then the laser may be striking the aluminum nozzle.



Step 45- Use the focus tool as a square. Check the spot to insure that it is coming out of the center of the focal tube in the y-axis plane. We remember that the laser should come into the focal head assembly center and high(step 29). The spot might be slightly to the left of center nozzle. If the mirror #3 is elevated out, then the spot will shift to the right. Do not excessively tilt the mirror. Tilting the mirror could make the laser beam strike the aluminum nozzle.

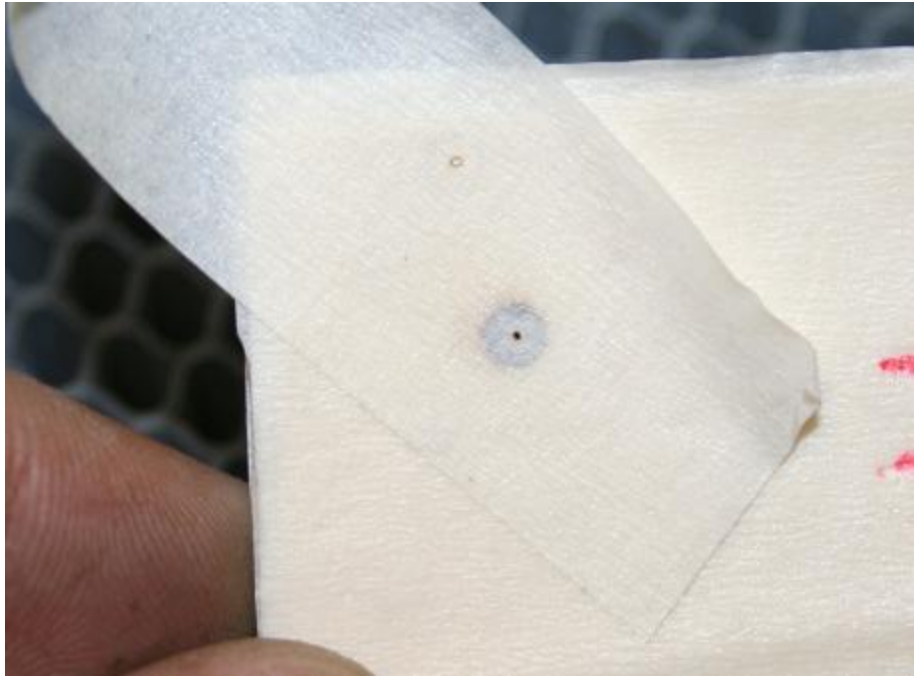


Step 46- Using the focus tool as a square, Check the spot to insure that it is coming out of the center of the focal tube in the x-axis plane.



Step 47- Bring the table up so that the masking tape target is in focus. Close the lid and press the laser button once. Check if the dot is in the center of the 1/4 spot. If the dot is high(to the rear of the machine), tighten the left and back-right screws. If the dot is low(to the front of the machine), tighten the front-right and left screws. If the dot is to the right, tighten the left screw. If the dot is to the left tighten both right screws.





Repeat the process of steps 42-47 until the results are 1/4 spot and center dot. ... Then you're done.

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