

# “Build a Laser” Kit

## Instruction Manual



Model Number:  
ML 801

INDUSTRIAL FIBER OPTICS

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# ***INTRODUCTION***

*This booklet contains instructions for building an ML801 Helium-Neon Laser using parts supplied in the kit. It is assumed that whoever is building the kit has had some experience in wiring electronic circuits and in soldering components to printed circuit boards. It is also assumed that the person building the kit has adequate tools.*

*Because the electronic power supply generates high voltages and because the concentrated light output from this low powered (typically 0.5 mW) laser can be harmful to the eyes, it is particularly important to follow instructions in the sequence described in this manual.*

*Sincerely,*

**The Industrial Fiber Optics Team**



# **TABLE OF CONTENTS**

<b>Introduction</b> .....	i
<b>LASER CLASSIFICATIONS</b> .....	iv
<b>NOTES, CAUTIONS AND WARNINGS</b> .....	1
<b>REQUIRED ITEMS</b> (not supplied with kit).....	1
<b>UNPACKING AND CHECKING PARTS</b> .....	2
<b>SOLDERING</b> .....	7
<b>ASSEMBLY INSTRUCTIONS</b> .....	8
Mounting Diodes.....	8
Mounting Resistors.....	9
Mounting Capacitors.....	10
Mounting Transformer T1.....	10
Mounting Transistor Q1.....	12
Mounting the Laser Tube on the PC Board.....	14
Connecting the Rear End Cap to the PC Board.....	15
Visual Inspection.....	16
Adjusting Laser Tube Current.....	18
Final Assembly.....	19
<b>WARRANTY</b> .....	21
<b>SHIPMENT DAMAGE CLAIMS</b> .....	21

# LASER CLASSIFICATIONS

All manufacturers of lasers used in the United States must conform to regulations administered by the Center for Devices and Radiological Health (CDRH), a branch of the U.S. Department of Health and Human Services. CDRH categorizes lasers as follows:

Class	
I	A laser or laser system, which does not present a hazard to skin or eyes for any wavelength or exposure time. Exposure varies with wavelength. For ultraviolet, .2 to .4 $\mu\text{m}$ , exposures are less than .8 to 264 nW. Visible light exposure varies from .39 to 60 $\mu\text{W}$ , and for near-IR, the exposure is < 200 $\mu\text{W}$ . Consult CDRH regulations for specific information.
II	Any visible laser with an output less than 1 mW of power. Warning label requirements – yellow caution label stating maximum output of 1 mW. Generally used as classroom lab lasers, supermarket scanners and laser pointers
IIIa	Any visible laser with an output over 1 mW of power with a maximum output of 5 mW of power. Warning label requirements – red danger label stating maximum output of 5 mW. Also used as classroom lab lasers, in holography, laser pointers, leveling instruments, measuring devices and alignment equipment.
IIIb	Any laser with an output over 5 mW of power with a maximum output of 500 mW of power and all invisible lasers with an output up to 500 mW. Warning label requirements – red danger label stating maximum output. These lasers also require a key switch for operation and a 3.5-second delay when the laser is turned on. Used in many of the same applications as the Class IIIa when more power is required.
IV	Any laser with an output over 500 mW of power. Warning label requirements – red danger label stating maximum output. These lasers are primarily used in industrial applications such as tooling, machining, cutting and welding. Most medical laser applications also require these high-powered lasers.

# NOTES, CAUTIONS AND WARNINGS

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While working through this manual, there will be several paragraphs headed NOTES, CAUTIONS and WARNINGS. Heed them carefully.

**NOTE:** Gives additional background information, hints, and suggestions for building techniques that can save time, trouble, and effort and result in a professionally built piece of equipment that will give many years of service.

**CAUTION:** Provides information that will help prevent damage to the equipment. Cautions must always be taken seriously and should never be ignored.

**WARNING:** Given whenever there is the likelihood that injury to the kit builder or others can occur. The necessity of heeding all warnings cannot be overemphasized.

## REQUIRED ITEMS (NOT SUPPLIED WITH KIT)

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All of the necessary circuit elements, connecting leads, fasteners and other assembly parts are provided with the kit. In addition, the following items should be available:

<b>Soldering iron</b>	A low-power (25 to 30 watts) soldering iron to mount circuit elements
<b>Long-nose pliers</b>	A pair of long-nose pliers to bend and dress wire leads
<b>Diagonal pliers</b>	Diagonal pliers, or a similar tool, to strip insulation and to trim leads after soldering
<b>Screwdrivers</b>	One small Phillips head and one slotted
<b>Allen wrench</b>	5/64th-inch Allen wrench

Also obtain the following items, readily available in hardware stores:

- Roll of rosin core solder (.031 inch diameter or smaller)
- Tube of clear silicone sealant or tub/shower-type caulk
- Roll of plastic electric tape
- Tube of fast-drying cement suitable for plastic, glass and metal
- Clear spray paint or conformal coating compound

**CAUTION:** Acid flux or acid core solder is corrosive and should never be used on electronic circuits. The use of acid solder voids all manufacturer's guarantees.

# UNPACKING AND CHECKING PARTS

Before attempting to assemble the kit, identify and check off each part to be sure the kit is complete.

**Table 1. Resistors.**

Symbol	Resistance (ohms)	Power (watts)	Color Band on Resistor (see note below)	Part #
R1	22 k	2.	red, red, orange	15-15001
R2	22 k	2.	red, red, orange	15-15001
R3	4.7 M	0.5	yellow, purple, green	13-13553
R4	4.7 M	0.5	yellow, purple, green	13-13553
R5	15 k	1	brown, green, orange	14-14507
R6	1.0 M	0.5	brown, black, green	13-13533
R7	22 k	2	red, red, orange	15-15001
R8	22 ohms	0.5	red, red, black	13-13542
R9	560 ohms	0.5	green, blue, brown	13-13537
R10	100 k	0.5	brown, black, yellow	13-13552
R12	10 ohms	1	brown, black, black	14-14513
R13	30 ohms	0.5	orange, blue, black	61 0506
R14	2.2 M	0.5	red, red, green	13-13558

**NOTE:** Gold-banded resistors are +/- 5% tolerance  
Silver-banded resistors are +/- 10% tolerance

**Table 2. Capacitors.**

Symbol	Capacitance	Type / Markings	Volts	Part #
C1	100 pF	Disc/101	3 kV	21-21047
C2	100 pF	Disc/101	3 kV	21-21047
C3	100 pF	Disc/101	3 kV	21-21047
C4	100 pF	Disc/101	3 kV	21-21047
C5	100 pF	Disc/101	3 kV	21-21047
C6	.01 $\mu$ F	Disc/103M	3 kV	21-21005
C7	.01 $\mu$ F	Disc/103M	3 kV	21-21005
C8	.01 $\mu$ F	Disc/103M	3 kV	21-21005
C9	100 pF	Disc/101	3 kV	21-21047
C10	.001 $\mu$ F	Disc/102M	3 kV	21-21138
C11	.1 $\mu$ F	Mylar/100 V, 104K	100 V	22-22030
C12	.001 $\mu$ F	Disc/102K	1 kV	64 0031
C13	47 $\mu$ F	Electrolytic	250 V	20-20037

**Table 3. Diodes.**

Symbol	Type	Comments	Part #
D1-D6	R4000F	Printed on each of these six diodes is a band that indicates the negative (-) end.	71 0130
D7, D8	XG6 or SL800	Similar to the R4000F above, but larger.	23-23030
D9	1N5223B	Tiny diode with numbers 5223B printed on it. The band indicates negative (-) end.	23-23018
D10- D13	1N4007	The band around one end indicates negative (-) end.	71 0016

**Table 4. Transistors.**

Symbol	Type	Comments	Part #
Q1	TIP 50	Terminal at the center is the Collector. Metal tab mount.	71 0140

**Table 5. Transformer.**

Symbol	Type	Comments	Part #
T1	2.0 mW 115 V	The terminal closest to the groove in the base is Terminal No. 1.	40-40023

**Table 6. Laser tube.**

Symbol	Type	Comments	Part #
LT1	0.5 mW output	Hard seal, HeNe, cathode emitting with attached pre-aligned end mirrors.	76 0167

**Table 7. Miscellaneous parts.**

Type	Comments	Part #
Laser Case	Cast aluminum, 2.7 x 2.7 x 9.25 inches. Threaded tripod mount at bottom.	42 0205
Laser Cradle	Two strips of black plastic each about 1 inch long. Mounts laser tube on circuit board.	41 0250
Cushion Tape	Two lengths of ¼-inch x 9.25-inch rubber. Used to cushion bottom of laser case.	00-00155
Front End Cap Assembly	Aluminum plate with shutter mounted in a threaded aperture.	44-44293
Printed Circuit Board	Glass epoxy. Laser tube and resistor R1 mount on foil side and all other parts mount on the reverse side.	43 0216
End Cap Screws	Eight black screws 4-40 x ½-inch. Secure end caps to laser case.	22 0023
Stay Wraps	Two plastic strips. Hold laser tube on PC board.	35 0121
Cathode Lead	One 2-inch black wire.	55 0050
Anode Lead	One 6-inch red wire.	55 0051
Insulators	1.5 inch x 2 inch Kapton® insulating tape (two pieces) taped to the PC board. Remove and store on a clean surface before beginning construction of the PC board.	14 0115

**Table 8. Heat Sink Subassembly.**  
(Refer to Figure 3.)

Type	Comments	Part #
Micro Jack	A small metal socket for connecting to the laser tube cathode.	51 0131
Screw	4-40 x ½-inch mounts transistor on heat sink.	22 0025
Washer	White alumina. Provides heat conduction and electrical isolation for transistor tab.	23 0060
Washer	Nylon shoulder washer.	23 0040
Nut	No. 4 hexagonal nut.	21 0015
Screw	6-32 x ¼-inch Phillips head pan screw.	22 0110
Screw	6-32 x ¼-inch Phillips flat head screw.	22 0024
Washer	No. 6 internal tooth.	23 0032
Thermal Compound	White paste packed in foil.	32 0300
Rear End Assembly	Plug-in assembly. Contains switch, pilot lamp, fuse and line cord. Its 4-inch leads are soldered directly to the PC board.	44-44103
Fuse (replacement part)	¾ Amp fuse.	00-00484
Instruction Manual 45-801	Complete instructions for building Laser ML801.	12 0113
Operator's Manual	Hard-Seal Helium-Neon Laser Installation and User's Guide.	12 0098

# SOLDERING

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Although it is assumed that those building this laser kit have experience in wiring and soldering, a few reminders of good soldering techniques may be helpful.

- Use a low-power (25 to 30 watts) soldering iron to mount circuit elements. Excessive heat can damage the printed circuit board and components. Never use a soldering gun to mount solid-state diodes or transistors. The electromagnetic field surrounding the tip can permanently damage these sensitive components.
- Use a spool of very thin (.031 inch diameter or smaller) rosin-core solder. Solders with acid cores or those requiring acid flux are corrosive and should never be used for electric circuits.
- Check to make sure that the tip of your soldering iron is clean. If necessary, remove any corrosion from the tip with emery cloth or steel wool. Then make the tip shiny by applying a drop of melted solder and wiping off the excess with a damp rag or sponge.
- Insert leads of a resistor or other component in the specified holes of the circuit board. Before soldering, check that the leads are in the correct holes with the component close to, but not touching, the circuit board.

When the soldering iron is hot, hold its tip against the circuit board foil and component leads to be soldered. Apply solder to the connection until the solder melts. Melt the solder with the hot component lead and foil – not the soldering iron. Carefully remove the soldering iron and with the parts motionless for a few seconds, allow the solder to cool and solidify. A good solder joint is clean, smooth, shiny and round. When soldering many connections, keep the tip of the soldering iron shiny by periodically applying solder directly to it, then wiping off the excess.

- Special care is needed to prevent overheating diodes and transistors. Before applying the soldering iron to one of the leads, grasp the lead near the base of the component with a pair of needle nose pliers. Hold the pliers firmly on the lead while the connection is being heated with the soldering iron. The pliers act as a heat sink, preventing heat conduction into the body of the diode or transistor.
- Never apply more solder than absolutely necessary to join the connection parts. Large gobs of solder can form solder bridges between conductors on the circuit board and cause short circuits when power is applied.

# ASSEMBLY INSTRUCTIONS

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The electronic components of the laser, including the laser tube, must all be mounted on printed circuit board PC1. Although the board is very handy when building, testing and troubleshooting the laser, always be aware of the hazards of operating an electrical circuit without its protective case securely mounted in place. Exposed terminals on the rear end cap carry 110 volts from the AC power cord, but up to 12,000 volts could be encountered on the printed circuit board and at the terminals of the laser tube. Also, when the laser is operating, ultraviolet light is emitted from the sides of the laser tube, and a coherent laser beam radiates from both ends.

**WARNING:** Accidents can be prevented by following the advice of professionals: Never apply power until all connections have been double checked and that it is certain that the laser is pointed away from the eyes of anyone in the vicinity or from reflecting objects. Resist the urge to apply power and try the laser before the entire circuit has been completely wired and adequate safety precautions have been taken.

## Mounting Diodes

Follow the instructions below to mount the 13 diodes (D1 through D13) on the printed circuit board. Refer to the printed circuit assembly diagram (Figure 1) for their correct positions.

1. With a pair of pliers, make a smooth right-angle bend in each lead of the diode so the diodes will fit exactly between the appropriate sets of pre-punched holes on the circuit board.
2. Insert the leads of each diode into the printed circuit board making sure that the body of each diode is as close as possible to the board and that the negative (-) end of the diode is facing the correct direction. If any of the diodes are mounted backwards, the laser will not operate, and further damage can result in the electronic circuit.
3. Make certain that each diode is on the circuit board and facing the correct direction. Then apply a small amount of rosin-core solder at the base of each lead on the foil side of the board.

**CAUTION:** Diodes are heat sensitive. Never use a large or high-wattage soldering iron or apply heat longer than necessary to melt the solder and fuse the leads to the printed circuit board.

4. Using a pair of diagonal cutting pliers, snip off the excess lengths of diode leads as close as possible to the printed circuit board and discard them.

*This completes mounting the diodes.*

## Mounting Resistors

There are 12 resistors to be mounted on the printed circuit board. R1 is mounted to the laser tube and will be installed later. Follow the instructions below and refer to Figure 1 for placement locations.

**NOTE:** Unlike diodes, the direction that a resistor faces in a circuit is unimportant. As long as a resistor is in the correct holes of the circuit board, it will function correctly.

1. With a pair of pliers, make smooth, right-angle bends in the resistor leads of R2–R10 and R14, so the resistors will fit exactly between the appropriate sets of holes on the circuit board.
2. Insert the leads of resistors R2, R5 and R7 in the designated holes at the left side of the board. Because these resistors become hot when the circuit is operating, the body of each of them should not be mounted too close to the circuit board. Hold each resistor about a quarter to a half inch above the circuit board and make sure the leads are in the correct holes. Then apply a small amount of solder to the resistor leads on the foil side of the circuit board.
3. Insert the leads of resistors R3–R4, R6, R8–R10, R13–R14 in the designated holes of the circuit board. Make sure the bodies of these resistors are as close as possible to the circuit board. Apply solder at the foil side of the board.
4. R12 is mounted on the PC board standing up instead of lying down like the other resistors. Insert one of the leads of resistor R12 into the designated hole near the lower right corner of the PC board and push it all the way into the hole until the end of the resistor body touches the board. Holding it in this position, apply a small amount of solder to the resistor lead on the foil side of the board. When the solder has cooled, bend the other lead down, insert it into its designated hole at the lower right corner of the board and solder it in place.
5. Using a pair of diagonal cutting pliers, snip off the excess lengths of resistor leads and discard them.

*At this point all of the diodes and resistors that are on the circuit board have been mounted.*

## Mounting Capacitors

Refer to the assembly diagram (Figure 1) and the instructions below to mount the 13 capacitors on the printed circuit board.

**WARNING:** Capacitor C13 is an electrolytic filter capacitor. If it is mounted backwards with the leads reversed, the capacitor and other electronic components will be permanently damaged when power is applied. When capacitor C13 leads are all the way in the correct holes, press the body of the capacitor against the board, apply a small amount of solder to the leads at the foil side and snip off excess lead lengths.

1. Place the leads of capacitor C13 in the designated holes of the printed circuit board making sure that the negative (-) end points toward the top of the board and the positive (+) end is down. If there are no + or – signs on the capacitor, look for arrows running along its length. The arrow points to the negative (-) end.
2. Mount capacitors C1 through C12 in the designated holes of the PC board. Because these capacitors are not polarized, it is not important that they face any particular direction, and the leads may be reversed without harm. Each of these capacitors should be held as close as possible to the printed circuit board. Apply small amounts of solder to the leads at the foil side of the board. Snip off excess lead lengths.

*At this point all of the capacitors, diodes and resistors have been mounted.*

## Mounting Transformer T1

Refer to Figure 1 and follow the instructions below to mount transformer T1 on the printed circuit board.

1. Hold transformer T1 so the base is down and the groove at the base (which identifies terminal 1) is at the lower right.
2. Insert the transformer in the printed circuit board so that all 12 terminals at the transformer base are firmly seated in the corresponding holes of the board.
3. Apply a small amount of solder to each of the transformer terminals at the foil side of the board.

**NOTE:** When soldering the terminals, be especially careful to avoid solder bridges between adjacent terminals. These can short out electronic circuits when power is applied.

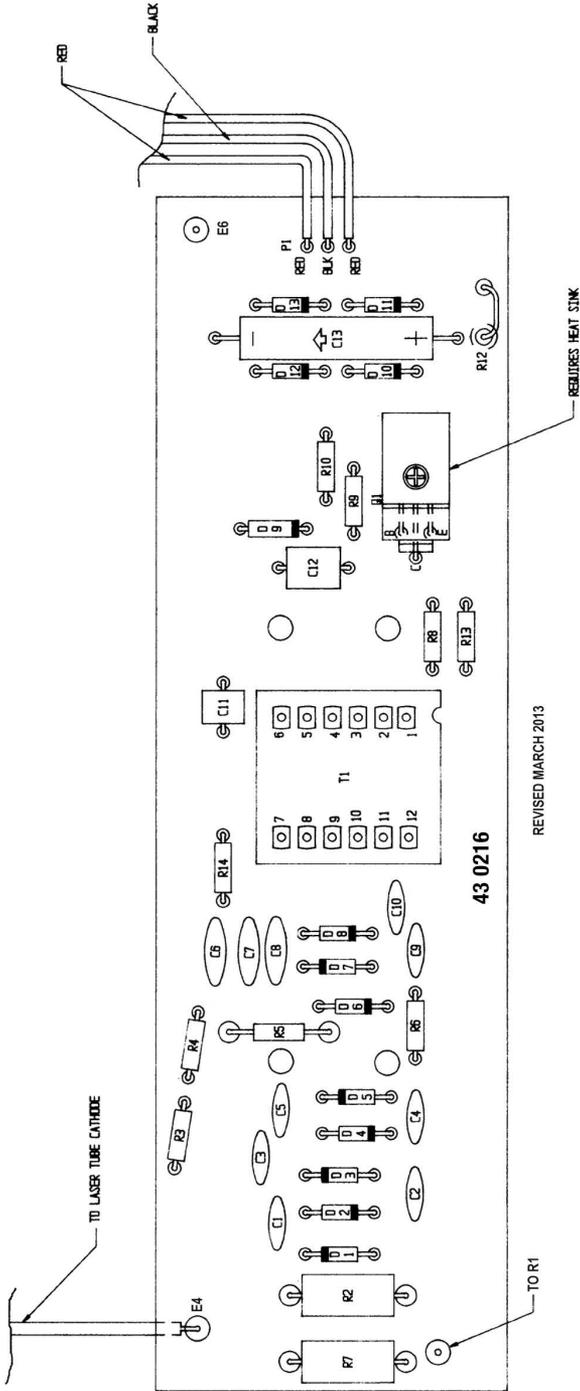


Figure 1. Printed circuit board assembly diagram.

# Mounting Transistor Q1

Transistor Q1 is perhaps the most challenging component to mount on the printed circuit board. This is because it must not only be mounted in the correct location but additional heat sinking precautions also must be taken to avoid premature failure of this sensitive part. Refer to the exploded view of transistor Q1 and its heat sink mounting components in Figure 2.

1. Hold transistor Q1 so its metal mounting tab is facing the aluminum heat sink as shown in Figure 2.
2. Mount the transistor to the heat sink with a screw and alumina washer as shown in Figure 2. Use approximately one-half of the heat sink compound supplied, liberally coating both sides of the washer. The remaining heat sink compound will be used in a later step. The shoulder washer and nut go on the other side of the heat sink, with the “neck” of the washer fitting into the hole in the heat sink. Tighten the nut firmly to get tight surface contact between the transistor, alumina washer and heat sink.

**NOTE:** Because the metal tab on the transistor is internally connected to the emitter, it must be electrically isolated from the heat sink. The alumina washer provides both electric isolation and heat conduction.

3. Bend the transistor terminals so they fit into the three designated holes in the PC board.
4. Secure the aluminum heat sink to the board with a No. 6 pan head screw and lock washer. (Before beginning this step, read the note below.)

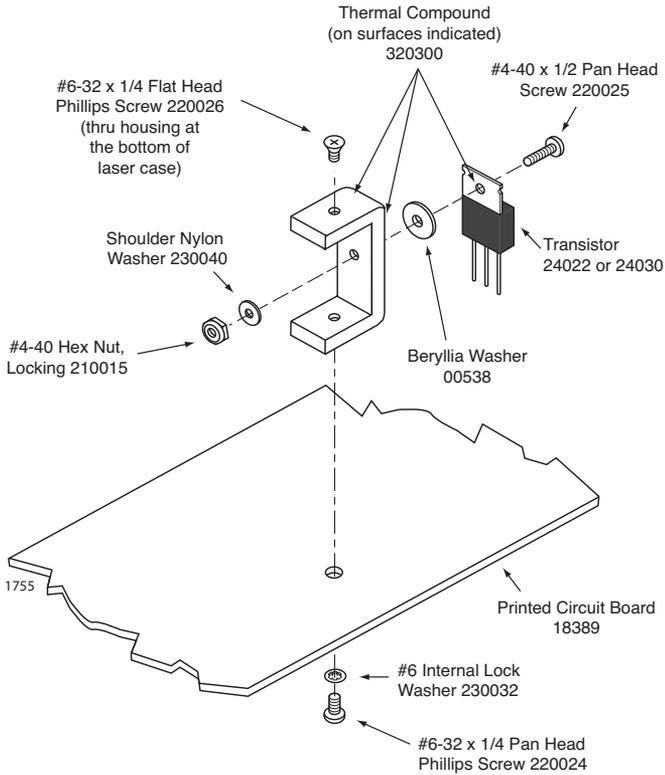
**NOTE:** When tightening the pan head screw at the bottom of the heat sink, hold the aluminum U-block steady so it does not twist and break the leads of the transistor. It is imperative that the bottom of the aluminum U-block contacts the PC board.

**CAUTION:** Failure to make a tight connection or failure to use heat sink compound is likely to result in extensive damage to the transistor and several nearby diodes.

5. Apply a small amount of solder to the transistor leads on the foil side of the PC board.
6. Check to be sure that everything is sufficiently tight to provide heat sinking action when the circuit is operated.
7. Using a pair of diagonal cutting pliers, snip off the excess lengths of the transistor leads as close as possible to the printed circuit board and discard them.

**NOTE:** At this point we recommend an optional procedure to increase the laser longevity. Spray two or three thin coats of clear paint, or lacquer or a conformal coating compound on both sides of the PC board from the transformer to the high voltage output end.

*This completes the mounting of all components on the printed circuit board except the laser tube.*



**Figure 2 Heat sink assembly.**

## Mounting the Laser Tube on the PC Board

Laser tube LT-1 and resistor R1 are the only components mounted on the foil side of the circuit board. Follow the instructions below and refer to Figure 3.

1. With the foil side up, cement the flat side of a laser cradle to the PC board between the holes located between diodes D5 and D6 using a thin coat of fast-drying cement.

**NOTE:** The laser cradles provide the right amount of elevation for aligning the laser tube with the openings in the outer case. Check to be sure that there are no foreign materials or globs of solder on the foil side of the PC board near the laser cradles.

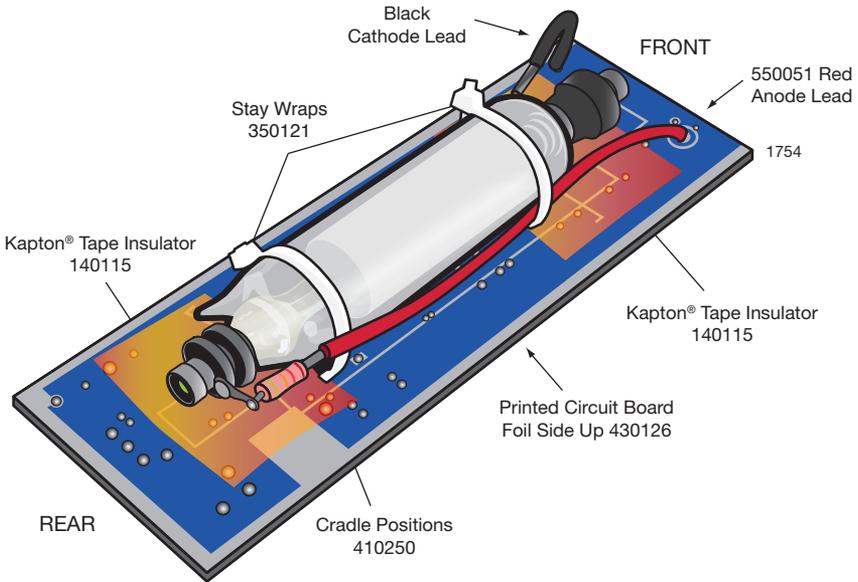
2. Cement the flat side of the second laser cradle to the foil side of the PC board between the holes near transformer T1 and capacitor C12.
3. Carefully lay the laser tube on the cradles and position the two pieces of Kapton® tape on the PC board, directly under the anode and cathode of the tube. Make sure one edge of the tape is pressed up against each of the cradles. Slit the tape near the hole labelled R1. Remove the tube and apply pressure to the tape to securely adhere it to the board.
4. With the printed circuit board foil side up, insert the pointed end of a plastic stay wrap through one of the large holes between diodes D5 and D6. The corrugated side of the stay wrap must face the middle of the PC board and the smooth side must be closest to the edge of the board. Now thread it back through the other hole as shown in Figure 3.
5. Repeat the procedure in step 4 above and insert a second stay wrap through the holes between transformer T1 and capacitor C12.
6. Carefully place the laser tube on the circuit board in the position shown in Figure 3. The cathode end of the tube has the aluminum shield inside the glass envelope.

**CAUTION:** Be very careful when handling the laser tube. It is fragile and the pre-aligned end mirrors can be damaged by dust or fingerprints. The tube can also be damaged by even very slight bumps.

7. Pass the pointed end of the anode end stay wrap through its end lock as shown in Figure 3. Draw the stay wrap tightly against the laser tube and snip off the wrap's protruding end.
8. Solder one end of the black 2 inch cathode wire to the closed end of the microjack. Solder the other end of the wire to the hole in the ground plane as shown in Figure 3. Push the microjack onto the wire on the cathode end of the laser tube.

9. Trim the excess lead length off the free ends of R1, leaving  $\frac{1}{4}$ " of lead. Solder one end of the red, 6 inch anode wire to one end of R1. Solder the other end of R1 to the laser tube anode solder tab. Before soldering the other end of the wire, measure the length required to reach the PWB. Trim off any excess length of wire and discard. Solder this end of the wire to PWB.
10. Pass the pointed end of the cathode end stay wrap through its end lock going over the anode wire as shown in figure 3. Draw the stay wrap tightly against the tube and snip off the wrap's protruding end.

*This completes a temporary mounting of the laser tube on the PC board.*



**Figure 3. Laser tube mounting diagram.**

## Connecting the Rear End Cap to the PC Board

Solder the three leads to the three holes designated P1. Solder the black wire into the hole labeled BLK and the two red wires into the holes labeled RED. The red wires are not polarized, either one can be soldered into either of the RED holes.

*This completes all the laser's electrical connections.*

## Visual Inspection

Before the laser is mounted in its outer case, make a thorough check of the laser's electrical components as follows:

**CAUTION:** Do not connect power to the laser until all of the preliminary checks are made and specific instructions are given to do so. Premature application of power can cause extensive damage.

1. Check that diodes, resistors, capacitors and other electrical parts are mounted in the correct positions of the printed circuit board. Refer to both the assembly diagram (Figure 1) and the schematic diagram (Figure 4) while checking each part.
2. Wiggle each of the electrical components methodically while watching the printed circuit board for any movement that could indicate solder failure or a cold solder joint. If available, check each joint with a magnifying glass or eye loupe.
3. Scan the foil side of the printed circuit board for any solder bridges between circuits that will cause shorts.
4. Search for and remove any deposits of solder around the outer edge of the printed circuit board that might interfere with sliding the board into the outer case of the laser.
5. Inspect the mounting of the transistor and its heat sink to be sure all of the mechanical connections are tight and there is a liberal amount of heat sink compound on both sides of the alumina washer.
6. Make sure that the stay wraps on the laser tube are tight and the anode/cathode pin connectors are secure on the laser tube terminals.
7. Open the fuse holder at the rear end cap to be sure that the correct fuse (type 3AG,  $\frac{3}{4}$  ampere) is inside.
8. Move the power switch on the rear end cap to the OFF position.
9. Place some books or boxes on the table at the ends of the laser tube to act as beam stops when the laser is in operation.
10. Insert the plug into a 3-conductor GROUNDED wall outlet, 105-120 volts AC, 60 Hz.

**WARNING:** If the plug is inserted in an ungrounded outlet, dangerous voltages could appear on the laser case.

11. Move the power switch on the rear end cap to the ON position. The pilot light in the rear end cap should go on. The inside of the laser tube should glow orange-red. A strong laser beam should come out of the front end of the laser tube and a weaker beam should come out of the opposite end.



## Adjusting Laser Tube Current

For optimal operation, the laser tube current should be between 3.25 and 3.75 milliamperes. Most lasers will operate properly with the correct tube current when assembled according to the instructions provided above. However, because small differences exist in the electrical characteristics of individual laser tubes, there is a small possibility that the tube current in your laser will not fall within these specified limits. If the tube current is much too low, the laser will produce pulsating bursts of light rather than a steady beam. If the current is too high, the life of the tube may be shortened. To adjust the tube current, proceed as follows:

**NOTE:** The laser tube current will slowly increase as the circuit warms up. It will stabilize within 10 minutes.

1. Remove all power from the laser and move the switch on the rear end cap to OFF.
2. Slip off the black lead connected to the cathode terminal of the laser tube.
3. Connect the negative (-) milliammeter lead to the black cathode wire and the positive (+) milliammeter lead to the cathode terminal of the laser tube.

**WARNING:** High voltage appears at the laser tube terminals when it is operating. Do not touch the milliammeter, the laser tube, or the printed circuit board while the laser is plugged into a wall socket.

4. Make sure the apparatus is positioned so that the meter can be observed without touching it; insert the plug into a wall socket and turn the power switch ON.
5. If the milliammeter indicates between 3.25 and 3.75 mA, skip the rest of this procedure. The beam current is within specified limits and no adjustment is necessary. In this case, turn off the power, remove the ammeter and reconnect the black lead to the laser tube.
6. If the milliammeter indicated LESS THAN 3.25 mA, disconnect the power, unsolder resistor R13 from the printed circuit board and replace it with a 27-ohm resistor. Reapply power. If the milliammeter still indicates less than 3.25 mA, try replacing resistor R13 with a 24 or 22-ohm resistor. Always remember to remove power before touching the laser or the meter.
7. If the milliammeter indicates MORE THAN 3.75 mA, replace resistor R13 with a 36-ohm, 39-ohm, 43-ohm or 47-ohm resistor in turn until tube current falls within the 3.25 to 3.75 mA range.

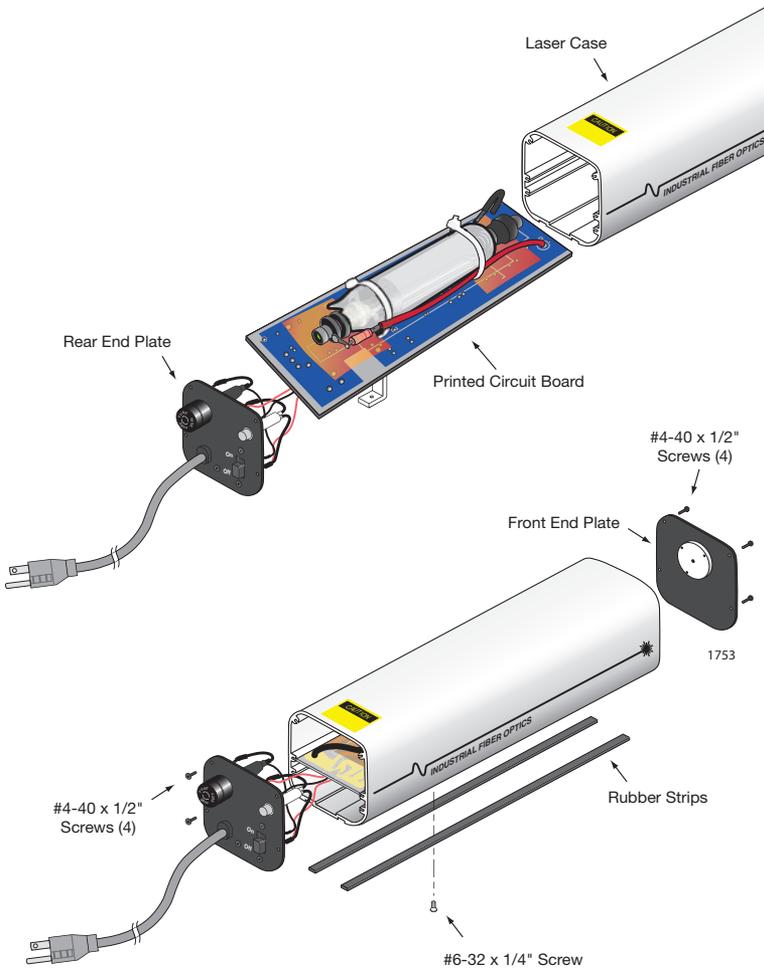
**WARNING:** Remember to remove power whenever touching the laser or the meter.

8. Once the tube current has been checked and adjusted, turn off the power, remove the meter and reconnect the black cathode lead to the laser tube terminal.

*This completes the laser tube current adjustment.*

## Final Assembly

Final assembly consists of placing all electronic parts inside the laser case and aligning the laser beam so it emerges from the aperture in the front end plate. During this phase, operating the laser with charged electronic components partially exposed will be necessary, so again be very careful when proceeding.



**Figure 5. Inserting laser in case.**

1. With power disconnected, slide the printed circuit board into the laser case as shown in Figure 5, until the threaded hole in the heat sink is aligned with the hole in the bottom of the case.
2. With the laser aimed so it cannot strike any reflecting objects or the eyes of anyone in the vicinity, connect power and turn the laser on. The pilot lamp should light and a strong beam should come out of the front of the laser. A much weaker beam might emerge from the rear.
3. Disconnect the power and mount the front end cap using four of the 4-40 x ¼ inch screws. Point the laser at a wall, or other dull, non-reflective surface and reapply power. Vary the position of the aperture until you see the laser beam “spot” on the surface. When the spot is a perfect circle, without any streaks or fringes surrounding it, it is passing cleanly through the aperture.

**WARNING:** Do not look into the aperture to see the laser beam. Observe only the laser spot on the surface.

4. It may be necessary to remove the front end cap and use a non-metallic object such as a comb or a piece of wood to push the laser tube to a central position inside the case to help line up the beam and the aperture.

**WARNING:** There are high voltages at the laser terminals, and the metallic ends of the laser tube are also charged. Do not use your fingers or any conducting object for aligning the laser beam.

If you experience difficulty in getting the beam aligned with the front end plate, check for any irregularities or gobs of solder under the laser cradles that might be tilting the laser tube. If any are found, the power should be disconnected and the obstructions carefully removed.

Once the aperture and tube have been properly aligned, tighten the three screws securing the aperture to the front end cap with a 5/64 inch allen wrench.

Shut off the power. Slide the printed circuit board out of the laser case being very careful not to misalign the laser tube. Squeeze out a liberal quantity of clear silicone sealant or tub/shower caulk and apply it between the sides of the laser tube and the PC board near each laser cradle. Do not disturb the laser until the cement has cured.

5. When the cement is firm, slide the PC board back into its laser case. Make sure that there is a liberal amount of heat sink compound at the place where the heat sink contacts the laser case.
6. Insert the 6-32 x ¼ inch screw through the bottom of the laser case into the threaded hole of the aluminum heat sink block.
7. Mount the rear end cap with the other four 4-40 x ½ inch screws.
8. Apply foam tape to the grooves on the underside of the case.

*This completes assembly and alignment of the entire laser.*

# WARRANTY INFORMATION

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This kit was carefully inspected before leaving the factory. If any components were damaged in shipping, Industrial Fiber Optics will repair or replace them at its discretion. Since soldering and incorrect assembly can damage electrical components, no warranty can be made after assembly has begun. If any electrical parts become damaged, replacements may be obtained from most radio/electronics supply shops or from Industrial Fiber Optics. Refer to the parts lists of this manual for part numbers.

Industrial Fiber Optics recognizes that responsible service to our customers is the basis of our continued operation. We welcome and solicit your feedback about our products and how they might be modified to best suit your needs.

# SHIPMENT DAMAGE CLAIMS

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If damage to an Industrial Fiber Optics product should occur during shipping, it is imperative that it be reported immediately, both to the carrier and the distributor or salesperson from whom the item was purchased. **DO NOT CONTACT INDUSTRIAL FIBER OPTICS.**

Time is of the essence because damage claims submitted more than five days after delivery may not be honored. If shipping damage has occurred during shipment, please do the following:

- Make a note of the carrier company; the name of the carrier employee; the date, and the time of the delivery.
- Keep all packing material.
- In writing, describe the nature of damage to the product.
- Notify the carrier immediately of any damaged product.
- Notify the distributor from whom the purchase was made.

# *Rules for Laser Safety*

- Lasers produce a very intense beam of light. Treat them with respect. Most educational lasers have an output of less than 3 milliwatts, and will not harm the skin.
- Never look into the laser aperture while the laser is turned on! PERMANENT EYE DAMAGE COULD RESULT.
- Never stare into the oncoming beam. Never use magnifiers (such as binoculars or telescopes) to look at the beam as it travels – or when it strikes a surface.
- Never point a laser at anyone's eyes or face, no matter how far away they are.
- When using a laser in the classroom or laboratory, always use a beam stop, or project the beam to areas, which people won't enter or pass through.
- Never leave a laser unattended while it is turned on – and always unplug it when it's not actually being used.
- Remove all shiny objects from the area in which you will be working. This includes rings, watches, metal bands, tools, and glass. Reflections from the beam can be nearly as intense as the beam itself.