

## 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.
- Never disassemble or try to adjust the laser's internal components. Electric shock could result.

## ***ML 801 “Build a Laser” Kit***

### **Instruction Manual**

**Model Number:  
ML 801**

**INDUSTRIAL FIBER OPTICS**

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Rev. E

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The structure of this manual and its content are based on a previous edition were written by Herbert H. Gottlieb for Metrologic Inc. Much of the content has been rewritten for Industrial Fiber Optics to reflect several upgrades and redesigns. But the sequence and form of the assembly instructions have been maintained to provide continuity for teachers and instructors already using Metrologic's ML801 "Build a Laser" Kit (now supplied by Industrial Fiber Optics) in their curriculums.

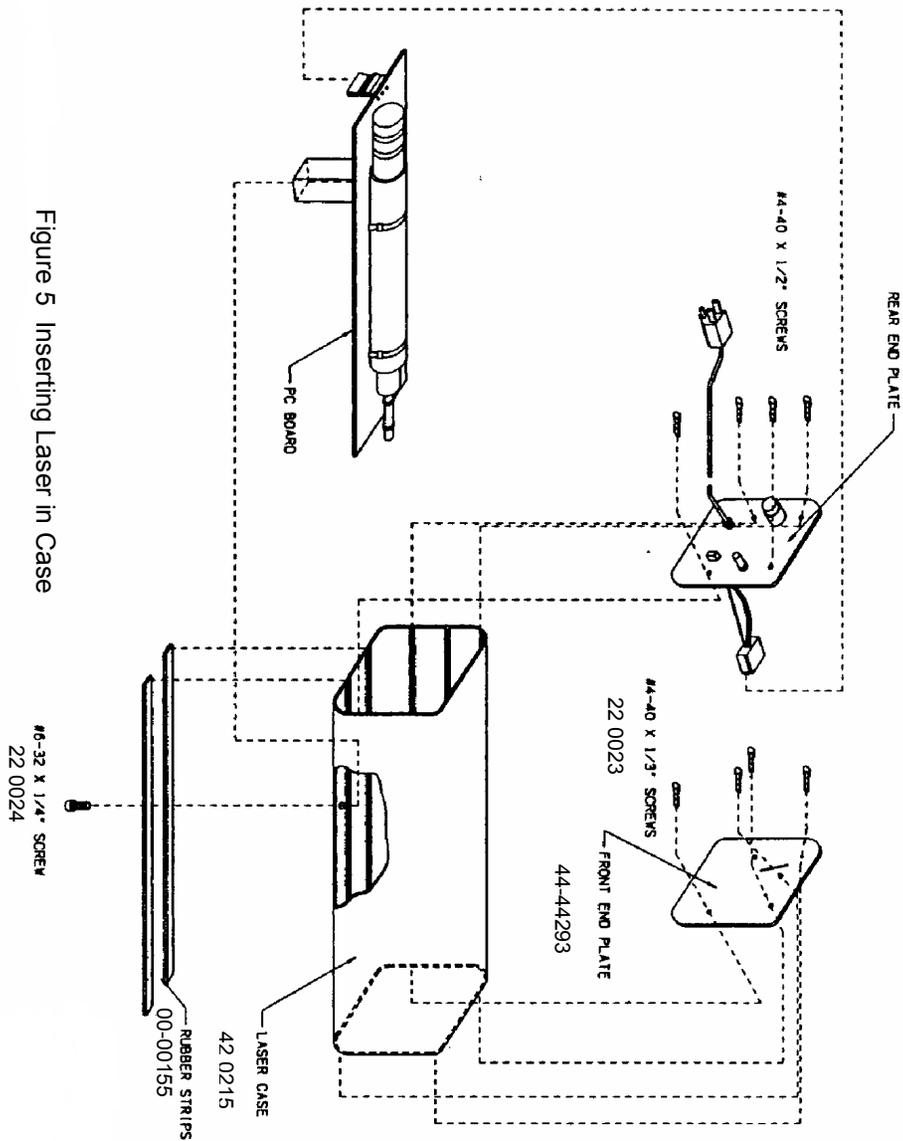


Figure 5 Inserting Laser in Case

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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, following instructions in the sequence given in this manual is especially important.

## Notes, Cautions, and Warnings

While working through this manual, there will be several paragraphs headed NOTES, CAUTIONS and WARNINGS. Do not ignore them!

**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.

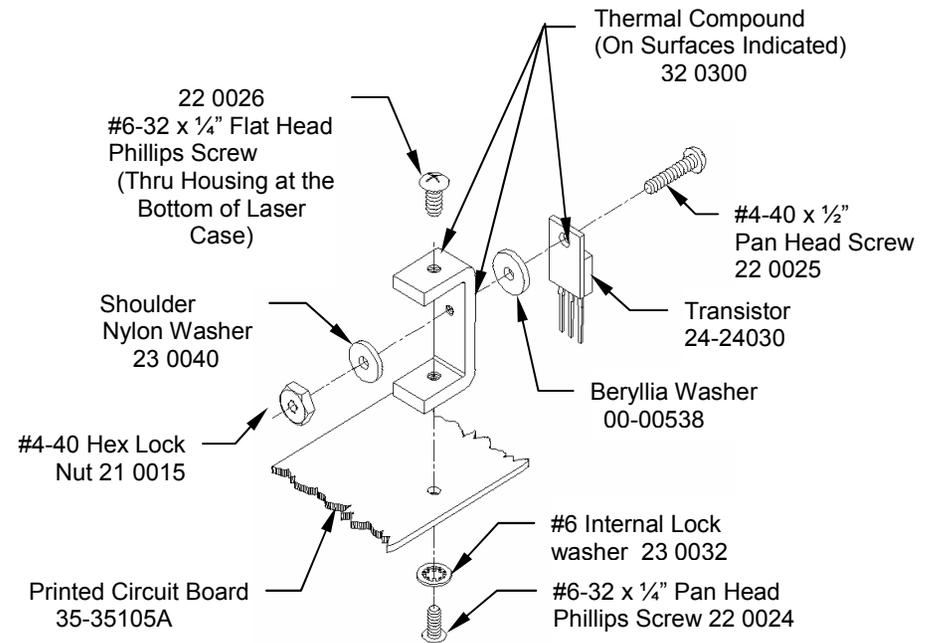


Figure 3 Heat Sink Assembly

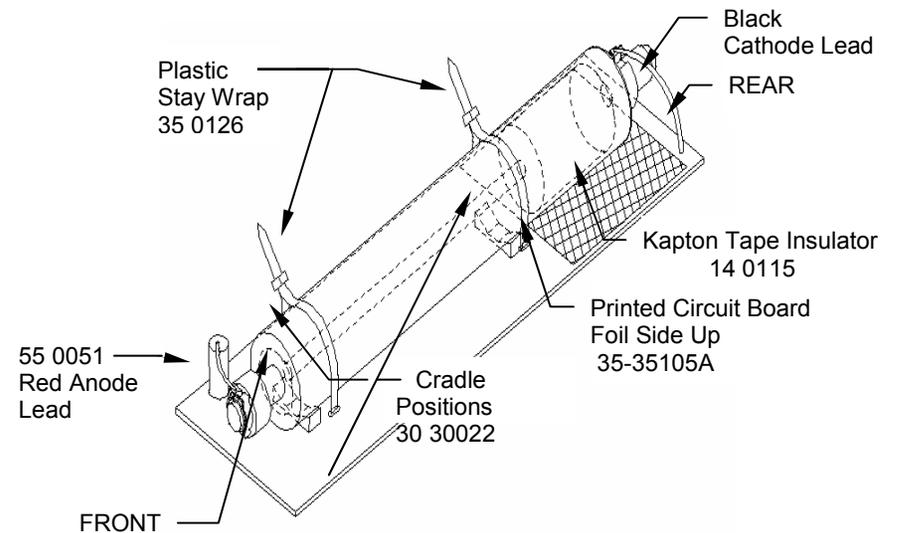
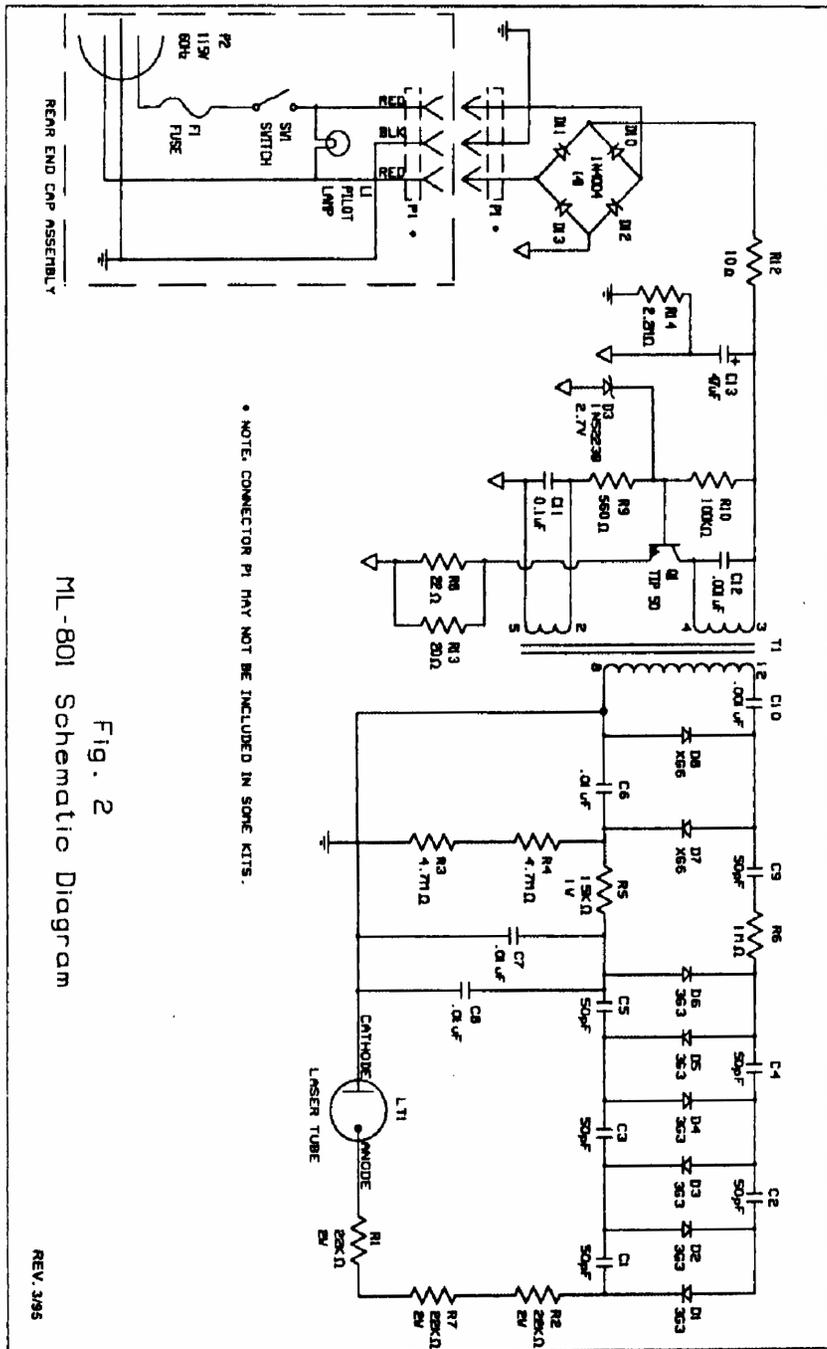


Figure 4 Laser Tube Mounting Diagram



## Required Items Not Supplied with Kit

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.

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

Also, the following items, which are readily available in local hardware stores.

- Roll of rosin core solder (.031 inch diameter or smaller)
- Tube of Dow Corning Clear Sealant (or bathtub caulking)
- A roll of plastic electric tape
- A tube of DUCO (or similar fast drying cement)
- Spray point, Krylon crystal clear, No. 1302

**Caution:** Acid flux or acid core solder is corrosive and should never be used for electronic circuits. The use of acid solder voids all guarantees provided by the manufacturer.

## Unpacking and Checking Parts

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

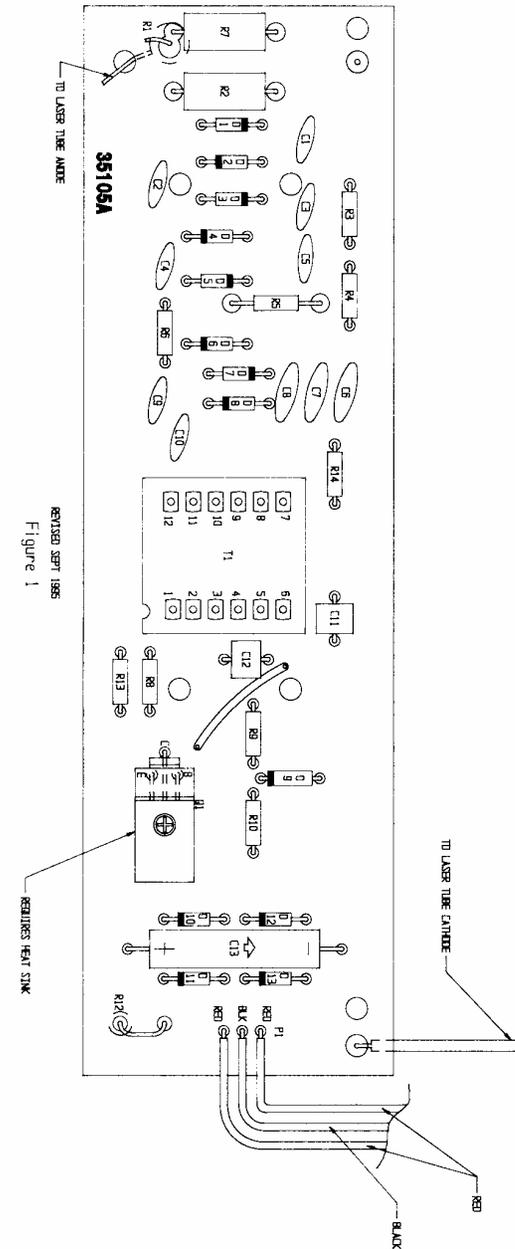
### Resistors

Symbol	Resistance (ohms)	Power (watt)	Color bands on Resistor (see note below)	Part #	Replace Cost
R1	22 k	2.	red, red, orange	15-15001	\$ .50
R2	22 k	2.	red, red, orange	15-15001	\$ .50
R3	4.7 M	0.5	yellow, purple, green	13-13553	\$ .30
R4	4.7 M	0.5	yellow, purple, green	13-13553	\$ .30
R5	15 k	1	brown, green, orange	14-14507	\$ .35
R6	1.0 M	0.5	brown, black, green	13-13533	\$ .20
R7	22 k	2	red, red, orange	15-15001	\$ .50
R8	22 ohms	0.5	red, red, black	13-13542	\$ .35
R9	560 ohms	0.5	green, blue, brown	13-13537	\$ .20
R10	100 k	0.5	brown, black, yellow	13-13552	\$ .20
R12	10 ohms	0.5	brown, black, black	14-14513	\$3.35
R13	39 ohms	0.5	orange, white, black	61 0515	\$ .20
R14	2.2 M	0.5	red, red, green	13-13558	\$ .20

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

### Capacitors

Symbol	Capacitance	Type/Markings	Volts	Part #	Replace Cost
C1	100 pF	100M	3 kV	21-21047	\$1.00
C2	100 pF	100M	3 kV	21-21047	\$1.00
C3	100 pF	100M	3 kV	21-21047	\$1.00
C4	100 pF	100M	3 kV	21-21047	\$1.00
C5	100 pF	100M	3 kV	21-21047	\$1.00
C6	.01 $\mu$ F	103M	3 kV	21-21005	\$ .60
C7	.01 $\mu$ F	103M	3 kV	21-21005	\$ .60
C8	.01 $\mu$ F	103M	3 kV	21-21005	\$ .60
C9	100 pF	100M	3 kV	21-21047	\$1.00
C10	.001 $\mu$ F	102M	3 kV	21-21138	\$2.00
C11	.1 $\mu$ F	Mylar/100 V, 104K	100 V	22-22030	\$2.00
C12	.001 $\mu$ F	.001M	1 kV	64 0031	\$2.00
C13	47 $\mu$ F	Electrolytic	250 V	20-20037	\$2.50



## Disclaimer

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<b>Diodes</b>				
Symbol	Type	Comments	Part #	Replace Cost
<b>D1-D6</b>	3G3	Printed on each of these six diodes is a band (formed of alternating triangles) which indicates the negative (-) end.	23-23021	\$3.75
<b>D7, D8</b>	XG6	Similar to the 3G3 above, but the XG6 diodes are larger	23-23030	\$4.10
<b>D9</b>	1N5223B	Tiny diode with numbers 5223B printed on it. The band indicates negative (-) end.	23-23018	\$0.60
<b>D10-D13</b>	1N4007	The band around one end indicates negative (-) end.	71 0016	\$0.25
<b>Transistors</b>				
<b>Q1</b>	TIP 49	Terminal at the center is the Collector. Metal tab mount.	24-24022	\$2.25
<b>Transformer</b>				
<b>T1</b>	2.0 mW 115 V	The terminal that is closest to the groove in the base is terminal No. 1	40-40023	\$24.55
<b>Laser tube</b>				
<b>LT1</b>	0.5 mW output	Hard seal, HeNe, with attached pre-aligned end mirrors and connectors	76 0161	\$145.00

## Miscellaneous parts

Type	Comments	Part #	Replace Cost
<b>Laser Case</b>	Cast aluminum, 2.7 x 2.7 x 11.0 inches Threaded tripod mount at bottom	42 0215	\$40.00
<b>Laser Cradle</b>	Two strips of black plastic each about 1 inch long. Mounts laser tube on circuit board	30-30022	\$4.00
<b>Cushion Tape</b>	Two lengths of ¼ inch x 11 inch rubber. Used to cushion bottom of laser case	00-00155	\$3.00
<b>Front End Cap Assembly</b>	Aluminum plate with shutter mounted in a threaded aperture	44-44293	\$50.00
<b>Printed circuit Board</b>	Phenolic. Laser tube and resistor R1 mount on foil side and all other parts mount on the reverse side	35-35105A	\$30.00
<b>End Cap Screws</b>	Eight black screws 4-40 x ½ inch Secure end caps to laser case.	22 0023	\$0.50
<b>Stay Wraps</b>	Two plastic strips. Holds laser tube on PC board	35 0126	\$0.25
<b>Cathode Lead</b>	One 4 inch black wire	55 0050	\$1.60
<b>Anode Lead</b>	One 4 inch red wire	55 0051	\$1.55
<b>Insulators</b>	2 inch x 2 inch Kapton insulating tape (2 pieces) taped to the PC board. Remove and store on a clean surface before beginning construction of the PC board.	14 0115	\$1.85

any loss or damage during shipment as long as the buyer observed the following rules:

- Refuse any package which is not in perfect condition. Once a package has been accepted, the buyer must initiate and collect insurance claims.
- If damage is discovered during unpacking, notify the carrier and the distributor (or Industrial Fiber Optics if the item was purchased directly) from whom the item was purchased immediately. The carrier must note the damage and make a concealed damage report. Time is of essence because damage claims submitted more than five days after the delivery may not be honored by the carrier.
- Keep all packing material.
- In writing, describe the specific nature of the damage to the product.
- In cases of severe damage, do not attempt to use the product.

## Return Policy

Industrial Fiber Optics will pay the return-to-customer shipping and insurance charges for warranty repair deliveries made within the United States by United Parcel Service or Parcel Post. Any other delivery means must be paid by the customer. The cost of return shipments for out-of-warranty items is paid by the customers.

## Warranty – Shipping - Service

### Limited Warranty

This kit was carefully inspected before leaving the factory. If any components are missing, or (except for the laser tube) were damaged during shipping, Industrial Fiber Optics will 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 parts become damaged, replacements can be obtained from most radio/electronics supply shops, or from Industrial Fiber Optics.

While Industrial Fiber Optics does not assume any responsibility for defects that have been caused by the failure of a purchaser to follow the kit building instructions, it can assist in repairs of damage caused by the incorrect assembly. In such instances, the entire kit can be returned to Industrial Fiber Optics for an evaluation and quote on the cost of these repairs. Send the entire kit to;

Industrial Fiber Optics  
627 S. 48<sup>th</sup> St. Ste. 100  
Tempe, AZ 85281

Be sure to include sufficient contact information so that Industrial Fiber Optics can reply with results of the evaluation and a repair cost quote. Also, include a return address for return shipping.

**This warranty does not cover failure due to transistor and diode breakdowns caused by failure to provide adequate heat sinking as specified in the kit builder's instructions.**

It is assumed that the same reasonable care will be given to the laser as one gives to any electronic device. Store in a dust-free atmosphere and avoid extremes of temperature and humidity. However, the ML-801 is a hard-seal laser and unlike previous lasers, continuous or periodic operation is **not required** to ensure a long life.

Industrial Fiber Optics shall have no responsibility for the installation or maintenance of the product or for any personal injury, property damage or any special incidental, contingent or consequential damages or losses of any kind resulting from defects of the product or failure of the product to perform, or failure of the kit builder to heed the warnings in this manual.

### Damage or Loss in Shipment

Standard rules govern loss and damage in shipping. As soon as the package leaves the F.O.B. point, it becomes the customer's property, even lost or damaged in shipment. The carrier, however, will be responsible for

## Heat Sink Subassembly (Refer to Figure 3)

Type	Comments	Part #	Replace Cost
<b>Heat Sink</b>	Aluminum U-block with drilled holes	31-31141	\$6.00
<b>Screw</b>	4-40 x .5" Mounts transistor on heat sink	22 0025	\$0.25
<b>Washer</b>	White beryllia. Provides heat conduction and electrical isolation for transistor tab	00-00538	\$4.00
<b>Washer</b>	Nylon shoulder washer	23 0040	\$0.20
<b>Nut</b>	No. 4 hexagonal nut	21 0015	\$0.20
<b>Screw</b>	6-32 x 3/16" Phillips head pan screw	22 0026	\$0.20
<b>Screw</b>	6-32 x 1/4" Phillips flat head screw	22 0024	\$0.20
<b>Washer</b>	No. 6 internal tooth	23 0032	\$0.20
<b>Thermal Compound</b>	White paste packed in tin foil	32 0300	\$0.50
<b>Rear End Assembly</b>	Plug in assembly. Contains switch, pilot lamp, fuse and line cord. Its 4" leads are soldered directly to the PC board.	44-44103	\$50.00
<b>Fuse</b>	3/4 Amp fuse	00-00484	\$1.50
<b>Instruction Manual 45-801</b>	Complete instructions for building Laser ML801	12 0113	\$5.00
<b>Operator's Manual</b>	Hard-Seal Helium-Neon Laser Installation and User's Guide	12 0098	\$5.00

## Soldering

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 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 is absolutely necessary to join the connection parts together. Large globs of solder can form solder bridges between conductors on the circuit board and cause short circuits when power is applied.

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 of a liberal quantity of Dow Corning Clear Sealant (or bathtub caulking) 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 the foam tape to the grooves on the underside of the case.

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

## Final Assembly

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The final assembly consists of placing all of the electronic parts inside the laser case and aligning the laser beam so it will emerge 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.

1. With the power off, slide the printed circuit board all of the way into the laser case (Figure 5). Without touching the end mirrors of the laser tube, slide the tube forward or backward on the PC board so the front and rear end caps can be assembled without contacting the ends of the laser tube. Also, the hole in the bottom of the case should be aligned with the tapped hole in the aluminum heat sink block.
2. With the laser aimed so it cannot strike any reflecting objects or the eyes of anyone in the vicinity, turn the power on. The pilot lamp should light, a strong beam should come out of the front of the laser and a much weaker beam should 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 difficulty is experienced in getting the beam aligned with the front end plate, check for any irregularities or globs of solder under the laser cradles that might be tilting the laser tube. If obstructions are found, the power should be turned off and 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.

## 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 this engineering provision 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. Potentials high as 12,000 volts are available on the printed circuit board and at the terminals of the laser tube. Also, when the laser is operating, ultra violet light is emitted from the sides of the laser tube and a coherent laser beam radiates from both ends.

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

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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 sharp right angle bend in each lead of the diode so the diodes will exactly fit between the appropriate sets of pre-punched holes on the circuit boards.
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 is 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 PC board.

**Caution:** Diodes are heat sensitive. Never use a large soldering iron, a high wattage solder gun, or apply heat longer than is 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 the mounting of the diodes.*

## **Mounting Resistors**

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There are 13 resistors to be mounted on the printed circuit board. Follow the instructions below and refer to Figure 1 for the placement of the resistors.

1. Resistors R12 and R1 are 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 at 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.
2. Resistor R1 is the only resistor mounted on the foil side of the circuit board. To mount this resistor, pass one of its leads through the hole provided near the front of the circuit board. Then, on the component side of the board, bend this lead and insert it into the solder hole that is located near the bottom of resistor R7 (See figures 1 and 4). Solder the lead and trim any excess of the lead that protrudes through the solder hole. Do not connect the free end of the resistor R1 at this time. Later it will be connected to the anode at the front of the laser tube.
3. With a pair of pliers, make sharp, right angle bends in each of the remaining resistor leads so the resistors will exactly fit between the appropriate sets of pre-punched holes on the circuit board.
4. 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 these resistors 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 at the foil side of the circuit board.

**Warning: Remember to turn off the power whenever touching the laser or the meter as necessary.**

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.*

## Adjusting Laser Tube Current

For optimal operation, the laser tube current should be between 3 and 3.5 milliamperes. Most lasers will operate properly with the correct tube current when assembled according to the instructions given above. However, because there are small differences in the electrical characteristics of individual laser tubes, there is a small possibility that the tube current in your laser does 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:

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 that 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 and 3.5 mA, skip the rest of this procedure. The beam current is within specified limits and no adjustment is necessary. In that 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 mA, disconnect the power, unsolder resistor R13 from the printed circuit board, and replace it with a 36-ohm resistor. Reapply power. If the milliammeter still indicates less than 3 mA, try replacing resistor R13 with a 27-ohm resistor. **Always remember to remove power before touching the laser or the meter.**
7. If the milliammeter indicates MORE THAN 3.5 mA, replace resistor R13 with a 43-ohm, 47-ohm or 56-ohm resistor in turn until the tube current falls within the 3 to 3.5 mA range.

**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.

5. Insert the leads of the remaining eight resistors 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.
6. 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 have been mounted on the circuit board.*

## Mounting Capacitors

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

1. Place the leads of capacitor C13 in the designated holes of the printed circuit board making sure that the negative (-) is toward the top of the board and the positive (+) end is down. If there is no + or - signs on the capacitor, look for arrows running along its length. The arrow head points to the negative (-) end.

**Caution:** 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.

2. Mount capacitors C1 through C12 in the designated holes of the PC board. Capacitors C1 through 10 are ceramic discs and capacitors C11 and C12 are tubular Mylar types. 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 closely 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.

## **Mounting Transistor Q1**

Transistor Q1 is perhaps the most difficult 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 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 3.

1. Hold transistor Q1 so its metal mounting tab is facing the aluminum heat sink as shown in Figure 3.
2. Mount the transistor to the heat sink with a screw and beryllia washer using plenty of heat sink compound on both sides of the beryllia washer. The shoulder washer and nut go on the other side of the heat sink as shown on Figure 3, the "neck" of the shoulder washer fits into the hole in the heat sink. Make the nut as tight as possible without breaking the screw.

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

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. Operate 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 blue 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.

**NOTE:** If everything has been done correctly, the laser should be working properly. However, since individual laser tubes have different operating characteristics the laser beam current can be adjusted for optimum operation in the particular laser. This optional procedure is described in the next section.

## Visual Inspection

Before the laser is mounted in its outer case, make a thorough check of the electrical components of the laser 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. The 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 2) while checking each part.
2. Wiggle each of the electrical components methodically while watching the printed circuit board for any movement that would 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 looking 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 that all of the mechanical connections are tight and there is a liberal amount of heat sink compound on both sides of the beryllia 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, ¼ ampere) is inside.
8. Operate 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 stoppers when the laser starts to operate.

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 at 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.

**NOTE:** At this point we recommend an optional procedure to increase the laser longevity. Spray two or three thin coats of Krylon crystal clear No. 1302 on both sides of the PC board from the transformer to the anode/cathode end.

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

## 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 4.

1. With the foil side up, cement the flat side of a laser cradle to the PC board between the holes located between diodes D3 and D4 using a thin coat of Duco (or similar) 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 resistor R9 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. 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 D3 and D4. 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 4.
5. Repeat the above procedure and insert a second stay wrap through the holes between resistor R9 and capacitor C12.
6. Carefully place the laser tube on the circuit board in the position shown in Figure 4.

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

7. Pass the pointed end of each stay wrap through its end lock as shown in Figure 4. Draw the stay wraps tightly against the laser tube and snip off the protruding ends of the wraps.

8. A 4-inch length of red wire, called the anode lead, is included in the kit. Attach one end of this wire to the metal clip mounted on the front of the laser tube (*Refer to Figure 4*). Before connecting the other end of the anode lead, measure the distance required for it to reach resistor R1. Cut off and discard part of the red wire and solder the remainder to the free end of resistor R1.
9. Solder one end of a black 4-inch cathode wire to the metal connector on the back of the laser tube. Solder the other end of this wire to the ground connector at the corner of the circuit board (*Refer to Figure 4*).

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

## Connecting the Rear End Cap to the PC Board

Solder the three leads from the rear end cap assembly directly to the PC board as shown in Figure 1).

*This completes all of the electrical connections of the laser.*