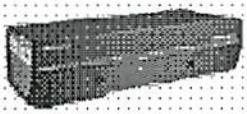

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System Components

ORC-1000, Version 3.6

Latest Upgrade: October 21, 1996

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Graphic Symbols Explained

The following graphic symbols are used throughout this manual to draw your attention to situations or procedures that require extra attention. They warn of hazards to your eyesight, damage to equipment, and necessary performance specifications.

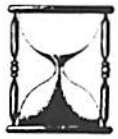
Performance Specifications. You should follow these instructions without deviation.

Eye protection required. Looking at laser beams can cause permanent eye damage.

Graphic to draw your attention to a warning or important note.

Wear protective gloves when handling optical components.

Take care! This is an electrical hazard.



Wait — there is a warming-up period. Do yourself a favor and wait.

Post warning signs that alert others to the presence of laser radiation.

Authorized personnel only! Assemble and operate this system in an enclosed room.

1. Introduction

This manual is a comprehensive tool that serves as a reference for the **ORC-1000** laser. Chapters of this manual identify and describe the major assemblies, summarize their operation, and list requirements for periodic maintenance.

1.1 Warranty Limitation

This manual provides the guidance needed for routine maintenance and alignment of the **ORC-1000** laser system (laser head and power supply).

The owner/operator is not authorized to remove any of the fixed modules from the **ORC-1000** laser system, except as described elsewhere in this manual for the completion of routine maintenance tasks. Removal of any of these modules will be considered unauthorized modification or misuse of the laser and will void Clark-MXR, Inc.'s warranty. Clark-MXR, Inc. will not be responsible for problems arising from repairs made by unauthorized personnel.

1.2 Overview and Specifications

The model **ORC-1000** consists of a free-standing laser head and a separate power and cooling station connected by appropriate cabling and cooling lines.

1.2.1 Specifications:

1.2.1.1 Laser head

Mechanical

- length: ..... 33 in./84 cm.
- width ..... 13 in./33 cm.
- height ..... 9 in./23 cm.
- beam height ..... 6 in./15 cm.
- weight ..... approx. 50 lbs./23 kg.

Optical

- wavelength: 532 nm multimode
- output power (green)
- cw > 3 watts
- Q-switch (5kHz) > 25 watts
- Q-switch (1kHz) > 9 watts
- Beam profile: Multi transverse mode

1.2.1.2 Power supply

- length ..... 30 in./76 cm.
- width ..... 23 in./58 cm.
- height ..... 31 in./79 cm.
- weight ..... approx. 550 lbs./250 kg.

Figure 1-1. Front of laser head.

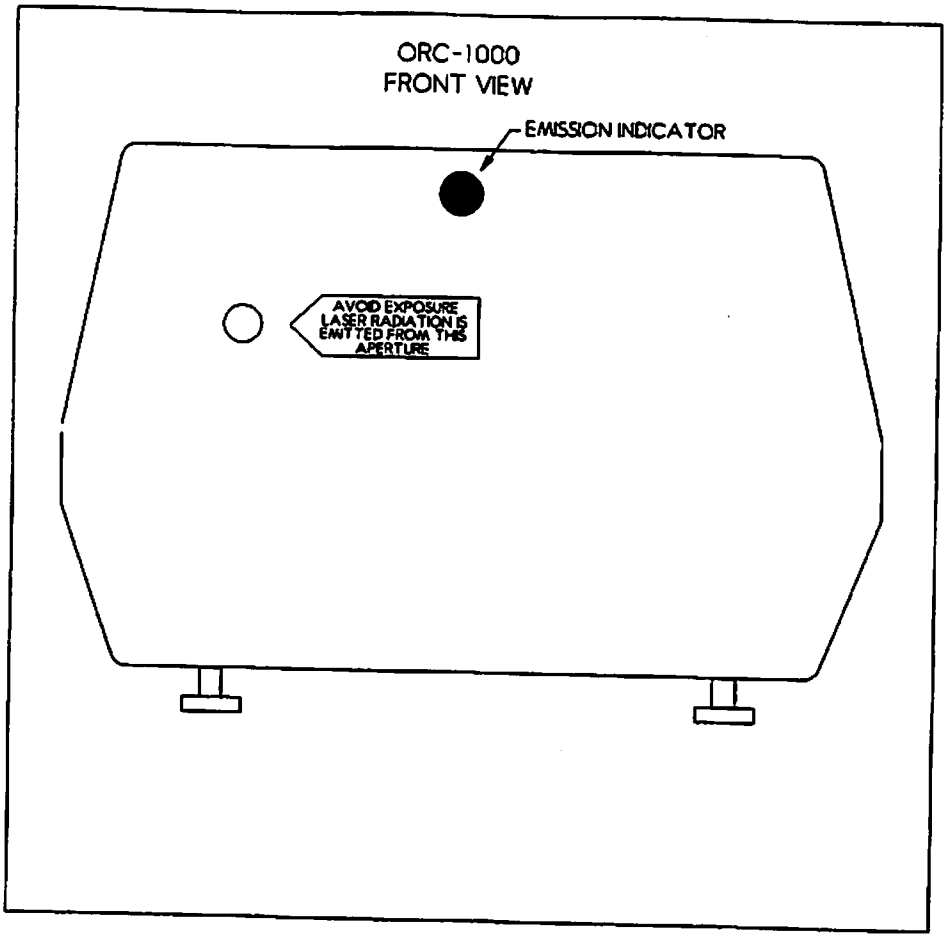


Figure 1-2 Back of laser head.

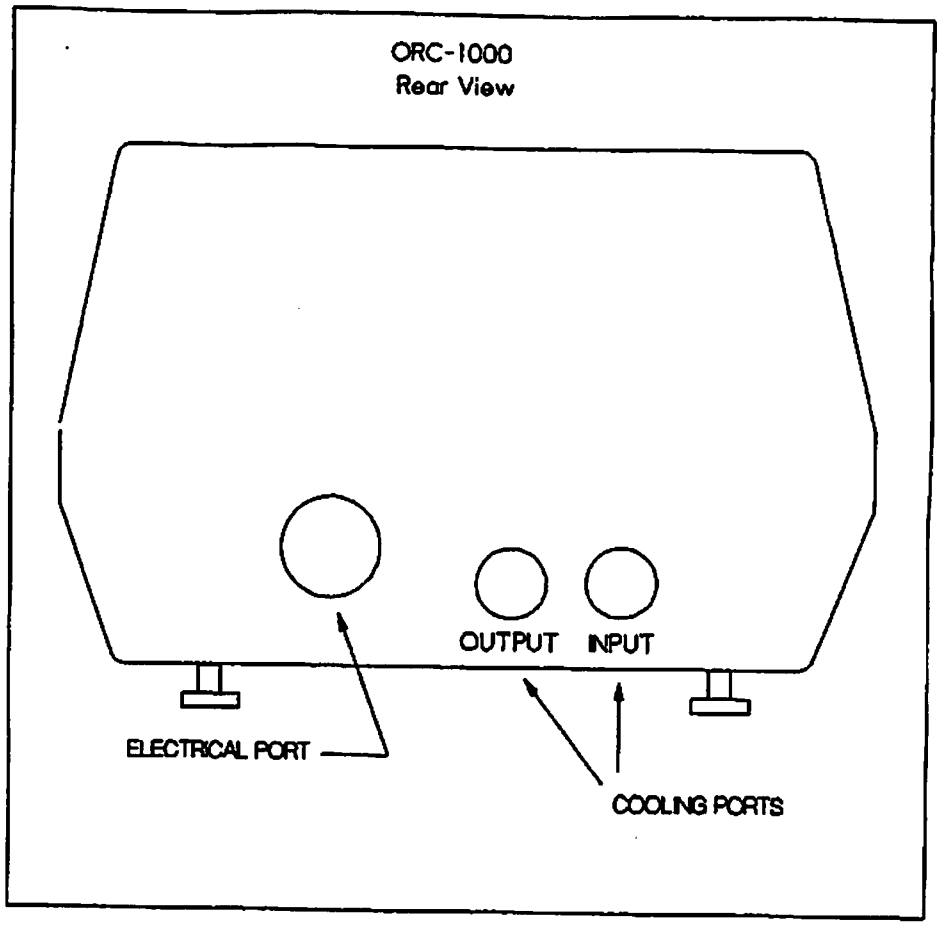


Figure 1-3 Front of power and cooling station.

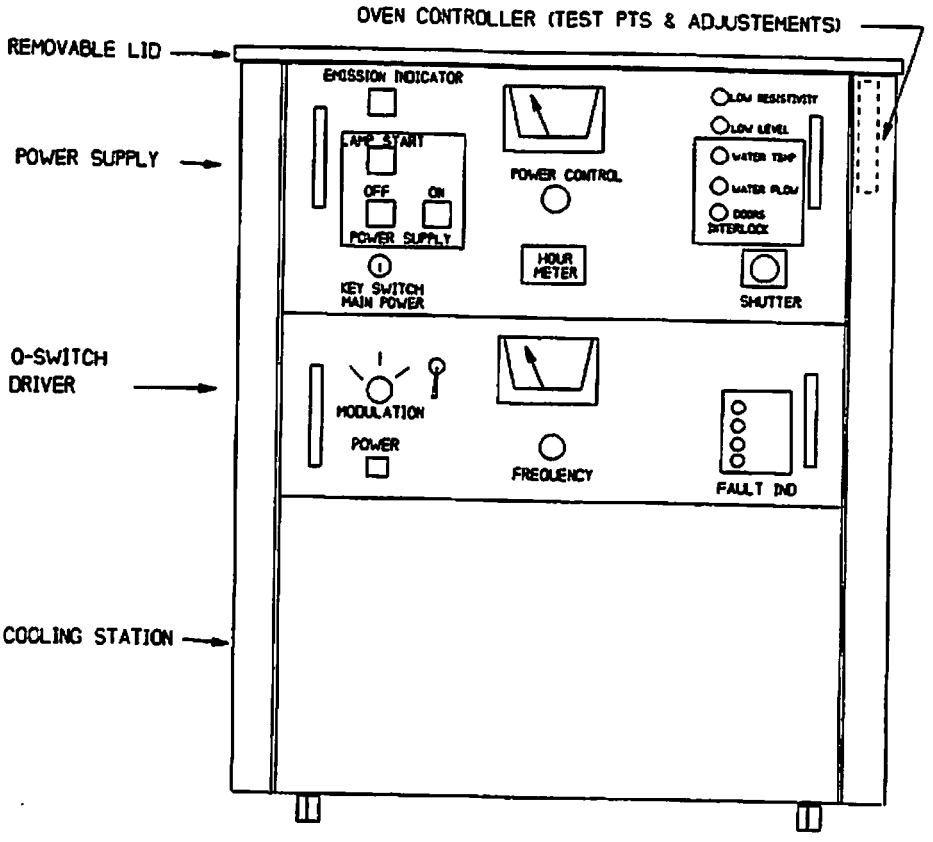
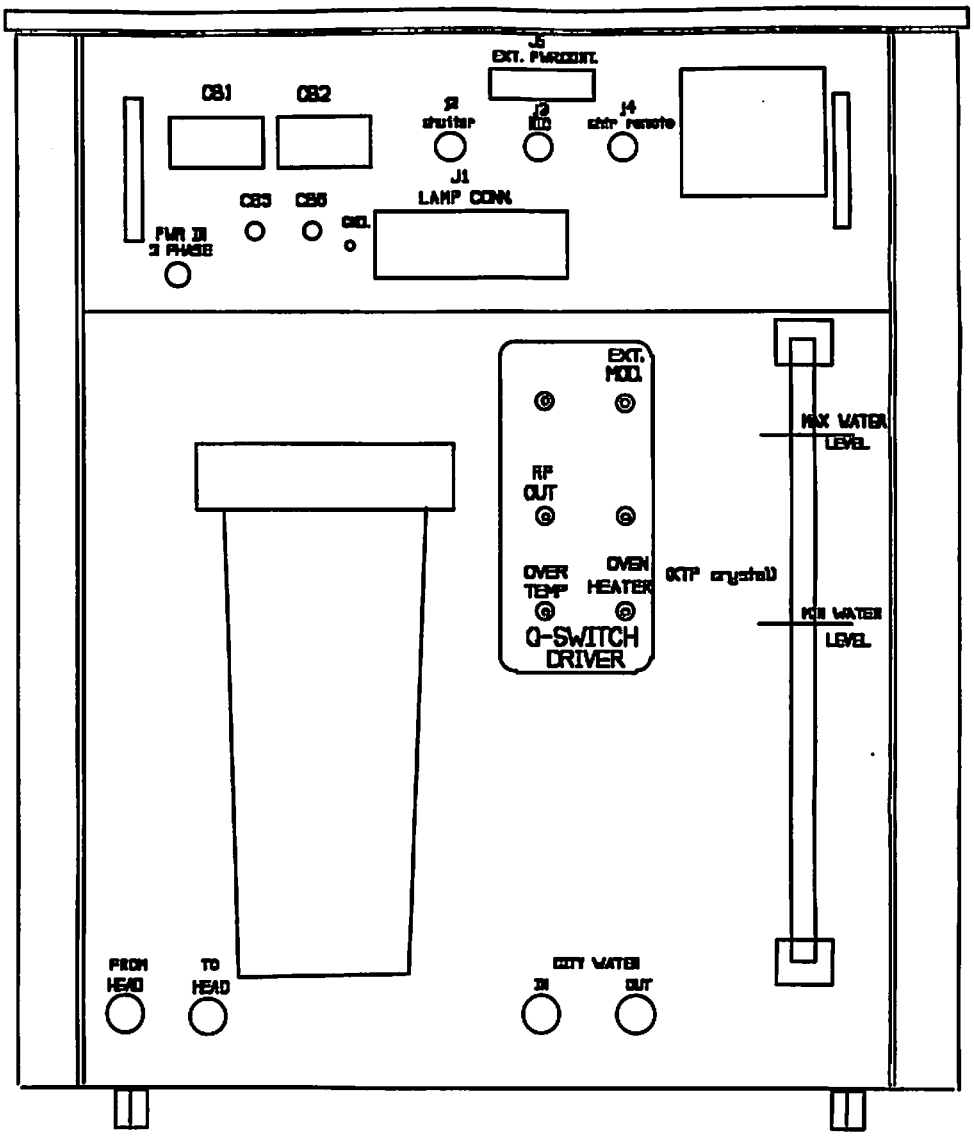


Figure 1-4 Back of power and cooling station.



2. Safety

2.1 Safety Rules

Read this safety section before operating the **ORC-1000** laser system. Laser safety depends on your awareness that this instrument can cause **serious bodily harm.** Follow all safety precautions described throughout the manual to ensure that all personnel who come in contact with, operate, or maintain the laser are protected from accidental or unnecessary exposure to laser radiation.

■ **The ORC-1000 is a Class IV laser. Laser light from the model ORC-1000 presents a severe eye hazard (*for example*, loss of vision) when viewed directly or when reflected off another object. Also, Laser light poses a skin hazard with the potential for burns and clothing fire.**

The wavelength, pulse energy, and operating power emitted by the ORC-1000 are listed in Table 2-A. Use this table and good sense to decide what level of eye and skin protection is needed.

Table 2-A
Laser parameters affecting the user's safety

Laser	Wavelength (nm)	Power (watt)	Pulse Energy (mJ)
ORC-1000	532 nm	< 60 W	< 20 mJ

■ **Post the laser parameters (shown in the preceding chart) near the laboratory to alert everyone to the presence of laser radiation.**

■ **Assemble and operate this system in an enclosed room. Periodically inspect the area for stray beams and reflections. Block those that propagate outside of the working area during assembly and alignment. Avoid uncontrolled reflections.**

The laser beams can remain collimated over large distances and remain a hazard far from the original source. It is good safety practice to clearly mark the door to the room with warning signs and interlocks connected to the pump laser to prevent accidental exposure to the beams.

■ **Post warning signs that alert others to the presence of laser radiation.**

Do **NOT** operate the system while untrained personnel are present. Warn anyone in the area where beams are located of the dangers associated with laser beams. **Verbal warnings** help to ensure that others in the area are *not* injured by stray radiation.

■ **Limit access to the equipment to trained personnel who have a need to use it.**

The "Eye Protection Required" symbol warns you that **serious bodily harm** may result from exposure to radiation either present in the area, or radiation that may be created when doing the step detailed along side it (see also *Graphic Symbols Explained* at the beginning of this manual).

■ **Observe and understand the symbol that follows.**

■ **Remember, safety is your responsibility! Follow these safety procedures when working with this product.**

2.2 Electrical Hazards

Disconnect main power lines prior to working on any electrical equipment whenever it is not required to have the power on.

Applying AC power to the system with the laser head or power supply cover panels removed will expose the user to high voltages. At such times, practice common sense when placing hands inside the enclosure, and do not allow foreign objects to fall inside.

Wait at least five (5) minutes for the power supply output capacitors to discharge and then measure the output before touching any electrical equipment.

Do not short or ground the power supply output. **Positive protection against possible hazards requires proper connection of the ground terminal on the power cable, and an adequate external ground.** Check these connections at the time of installation, and periodically thereafter.

Never work on electrical equipment unless there is another person nearby who is familiar with the operation and hazards of the equipment, and who is competent to administer first aid.

When possible, keep one hand away from electrical equipment to reduce the danger of current flowing throughout the body if a live circuit is accidentally touched.

Always use approved, insulated tools when working on equipment.

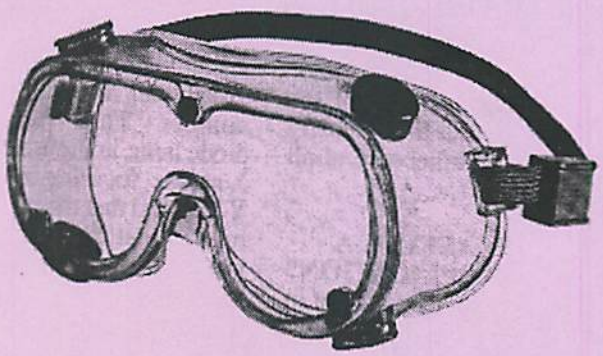
Special measurement techniques are required for this system. Ground references must be selected by a technician who has a complete understanding of the system operation and associated electronics.

2.3 Optical Radiation Hazards

The principal optical hazards are eye injury, burns, and ignition of flammable materials.

■ **When setting up or aligning the system or subsystems, KEEP ALL BEAMS BELOW EYE LEVEL. *Never* look in the plane of propagation of the beam.**

EYE INJURY Visible light and near infrared laser energy pass through the transparent components of the eye (the cornea, lens, aqueous and vitreous humor) and are focused on the retina at the back of the eye. This light can therefore cause an accidental retinal burn, the degree of damage depending on the power of the beam, the amount of focusing carried out by the lens, and the duration of the exposure. **Minimum precautions against eye injury include wearing safety eye wear designed for protection at 532 nm and of sufficient optical density at 532 nm to protect the wearer from the high peak power associated with the Q-switched laser output.**



Remember that safety goggles *can be a hazard as well as a benefit.* To protect the eyes from the laser beam, the goggles must attenuate to the point where the beam is no longer visible. Therefore, the user can be exposed to **flesh burns** or **clothing fire** without seeing it happen. *Be*

aware of this potential. Follow the specific recommendations called for in this manual at various stages during the alignment procedure.

With the laser head top cover removed you will have access to laser beams that would otherwise be contained within the protective housing. These beams may be of multiple wavelengths (532 nm and 1064 nm). **At such times, always wear optical safety glasses designed for protection at 532nm and 1064nm. The optical density at these wavelengths should be sufficient to protect the wearer from the high peak power associated with a Q-switched laser.**

- **When servicing the system do not wear jewelry (*for example,* rings, chains, etc.), that might pass into the laser beam line. Uncontrolled reflections may result!**

BURNS Accidental irradiation of skin/tissue will result in a laser burn. In addition, be careful when handling beam blocks and power meters that have been exposed to the laser output. They may be very hot.

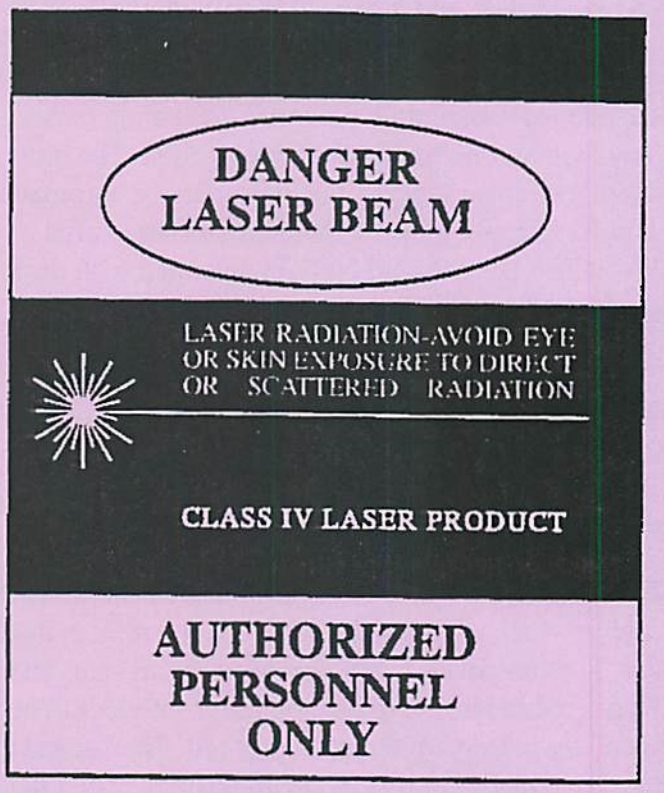
IGNITION OF FLAMMABLE MATERIALS

The **ORC-1000** laser is intense enough to ignite flammable materials placed in the beam path. This includes "beam blocks," clothing, etc. Care and precision in pointing the laser is of paramount importance. Always align the system at the lowest output power.

2.4 Laser Room

The area where the laser is used should be clearly labeled at all entrances with warning signs when the laser is actually in use. The sign should indicate the laser being used. Figure 2-1 shows an example of a sign suitable for use with the **ORC-1000** laser.

Figure 2-1 Warning sign for room.



The power supply is provided with a remote interlock socket which should be connected to a door switch. This will automatically switch off the laser in the event of the door's being opened (see below). Personnel present in the room should be limited to those essential to the laser operation or experiment. Appropriate protective eye wear should be available for all personnel in the room.

In addition to the possible hazard of accidental laser burns of the eye and the skin, there is an associated electrical hazard such as is found with any piece of electrical equipment. Accordingly, care must be taken when connecting or disconnecting the system.

2.5 Protection of Operators and Users

The laser user is encouraged to obtain a copy of ANSI Z136.1, which is a guide to the safety standards required of laser users. "American National Standard for the Safe Use of Lasers" is published by the American National Standards Institute, 1430 Broadway, New York, NY 10018.

The safety features listed below are incorporated into the model **ORC-1000** in compliance with Title 21, Code of Federal Regulations, Subchapter J (21 CFR 1040.10). Any alterations to the **ORC-1000** laser system which modifies any of these features invalidates the Class IV certification of the **ORC-1000**.

REMOTE INTERLOCK CONNECTOR An interlock socket and plug is provided on the rear of the power supply. This is intended to be connected to a switch on the laser room doors so that the laser will be disabled if the doors are opened accidentally, thereby preventing exposure to laser radiation by anyone entering the laser operating area. The laser is disabled by shutting down the power supply. Lasing cannot be automatically resumed. The power supply must be manually restarted after an interlock caused shutdown. The laser should NOT be operated with the remote interlock function disabled.

KEY SWITCH A key is required to energize the **ORC-1000** laser power supply. The key for the ON/OFF switch can only be removed when the switch is in the OFF position. (This prevents removing the key without first turning off the system, and additionally controls the use of the laser to prevent use by unauthorized personnel.)

PROTECTIVE HOUSING The **ORC-1000** laser head is enclosed in a protective housing which encloses the laser beam until it exits through the output aperture. The top cover can be removed for service. The laser head is equipped with a redundant electrical top cover interlock. The interlock can be "defeated" by pulling up the actuating rod. The "defeated" status is indicated when the actuating rod is in the up position. The **ORC-1000** should not be operated with the protective covers removed except for service or maintenance by knowledgeable and qualified personnel.

EMISSION INDICATOR Two visible emission indicators are used on the **ORC-1000** laser system: (1) An amber indicator on the power supply and, (2) An amber indicator on the laser head. Both indicators are energized whenever the key switch is turned on.

This indicates the laser is being readied for emission of laser radiation. The indicators remain on as long as the laser power supply is energized. The emission indicators light prior to actual emission to warn nearby personnel of impending laser radiation.

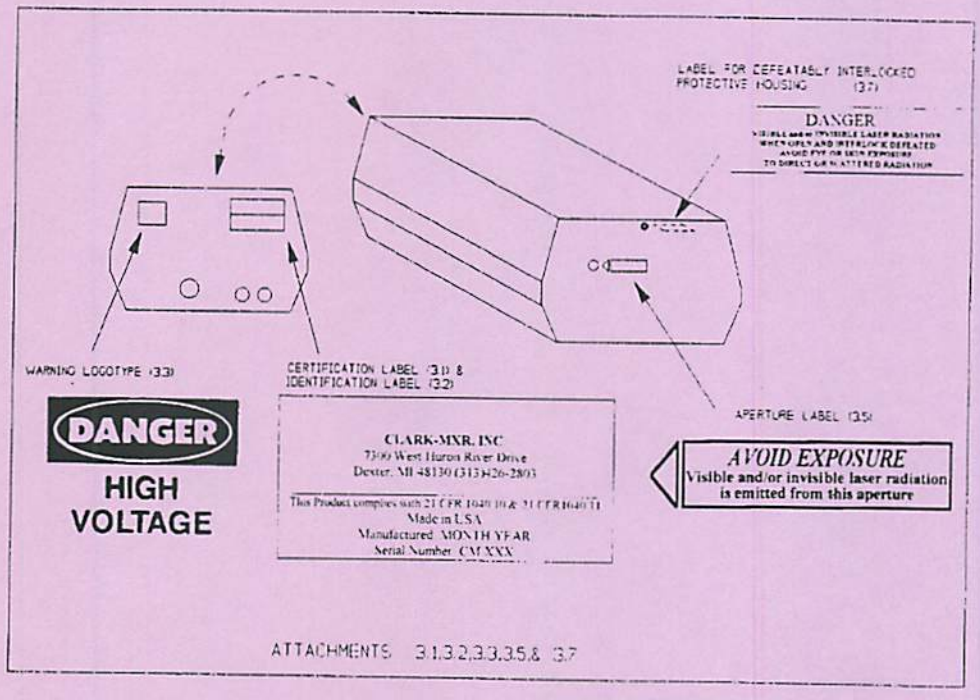
LOCATION OF CONTROLS Controls for operation of the **ORC-1000** laser are located on the power supply control panel. This ensures that exposure to laser radiation is avoided during operation.

WARNING LABELS Warning labels and the compliance certification are attached to the **ORC-1000** laser head as indicated in Figure 2-2. The function of the labels is to provide the user with information on the wavelength and power emitted and to warn the user against exposure to laser radiation.

OPERATING INSTRUCTIONS The instructions for safely operating and maintaining the **ORC-1000** laser system are provided in this manual.

SAFETY SHUTTER A rotary solenoid actuated safety shutter is mounted in the **ORC-1000** optical head. It is controlled by a switch on the power supply.

Figure 2-2 Placement of Labels.



3. Power/Water Requirements

3.1 Facility Connections

3.1.1 Electrical

The AC power required for the North American version is 215 ±5 % VAC, three phase, 60 Hz. (30 A/line @ 220V)

The AC power required for the European version is 400 ±10% VAC, three phase, 50 Hz (20 A/line @ 400V)

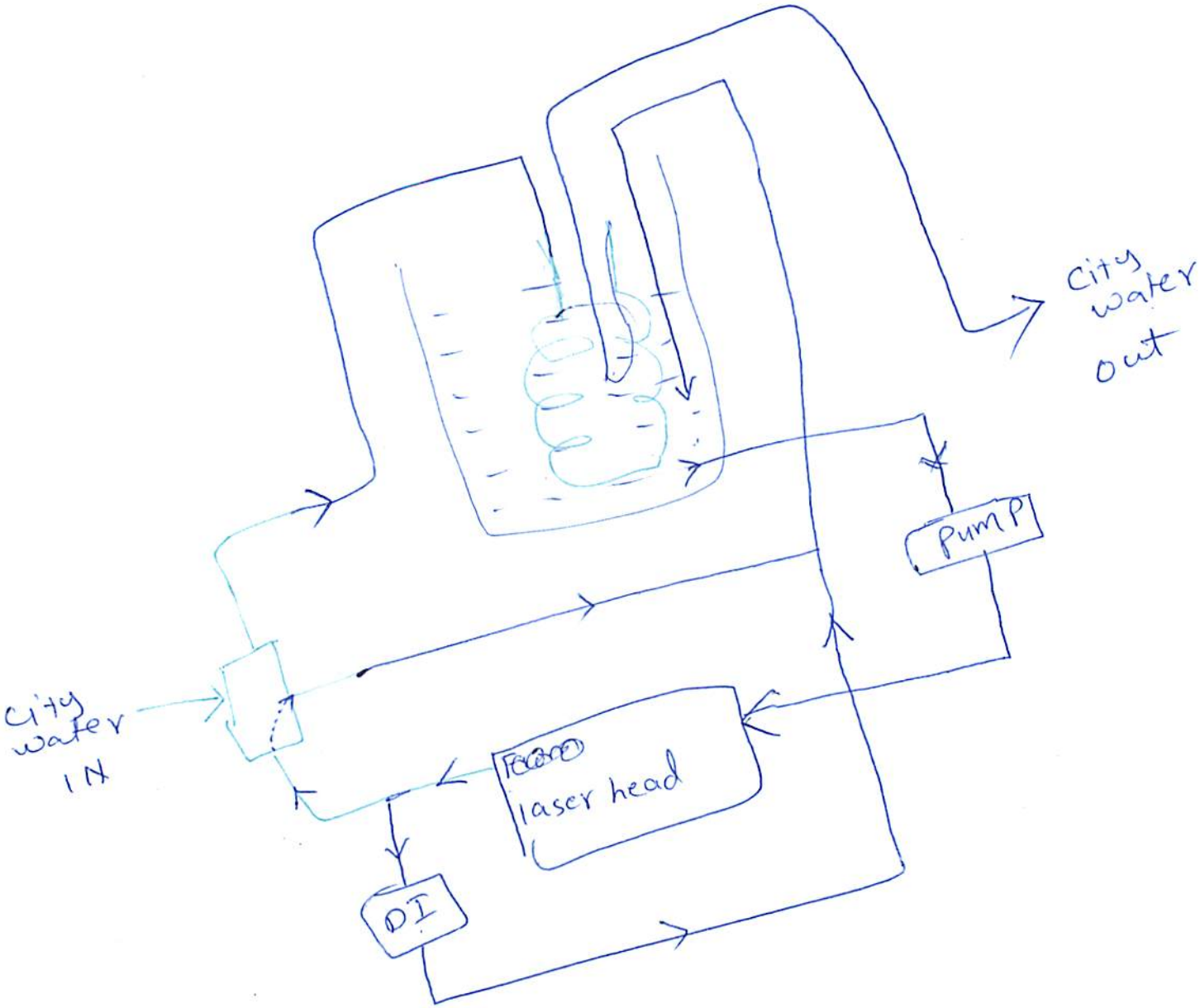
An imbalance of incoming AC line phases will result in a noisy laser output modulated at the phase imbalance frequency.

3.1.2 Water

Nominal supply water requirements are as follows: 4 GPM at 30 to 50 psi. The flow (intermittent) is controlled by a built-in thermostat. The power station contains a closed circuit heat exchanger filled with 8 gallons of distilled water for the actual cooling of the laser head.

The following characteristics of the tap water supply can have a significant effect on the system operation:

- Undissolved solids: Although moderately high levels of dissolved solids (hard water) can be tolerated, pre-filtering is required to ensure optimum performance.
- Inlet static pressure: A water pressure regulator should be installed if the inlet static pressure is greater than 60 psi. (The minimum should be 30 psi.)
- Inlet water temperature: The heat exchanger inside the laser power supply will not be able to adequately cool the laser and resonator assembly if the inlet water temperature exceeds 75 degrees Fahrenheit (24° C).


city water out
Pump
city water IN
laser head
DI

4. System Description

4.1 Laser Beam Paths

The laser system can be divided into several subsystems. A brief description of these subsystems is given below, followed by the various modes of operation of the entire laser system.

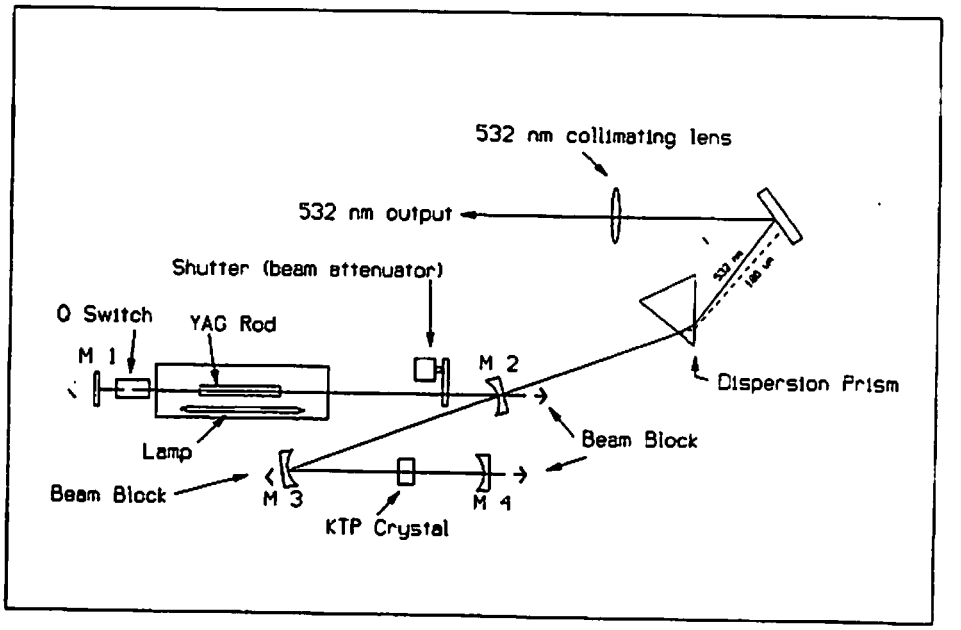


Figure 4-1. Schematic View of ORC-1000 beam path.

A single Krypton arc lamp is used to energize the YAG rod.

The light absorbed by the YAG rod will excite the Neodymium ions in the rod and cause the rod to act as a light amplifier for the 1064 nm infrared wavelength. As shown in figure 4-1 above, some of the amplified light emerges from one end of the rod and strikes mirror M1, which is a high reflecting mirror at 1064 nm that reflects nearly all of the light back into the YAG rod. (The small portion of light, about 0.2%, that does manage to pass through the mirror is absorbed by the bulkhead beam block behind the mirror.)

The 1064 nm radiation is reflected by the output coupler M2 and reaches mirror M3, which is another high reflecting mirror at 1064 nm. After that, the 1064 nm light passes through the KTP crystal and strikes mirror M4, where it is again reflected and retraces the same path back to the YAG rod. (The small portion of the 1064 nm light that passes through mirrors M3 and M4 is absorbed by the appropriate beam blocks.) The returning light is further amplified by the YAG rod, until eventually the gain of the YAG becomes saturated.

As 1064 nm light passes through the KTP crystal, a portion is frequency doubled to 532 nm. The green light that emerges from the KTP crystal also reflects off mirror M4 towards the KTP crystal. The "leftover" 1064

nm light that propagates through the KTP generates more 532 nm light that adds to the 532 nm light generated on the first pass. The 532 nm light reflects off mirror M3 and reaches the output coupler M2. This output coupler mirror is highly transmissive for 532 nm light and highly reflective for 1064 nm light. As a result, 532 nm light passes through the mirror and goes on to the next optical components while 1064 nm light is reflected back into the resonator.

4.2 Q-switch

The Q-switch is an optical switch that can be closed to block the laser emission. When this happens, the 1064 nm light is prevented from oscillating in the resonator and consequently no green light is generated (the lamp is still on). The lamp energy is stored in the YAG rod and the gain builds up. When the Q-switch is opened, all the energy stored in the YAG rod is dumped in the laser resonator, causing a large pulse of 1064 nm light in the laser. The KTP crystal conversion of infrared to visible green is nonlinear. Consequently the peak KTP power is increased considerably by Q-switching the laser. This Q-switching process (opening and closing) is repeated at a typically kHz or multi-kHz rate.

The Q-switch is controlled by an RF driver. With no RF applied, the Q-switch is off and the YAG laser runs in its continuous wave (CW) mode. This produces very little green conversion. With the RF on and gated, the Q-switch turns on and off at a high repetition rate, the peak laser power is high, and the average 532 nm green output power is high.

4.3 Intracavity Shutter

The shutter is a solenoid operated beam block that rotates into the intracavity beam path and stops the lasing process. The shutter is actuated by a switch located on the front of the power supply.

4.4 KTP Oven

To avoid fluctuations in the doubling efficiency process, the KTP crystal is mounted in a temperature stabilized oven. The oven is actuated whenever the water pump is on. A time delay prohibits opening the laser shutter until the KTP has reached its operating temperature.

5. Control Overview

5.1 Laser System Controls/Indicators and Functions

CAUTION: Use of controls or adjustments or performance of procedures other than those specified herein may result in hazardous radiation exposure.

5.1.1 Power Supply (front panel)

The power supply front panel is illustrated in Fig. 5-1.

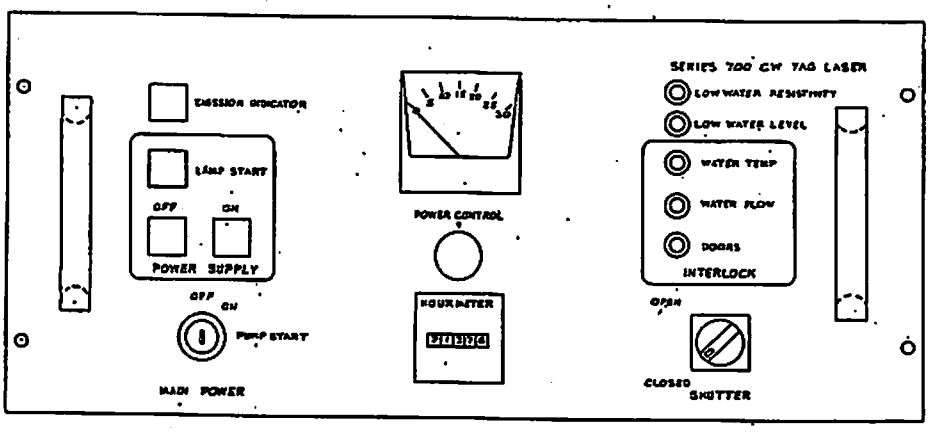
KEY SWITCH: Controls main power on and off, and water pump start. Control power is enabled when the key is turned to ON (Main power contactor is not engaged at this time.) To start the pump, turn to PUMP START and hold until water flow is started. When released, the key will return to the ON position.

The key switch is designed so that the key can be removed only in the OFF position.

EMISSION INDICATOR: This indicator lights when the key-switch is turned ON to indicate that laser emission is eminent.

POWER SUPPLY ON: A green push-button switch used to turn the lamp power supply on. The indicator in the switch lights when the switch is depressed.

Figure 5-1. Power supply (front panel).



LAMP START: A white push-button switch to start the Krypton arc lamp. The indicator turns off when the lamp is started. The lamp will not start if the shutter control is turned on.

POWER CONTROL: Used to adjust lamp current.

SHUTTER OPEN/CLOSE: Used to actuate the safety shutter.

DC AMPERE METER: Indicates Krypton arc lamp current.

HOUR METER: Non-resettable, indicates power supply usage.

LOW WATER LEVEL: Illuminates when there is insufficient deionized water in the cooling system.

WATER TEMPERATURE INTERLOCK: Illuminates when the deionized water is above 105 degrees Fahrenheit (40° C) to indicate insufficient cooling to the laser head. The interlock then engages to shut down the laser system. The interlock can be temporarily bypassed by turning the key switch to the PUMP START position and holding the key there.

WATER FLOW INTERLOCK: Indicates insufficient flow of deionized cooling water, and shuts down the laser when engaged. The interlock can be temporarily bypassed by turning the key switch to the PUMP START position and holding the key there.

DOOR INTERLOCK: Illuminates when any one of the following three situations occur: **1.** the RIC (J3) circuit **or 2.** the high-voltage interlock switch (behind the high-voltage connector block, Jl, at the rear of the power supply) **or 3.** the protective housing interlock has been interrupted, and shuts down the lamp power supply. The cooling system will continue to operate during a DOOR INTERLOCK condition.

LOW WATER RESISTIVITY: Indicates low electrical resistivity of deionized water.

5.1.2 Q-switch Driver (back panel)

The back panel of the ORC-1000 laser head is illustrated in Fig. 1-4.

RF OUT: Power connection for the Q-switch load **must be connected at all times when energized to prevent severe damage to the Q-switch driver.**

OVER TEMP: Connect to the Q-switch to provide thermal protection against overheating of the Q-switch.

EXT. MOD: Input for external modulation frequency input (TTL levels).

SHUTTER: Not used.

GATE: Not used.

5.1.3 Q-switch Controls (front panel)

The front panel of the Q-switch driver is shown in Fig. 5-3.

ON/OFF: Push button switch used to power the Q-switch driver.

MODULATION CONTROL: Rotary switch used to select the Q-switch repetition rate clock source. EXTERNAL allows the use of an external clock or source to drive the Q-switch. The clock should be able to provide TTL level signals. OFF disables all gating to the Q-switch. INTERNAL allows the internal variable clock source to control the Q-switch, either free running or gated.

GATED/FREE RUNNING: A toggle switch active whenever the modulation control is in the *internal mode*. The switch should be in the free running position. The gated position is not normally used.

METER SCALE CONTROL: Toggle switch used to select the meter range displayed.

INTERNAL FREQUENCY ADJUST: Used to adjust the *internal* clock frequency. Only active with the modulation control in the internal position.

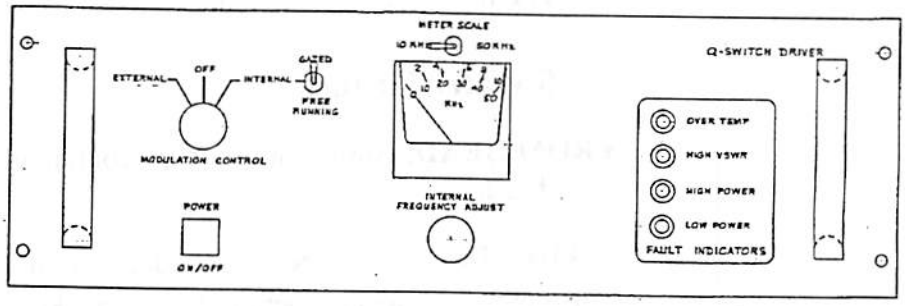


Figure 5-3
Q-switch driver (front panel)

CAUTION: During initial alignment the Q-switch must be operating at a nominal 5000 Hz.

5.1.4 Power Supply (back panel)

The back panel of the power supply is shown in Fig. 1-4.

CB1: Circuit breaker for main input power. Also provides overload protection.

CB2: Overload protection circuit breaker for the cooling pump.

CB5: Overload protection circuit breaker for control voltage. Push to reset.

CB6: Overload protection circuit breaker for the power supply control. Push to reset.

J2 SHUTTER: Provides power connection point for the safety shutter.

J3 RIC: Provides for electrical interlock shut down of the power supply when the circuit is open.

J4 SHUTTER REMOTE: Allows connection of a remote switch to actuate the shutter. The front panel shutter must be in the open position to use the remote shutter.

PWR IN: Main input power required is 220/400 VAC, ± 10%, 50/60 Hz.

Jl LAMP CONN: Two-pin connector for the high voltage laser lamp cables. The connector is interlocked so that the power supply will be shut down when the connector is open.

J5 EXT PWR CONN: Optional feature for external digital or analog computer current control.

OVEN HEATER: (Located within "Q-switch" section on back of power station.) Five-pin connector used to connect the internal oven controller to the KTP oven in the laser head.

5.1.5 Water Fittings

FROM HEAD: Hose connection for cooling water returning from the laser head.

TO HEAD: Hose connection for cooling water flowing to the laser head. This hose and hose connection should be labeled with red markers.

■ **CAUTION: Do not interchange supply and return hoses connecting the power supply and laser head.**

CITY WATER IN: Hose connection for incoming city water used in secondary cooling *of the deionized laser cooling water.*

CITY WATER OUT: Hose connection for city water discharge.

MINIMUM WATER LEVEL: Indicates the minimum level of deionized water required for proper cooling of the laser head.

MAXIMUM WATER LEVEL: Indicates the maximum level of deionized water permitted in the cooling system. DO NOT FILL ABOVE THE INDICATED LEVEL.

6. Installation and Operating Instructions

6.1 Inspection

The **ORC-1000** laser head and power supply are packaged separately in specially designed shipping containers. Inspect the shipping containers and equipment for damage (dents, broken parts). If the equipment is damaged, notify the carrier promptly and document any damage noted. Any damage should also be reported immediately to Clark-MXR, Inc.

6.2 Unpacking the System

1. Remove the **ORC-1000** laser head and power supply from the shipping containers very carefully to prevent damage.

2. The power supply is bolted to the bottom of its shipping crate with four "lag" bolts. Remove the power supply side panels to gain access to the bolts.

6.3 Installation Procedure

First, ensure that the installation area is stable, flat and clear and has sufficient working space.

6.3.1 Laser Head

1. Use the four feet clamps provided with the **ORC-1000** to secure the laser head to the table.

The **ORC-1000** laser head is completely assembled and aligned at the factory, and should not require adjustment following installation.

2. Prior to connecting the laser head to the power supply, check the lamp connections, hose connections and fasteners, and tighten as necessary.

■ **CAUTION! Do not connect the power station to the main incoming power line until the following procedures are completed.**

6.3.2 Umbilical Cord and Power Supply

1. Mate the umbilical connections to the back of the power supply (see Figure 1-4).

These connections include: the two high voltage lamp cables, the shutter cable, the RF output and the overheat protection cables for the Q-switch, the oven heater/control cable, and the ground wire cable. The contacts on J4 SHUTTER REMOTE on the rear panel must be shorted with the

shorting cap provided, or must be connected to an external switch with the contacts on the switch closed.

■ **The remote interlock connector (RIC) should be functioning, so that the laser becomes disabled when the laser room doors are accidentally opened.**

2. Secure the umbilical cord to the back side of the power station using the two cable clamps provided.

3. Connect the provided water hoses from the power supply to the laser head.

■ **Note that the hoses are** PERMANENTLY **attached to the laser head, the connectors are for strain relief only! Observe the labeling on the power supply and laser head. The input and output are** NOT **interchangeable.**

4. Secure the hose on the power supply end with the hose clamps provided.

5. Connect a ½ inch I.D. high-operating pressure hose from the building water supply to the fitting labeled "city water in" on the rear of the power supply.

6. Connect a ½ inch I.D. high-operating pressure hose to the fitting labeled "city water out" on the rear of the power supply and the other end to a suitable drain.

7. Fill the primary water tank in the laser cooling system with distilled or deionized water through the fill port on top of the tank.

Approximately seven gallons of water are required to fill the primary water tank. The fill port is accessible by removing the right side panel (as viewed from the rear of the power supply). A water level gauge is on the rear of the power supply.

The **ORC-1000** laser is shipped from the factory without a plug attached to the line cord.

8. Have a qualified electrician prepare the line cord.

■ **Do not connect the power supply to the AC power at this time.**

9. Verify the incoming power voltage. The three phases must all be at the same voltage (± 1 volt) for optimum performance.

6.4 Initial System Check

The following procedure should be followed for initial turn-on (first time following initial installation) of the **ORC-1000** system to ensure that the installation is correct, and to acquaint the user with the system controls.

1. If not already done, verify that the correct input power is supplied to the laser (see system specifications in Chapter 3).
2. Make sure that all the applicable procedures and precautions in Chapter 2, EYE SAFETY, and Section 6.3, INSTALLATION, have been followed.
3. Turn the main key switch to the OFF position.
4. Turn the POWER CONTROL to the fully counterclockwise position.
5. Set the SHUTTER control to the CLOSED position.

■ **CAUTION: Make sure the cooling water hoses are connected as described in Section 6.1, the water reservoir has been filled to the proper level with clean deionized water, and the incoming city water has been turned on.**

6. Connect the main power cable to the incoming AC power source. The phase sequence is important (see below).
7. Verify that the main power circuit breakers (CB1 and CB2) are in the ON position.
8. Turn on the main power key to the "power start" position. If this yields no response, interchange any two of the three phase incoming wires at the supply side of the ORC-1000 power cable and proceed.

■ **NOTE: With the main power key switch at the ON position, the EMISSION INDICATOR and the WATER FLOW interlock light should be illuminated. (The cooling pump should not be running.)**

9. Turn the key switch to the PUMP START position and hold momentarily until the pump starts. (Note that on the initial turn on, it may be necessary to turn the pump on and off several times in order to prime the water pump.) Release the key and it will return to the ON position. The WATER FLOW indicator light should now be OFF.

10. *Wait* five minutes.

11. Check the operation of the safety shutter by actuating the SHUTTER OPEN/CLOSE switch. (The shutter solenoid should be audible.) This must be done with the key switch in the ON position. Note that the time delay will inhibit this action for approximately 3–5 minutes.

12. Turn the key switch OFF to shut down the pump and power supply.

13. Check all the water fittings on the power supply, laser head, and Q-switch for leaks, and tighten as required.

14. If there are no leaks, the cooling system can be restarted by beginning at Step 5 above.

6.5 Normal System Start-up

1. Turn the key switch on to energize the water pump and oven heater. It will take approximately 5 minutes for the oven heater to warm up.

2. Turn the POWER CONTROL fully counterclockwise. Push the Q-switch main power control to the OFF position; this will force "cw" operation.

3. Turn the SHUTTER switch to the CLOSED position. If the SHUTTER switch is in the OPEN position the lamp cannot be energized.

4. The DOORS interlock indicator should be OFF.

5. Push the POWER SUPPLY ON button to turn on the power supply. The POWER SUPPLY OFF indicator should go off, and the POWER SUPPLY ON indicator should light.

■ **NOTE: The power supply will be shut down if the remote interlock circuit is opened while the power supply is running.**

6. The LAMP START indicator should gradually light in approximately 30 seconds indicating the capacitors are fully charged.

7. Press the LAMP START switch to fire the Krypton arc lamp. The LAMP START indicator should go off, and the lamp current meter should indicate approximately 15–20 A.

8. Set the current to the desired operating level by rotating the POWER CONTROL knob clockwise while observing the current meter.

■ **NOTE: Laser output is not optimized at this time; it may take approximately 20 minutes of system warm up time.**

9. Lasing can be initiated by setting the SHUTTER SWITCH to the OPEN position. (Note that the built-in time delay will inhibit the shutter opening upon initial turn on.)

10. Energize the Q-switch driver and select the desired modulation mode for Q-switch operation.

11. Under normal conditions, no alignment will be required to achieve the correct operating levels. If the output needs adjustment, refer to the following section.

6.6 Laser Alignment

The ORC-1000 should NOT require any alignment, even after shipping. Please do NOT start any alignment procedures without *first* contacting Clark-MXR.

■ **CAUTION: In order to avoid damaging the KTP crystal, initial adjustments should always be made in the cw-mode. Do not operate the ORC in the Q-switch mode if the crystal is misaligned.**

6.6.1 CW-mode Alignment

1. Allow at least 10 minutes warm-up prior to alignment.

2. The Q-switch driver must be turned **OFF**.

3. Adjust the current to approximately 25 Amps.

4. Maximize 532 nm output power by adjusting both the horizontal and vertical tilt controls of mirror M-4 and the horizontal tilt control only on the KTP mount. Proceed slowly and carefully to ensure that you have achieved operation on the maximum KTP peak. (Minor peaks can be observed on either side of the main peak.)

6.6.2 Q-switch Mode Alignment

■ **WARNING! When the laser is being Q-switched, the KTP crystal is vulnerable to damage if adjustments are made to reduce conversion of infrared to green light. For this reason, it is desirable to operate at relatively low peak power (high repetition rates and low lamp current). Additionally, do not make adjustments to the crystal temperature or crystal position while the laser is Q-switched. Make only small adjustments to the crystal angle while the RF is on, and do this carefully in order to maintain a high green conversion efficiency.**

1. Turn laser on to 25 amps. Allow laser to warm up for five (5) minutes.
2. Select INTERNAL and adjust for a nominal 5.0 kHz modulation on the Q-switch control panel.
3. Turn RF on.
4. Very carefully make minor adjustments to mirror M-4 horizontal and vertical tilt controls and to the horizontal tilt control only on the KTP mount to maximize the laser output. (This compensates for the slight variations between CW and Q-switched optimum alignment.) Do **NOT** translate the KTP crystal along the X or Y axis. The X and Y translation adjustments are factory set. Translating the KTP may void the Clark-MXR warranty.

7. Maintenance

7.1 Cooling system maintenance

1. Replace the deionization filter every six months or whenever the lamp is changed.

Except for replacement of the deionization filter, periodic maintenance is not required on the cooling system.

2. Check all hose clamps for tightness when the deionization filter is replaced.

Replacement of the cooling water will normally not be required unless it becomes contaminated.

■ **Ensure that only demineralized, distilled water is used in the cooling system. Otherwise, internal components of the laser head including the laser rod, KTP crystal, and the Q-switch can be damaged.**

3. Check water line strainers periodically.
4. Check filter on secondary water system, if used.

7.2 Power supply maintenance

Under normal operation, periodic maintenance is not required on the power supply.

7.3 Laser Head Maintenance

Normal maintenance on the laser head consists of replacing the arc lamp, the lamp/rod cavity reflectors and the YAG rod mounting/seal assemblies. Suggested replacement intervals are guidelines only. Actual useful life-times under which acceptable performance is achieved vary considerably, depending on operating parameters, water quality, and normal variations within parts.

7.3.1 Lamp replacement

■ **NOTE: Whenever the arc lamp is replaced, the YAG rod mounting/seal assemblies should be examined for signs of erosion induced by optical radiation from the arc lamp. Refer to section 7.3.7 for further information.**

1. De-energize the circuit breaker, then remove the main power plug from the wall outlet.

2. Remove the top cover of the **ORC-1000** laser head by removing the four screws securing it in place.

3. Remove the Nylon top plate and white protective blocks from the lamp housing, then measure across both terminals for ***zero*** volts.

■ **NOTE: It takes several minutes for the lamp voltage to "bleed" off the filter capacitors.**

4. Put on protective goggles to guard against possible lamp explosion.

■ **WARNING! Because of potential danger from an exploding lamp, protective goggles must be worn before removing the top from the lamp housing.**

5. Remove the eight socket cap screws from the lamp housing. Lift the top of the lamp housing slightly, (do not completely remove the top) and let the housing sit momentarily to enable any excess water to drain out.

6. Remove the top cover. The lamp is attached to the back of the top cover.

7. Remove two button-head screws from each of the lamp mount connectors.

8. Carefully note the orientation of the anode and cathode of the old lamp. The lamp base coded red is the anode and should be connected to the "+" power station lead. (The lamp anode tip is rounded while the cathode tip is pointed.)

9. Slide the lamp out either end.

■ **WARNING! Do not touch the envelope of the new lamp with your bare fingers. If this happens, clean the lamp with acetone or methanol before installing it. (This prevents skin oil from etching the lamp.)**

10. Check the orientation of the anode and cathode of the new lamp in the holders. Attach lamp mount connectors on each end. Make sure the lamp is centered within the holders, both lamp bases should be equally inserted into the spring end connectors. Screw two button-head screws into the mounts.

11. Replace the white protective blocks, the nylon protective top, and the securing screws. (Do **NOT** overtighten the 8 securing screws.)

12. Replace the deionizing filter on the back of the power supply.

13. "Defeat" the system interlock by pulling it into the up position.

14. Turn the pump on and verify that there are no water leaks. Bring the system up. Realignment should not be necessary.

15. Shut down the system and push the interlock defeat switch to the down position. Replace and secure the cover.

7.3.2 Laser rod replacement

1. Turn the system off, de-energize the breaker, and remove the plug from the wall.

2. Remove the top cover of the laser head (as previously described). The lamp will be attached to the top cover.

3. Carefully remove the glass shield located above the rod. Do **NOT** touch with your fingers.

4. Soak up as much water in the housing as possible to preclude any water from accidentally coming into contact with the rod faces.

Several variations of the cavity geometry exist. Depending on the particular geometry, it may be necessary to perform one or more of the following steps to gain access to the three socket cap screws securing the end rod seal assembly to the pump housing and to provide space for the rod seal assemblies when they are unscrewed from the lamp housing. It may be necessary to loosen the Q-switch assembly and/or remove the top of the shutter enclosure to remove the beam enclosure tubes from both ends of the housing.

5. If the Q-switch assembly is adjacent to the lamp housing, loosen the Q-switch assembly by removing the two 8-32 socket cap screws fixing the Q-switch mounting bracket to the laser base plate and gently work it upward to free the beam enclosure tube between the Q-switch assembly and the housing.

6. If the shutter housing is adjacent to the lamp housing, remove the top of the shutter enclosure by removing the four screws securing the top and pulling upward. Rotate the shutter blade in order to provide a space for the beam enclosure tube. Gently pull the beam enclosure tube into the shutter assembly.

7. With the beam enclosure tubes removed from both ends of the housing, remove the three 8-32 socket set screws securing the white Delrin rod seal assemblies on both ends of the housing.

8. Pull both rod seal assemblies gently away from the housing enough to clear the exposed rod mount assembly.
9. Unscrew the four socket cap screws securing the rod mount assembly to the housing.
10. Lift up the rod mount assembly.
11. Check that the housing is fully dry before installing the new rod.
12. Check that there is absolutely no water on the faces of the new YAG rod.
13. Reverse the above sequence to install the replacement assembly.
14. Plug the main power cable into the wall outlet and energize the water pump. Verify the absence of water leaks.
15. Verify the system performance. If not satisfactory, it may be necessary to perform a realignment of the laser at this time (see Section 6.4).

7.3.3 Replacement and alignment of the Q-switch

7.3.3.1 Q-switch replacement and cleaning

1. Turn the system off (laser and Q-switch).
2. Disconnect power to the power supply.
3. Disconnect the BNC cable (RF and overheat protection) from the Q-switch.
4. Remove the 6-32 socket head cap screws from the Q-switch mount. (Two or three screws are used to secure the Q-switch.)
5. Lift up the Q-switch and remove the water lines from the Q-switch.
6. Connect water lines to the new Q-switch and verify the absence of leaks by briefly energizing the pump.
7. Install the new Q-switch to the mount. (The Q-switch should sit square to the mount, with the top of the Q-switch flush with the top of the mount.)
8. Install the BNC cables (RF and overheat protection).
9. Turn the system back on. It will be necessary to perform a realignment at this point as described as follows.

7.3.3.2 Q-switch alignment

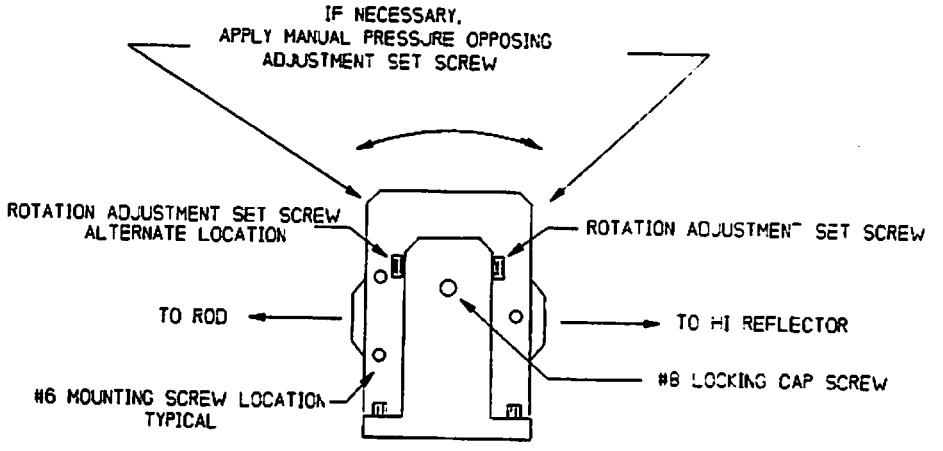
1. Ensure that the Q-switch Coaxial cables are attached.

2. Turn the laser on, set the current at approximately 25 amps, and allow it to warm up for ten minutes.

3. Verify that the RF drive power to the Q-switch is approximately 50–60 watts for the model 35s Q-switch, and approximately 75 watts for the model 11 Q-switch.

4. Set the Q-switch modulation control to OFF. (This will maintain a continuous RF drive, hence a continuous hold-off, by the Q-switch.)

Figure 7-1
Q-switch mounting plate



5. Loosen the Q-switch socket cap screw (on the side of the mounting plate) enough so that the Q-switch is free to rotate. A rotation adjustment set screw is used to rotate the Q-switch to obtain the maximum hold-off. An internal spring is used to hold the Q-switch rotation mechanism against the adjustment set screw. Because of the resistance offered by the beam enclosure tubes, it may be necessary to manually put pressure on the Q-switch mount to force it against the adjustment set screw.

6. Open the shutter and slowly increase the current until lasing is observed. This is "leakage" that the Q-switch cannot hold-off. Iterate between rotating the Q-switch and adjusting the lamp current until maximum "hold-off" is found. There will be two "dips" or angles corresponding to maximum hold-off. Either one may be used.

7. Secure the mount to prevent further rotation by tightening the cap screw on the side of the mounting plate. Observe the green leakage while tightening to ensure that the Q-switch remains at the optimum position.

8. Verify that the Q-switch hold-off is optimized. This can be achieved by operating the laser below 2 kHz, increasing the lamp current, and observing the pulse shape and pulse energy. The pulse shape should remain "clean" up to at least the 10 mJ level.

9. It may be necessary to fine tune the laser with mirror M4 and/or make *very slight* adjustments of the KTP horizontal tilt. Note that adjusting mirror M4 will have a slight effect on the Q-switch "hold-off".

10. If satisfactory performance is still not achieved, it may be necessary to repeat the above procedures starting at step four above. Very small rotation adjustments of the Q-switch have a very large effect on the ultimate "hold-off" characteristics of the laser.

11 Slight refinements of the laser operating characteristics can be accomplished by adjusting the RF drive power to the Q-switch. The operating efficiency is enhanced by reducing the RF drive power slightly while the ultimate "hold-off" and hence the maximum power is optimized by increasing the RF drive power. The power should not be increased beyond the 50–60 watt level for the model 35s and 70–80 watt level for the model 11.

7.3.4 KTP assembly replacement

The KTP crystal is factory positioned within a temperature controlled oven. If the KTP crystal or oven is suspect, contact Clark-MXR prior to disassembly or adjustment. Unauthorized adjustment or replacement of the KTP crystal or its associated mount or oven may void the Clark-MXR warranty.

7.3.5 Replacement of upper lamp reflector

The diffuse reflector surrounding the arc lamp has a nominal lifetime of 2000–4000 hours after which the decrease in reflection efficiency caused by waterborne contaminants and intense optical radiation may no longer be acceptable.

7.3.5.1 Remove lamp housing cover

1. Turn system off. De-energize the main power breaker. Allow several minutes for the power supply filter capacitors to discharge completely.

2. Remove the lid on the ORC-1000 by removing the four thumb screws securing it.

3. Remove the nylon high-voltage shield and the two protective white plastic blocks from the top of the lamp housing.

4. Verify zero volts across the lamp terminals, then remove the two high voltage lamp cables.

5. Remove the eight 8-32 socket cap screws that hold the top of the lamp housing to the lamp housing body.

6. Gently pull up on the upper housing and remove.

7.3.5.2 Remove the arc lamp

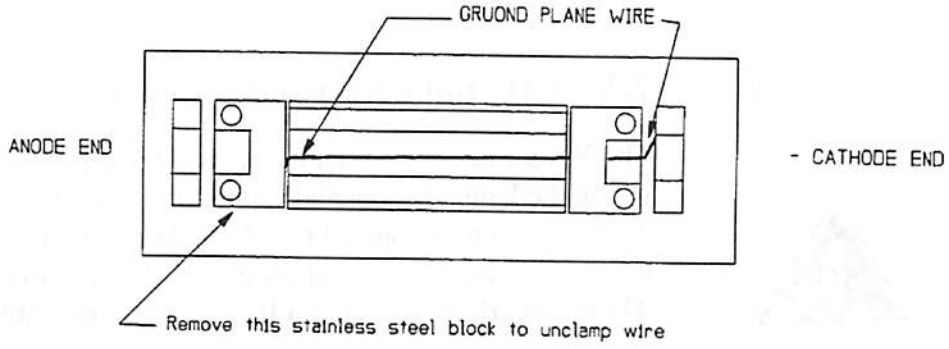
■ **CAUTION: Wear safety goggles at all times when exposed to or handling the arc lamp.**

1. Unscrew the stainless steel button head screws securing the lamp base clamps, then remove the clamps. The clamps incorporate an internal spring assembly that secures the lamp base.

7.3.5.3 Remove the old upper reflector

■ **NOTE: The lamp housing reflector is glued in place using a waterproof "RTV." It is necessary to pry the old housing off and clean the existing surface prior to regluing the new reflector in place. In addition, a ground plane wire runs along this reflector and needs to be carefully repositioned along the new reflector. This ground plane wire is "clamped" under the stainless block as shown in the following diagram.**

Figure 7-2
Schematic view of lamp housing with lamp removed.



1. Remove the stainless steel block on the anode end to unclamp the ground plane wire. This block is secured by two stainless steel socket cap screws.

2. Pry the old reflector loose by inserting a flat, thin screwdriver blade between the ceramic and the housing cover in the vicinity of the area exposed by removing the stainless steel block. Clean the black base block to accept the replacement reflector (remove the old adhesive).

3. Glue the new reflector in place using a good quality waterproof RTV adhesive. Allow to cure fully before reinstallation.

4. Reverse the above procedures to reassemble the top lamp/reflector housing. Center the lamp in the housing.

5. Do not overtighten the eight screws securing the housing top to the housing body. It is possible to crack the housing body by over-tightening.

■ **A realignment should NOT be necessary.**

7.3.6 Replacement of lower lamp reflector

The diffuse reflector surrounding the YAG rod has a nominal lifetime of 2000–4000 hours after which the decrease in reflection efficiency caused by waterborne contaminants and intense optical radiation may no longer be acceptable.

1. Remove and set aside the top lamp housing cover as described in section 7.3.5.1.
2. Remove the glass shield, the beam enclosure tubes and the two white Delrin rod seal assemblies included in the YAG rod assembly as described in section 7.3.2.
3. Lift up and replace the lower reflector while ensuring that the "O" ring is seated in the groove under the reflector.
4. Reverse the above sequence to reassemble the housing remembering to reinstall the glass filter between the lower and upper reflectors.
5. A minor adjustment of the end mirror M4 may be required to peak up the power.

7.3.7 YAG rod holder replacement

The YAG rod holder assemblies, made of white Delrin, seal the YAG rod inside the lamp housing and support the beam tubes. These assemblies are exposed to intense optical radiation. After a nominal 2000 hours, sufficient erosion can take place to allow a water leakage to occur.
Therefore, these seals must be replaced after 2000 hours.

The assemblies are secured to the outside of the lamp housing by three 8-32 socket cap screws. Once the socket cap screws are removed, the assemblies can be removed. Several variations of the cavity geometry exist. Depending on the particular geometry, it may be necessary to perform one or more of the following steps to gain access to the three socket cap screws securing the assemblies to the pump housing and to provide space for the removal of the assemblies. It may be necessary to loosen the Q-switch assembly and/or remove the top of the shutter enclosure to remove the beam enclosure tubes and thereby gain access to the socket cap screws.

1. Remove the beam enclosure tubes from the seal assemblies (see the following steps).

2. If the Q-switch assembly is adjacent to the lamp housing, loosen the Q-switch assembly by removing the two 8-32 socket cap screws fixing the Q-switch mounting bracket to the laser base plate and gently work it upward to free the beam enclosure tube between the Q-switch assembly and the housing.

3. If the shutter housing is adjacent to the lamp housing, remove the top of the shutter enclosure by removing the four screws securing the top and pull upward. Rotate the shutter blade in order to provide room for the beam enclosure tube. Gently pull the beam enclosure tube into the shutter assembly.

4. Remove the socket cap screws securing the assemblies to the lamp housing.

5. Gently pull the old assemblies out of the housing; pull straight out on the optical axis, then discard.

6. Insure that the "O" rings are installed in the replacement assemblies.

7. Gently install the replacement assemblies by pushing them in place. Rotating the assemblies as they are pushed in place will facilitate the installation.

8. Reverse the above steps to finish the installation.

9. A slight adjustment of mirror M4 may be required to peak the laser output.

8. Troubleshooting

The following guide is provided to assist the user in diagnosing problems which may occur. Any problem which cannot be corrected by the user should be referred to Clark-MXR, Inc. for prompt assistance.

8.1 Power Supply & Cooling Station

Problem	Solution
1. No emission/water flow indicators shown.	1. It indicates phases are not correct. Exchange any two wall power lines. This is only for initial installation. 2. Check phase detect circuit on A2 interlock board.
2. Emission indicator is on, but no "Water Flow" indicator.	1. Tap flow switch lightly, because the water flow switch is stuck on the upper position. 2. Check A2 interlock board. 3. Check the "Water Flow" Indicator lamp.
3. "Low Water" indicator is on.	1. Add DI water to water tank. 2. Check water level switch.
4. "Water Temperature" indicator is on.	1. DI water temperature is too high. No city water! 2. Over temperature sensor is open or has a broken wire. Check J9 on side panel. 3. Check A2 interlock board.

Problem	Solution
5. "Low Water Resistivity" indicator is on.	1. Let cooling system run. 2. Change DI Filter.
6. Cannot open/close shutter.	1. Check the shutter wires. 2. Check the shutter power supply on the A2 interlock board. 3. Check for shorting cap J4 on power supply rear panel. 4. Check the interlock wire on the shutter assembly.
7. Pump will not start with normal indicators functioning.	1. Check J8 behind the right side panel. 2. Check the CB2 pump circuit breaker. 3. Check the pump.
8. The "OFF" light is *not* on and "Doors" indicator is *ON*.	1. Check J3 (RIC). 2. Check J1 (lamp power connector).
9. The "Off" light is *not* on and "DOORS" indicator is *not* on.	1. Check the "OFF" indicator lamp. 2. Check the K1 main contactor. 3. Check the A2 interlock board.

Problem	Solution
10. Pump starts, but will *not* stay on.	1. Check the water flow path. 2. Check the water flow switch. 3. Check over temperature switch. 4. Check the A2 interlock board. 5. Check the water line strainers.
11. No action when power supply "on" is pushed.	1. Wait for the time delay cycle to be completed after starting the pump (30 seconds). 2. Check the "doors" interlock (RIC). 3. Check the K2 contactor. 4. Check A2 interlock board. 5. Check the "on" switch.
12. Lamp will *not* start.	1. Set shutter switch to the "closed" position. 2. Check the boost voltage across TB2—10(+) and 8(-) on A1 (SCR power block assembly). 3. Check the lamp wire connections on laser head. 4. Check for a broken lamp. 5. Check the DI water quality.
13. Lamp starts, but will *not* stay on.	1. Check the SCR control card, A3. 2. Check the A1 (power block) TB2. Are there 1 black; 2 orange and 3 red wire colors? 3. Check the SCR's on A1 (power block).

After the initial alignment, realignment should not be required.

Clark-MXR, Inc.

ORC Rod Seal Replacement

I. Introduction

This notice provides the guidance needed for the periodic maintenance of the YAG rod assembly in the ORC pump laser system.

Due to the radiation from the arc lamps, the rod holder seals degrade with time, which can potentially allow water to be deposited on the face of the laser rod. Once water contaminates the rod surfaces, the YAG rod needs to be cleaned and, in some cases, the water may damage the rod, requiring the rod to be re-polished. This process is both costly and time consuming. To avoid damage to the laser rod, the YAG-rod seals must be replaced every two (2) years or 3000 hours. Clark-MXR, Inc. has put together a long-term YAG-rod seal maintenance kit. The kit consists of:

Two (2) Delrin knobs
Two (2) ceramic washers
Six (6) nylon o-rings
Two (2) Viton o-rings (black)

II. Safety

Read the safety section of the CPA-2001 User Manual before proceeding with this set of instructions. Laser safety depends on your awareness that this instrument can cause serious bodily harm. Follow all safety precautions described throughout the manual to ensure that all personnel who come into contact with, operate, or maintain the laser are protected from accidental or unnecessary exposure to laser radiation.

III. YAG Rod Seal Replacement

The YAG rod seal assemblies, made of white Delrin, seal the YAG rod inside the lamp housing and support the beam tubes. These assemblies are exposed to intense optical radiation. After 3000 hours or 2 years (whichever comes first) sufficient degradation can take place to allow water leakage to occur.

A. Turn the system off, de-energize the breaker, and disconnect the power supply from the wall outlet.

B. Turn off water.

C. As indicated in Figure 2 (see accompanying diagram), the rod seal assemblies are secured to the outside of the lamp housing by three (3) 8-32 socket cap screws.

Once the socket cap screws are removed, the rod seal assemblies can be removed. Always remove them by turning them in a clockwise direction. Operate in dirt-free conditions. To avoid dust contamination of the optical elements, **do not** leave the ORC open for long periods of time.

1. Remove the M1 end mirror (high reflector in Figure 2).

2. Remove the Q-switch assembly.

3. Slide the long beam tube into the shutter housing.

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4. Remove the short beam tube.

5. Remove the lamp-housing cover. Inspect the lamp and the contacts for corrosion and charring. Set them aside carefully.

6. Remove the six (6) 8-32 screws holding the white Delrin knobs to the sides of the lamp housing.

7. Unscrew the white Delrin knobs. Always turn these knobs clockwise.

8. Remove the glass filter plate and inspect it for damage or tarnishing. Set it aside on lens tissue.

9. Remove the four (4) 4-40 screws holding the rod frame to the lamp housing.

10. Lift the rod frame straight out of the housing. Carefully inspect the rod surfaces for damage or water stains.

11. Loosen the two (2) 4-40 set screws in the bottom of the rod frame.

12. Unscrew the two cylindrical rod clamps. Do not use a wrench or damage these parts.

13. Set the frame in a clean area on a flat surface and unscrew the four (4) 4-40 screws in the sides on the rod frame.

14. Lift the rod and the rectangular rod clamps straight out of the frame.

15. Re-inspect the rod surfaces for damage and water stains.

16. Clean the rod surfaces if necessary. Use methanol or acetone and clean lens tissue. Do not touch the rod surface with any tool or fingers. Wearing latex gloves or finger cots is highly recommended.

17. Carefully slide the old o-rings off the ends of the rod. Discard the old o-rings. Do not re-use o-rings after the rod clamps have been loosened.

Cleaning procedure:

1. Completely remove all excess dirt, dust or other contaminates on the rod by flushing it with methanol.

2. Apply the drip and drag method to the faces of the rod with lens tissue and methanol.

3. Inspect the surface. If not clean, repeat steps 1 and 2.

4. Swirl black O-rings in warm, soapy water for two (2) minutes, rinse in warm clear water and air dry for 20 minutes. **NEVER use acetone or methanol.**

18. Carefully put new, black Viton o-rings onto the rod. A good method for doing this is to slide one onto a straw and then carefully insert the rod into the straw. Next, slide the o-

ring on the end of the rod. Repeat this procedure with the other o-ring on the other end of the rod. Do not place the two o-rings on the same end of the rod.

19. Re-inspect the rod surfaces and clean if necessary.

20. There should be pencil marks on the rod 0.1 inch (2.54 mm) from each end. If they have worn off then make new marks there. These marks are needed to properly secure the rod in the frame.

21. Place the rod and the rectangular clamps into the frame. Slide the rectangular clamps up to each o-ring.

22. Carefully adjust the rod and clamps so that the pencil marks are just visible on the inner side of each clamp.

23. Screw in the cylindrical rod clamps. Do not strip the threads. Tighten with fingers. Do not use a wrench.

24. Screw the four (4) 4-40 screws into the side of the rod frame.

25. Tighten the two (2) 4-40 set screws in the bottom of the rod frame.

26. Re-inspect the rod surfaces for dust. If necessary, carefully blow dust out of the assembly with dry nitrogen. If necessary, take the assembly apart to re-clean the rod.

27. Place the rod frame into the lamp housing and fasten it with 4-40 screws. Tighten with fingers.

28. Replace the ceramic washers.

29. Screw the new rod knobs into the lamp housing. Turn in clockwise direction only. Screw in the six (6) 8-32 screws.

30. Clean the glass filter plate and place it onto the lower ceramic reflector. Do not touch the filter plate with fingers. Replace the filter plate if it is cracked or tarnished. Do not run laser without the filter plate!

31. Re-inspect the lamp and then close the lamp housing. Replace the lamp contacts if there is evidence of corrosion.

32. Secure the lamp housing cover by tightening the eight (8) 8-32 screws in a "boot-lace" pattern (See Figure 1). Use several iteration of the "boot-lace" pattern until all the screws are tight. Tighten firmly using a ball driver. **Do not use excessive torque.** Do not force the screws. Replace the screws or re-tap the holes if necessary.

33. Slide the long beam tube back into place.

34. Replace the Q-switch assembly and the M1 end mirror.

Clark-MXR, Inc.

Figure 1
"Boot-lace"pattern.

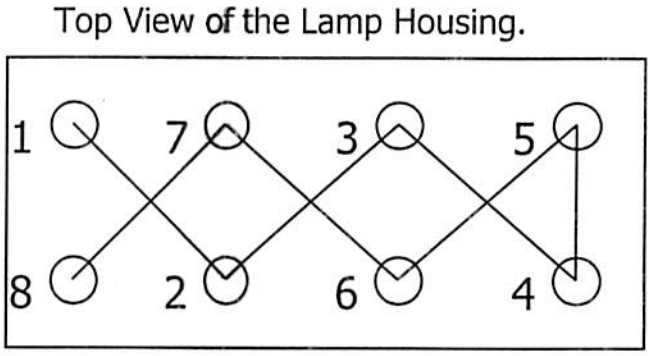
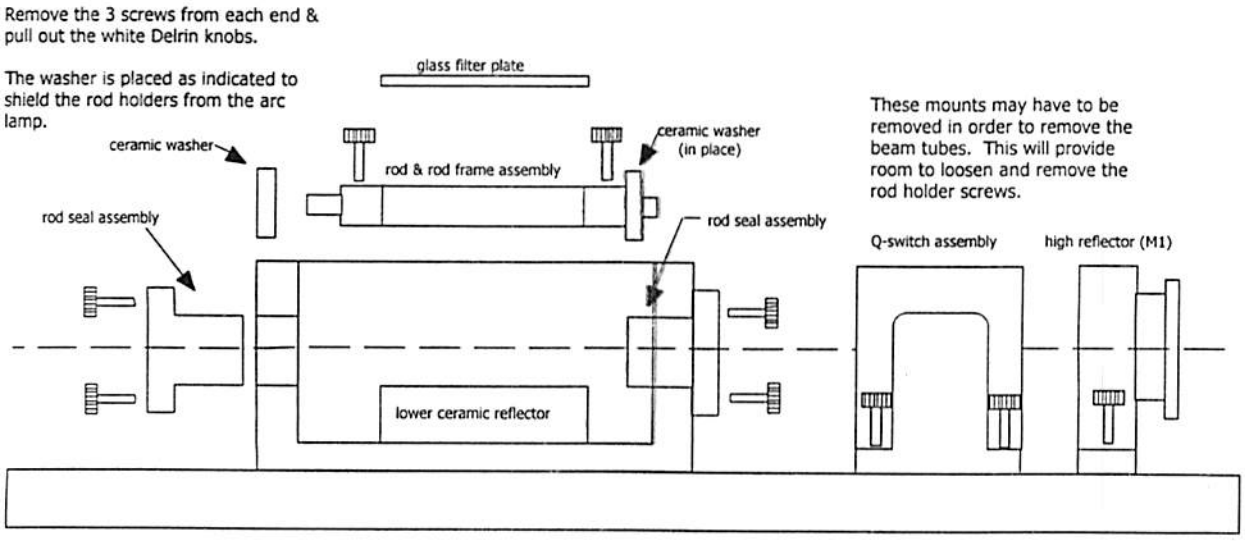


Figure 2
Schematic diagram
of ORC rod assembly.



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