Manual No. 990-500
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UNITEK MIYACHI LASERS
Laser Solutions for Advanced Manufacturing

OPERATION, MAINTENANCE AND SERVICE MANUAL

FOR THE

LW51, LW52 & LW100 COMPACT Nd:YAG LASER

Version 2.1

COMPLIES WITH 21 CFR 1040.10

Printed in the United States of America

Revision Record

Revision	EO	Date	Basis of Revision
A	None	3/93	Original publication.
B	16675	6/96	Format revised and quality upgraded. Service information (990-501) incorporated. Also incorporated information relative to remote interlock connector and I/O signal interface.
C	16775	10/96	1. Correct and add safety note to the Z axis adjustment procedure. 2. Correct receive/transmit cable pin assignments in Appendix C.
D	16906	3/97	Add steam-distilled water applicability. Moderate changes to water draining procedures. Serial number label relocation to inside front door.
E	17293	3/98	Add Addendum 995-500, Rev. B.
F	18264	5/00	Updated Appendix A, technical specifications
G	17912	6/00	1. Incorporate Addendum 995-500, Rev C. 2. Updated Maximum Allowable Input Energy/Power Per Fiber. 3. Updated Chapter 4, User Maintenance. 4. Updated Parts List.

CDRH COMPLIANCE STATEMENT

The Unitek Miyachi Corporation LW51/LW52/LW100 Nd:YAG Laser is certified to be fully compliant with all applicable standards and regulations as set forth by the United States of America's Health and Human Services (HHS), Food and Drug Administration (FDA), Center for Devices and Radiological Health (CDRH), standard 21 CFR 1040.10 for Class IV laser devices. Please refer to CDRH Accession #9311157-03.

FOREWORD

The purpose of this manual is to supply operating, maintenance and service personnel with the information needed to properly and safely operate, maintain and service the Unitek Miyachi Corporation's LW51/LW52/LW100 Nd:YAG laser systems.

We have made every effort to ensure that the information in this manual is accurate and adequate.

IMPORTANT: Please also read the supplied Laser Safety Manual. Follow the instructions in this manual and the Laser Safety Manual carefully for your safety and protection of the equipment

.

Should questions arise, or if you have suggestions for improvement of this manual, please contact:

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CAUTION

This instruction manual describes how to operate, maintain and service the LW51/LW52/LW100 Laser, and provides instructions relating to its SAFE use. Procedures described in this manual MUST be performed as detailed by QUALIFIED and TRAINED personnel.

For SAFETY, and to effectively take advantage of the full capabilities of the LW51/LW52/LW100 Laser, please read this instruction manual and the Laser Safety Manual thoroughly before attempting to use the LW51/LW52/LW100 Laser.

Procedures other than those described in this manual or not performed as prescribed in this manual, may expose personnel to electrical hazards and/or laser radiation hazards.

After reading this manual, retain it for future reference when any questions arise regarding the proper and SAFE operation of the LW51/LW52/LW100 Laser.

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CHAPTER 1
PRECAUTIONS

Prior To Using The LW51/LW52/LW100 Laser

NOTE: Please have all personnel who will be working with the LW51/LW52/LW100 Laser read this manual thoroughly before attempting to operate or maintain the laser.

WARNING: Operating, adjusting, maintaining or servicing the LW51/LW52/LW100 Laser in a manner other than described in this manual may expose personnel to laser radiation or electrical hazards.

Installation Site And Electrical Supply

- Install the LW51/LW52/LW100 laser securely on a level floor.
- Use as a power source 208 VAC or 230 VAC, 50 Hz/60Hz, 3-phase, with a minimum of 1.5 kVA capacity.
- Install good grounding.

CAUTION: When power is turned on, a surge current may be generated. Use a circuit breaker that has a rating of 10 amps or greater.

Handling The Fiber Optic Cables

Optical fibers may be damaged and become unusable when they are bent in excess of their minimum bend radius or subjected to the shock of a strong impact (refer to the listing below):

Minimum Bend Radius for Specified Core Diameter

Core Diameter (mm)	Minimum Bend Radius (mm)
0.2	100
0.3	100
0.4	100
0.6	150
0.8	200
1.0	250

Handling The Fiber Optic Cables (continued)

The LW51/LW52/LW100 Laser uses either SI or GI core fibers. The maximum input energy/power allowed per fiber is dependent upon core type and core diameter. Input energy/power values in excess of those listed below may cause damage to the fibers. Length specifications per fiber are: 5m, 10m, or 15m.

Maximum Allowable Input Energy/Power Per Fiber

Core Diameter (mm)	Single Fiber Output		Dual Fiber Output	
	Energy (J)	Power (W)	Energy (J)	Power (W)
0.2*	20	25	10	12
0.3*	20	40	10	20
0.4	25	50	12	25
0.6	50**	50/100**	25/50**	25/50**
0.8	50**	50/100**	25/50**	25/50**
1.0	50**	50/100**	25/50**	25/50**

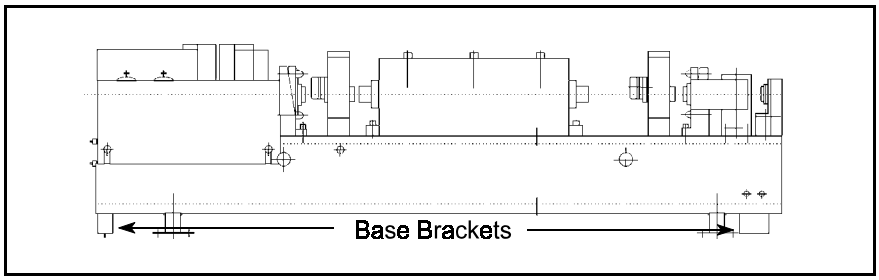
NOTES:

* The 0.2 and 0.3 mm fibers are not recommended for use in the LW100.

** Although the fibers can handle more energy and power, the values given are the maximums for the equipment. Where two numbers are given, the first one is the maximum for the LW51 and LW52; the second number is the maximum for the LW100.

Dirty or dusty end surfaces on the optical fibers will cause damage to the fibers. The damaged surfaces of the fibers can also cause contamination to adjacent lenses. Do not remove the rubber fiber end caps until it is necessary.

Removal Of Laser Head Base Brackets



Laser Head Base Brackets

To fasten the base of the laser head during transportation, hold down brackets are attached as shown in the illustration. Remove these brackets when installing the LW51/LW52/LW100 laser. Retain them for future use when transporting or relocating the laser. Use of these brackets will help to prevent misalignment and damage to the laser oscillator caused by severe vibrations.

Operation In Cold Weather

When the temperature drops below 0°C, the water inside the LW51/LW52/LW100 laser's cooling system can freeze and may damage the laser. In cold regions, take special care to keep the ambient temperature where the laser is located above 0°C. If the temperature will drop below 0°C, perform the procedure detailed in **Chapter 4**, *Coolant Water Draining: For Long Term Storage; When Transporting the Laser; or When Temperature Drops Below 0°C.*

When it is cold, a rapid temperature change caused by a heating system, for example, may cause dew condensation on the end faces of the Nd:YAG rod and on other optical surfaces. This will attract dust and can cause damage to the surfaces of the optics. **CAUTION :**Avoid rapid temperature changes.

WARNING

Be sure to turn off high voltage and the positioning He-Ne laser when checking the rod end and/or the mirror. If you do not turn them off, you are exposed to the possibility of electric shock or blinding.

If dew condensation is suspected, check the end surfaces of the laser rod and the optics. Inspect the rod's end surfaces by placing white paper on one end and using a dental mirror on the other end. You will need to remove the beam path covers on both ends of the laser cavity to do this inspection.

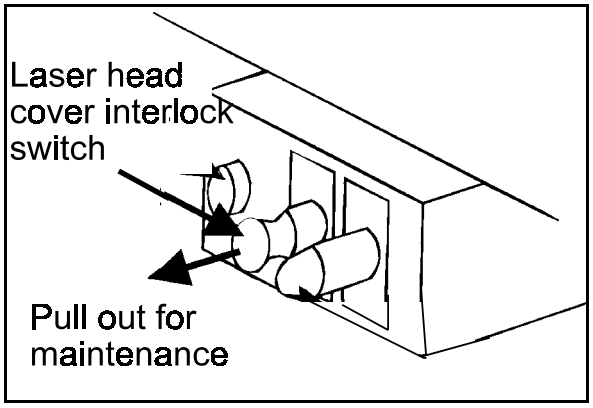
Operating the Laser

When operating the laser unit, always wear protective goggles having an optical density of at least 6 at a wavelength of 1064 nanometers.

Maintaining the Laser

Observe the following precautions when performing maintenance on the laser:

- Turn off power to the laser unit. If high voltage had been ON, wait at least 5 minutes for the capacitor to fully discharge before proceeding with maintenance.
- When turning on high voltage during maintenance, set the laser head cover interlock switch to the maintenance mode.
- When the high voltage is ON, YAG laser oscillation is enabled and you may risk exposure to the laser beam. Always wear safety goggles having an optical density of at least 6 at a wavelength of 1064 nanometers.



Laser Power Switch

Disconnection or Breakage of Optical Fibers

When optical fibers become disconnected or broken, they present a serious radiation hazard. High levels of visible and infrared laser energy can radiate from a damaged or disconnected fiber optic cable.

Although fiber optic cables and output focus heads can be equipped with safety interlocks that will shut down laser operation if the cable is disconnected at the focus head, there is no such protection that will shut down laser operation if the cable breaks.

The fiber optic cables that transport laser energy from the laser power supply to the output focus head must be routed and protected such that they will not be damaged by moving machinery. You must provide this protection. Avoid running the fiber optic cables across foot paths or in an area where fork lifts, hand carts, or any other mobile equipment could run over them. Also, be sure that the cables are not bent tighter than their minimum bending radius.

Software Selection of Laser Start/Stop

If you select laser start with the software, you must also select laser stop with the software. If the laser is not turned off at the end of the welding cycle, adjacent personnel could be exposed to radiation.

Other Precautions

Laser Safety Officer Responsibilities. The Laser Safety Officer (LSO) must provide personnel with sufficient training so that personnel can operate, maintain and service the laser safely. The LSO must take charge of the key to the key switch to ensure that the laser is operated only by qualified and authorized personnel.

Caution and Warning Indications. Make sure proper warning signs and warning lights are installed in and around the laser installation. Also, make sure access doors to the laser area are interlocked to the laser. Locate danger labels and other warning/caution notices on the door of the location where this laser will be installed to indicate that a laser will be used in this location.

Cleanliness. The exterior of the laser should be kept clean. Use a dry cloth or, if heavily soiled, use a cloth moistened with a mild detergent or alcohol. Do not use paint thinner or acetone.

Design Integrity. Do not modify the laser without prior written approval from Unitek Miyachi Corporation.

Maintenance. Before performing any maintenance on the laser, please read **Chapter 4**, *User Maintenance*, thoroughly.

CHAPTER 2
SYSTEM DESCRIPTION

SECTION 1: SYSTEM FEATURES

The LW51, LW52 and LW100 Nd:YAG Lasers are designed to weld small, precision parts. The lasers have the following features:

- Up to 16 welding schedules can be set (programmed) and stored in memory, including pulse shaping, allowing varying work pieces to be processed under optimum conditions.
- The power supply for the laser head and cooler are assembled as one unit, minimizing space requirements.
- Maintenance tasks, such as filter replacement, can be performed easily from the front of the laser.
- The operator can easily operate the laser unit and enter welding parameters through the liquid crystal display.
- The laser unit can be easily automated.
- Weld quality can be accurately controlled by monitoring both emitted energy in joules and average power in watts, as indicated by the power monitor.
- Laser output can be divided into up to four branches by means of optical fibers.

SECTION 2: SYSTEM COMPONENTS

Front, Top and Sides

1 MAIN POWER circuit breaker: Turns the laser unit power supply ON and OFF.

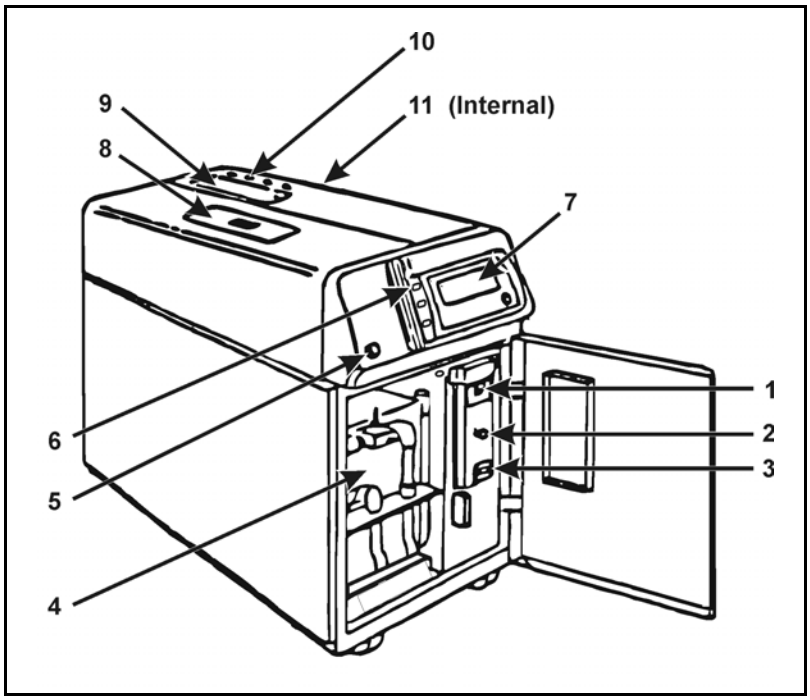
2 CONTROL Key Switch: The laser unit can be started when this switch is turned ON.

3 TEMP. CONT. temperature controller: Used to set the temperature alarm and the temperature of the deionized water. (See *Temperature Controller Detail* later in this section.)

4 Water cooling and filtration system (cooler).

5 EMERGENCY STOP emergency stop switch: Push in an emergency to turn off the high voltage and the cooler.

Front, Top and Sides (continued)



Front, Top, and Side Components

6 LED indicators which light when:

- POWER: Power is supplied.
- HIGH VOLTAGE: High voltage is supplied.
- READY: Capacitor is charged to the set voltage.

The LED indicators below light when the corresponding shutter is open:

- MAIN SHUTTER
- SHUTTER 1
- SHUTTER 2
- SHUTTER 3
- SHUTTER 4

7 Program Unit: Use to set and indicate program data. See *Program Unit Detail* later in this chapter.

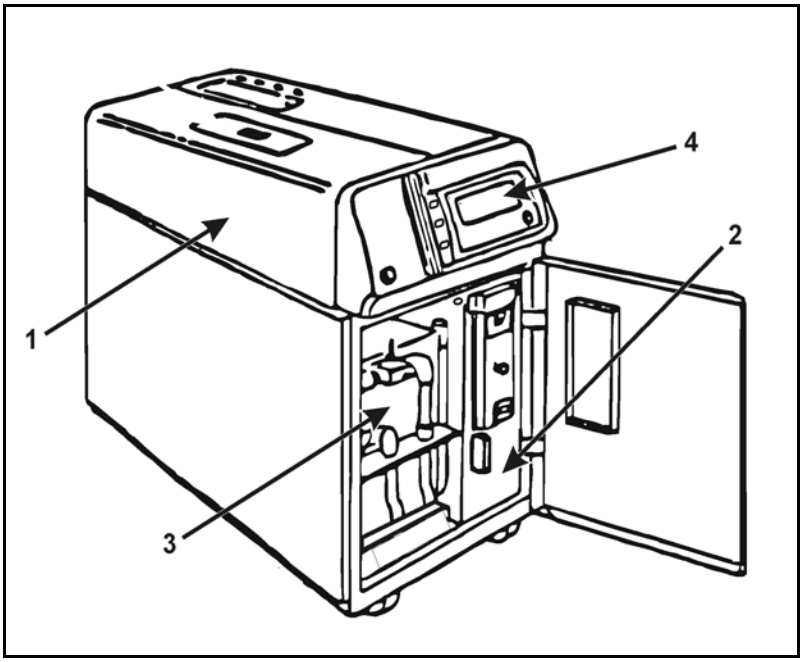
8 Lamp cover: Remove to replace the flash lamp.

9 Optical fiber access door: open to access the optical fiber.

10 Laser beam input unit: Routes the laser beam output from the laser head to the optical fiber.

11 Optical fiber outlet: Opening for the optical fiber.

Major Components



MajorComponents

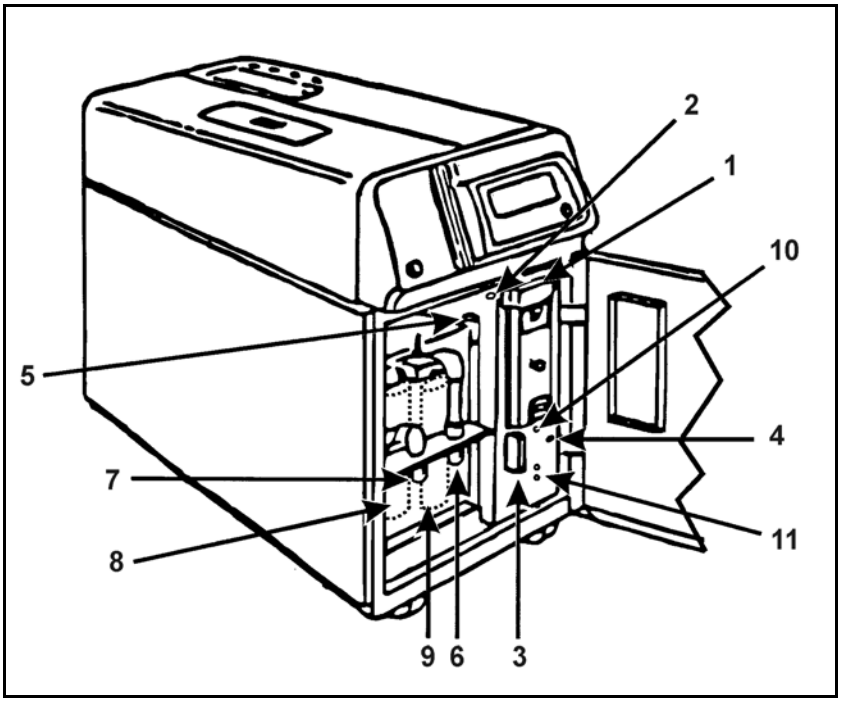
1 Laser head: Receives light from the flash lamp and outputs a laser beam from the YAG rod. Outputs an He-Ne laser beam for positioning. Splits the laser beam into the required number of optical fiber branches. Refer to *Laser Head* later in this section for part detail.

2 Laser power supply: Turns on the flash lamp. Measures laser power. Controls the cooler. Controls input and output.

3 Cooler: Cools the YAG rod and flash lamp with deionized water. The deionized water is cooled with the city water supply or other cooling water supply.

4 Program unit: Operates the laser unit. Up to 16 welding schedules can be set and stored in memory for the laser output. Indicates the power monitor values. Sets upper and lower limit values in the power monitor. Indicates the shot count. Refer to *Program Unit Detail* later in this section.

Front With Door Open



Front With Door Open

1 Power input terminals: Input terminals for the 230 VAC, 3-phase power.

2 Grounding terminal: Terminal for connecting the grounding wire.

3 External I/O connector: Connector for routing signals to and from external equipment (refer to Section 3 in this chapter, *External I/O Signals).*

4 Laser power analog output connector: BNC connector for outputting the laser power waveform.

5 Drain pipe: Drain for the deionized water.

6 Coolant inlet: Inlet for the cooling water supply.

7 Coolant outlet: Outlet for the cooling water supply.

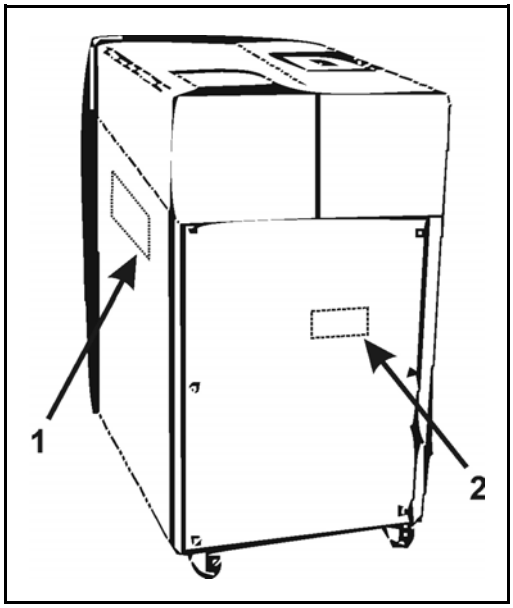
8 Ion exchange resin (deionizer): Compound for enhancing water purity.

9 Water filter: Separates impurities from the deionized water.

10 Remote interlock connector: Opening the remote interlock signal line causes the main (resonator) shutter to close and schedule processing to stop. Closing the remote interlock signal line returns the laser to the ready mode and turns the HV back ON.

11 RS-485 external communication ports (2).

Rear of Housing



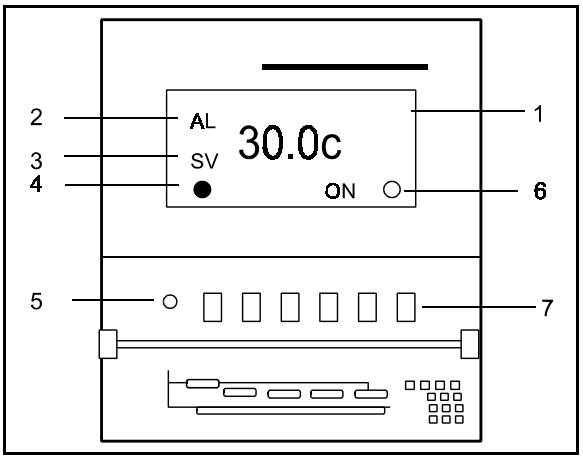
Rear of Housing

1 Fan motor: Exhausts warm air from the laser to cool the interior.

2 Fuse: 20 amp fuse for high voltage circuit protection.

Temperature Controller Detail

1 Display: In default operation, displays the present deionized water temperature. Other values are selected for display with the Setting Mode Selection key (5).



TEMPCONT.PCX

Temperature Controller Detail

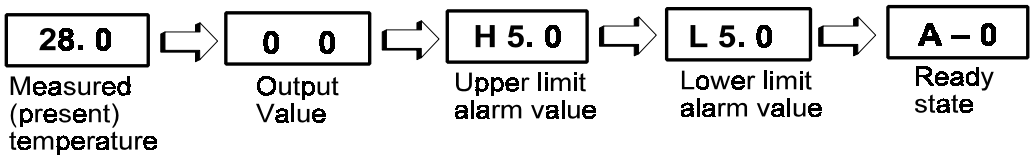
2 Alarm output indicator: This indicator flashes if the measured temperature exceeds the upper or lower alarm limit value, as set with the Setting Mode Selection key (5). If the temperature:

- Exceeds the upper alarm limit value (H), HIGH TEMP OF COOLANT is detected.
- Drops below the lower limit alarm value (L), LOW TEMP OF COOLANT is detected and the heater is turned on automatically.

3 Setting temperature indicator: This LED flashes SV if the indicated temperature equals the temperature set with the Set Value Input keys (7). Input the set temperature when this indicator is flashing.

4 Temperature indication change key: Either indicated present temperature or set temperature is displayed each time this key is pressed.

5 Setting mode selection key: This key scrolls through five values or states that are displayed in the following sequence:



NOTES: The upper and lower limit alarm values are indicated by the amount that they differ from the set temperature.

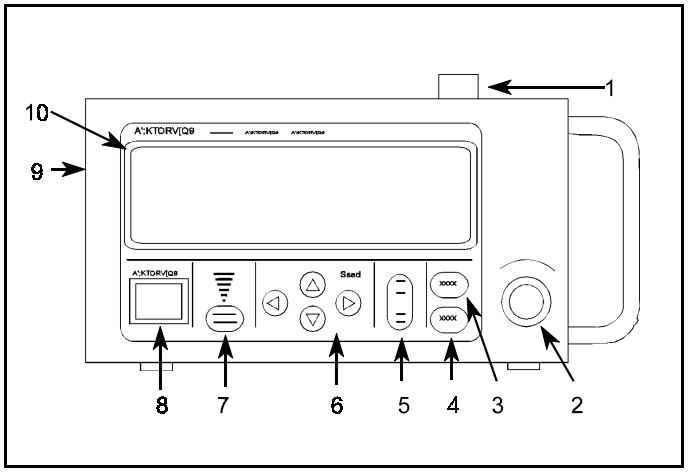
The factory default settings are:

- Temperature: 30.0°C (86°F)
- Upper limit alarm value (H): 5.0°C (41°F) above set temperature
- Lower limit alarm value (L): 5.0°C (41°F) below set temperature

6 Control output indicator: This indicator turns off when the water supply is turned OFF.

7 Set value input keys: Set temperature and upper/lower limit alarm values with these keys.

Program Unit Detail



Program Unit

1 Line cable connector: Connects the laser unit to the program unit.

2 EMERGENCY STOP switch: Push for an emergency. High voltage will be turned OFF and the internal water pump will stop

3 MENU selection key: The menu screen appears when this key is pressed.

4 ENTER key: Pressing this key completes data entry following the keying of a data change.

5 ± key: Changes a set value. + is ON and - is OFF.

6 CURSOR keys: These keys move the cursor in the direction indicated by the arrows.

7 TROUBLE RESET key: Pressing this key resets the trouble indications following rectification of the trouble.

8 LASER START key: When the high voltage is turned ON and this key is pressed, the laser beam is output.

9 Screen brightness adjustment: Turn this adjustment with a small-blade screwdriver to adjust the brightness of the liquid crystal display.

10 Liquid crystal display for displaying program data.

Laser Head

The following callouts refer to the illustration labeled **Laser Head Detail** on the next page.

1 Laser beam input unit: Converges the laser beam from the laser head to the input of up to four optical fibers.

2 Power adjustment unit: When two or more optical fiber branches are used, this unit will adjust their outputs to equal power levels.

3 He-Ne laser oscillator: Generates a helium-neon laser beam. This visible beam is used as a guide to adjust oscillation, adjust the optical axis, and position the welding point.

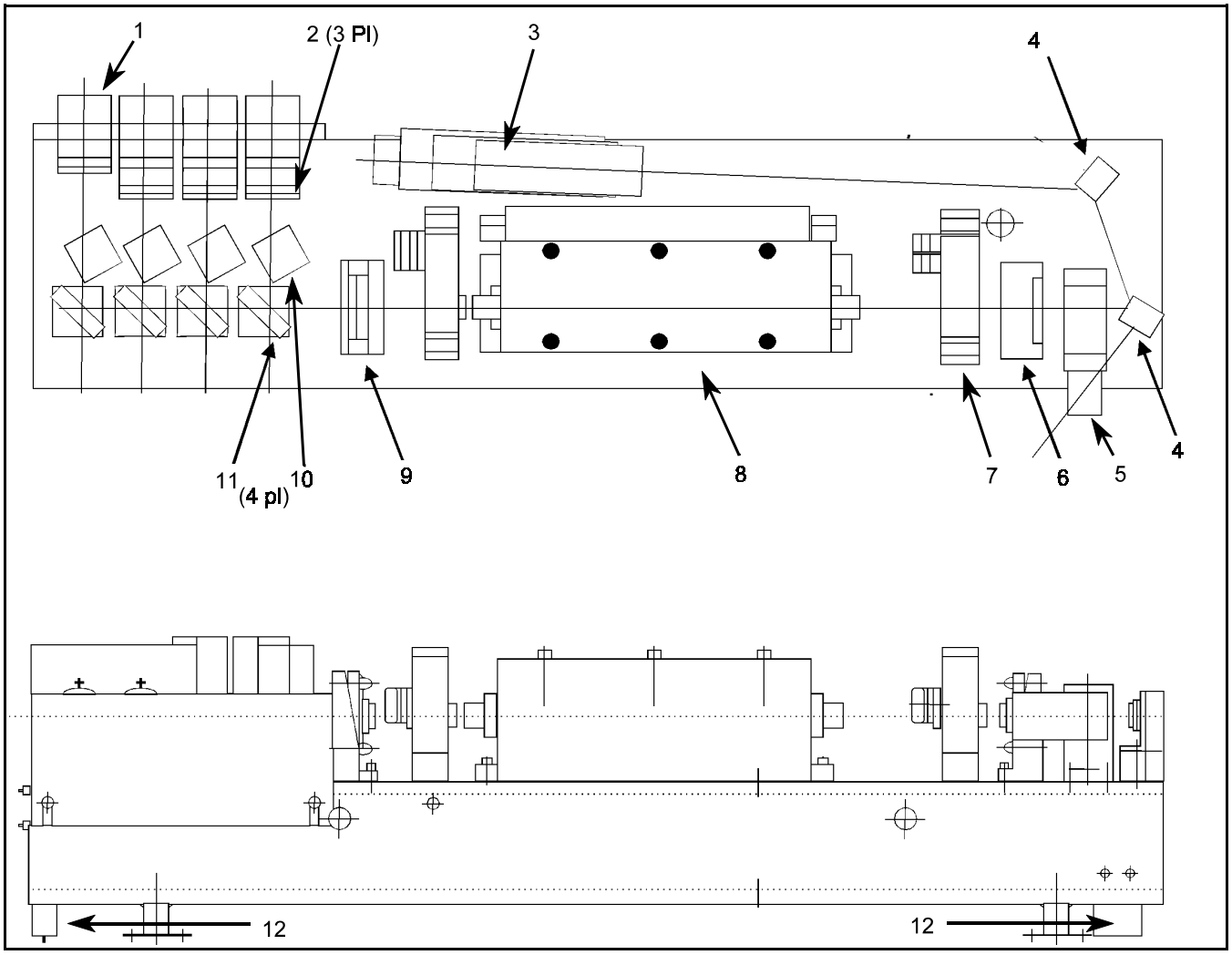
4 He-Ne laser beam reflecting mirrors: These two mirrors are used to adjust the He-Ne laser beam so that it passes through the center of the YAG laser beam path.

5 Power monitor unit: Measures the power of the laser beam.

6 M3 resonator mirror : The M3 resonator mirror, together with the M4 resonator mirror (9), amplifies the light excited in the laser cavity and outputs the light as a laser beam.

7 Resonator (main) shutter: When this shutter is closed, it prevents the laser from being oscillated, even if the flash lamp is turned on.

8 Laser cavity: This cavity houses the flash lamp and the YAG rod. The flash lamp excites the YAG rod to output laser light.



Laser Head Detail

9 M4 resonator mirror : The M4 resonator mirror, together with the M3 resonator mirror (6), amplifies the light excited in the laser cavity and outputs the light as a laser beam.

10 Branch shutters: Opening and closing these shutters selects the laser beam output units for output of the laser beam. **CAUTION:** When blocking the laser beam with a branch shutter, set the output below 10 joules per shot and the average output below 2 watts (1 shot in 5 seconds).

11 Branch mirrors: These mirrors split the laser beam into the required number of optical fiber branches and reflect them toward the laser beam input unit (1).

12 Base brackets: These brackets are used to secure the laser head during transportation of the laser unit. Remove them for laser unit operation.

SECTION 3: INPUT/OUTPUT SIGNALS

Input Signals

Input Signal Interface Methods. Input signals from external equipment may be connected to the laser unit through either dry contacts or transistors. Examples of both interfaces are shown in the schematic diagrams on the following pages.

Pin 15, +24 V output. When inputting signals through contacts, short this pin to Pin 16.

Pin 16, +12 V to +30 V input. If a transistor input is applied and a power supply of +12 to +30 VDC is available at the input device side, connect the positive (+) line of the power supply to Pin 16. Connect the common (0V) line of the power supply to Pin 17 or 45.

Pins 17 and 45, 0V (COM). Common input signal line.

Pin 29, Trouble Reset. After the trouble is rectified, this input signal resets the laser unit to the normal state.

Pin 30, Internal/External Control. External input signals are effective only when Pin 30 is connected to the COM bus line. With Pin 30 open, only internal control signals are effective.

Pin 31, HV-ON. When the COM to HV-ON circuit is closed, high voltage is turned ON in the laser unit.

Pin 32, HV-OFF. When the COM to HV-OFF circuit is closed, the high voltage is turned OFF in the laser unit even if the COM to HV-ON circuit remains closed.

Pin 33, Resonator (Main) Shutter. When the COM to Resonator Shutter circuit is closed, the resonator shutter is opened and the YAG laser can be excited.

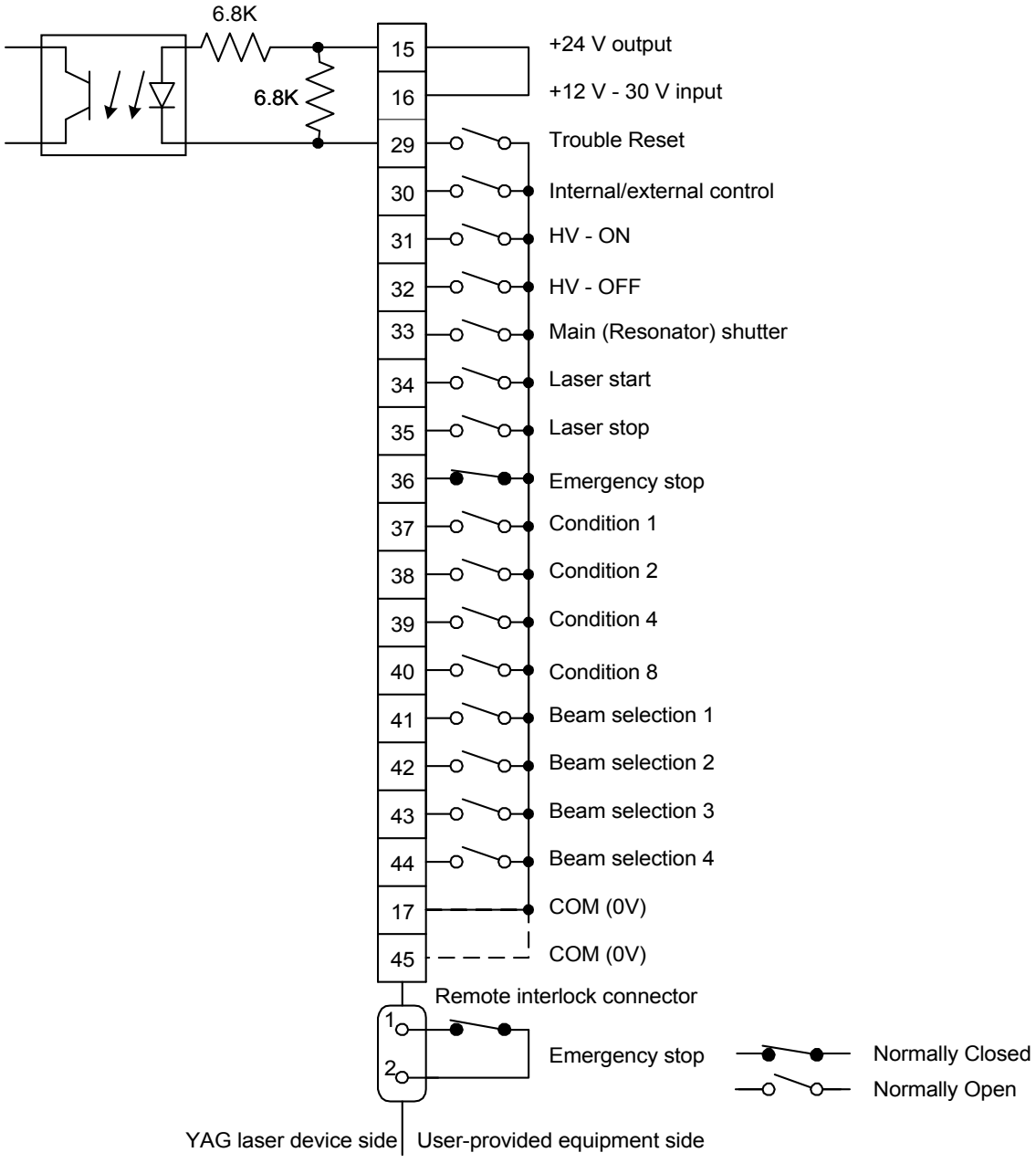
Pin 34, Laser Start. When the COM to Laser Start circuit is closed, the laser beam is output. The Laser Start signal must be applied for at least 40 milliseconds.

You can also select Laser start (and stop) with the software. The software selection sets Pin 30 to ground (External Start enabled). The External I/O Laser Start signal line will then accept the Laser Start signal and start the welding cycle. **WARNING:** You must also supply a Laser Stop signal because, if you do not turn the laser off at the end of the welding cycle, adjacent personnel could be exposed to radiation.

Pin 35, Laser Stop. When the COM to Laser Stop circuit is closed and the laser is being oscillated repeatedly (repeat, PPS mode), laser oscillation is stopped.

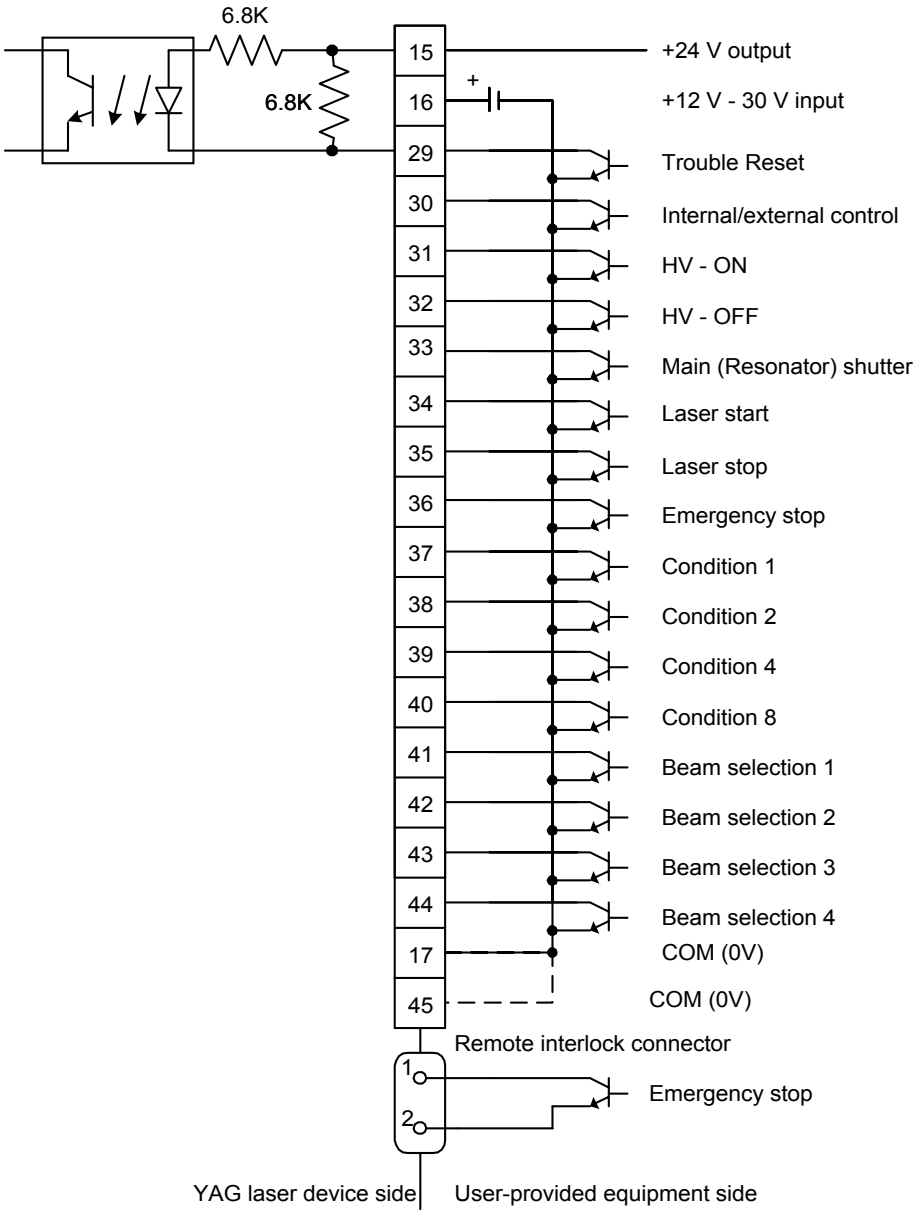
Pin 36, Emergency Stop. The COM to Emergency Stop circuit is normally closed. When the circuit is opened, the high voltage circuit is opened and laser oscillation is stopped. The cooler is also stopped. The emergency stop is applied regardless of the state of Pin 30 (Internal/ External control).

EXT-I/O SQUARE TYPE CONNECTOR



Contact Inputs

EXT-I/O SQUARE TYPE CONNECTOR



Transistor Inputs

Input Signals (continued)

Pins 37 - 40, Conditions 1,2,4,and 8. These signals form a BCD condition that selects a schedule from 0 to 15. The selection conditions are as listed in the following table, where the bullet represents the COM to Condition circuit closed and the blank represents the COM to Condition circuit open.

Schedule Selection Table

Selected Schedule	Input Condition			
	Condition 1	Condition 2	Condition 4	Condition 8
0				
1	●			
2		●		
3	●	●		
4			●	
5	●		●	
6		●	●	
7	●	●	●	
8				●
9	●			●
10		●		●
11	●	●		●
12			●	●
13	●		●	●
14		●	●	●
15	●	●	●	●

Pins 41-44, Beam Selection Signals 1 Through 4. When a COM to beam selection signal circuit is closed, the associated laser beam input unit is selected and the laser beam can be emitted from that laser beam input unit. For example, when the COM to beam selection signal 2 circuit is closed (pin 42), laser beam input unit 2 is selected, and the laser beam will be emitted from laser beam input unit 2.

Remote Interlock Connector. Opening the remote interlock signal line causes the resonator (main) shutter to close and the processing of the schedule to stop. Closing the remote interlock line returns the laser to the ready mode.

Output Signals

Output signal examples are shown schematically on the following page. Maximum output ratings are 30 volts and 20 milliamps.

Pins 1 - 2, Ready. When the capacitor is charged to the set voltage and the deionized water temperature is within the set range, this circuit outputs the READY signal.

Pins 3 - 4, High Voltage ON. When high voltage is ON in the laser unit, this circuit outputs the HV-ON signal.

Pins 5 - 6, Trouble. When the laser unit malfunctions, it keeps this circuit closed to output the TROUBLE signal until the TROUBLE RESET signal is input.

Pins 7 - 8, Finish. The END signal is output for 40 milliseconds after one shot of laser oscillation.

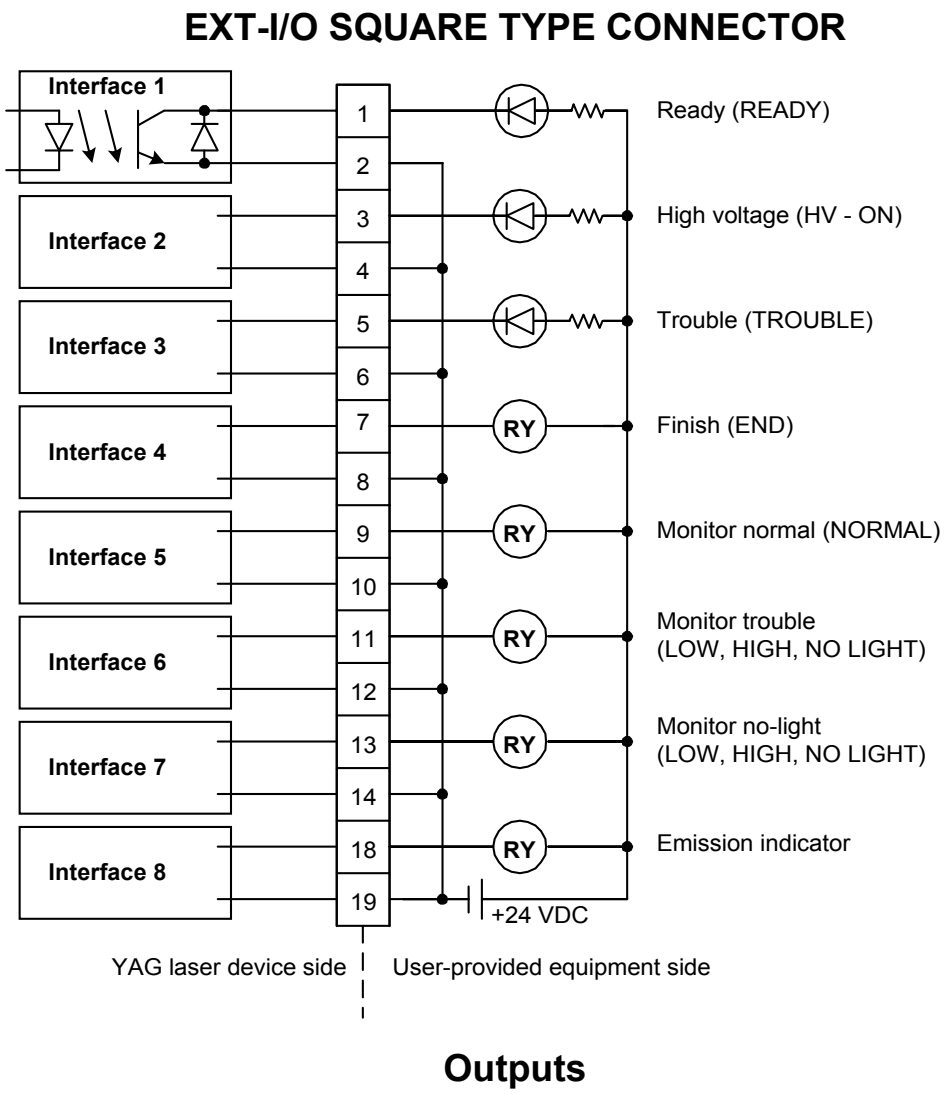
Pins 9 - 10, Monitor Normal. The NORMAL signal is output for 40 milliseconds when the laser power monitor value is set within the range between LOW and HIGH. The NORMAL signal is inhibited when the NO LIGHT signal is output (Monitor TROUBLE at Pins 11 - 12 or Monitor No Light at Pins 13 - 14).

Pins 11 - 12, Monitor Trouble. The Monitor TROUBLE signal is output under either of two conditions, when the:

- Laser power monitor value is outside the set range between LOW and HIGH, or
- NO LIGHT signal is being output.

Pins 13 - 14, Monitor No Light. The Monitor NO LIGHT signal is output under either of two conditions, when the:

Output Signals (continued)



Pins 18 - 19, Emission Indicator. The Emission Indicator signal is output from 4 to 19 seconds preceding the laser emission. Delay time is adjustable by a preset timer.

CHAPTER 3
OPERATING INSTRUCTIONS

SECTION 1: GETTING STARTED

WARNING: When operating the laser unit, always wear protective goggles having an optical density of at least 6 at a wavelength of 1064 nanometers.

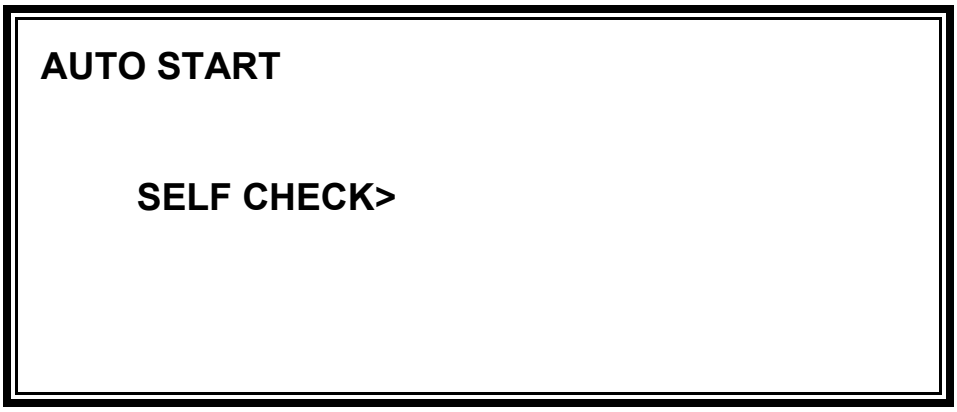
Be sure that you have read and understand the information in Laser Safety Manual.

To prepare the laser unit for operation:

1 Confirm that the city or chilled water supply for cooling and the laser 230 VAC, 3-phase power are properly connected.

2 Set the laser unit circuit breaker to the ON position (see **Chapter 1, Section 2**). The following series of displays will automatically appear on the program unit screen:

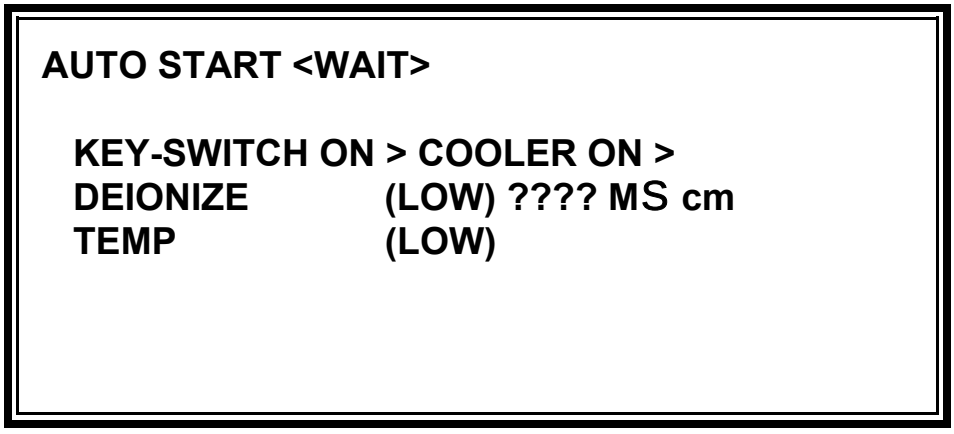
a)



During the laser unit self check, the following functions are checked:

- Opening and closing of the resonator (main) shutter
- LED indicator lamps
- Memory (sum check and data range)
- Inverted-phase sensing relay
- Flow switch
- Charge trouble

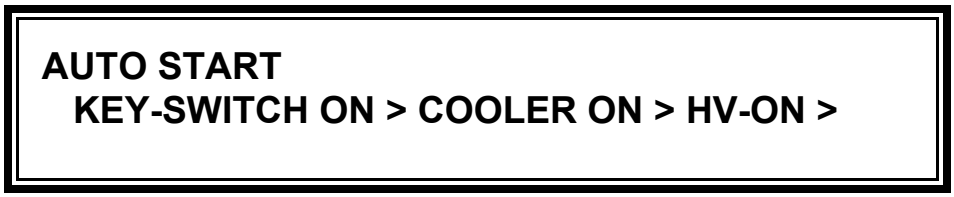
b)



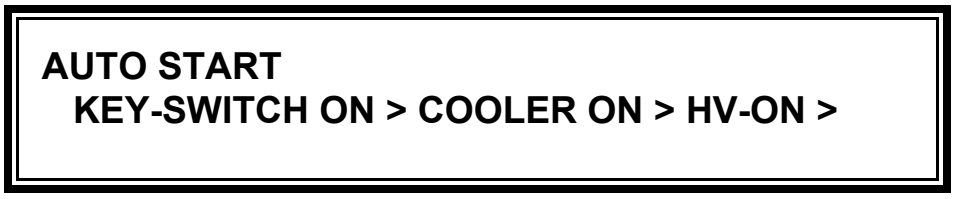
The DEIONIZE field displays the purity (electrical resistivity) of the deionized water in terms of being lower than 2.0 megohms/cm (LOW), lower than 3.0 megohms/cm (CAUTION), or higher than 3.0 megohms/cm (GOOD).

The TEMP field display the temperature of the deionized water in terms of being within the set range (GOOD), lower than the set range (LOW), or higher than the set range (HIGH).

When GOOD appears in both lines, the high voltage is turned on automatically and the following screen appears (if the laser has not been operated for some time, there may be some delay until the purity reaches an acceptable level):



c) This screen is displayed until the high voltage is turned on and the capacitor is fully charged:



d) **Monitor Screen.** This screen indicates the power monitor values of the schedule indicated on the screen (Schedule No. 15 in this case). After this screen appears, you may set (program) data with the input keys.

```
-- POWER MONITOR
   SCHEDULE No. 15
   ENERGY          23.5J
   AVERAGE         30.2W

   HV: OFF    MAIN-SHUTTER: OFF POSITION:
OFF
```

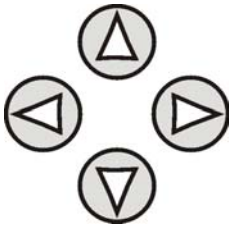
SECTION 2: OPERATING PROCEDURES

Data Entry (Editing)

To enter (edit) data:

1 

Press the MENU key

2 
Move the blinking cursor with the cursor keys.

3 

Set the value with the ± keys.

4 

Press the ENTER key to write the keyed in program.

Screens

Schedule/Monitor Schedule Screen. You may set input conditions and monitor values with this screen. The schedule/monitor schedule screens for the LW51 and LW52/LW100 Lasers are formatted respectively as follows:

```
-- SCHEDULE NO. 15          ENERGY        AVERAGE
   PULSE WIDTH 10.0ms       HIGH     99.0J
   LAMP VOLTAGE 499V        LOW      18.0J
                            MON.     20.0J      50.0W
      REPEAT=20pps                TOTAL COUNT  12345678
      SHOT=999                    GOOD COUNT   12345678
      DUMMY=99 shot
      HV:OFF    MAIN--SHUTTER:OFF      POSITION:OFF
```

LW51 Schedule/Monitor Schedule Screen

```
--    No. 13          TIME VOLT          ENERGY        AVERAGE
      FLASH 1  02.0ms    A      HIGH     99.0J
      COOL 1   02.0ms                LOW      18.OJ
      FLASH 2  12.3ms    B           MON.     20.OJ
50.0W                COOL 2   00.0ms                TOTAL COUNT
12345678             FLASH 3  00.0ms    A           GOOD COUNT
12345678
VOLT A=300V B=400V  20pps  999shot DUMMY=99
      HV:9ff     MAIN--SHUTTER:OFF      POSITION:OFF
```

LW52/LW100 Schedule/Monitor Schedule Screen

Input Condition Ranges. The ranges of the values that you can input to the schedule/monitor schedule screen are listed in the following table:

Input Condition Ranges

Screen Name	Condition	Unit	Range
SCHEDULE	Selection of condition (schedule number)	Numerals	00-15
PULSE WIDTH	Setting of lamp flash time (LW51)	msec	0.02-20.0
LAMP VOLTAGE	Setting of charging voltage (W51)	Volts	150-510
FLASH 1	Setting of first lamp flash time (LW52/LW100)	msec	00.0-20.0
COOL 1	Setting of first lamp cooling time (LW52/LW100)	msec	00.0-20.0
FLASH 2	Setting of second lamp flash time (LW52/LW100)	msec	00.0-20.0
COOL 2	Setting of second lamp cooling time (LW52/LW100)	msec	00.0-20.0
FLASH 3	Setting of third lamp flash time (LW52/LW100)	msec	00.0-20.0
VOLT A	Setting of charge voltage A (LW52/LW100)	Volts	150-510
VOLT B	Setting of charge voltage B (LW52/LW100)	Volts	150-510
REPEAT	Setting of repeated PPS	Numerals	00-50
SHOT	Setting of repeated number of shots	Numerals	00-999
DUMMY	Setting of number of dummy shots	Numerals	00-99
ENERGY (HIGH)	Setting of energy monitor upper limit	Joules	00.0-99.9
ENERGY (LOW)	Setting of energy monitor lower limit	Joules	00.0-99.9
VOLT (LW52/LW100)	Voltage setting on flashes 1, 2, and 3	Volts	A or B

Status Screen. The status screen allows you to control the opening and closing of the resonator (main) shutter, and turn the positioning guide light ON and OFF. The screen is formatted as follows:

```
--      STATUS [EXTERNAL CONTROL]

        SHUTTER -- 1:ON                 ROM VERSION
        SHUTTER -- 2:OFF          ML-2332B [V1--01A]
        SHUTTER -- 3:OFF          MLE-103B [V1--01A]
        SHUTTER -- 4:OFF          SERVICE MODE:OFF

HV:OFF    MAIN--SHUTTER:OFF       POSITION:OFF
```

Status Screen

- STATUS: Indicates whether the laser unit is under local (internal) or external I/O control.
- SHUTTER: Allows you to turn shutters 1-4 ON or OFF.
- ROM VERSION: ROM VERSION displays the software version of the laser unit (ML-2332B) and the program unit (MLE-103B).
- SERVICE MODE: Allows you to turn the service mode ON or OFF.
- HV:OFF: Allows you to turn the high voltage ON or OFF.
- MAIN--SHUTTER:OFF Allows you to turn the resonator (main) shutter ON and OFF.
- POSITION:OFF Allows you to turn the positioning He-Ne laser ON and OFF.

Power Monitor Screen. This screen allows you to view the energy value and the average power value.

```
-- POWER MONITOR                              [HV=OFF]

      SCHEDULE NO. 15

      ENERGY                 23.5J
      AVERAGE POWER          03.4 KW

HV:OFF     MAIN--SHUTTER:OFF        POSITION:OFF
```

Power Monitor Screen

- SCHEDULE NO.: Setting of condition (schedule number)
- ENERGY: Indication of energy monitor value
- AVERAGE POWER: Indication of the average power value in every second.
- HV:OFF: Allows you to turn the high voltage ON or OFF.
- MAIN--SHUTTER:OFF Allows you to turn the resonator (main) shutter ON and OFF.
- POSITION:OFF Allows you to turn the positioning He-Ne laser ON and OFF.

Count Monitor Screen. The count monitor screen allows you to view and reset the total shot count and the good shot count. The screen format is:

```
-- COUNT MONITOR                              [HV=OFF]

      TOTAL COUNT  12345678  (RESET ? NO)
      GOOD COUNT   12345678  (RESET ? NO)
```

Count Monitor Screen

- HV=OFF: This line allows you to turn high voltage ON or OFF.

- TOTAL COUNT: This line allows you to view and reset the total shot count.
- GOOD COUNT: This line allows you to view and reset the good shot count.

NOTE: To reset the count, move the cursor to NO, press the ON+ key, then press ENTER.

Copy Screen. This screen allows you to copy the condition data.

```
-- COPY
     LW Series---------------------->   PROGRAM UNIT MEMORY 1
     LW Series---------------------->   PROGRAM UNIT MEMORY 2
     PROGRAM UNIT MEMORY 1-------->LW51
     PROGRAM UNIT MEMORY 2-------->LW51
     PROGRAM [01]------------------->SCHEDULE [02] - [15]
```

Copy Screen

Selecting the five lines of this screen copies data to memory as follows:

NOTE: For the LW52 or LW100, LW52 or LW100 is indicated in place of LW51.

- Line 1: All data set in the LW51/LW52/LW100 memory are copied to Memory 1 of the program unit.
- Line 2: All data set in the LW51/LW52/LW100 memory are copied to Memory 2 of the program unit.

NOTE: The data copied from the LW51 to the program unit are stored for about 30 minutes after program unit power is turned OFF, even if the power cable is disconnected.

- Line 3: All data set in Memory 1 of the program unit are copied to the LW51 memory.
- Line 4: All data set in Memory 2 of the program unit are copied to the LW51 memory.
- Line 5: The data programmed for the displayed condition (01 in the example shown) are copied to the schedules displayed (02 through 15 in the example shown).

Maintenance Screen. The maintenance screen allows you to enter conditions for adjusting oscillation and resetting the TOTAL and GOOD counts. The display format is:

```
-- MAINTENANCE MODE:ON
      VOLT TIME
      300V       1.0ms      (0.6ms -- 1.1ms)

            (RESET ?: YES)       TOTAL COUNT  12345678
            (RESET ?:NO)         GOOD COUNT   12345678

HV:OFF    MAIN--SHUTTER:OFF      POSITION:OFF
```

Maintenance Screen

- MAINTENANCE MODE:ON: This line allows you to turn the maintenance mode ON and OFF. With the maintenance mode ON:
  - Only the laser start switch on the program unit will start the laser unit.
  - All branch shutters are closed.
  - The power monitor is inoperative.
  - External I/O control is inhibited.
- RESET TOTAL COUNT: This line allows you to reset the total shot count.
- RESET GOOD COUNT: This line allows you to reset the good shot count.
- HV:OFF: Allows you to turn the high voltage ON or OFF.
- MAIN--SHUTTER:OFF Allows you to turn the resonator (main) shutter ON and OFF.
- POSITION:OFF Allows you to turn the positioning He-Ne laser ON and OFF.

SECTION 3: OPERATING FUNCTIONS

Turning High Voltage ON and OFF

Controlling With the Program Unit. If HV:ON is showing in any screen other than the copy screen, the high voltage is ON. The capacitor is charged to the set voltage and the laser START signal will be accepted.

External I/O Control. If the HV-ON input signal is present, the high voltage is turned ON. If the HV-OFF input signal is present, the high voltage is turned OFF. If the HV-ON and HV-OFF input signals are present simultaneously, the HV-OFF input signal takes priority and high voltage stays OFF.

Turning the Positioning He-Ne Laser ON and OFF

The positioning He-Ne laser is used to adjust the YAG laser beam. If you change POSITION: OFF on the screens to POSITION:ON, the positioning He-Ne laser will be turned ON.

Changing Operating Conditions

> **NOTE:** When you change operating conditions, there may be some delay while the newly set charge voltage is reached.

Local Control. Refer to *Schedule/Monitor Schedule Screen* as previously described in this chapter in Section 2. When controlling the laser unit with the program unit (EXT I/O connector Internal/External circuit open):

1. Set the cursor on the condition number with the cursor keys.
2. Select the desired condition number with the ON+ and OFF- keys.
3. Press the ENTER key to change the condition number.

External Control. When the EXT I/O connector Internal/External circuit is closed, set the input Condition lines for the desired condition number (see **Chapter 2, Section 3**, Schedule Selection Table).

Selection of the Laser Beam

Local Control. Local control of this function requires the EXT I/O connector Internal/External circuit to be open. To locally select the laser beam input unit for emitting the laser beam:

1. Refer to *Status Screen* as previously described in Section 2.
2. At the status screen, turn on the desired shutter. The LED indicator for that shutter will light.

External Control. External control of this function requires the EXT I/O connector Internal/External circuit to be closed. Apply beam selection signals as described in **Chapter 2, Section 3,** under *Input Signals, Pins 41-44.*

Branch Selection Considerations. Any or all of the laser beam input units can be selected simultaneously.

- Time Branch: Any one laser beam input unit can be selected for up to the number of laser beam input units installed. If two or more laser beam input units are selected, the one having the lower number will be used.
- Two synchronous and Two Non-synchronous Branches simultaneously: Only laser beam units 1 and 2, or 3 and 4 can be selected. For a different combination, the unit having the lowest number will be used, even though 1 and 2 can be selected simultaneously.

Resonator (Main) Shutter Control

Local Control. Refer to *Screens* in Section 2. You may turn on the resonator (main) shutter by changing MAIN--SHUTTER:OFF to MAIN--SHUTTER:ON. With the resonator shutter open, the YAG laser can be oscillated.

External Control. With the EXT I/O connector Internal/External control circuit closed, the Main (Resonator) Shutter input signal will open the shutter (refer to **Chapter 2, Section 3**, under *Input Signals, Pin 33, Resonator (Main) Shutter).*

Laser Output

Local Control. When you press the LASER START key, the flash lamp oscillates the YAG laser rod. If the laser beam input unit selected and the resonator shutter is open, the laser beam is output.

External Control. With the EXT I/O connector Internal/External control circuit closed, the Laser START input signal performs the same function as the laser unit LASER START key.

CHAPTER 4
USER MAINTENANCE

Precautions

Before starting any maintenance, read the following precautions carefully:

- Read through the entire specific instructions, including all caution and warning messages, BEFORE starting any maintenance procedure.
- Turn OFF the power to the laser before starting maintenance work. Wait for 5 minutes after turning OFF power before starting work.
- The Nd:YAG laser becomes ready for oscillation if the high voltage is turned ON during maintenance work. Use extreme caution while performing any work on the laser.

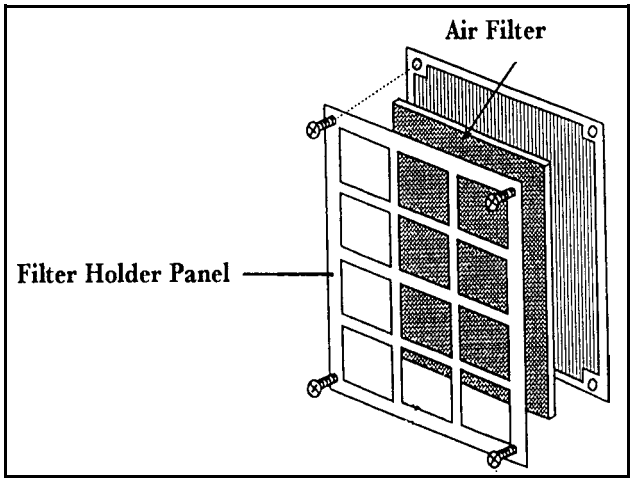
  WARNING: Maintenance workers or anyone who is subject to possible Nd:YAG laser beam exposure must wear safety goggles having a minimum optical density of 6 at 1.064 nanometers wavelength.

Filter Maintenance

WARNING: Before working on the cooler, turn off power to the laser unit. If the high voltage has been ON, wait at least 5 minutes for the capacitor to fully discharge before proceeding.

Air Filter Cleaning. You will need a Phillips screwdriver.

1. Remove the filter holder panel by removing the screws with a Phillips screwdriver.
2. Remove the filter and rinse it with tap water. If it is extremely dirty, wash it with a mild detergent.
3. Air dry the filter thoroughly. Replace it and secure it with the filter holder panel and screws.



Air Filter Removal

Cleaning or Replacing the Water Filter. To clean or replace the small water filter, you will need plastic (vinyl) gloves.

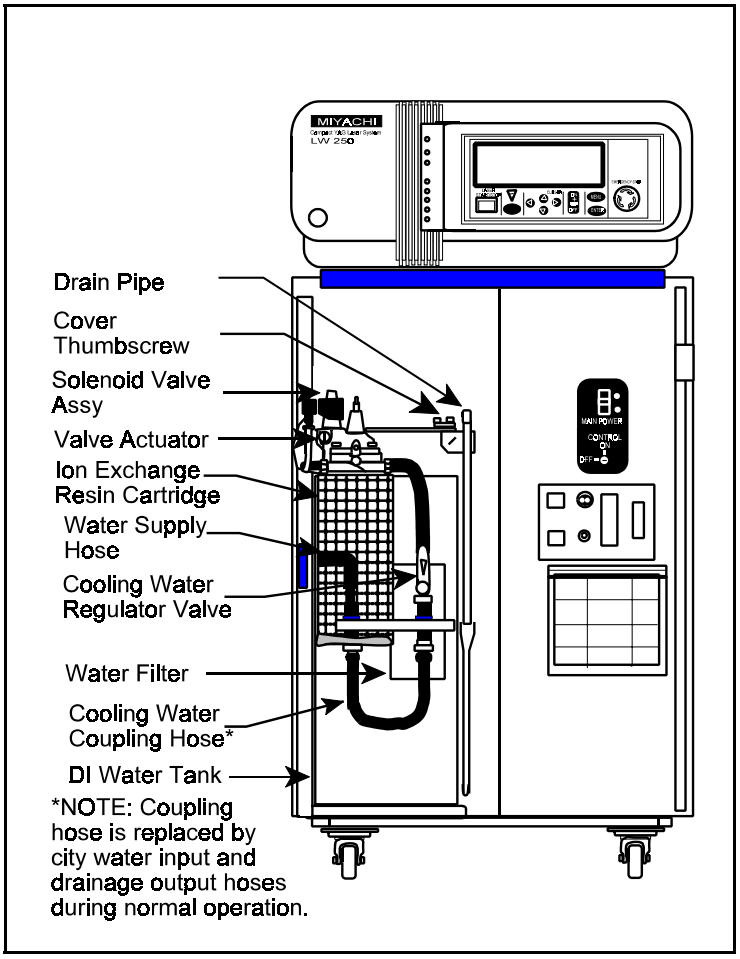
1 Remove the two thumb screws on the water tank cover, and remove the cover.

2 Using vinyl gloves remove the water filter located to the right of the resin cartridge. This filter may be removed more easily if it is twisted while it is being pulled upward.

3 Clean the filter or discard the filter and replace it with a new one. To clean the existing filter, remove all dirt in the mesh with a soft brush. Insert the clean filter until it is fully seated on the bottom post.

4 Check the water tank fill level and add water if needed.

5 Re-install the water tank top cover using the two thumb screws



L25COOL2.WPG

Cooling System Components

Water Draining Occasions. Both the deionized water (D.I.) and cooling (city) water should be drained on certain occasions, as specified in Table 4-1. The procedures for performing these functions are described in the following paragraphs.

Table 4-1. Water Draining Occasions

Occasion	Water Type	
	Deionized	Cooling (City)
Replacement of ion exchange resin cartridge	X	
Replacement of flash lamp	X	
Replacement of D.I. or steam-distilled water	X	
Storage or long periods of non-use, moving or transportation, or when ambient temperature drops below 0°C (32°F)	X	X
Cleaning of solenoid valve strainer		X
Replacing the flow rate controller	X	

Replacing the Ion Exchange Resin Cartridge and the D. I. or Steam-Distilled Water. The ion exchange resin cartridge and the D. I. or steam-distilled water should be replaced approximately every 6 months. The tools and materials you will need are:

- Plastic (vinyl) gloves
- Special tool for removal/replacement of the ion exchange resin cartridge
- D. I. or steam-distilled water

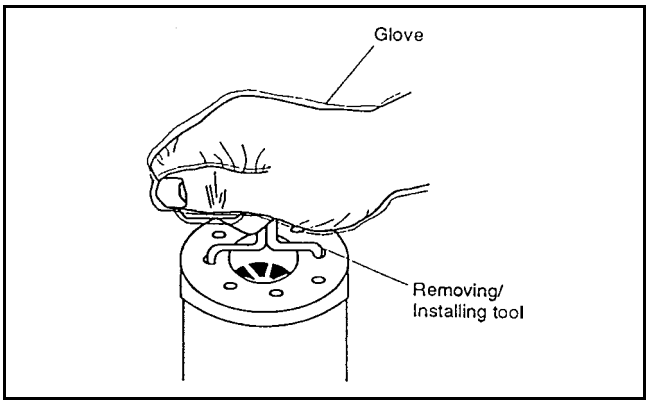
To replace the ion exchange resin cartridge and the D.I. or steam-distilled water:

1. Remove the thumb screw on the drain pipe clamp in the front of the D.I. water tank. Remove the cap on the end of the drain pipe and drain the D.I. water from the tank by rotating the flexible drain pipe tube until the outlet end is below the inlet end. Water may be drained into a shallow pan, or floor drain system.
2. Remove the lid of the D.I. water tank by removing four thumb screws. Use the special tool to remove the ion exchange resin cartridge, turning the cartridge counter-clockwise to remove it. Discard the cartridge.

3 Remove, clean or replace, and re-install the water filter located behind to the right of the resin cartridge, as described in *Cleaning or Replacing the Water Filter*, above.

4 Insert a new ion exchange resin cartridge in the water tank by turning it clockwise using the special tool. Stop turning the cartridge when it becomes slightly hard to turn.

CAUTION: Do not over tighten the cartridge. Over tightening may damage the threads.



GLVTOOL.PCX

Ion Exchange Resin Cartridge Removal

5 Re-install the drain pipe and its cap, then fill the tank with deionized or steam-distilled water up to the upper level mark.

6 Re-install the water tank top cover using the four thumb screws.

Replacing the Existing Flash Lamp. This procedure is given in **Chapter 5.**

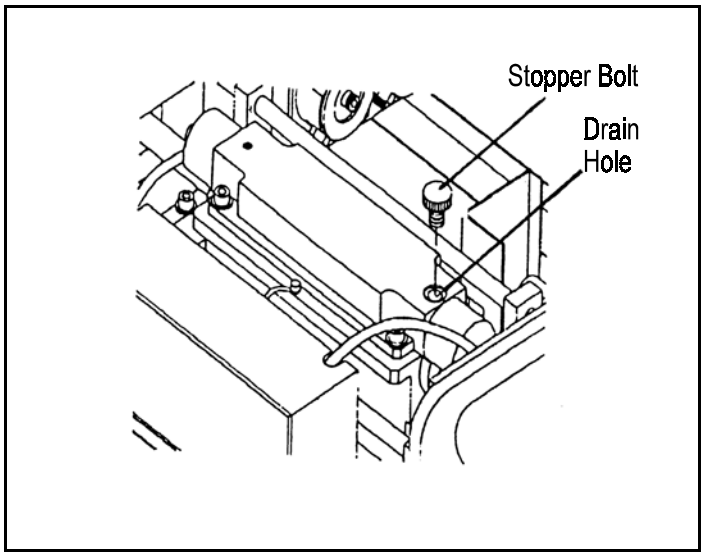
Replacing Existing Deionized or Steam-Distilled Water. To replace the existing deionized or steam-distilled water, proceed as follows:

1 Loosen the stopper bolt in the laser chamber water drain hole. Breaking the vacuum will allow the water in the laser chamber and its hose to drain into the water tank.

2 Remove the thumb screw on the drain pipe clamp. Remove the drain pipe cap. Rotate the flexible drain pipe tube until the outlet end is below the inlet end to drain the water into a shallow pan, or floor drain system.

3 Fasten the drain pipe and replace the end cap.

4 Fasten the stopper bolt in the laser chamber drain hole.



STPRBOLT.PCX

Laser Chamber Vacuum Release

5 Re-install the top cover using the two thumb screws.

6 Following the Operating Instructions, run the laser for about 30 seconds, then power it off. This will allow the laser chamber to fill with water.

7 Recheck the fill level of water in the water tank. If necessary, remove the tank cover, add water to the upper level mark, and replace the tank cover.

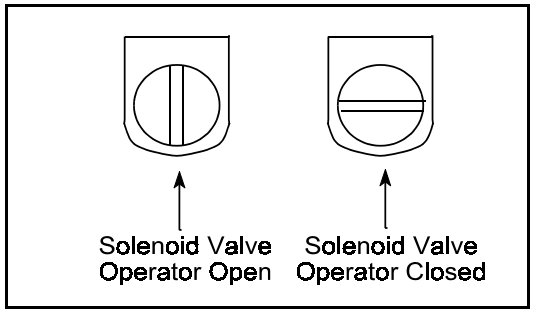
Water Draining: For Long Term Storage, When Transporting the Laser, or When Temperature Drops Below 0° C. When the laser is not used for a long period, when the laser is to be transported, or when the ambient temperature will drop below 0°C, all water (both cooling (city) water and D.I. or steam-distilled water) must be completely drained. To completely drain the cooling system water:

1 Drain cooling (city) water as follows:

a) Open the cooling water regulator valve.

b) With a blade-tip screwdriver, push and turn the solenoid valve operator to open the solenoid valve.

c) Put a pan or dish under the input and drainage hoses to prevent water from spilling on the floor, then remove the hoses from the cooling water inlet and outlet fittings and let the water drain.



L25VOPR.WPG

Solenoid Valve Operator

d) Close the solenoid valve.

e) If the laser is to be moved, connect the coupling hose to the cooling water inlet and outlet fittings.

2 Drain D.I. or steam-distilled water as follows:

a) Loosen the stopper bolt in the laser chamber water drain hole. Breaking the vacuum will allow the water in the laser chamber and its hose to drain into the water tank.

b) Remove the thumb screw on the drain pipe clamp. Remove the drain pipe cap. Rotate the flexible drain pipe tube until the outlet end is below the inlet end to drain the water into a shallow pan, or floor drain system.

c) Remove the four thumb screws on the water tank cover, and remove the cover.

d) Using the special tool for the ion exchange resin cartridge, turn the cartridge in the water tank counter-clockwise and remove the cartridge. Store the cartridge in a sealed plastic bag or container in a cool dark place to avoiding dryness and freezing temperatures.

CAUTION: The total shelf life of the resin cartridge is 12 months, however it will lose its efficiency if it becomes dry. If it is to be used again, store it as described above. Keep date records. Otherwise, dispose of it.

e) Remove the Phillips head screws located at the bottom of the left side panel, then remove the panel to gain access to the pump.

f) Remove the clamp on the pump outlet hose, then remove the hose end by lightly turning the end with a pair of pliers.

CAUTION: Be sure the water tank lid has been removed. Blowing compressed air into the water tank while the lid is on will cause the tank to burst.

g) Use clean compressed air, at 30 psi maximum pressure, to blow out any remaining coolant water in the outlet hose.

h) Blow air into the outlet hose connection joint to remove residual water in the tank.

i) When the water is completely drained, reconnect the outlet hose to the pump.

j) Reconnect the side panel, the water tank cover, the water tank drain pipe and cap, and the stopper bolt in the laser chamber water drain hole.

Cleaning the Solenoid Valve Strainer. The solenoid valve is located at the left of center under the front door. The tools required for cleaning the solenoid valve strainer are:

- Small bristle brush
- 10 mm wrench

To clean the solenoid valve strainer, proceed as follows:

1 Turn off the cooling water and disconnect the hose from the cooling water inlet.

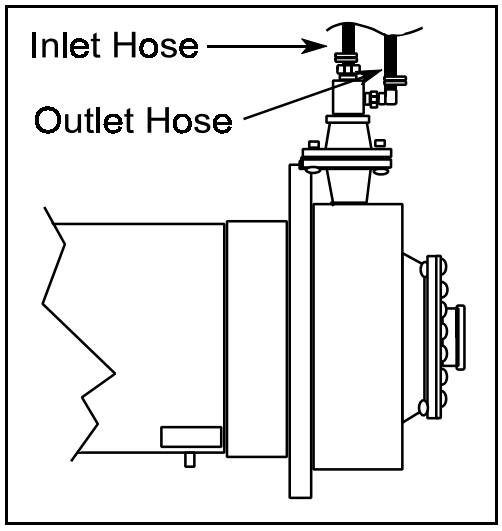
2 Drain the remaining cooling water from the hoses and cooling system as described in **Replacing Existing Deionized or Steam-Distilled Water.**

3 With a 10 mm wrench, remove the four bolts that secure the solenoid valve top housing to the valve body.

4 Remove the top housing and remove the spring and diagram.

5 Remove the strainer and clean it with water and a brush.

6 Return the strainer, diaphragm and spring to the solenoid valve body.



L25PUMP.WPG

Pump Hose Connections

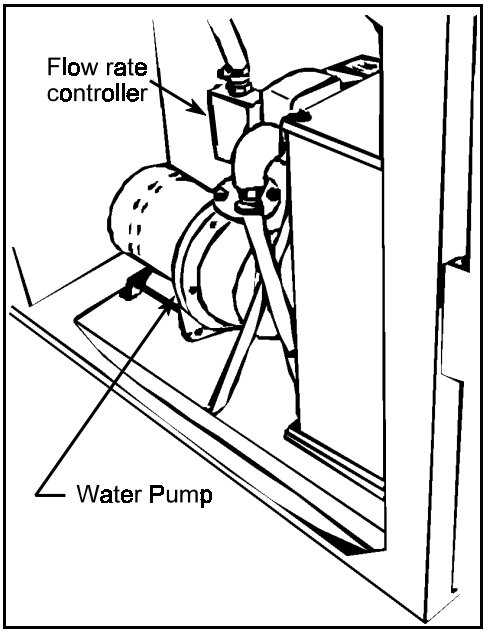
7 Secure the top housing on the solenoid body with four bolts.

8 Reconnect the coolant supply hose and turn on the water supply.

Replacing the Flow Rate Controller. The D. I. water flow rate in the cooler depends on the frequency of the mains AC power, which may be either 50 Hz or 60 Hz. If the power frequency is changed, you will need to replace the existing flow rate controller, which is located just above the water pump. The tools required for replacing the flow rate controller are:

- Phillips screwdriver
- 27 mm hex wrench

1 With a Phillips screwdriver, remove the left side cover of the laser.
2 Drain half of the D. I. water from the tank.
3 Remove the flow rate controller with a 27 mm hex wrench.
4 Install a flow rate controller matching the frequency of the new AC power input.
5 Fill the D. I. water tank with D. I. water.
6 Pull out the tip of the cover interlock switch to set the laser to the maintenance mode.
7 Turn On AC power and turn ON the key switch to start the cooler. Confirm that no water leakage occurs.
8 Turn OFF the key switch and the AC power.
9 Install the left side cover on the laser.



LASER5.PCX

Flow Rate Controller Location

SECTION 3: GENERAL MAINTENANCE

Connection of the Main Power Cable

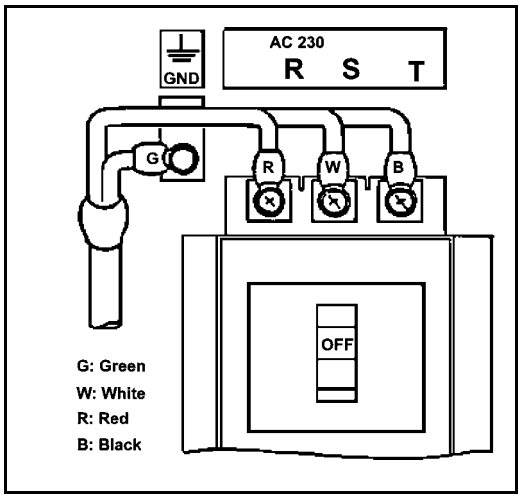
To connect the main power cable:

NOTE: A 5 meter (16 foot) long cable with four 2 mm^2 leads is provided with the laser.

1 Open the laser front door and remove the terminal cover.

2 Feed the power cable through the bottom of the laser and connect the four leads to the terminals as shown.

CAUTION: Be sure to connect the ground lead to a Class 3 grounding system.



LASER18A.PCX

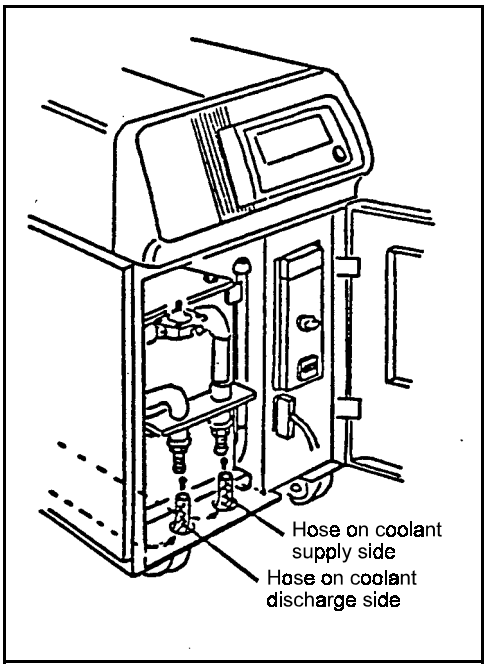
Main Power Connection

Connection of Coolant Piping

The requirements for the city (or clean, industrial use) water supply are:

- Pressure: 1-3 kg/cm^2
- Flow Rate (min): 8 l/min
- Temperature: Below 25°C (77°F)
- Supply hose ID: 15 mm

Connect the hoses as shown with band-type hose clamps.



LASER19A.WPG

Coolant Piping

Connection of Optical Fibers

WARNING

Breakage of fiber optic cables presents a serious radiation hazard. High levels of visible and infrared laser energy can radiate from a damaged fiber optic cable.

Although the fiber optic cables and output focus heads can be equipped with safety interlocks that will shut down laser operation if the cable is disconnected at the focus head, there is no interlock that similarly shuts down laser operation if the cable is broken.

The fiber optic cables used to transport laser energy from the laser power supply to the output focus head must be routed and protected in such a way that they will not be damaged by moving machinery. You must provide this protection. Avoid running the fiber optic cables across foot paths or in an area where fork lifts, hand carts, or any other mobile equipment might run over them. Also, ensure that the cables are routed such that they are not bent tighter than their minimum bending radius.

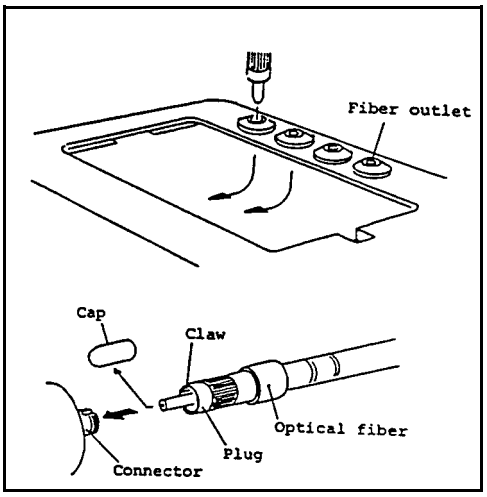
Preparation. Before connecting the optical fibers, remove the end cap and verify that the end surfaces are not stained or contaminated with dust. Remove dust with compressed air or lens cleaning tissue.

Connection to the Laser Beam Input Unit. To connect an optical fiber to a laser beam input unit:

1 Open the optical fiber connection door.

2 Remove the cap from the fiber end face and insert the fiber into the input unit connector.

3 Match the plug pins to the input unit connector and rotate the plug clockwise to secure it.

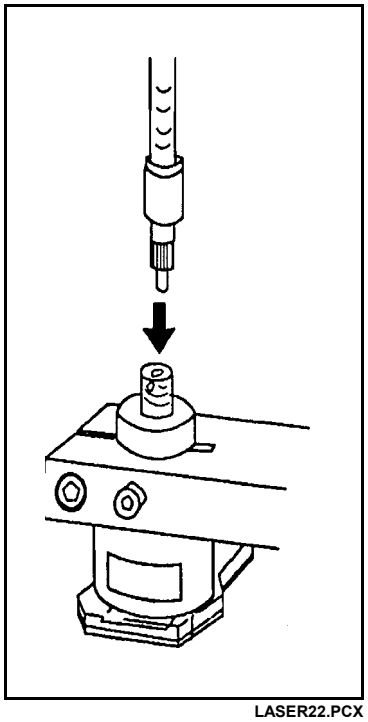


LASER23.PCX

Optical Fiber Connection

Connection of Fiber to the Emitter Unit. Remove the cap from the end face and secure the fiber to the emitter unit as shown at the right.

CAUTION: Use an optical-grade blower to clean contaminants from the fiber end face.



LASER22.PCX

Emitter Unit Connection

Optical Axis Adjustments

X and Y Axes. When you have reconnected the original fiber, X and Y axis adjustment should not be required. If you have installed new fiber, the optical axis of the laser beam unit will require adjusting. Refer to **Chapter 5** for adjustment instructions.

CAUTION: If these axes are not adjusted, the fiber incidence end face may burn.

Z Axis (Focus). When changing the fiber diameter, adjust the focus of the laser beam input unit. If the focus is out of adjustment, you cannot increase laser beam power to the maximum allowable fiber input. For focusing instructions, refer to **Chapter 5.**

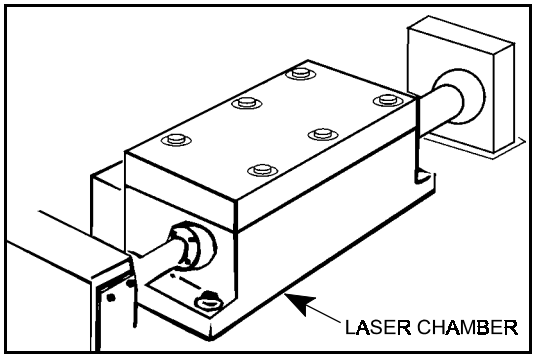
CHAPTER 5
SERVICE

SECTION 1: LASER HEAD

Flash Lamp Replacement

1 Turn off power to the Nd:YAG laser unit.

CAUTION: If high voltage has been on, wait for at least 5 minutes after the power is turned off before proceeding.

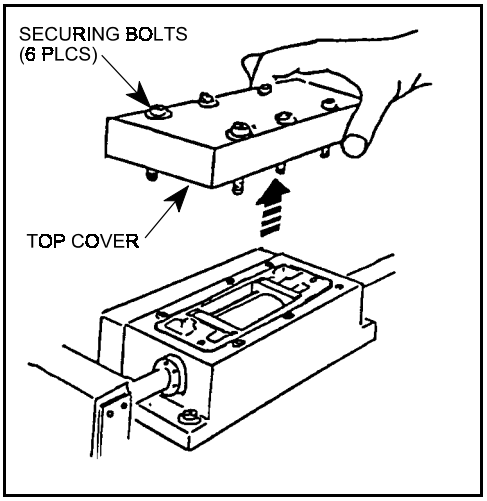


LASER1.PCX

Laser Chamber

2 Remove the lamp replacement cover in the oscillator cover to access the laser chamber.

3 Remove the six M6 bolts securing the laser chamber top cover to the laser chamber and lift the top cover free of the laser chamber.

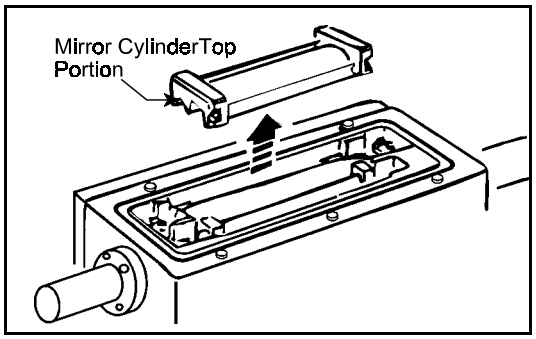


Laser Chamber Cover Removal

Flash Lamp Replacement (continued)

CAUTION: In the following steps, the need for careful and non contaminating handling of the optical parts is essential.

4 Hold both sides of the top portion of the oval mirror cylinder and carefully lift it up, taking care not to damage the inside of the cavity. **CAUTION:** If the reflector panel in the mirror cylinder is scratched or stained, laser beam output could be reduced.



LASER3.PCX

Mirror Cylinder

NOTE: Most models of the laser unit are equipped with flash lamps with clips to insure good electrical contact. Some earlier models have flash lamps without clips. Call Unitek Miyachi to obtain an upgrade kit to convert to the clip-style flash lamp.

5 a) Flash Lamp Without Clips: Loosen the M4 lamp holder screws and remove the two lamp holders, being careful not to break the flash lamp.

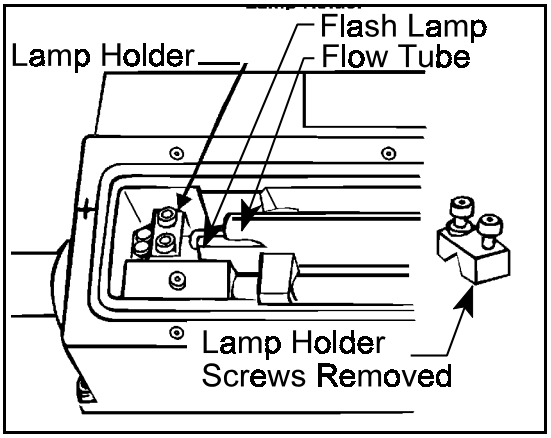
b) Flash Lamp With Clips: Loosen the M3 lamp holder screw at each side of the flash lamp.

c) Place the lamp holders on a clean cloth.

CAUTION: Do not touch the glass surfaces of the flash lamp or the flow tube. The contamination will break the glass when the glass is heated.

6 With both hands, hold both openings of the flow tube and lift it and the flash lamp from the laser chamber cavity.

7 Carefully separate the flow tube and the flash lamp, and place them on a clean cloth.



Flash Lamp Holder

NOTE: If the flash lamp has no clips, you may wish at this point to upgrade to the flash lamp with clips. If you wish to upgrade, proceed to Step 8. Refer to the upgrade parts list at the end of this procedure. If you do not wish to upgrade, proceed to step 10.

Upgrade Steps Only

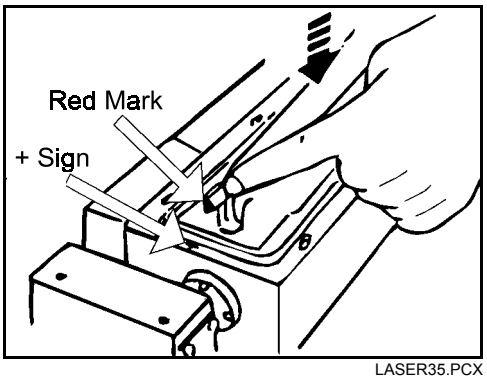
8 Remove the existing S-shaped lamp holder by loosening the two M3 screws on both sides of the laser cavity.

9 Install Lamp Holder Spacer + (PN A4-02040) and Lamp Holder Spacer - (PN A4-02041) with M3 screws on both sides of the laser cavity.

10 Clean the flash lamp with alcohol.

11 Place the cleaned flash lamp in the flow tube. Place the flash lamp in the lamp holders, observing correct lamp polarity. The electrode with the red mark is the positive anode. Place it in the lamp holder at the end of the laser cavity marked with the + sign.

12 Adjust the lamp position so that it is located at the center of the oval mirror cylinder, then secure it with the lamp holder screws. **CAUTION:** Do not apply excessive force to the lamp. If the lamp holder and lamp electrode become electrolytically corroded, replace the lamp holder.



Flash Lamp Polarity

13 Carefully replace the top portion of the oval mirror cylinder.

14 Install the top cover on the laser chamber. Tighten the securing bolts, torquing them such that there is equal pressure around the O-ring between the top cover and the cavity. **CAUTION:** Never turn on unit power unless the top cover is secure.

Flash Lamp Replacement (continued)

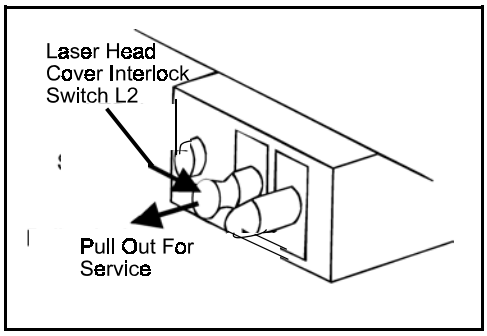
15 Pull out the tip of Laser Head Cover Interlock Switch L2 to set the oscillator head to the service mode.

16 Supply power to the Nd:YAG laser unit and turn on the key switch to start the cooler. Check for water leakage.

17 After confirming that no water is leaking and the unit is operating normally, turn off the power to the unit.

18 Install the lamp replacement cover in the oscillator cover.

19 Turn on the power to the unit and age the lamp. (Flash about 500 shots with the resonator shutter closed, at a pulse width of 1.0 milliseconds and an amplitude of 400 volts.).



Interlock Switch

Flash Lamp Assembly Parts

Part	Part No.	Qty
Flash lamp without clips	4-60003-01	1
Lamp holder for flash lamp without clips	4-60009-01	2
Flash lamp with clips	4-60200-01	1
Lamp holder spacer (+) – 9 mm slot	A4-02040	1
Lamp holder spacer (-) – 7 mm slot	A4-02041	1
M3 × 8 screw	625-864	2*
M3 lock washer	755-314	2*
M3 flat washer	755-315	2*

TABLE NOTE 1: Parts in the shaded table cells are for upgrading from the flash lamp without clips to the flash lamp with clips.
TABLE NOTE 2: The parts marked with an asterisk (*) are for securing the clip portion of the flash lamp to the lamp holder.

Oscillator and Optical Axis Adjustment

Tools and Materials. You will need the following items for performing the adjustment procedures:

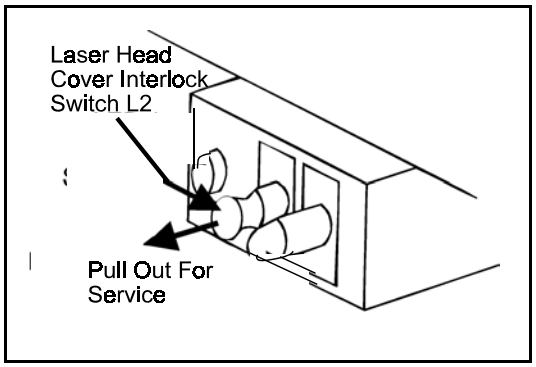
- Goggles with an optical density of 6 or more at a wavelength of 1064 nanometers.
- Sheets of white paper.
- Sheets of black paper
- 8 mm Allen wrench
- Fiberscope
- Fiberscope holder

WARNING

Always wear protective goggles when adjusting the oscillator and optical axes.

Adjustment Preparation. To prepare the laser oscillator and optical axes for adjustment, proceed as follows:

1. Remove the laser head cover. (If the Nd:YAG laser unit is in operation, HEAD COVER trouble Display Code 02 is indicated.)
2. Pull the tip of Laser Head Cover Interlock Switch L2 outward to set the oscillator head to the service mode. If HEAD COVER trouble is indicated (Display Code 02), reset Laser Head Cover Interlock Switch L2.
3. Turn on the power to the Nd:YAG laser unit.
4. Turn off the high voltage (HV).
5. Turn on the positioning He-Ne laser (POSITION).
6. Turn on the resonator shutter (MAIN SHUTTER).

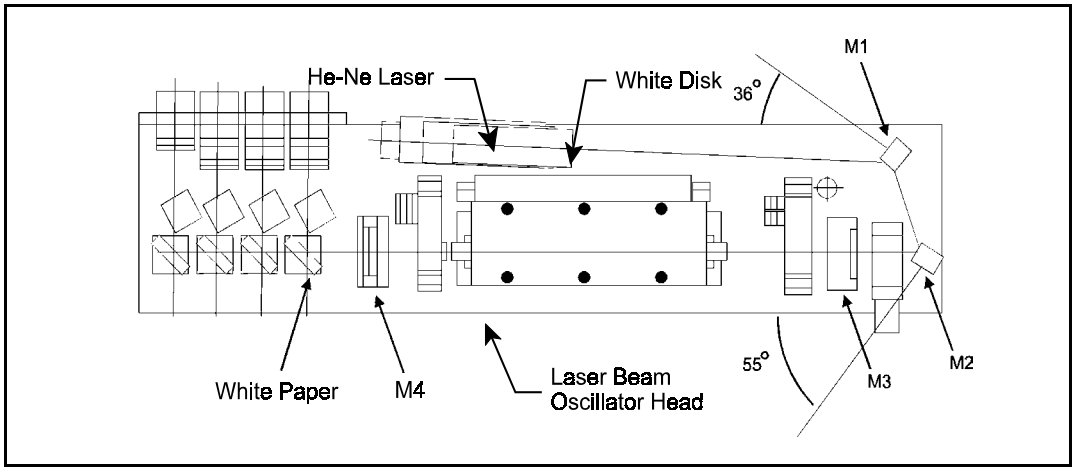


Interlock Switch

Oscillator and Optical Axis Adjustment (continued)

He-Ne Laser Reflecting Mirror Adjustment. To adjust the He-Ne reflecting mirror:

1 Place a sheet of white paper on the optical axis of the Nd:YAG laser beam, a short distance from, and on the output side of the M4 mirror.

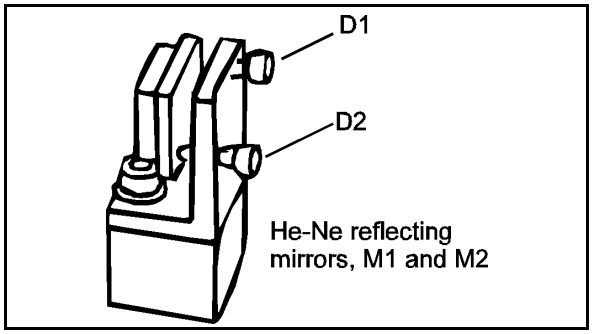


LASER37.PCX

Path of Laser Beam

2 Adjust the M1 and M2 mirrors so that they are at an angle of about 36° and 55° respectively with respect to the side of the oscillator base.

3 Rotate the D1 and D2 knobs of the M1 mirror so that the He-Ne laser beam reaches the white paper.



LASER38.PCX

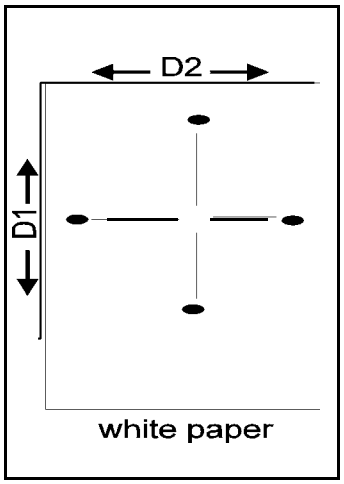
Reflecting Mirrors M1 and M2

He-Ne Laser Reflecting Mirror Adjustment (continued)

4 Rotate the D1 knob of the M1 mirror to the right or left so that the He-Ne laser beam is semicircular and marks the white paper. (The laser moves vertically.)

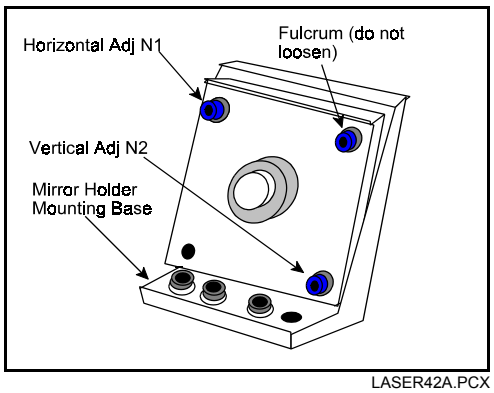
5 Similarly, rotate the D2 knob to the right or left to mark the white paper. (The laser moves horizontally.)

6 Rotate the D1 and D2 knobs further so that the He-Ne laser will be applied to the center of the four marks.



LASER39.PCX

7 Loosen the N1 and N2 adjustment nuts of the M3 and M4 resonator mirror holders with an 8 mm wrench. This action will slightly misalign the M3 and M4 mirrors so that you can distinguish the laser reflected in the rod end face from that reflected in the resonator mirror. For re-adjustment of the resonator mirrors, refer to the next procedure titled *Resonator Mirror Adjustment.*



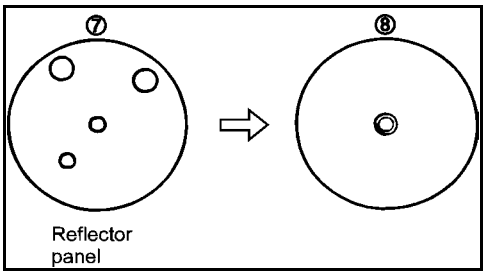
LASER42A.PCX

Mirror Adjustment

8 Rotate the D1 and D2 knobs of the M2 mirror so that the reflected He-Ne laser beam from the end face of the Nd:YAG rod hits the reflector plane of the laser beam oscillator.

9 Repeat Steps 3 through 8 until the optical axis of the He-Ne laser beam is aligned with that of the Nd:YAG laser beam. (When both optical axes are in alignment, a faint interference fringe will appear on the reflector panel.)

10 Remove the white paper.



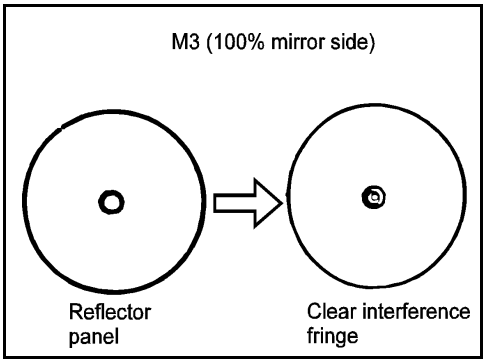
LASR41.PCX

Laser Beam Alignment

Resonator Mirror Adjustment. To adjust the resonator mirror:

1 Rotate the N1 and N2 adjustment nuts of the M4 resonator mirror holders to bring the reflected laser beams to the center of the reflector panel. (When the reflected laser beams are aligned, an interference fringe appears on the reflector panel.)

2 Rotate the N1 and N2 adjustment nuts of the M3 resonator mirror holders to bring the reflected laser beams to the center of the reflector panel. (When the reflected laser beams are aligned, an interference fringe appears.)



Adjust Resonator Mirror

ADJUSTMENT HINTS

A. Use the N1 and N2 adjustment only for fine adjustment. If you need to make coarse adjustments, loosen the three mirror base mounting bolts and adjust the base. Then, make fine adjustments with N1 and N2.

B. The mirror holder and mounting base should remain approximately parallel. Factory set separation distance is 23.5 mm.

C. When adjusting the beams by rotating the N1 and N2 nuts in the clockwise (tightening) direction, keep rotating the nuts in the clockwise direction from the beam-adjusted position to fix the position and complete the adjustment. When adjusting the beams by rotating the N1 and N2 nuts in the counterclockwise (loosening) direction, rotate them counterclockwise from the beam-adjusted position more than is necessary, then rotate them slightly clockwise to fix the position and complete the adjustment.

Burning Pattern Adjustment. To adjust the burning pattern:

1 Set the unit to the Service Mode No. 1 or set the laser output to 300 volts and 0.8 to 1.0 milliseconds.

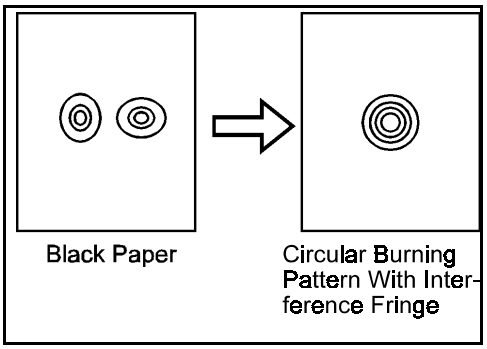
2 Turn on the high voltage (HV).

3 Open the main (resonator) shutter (MAIN SHUTTER).

4 Place a sheet of black paper on the optical axis of the Nd:YAG laser beam, a short distance from, and on the output side of, the M4 mirror.

5 Push the laser start switch. The black paper will be slightly burned and a burning pattern will be obtained.

6 Rotate the N1 and N2 adjustment nuts of the M3 mirror so that the burning pattern becomes circular. (Circular burning pattern has an interference fringe.)



Black Paper Placement

CAUTION: The circular burning pattern will cause the paper to burn more intensely, thereby producing more smoke and flame. Lower the voltage or shorten the pulse width so that the optical parts will not be stained.

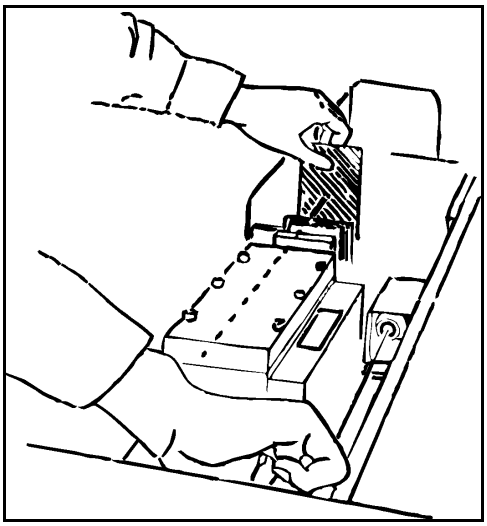
Optical Axis Adjustment Preparation. To prepare the three optical axes for adjustment:

1 Position a new sheet of black paper. (Output condition: 300 volts and 08 - 1.0 milliseconds, or Service Mode No. 1 or No. 2.)

2 Push the laser start switch.

3 Move the knob of the M1 mirror so that the He-Ne laser beam is applied to the center of the burning pattern.

4 Move the knob of the M2 Mirror so that the reflected laser beam is applied to the center of the reflector panel. (If it is applied to the center, the black paper becomes as adjusted in Step 2 of resonator mirror adjustment procedure.)



M1 and M2 Mirror Adjustment

Optical Axis Adjustment Preparation(continued)

5 Repeat Steps 3 and 4 to align the optical axis of the YAG laser beam with that of the He-Ne laser beam.

6 Position a new sheet of black paper, then push the laser start switch.

7 Confirm that the He-Ne laser beam is applied to the center of the burning pattern.

> ***WARNING:*** Wear safety goggles with an optical density of at least 6 at a wavelength of 1064 nanometers when adjusting the X, Y and Z axes.

Z Axis Adjustment. To adjust the Z axis:

1 Place a centering target over the input side of the input focusing unit.

2 Verify that the He-Ne beam is centered on the target cross hairs.

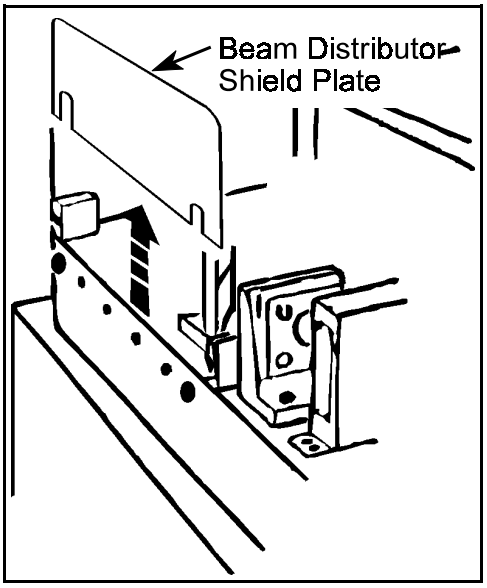
3 Loosen the screws securing the beam splitter or time share unit to the base plate. Reposition the beamsplitter or time share unit as needed to center the He-Ne beam onto the target.

4 Tighten the mounting screws.

5 Adjust the polarizing ocular lens cap on the fiberscope to reduce the observed He-Ne beam intensity to the minimum level necessary to perform these adjustments.

6 Remove the shield plate at the beam distributor section. The HV becomes off line automatically.

7 Connect the fiberscope to the fiberscope holder. Install this assembly onto the branch of the laser head base.

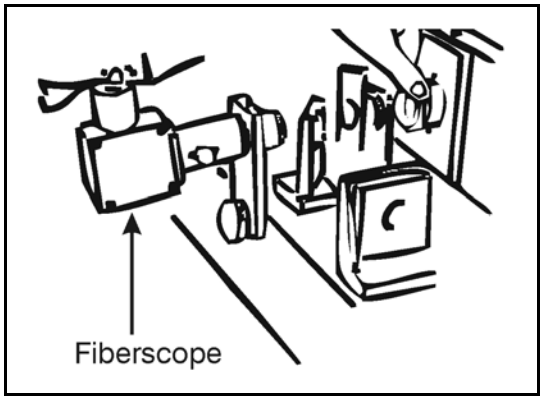


LASER46.PCX

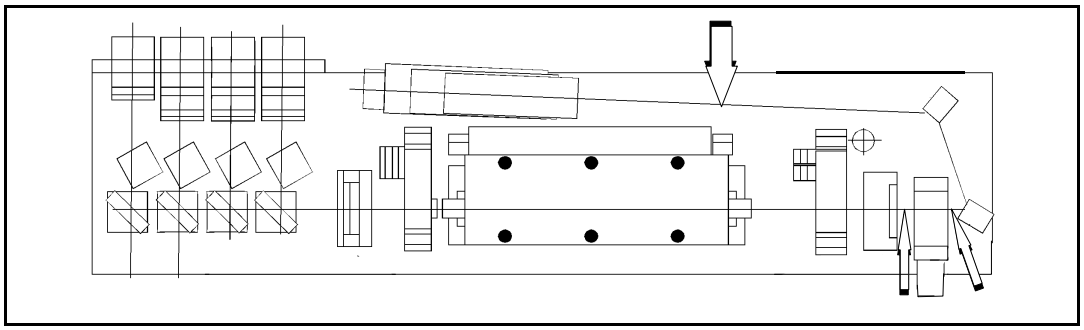
Adjust M1 and M2 Mirrors

8 Mount the connector onto the laser beam input unit side of the optical fiber to the laser beam input unit.

WARNING: Confirm that the high voltage (HV) is turned off and wear goggles having a minimum optical density of 6 at 632 to 650 nm before looking into the fiberscope. Viewing the laser beam through the fiber-scope should be comfortable to the eye. During the axis adjustment procedure, use a neutral density (ND) filter, Part No. 318-011, to reduce the brightness of the laser beam as viewed through the fiberscope. Referring to the following diagram, locate the filter in any one of the three indicated positions.



Fiberscope Connection



Laser Beam Path

9 Remove the cap on the emitter side of the optical fiber. Fix the optical fiber so that the light from fluorescent lamp or other light source enters the optical fiber. (Take care not to over bend the optical fiber past the minimum bending radius. Protect it from dust.)

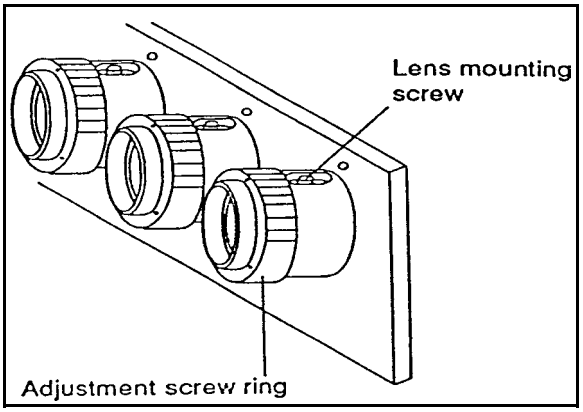
NOTE: If the branch mirror holder is moved, readjust it so that the laser beam reflected in the branch mirror is applied to the center of laser beam input unit lens at an incident angle of 0°.

Z Axis Adjustment (continued)

10 Loosen the lens mounting screw of the laser beam input unit.

11 Open the branch shutter.

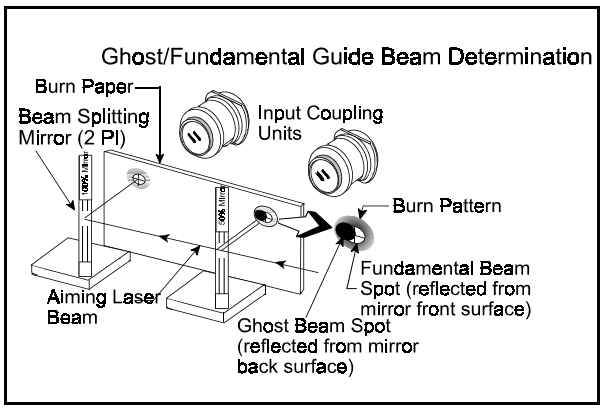
12 While observing the end face of the optical fiber through the fiberscope, turn the adjustment screw ring of the laser beam input unit so that the He-Ne laser beam diameter is converged to the smallest possible point.



LENSMNT.WPG

Adjustment Screw Ring

NOTE: The brightest guide beam laser spot may not always belong to the direct (fundamental) aiming beam. To distinguish between the true fundamental beam spot and the ghost beam spot, refer to the illustration titled ***Ghost/Fundamental Guide Beam Determination***.

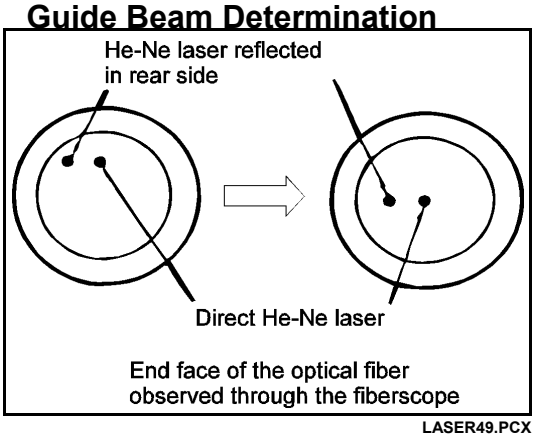


LW5XBM.WPG

Ghost/Fundamental Guide Beam Determination

13 Observe the end face of the optical fiber through the fiberscope. Turn the adjustment screw ring clockwise from the position set in Step 12 according to the chart titled ***Adjustment Screw Ring Turns Required for Defocus***. Use the instructions for the appropriate fiber size. (Only the laser beam reflected in the rear side of the branch mirror will move to the left.)

14 Tighten the lens mounting screw of the laser beam input unit.



LASER49.PCX

Fiberscope Image

Adjustment Screw Ring Turns Required for Defocus

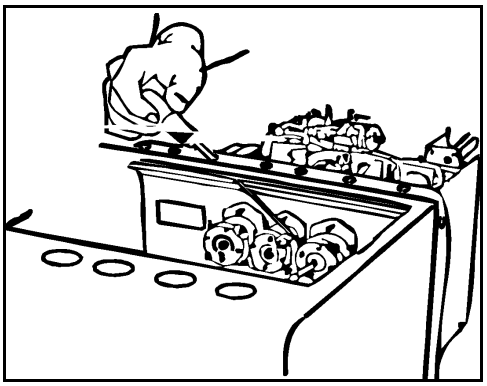
Fiber Diameter (mm)	LW-51/52 Turns for Defocus	LW-100 Turns for Defocus
0.2	N R*	N R*
0.3	1.0	NR*
0.4	1.5	NR*
0.6	2.0	2.0
0.8	2.0	2.0
1.0	2.0	2.0

***NR = Setup is not recommended. Use larger diameter fiber for optimum operation.**

X and Y Axis Adjustment. To adjust the X and Y axes:

1 Loosen the lock nut of the X and Y axes adjustment screws at the connection of the laser beam input unit optical fiber.

Note: The brightest guide beam laser spot may not always belong to the direct (fundamental) aiming beam. To distinguish between the true fundamental beam spot and the ghost beam spot, refer to the illustration titled ***Ghost/Fundamental Guide Beam Determination***.



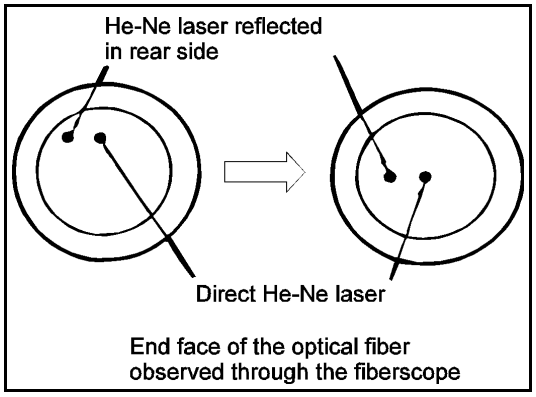
LASER50.PCX

X and Y Axis Adjustment

X and Y Axis Adjustment (continued)

2 Observing the end face of the optical fiber through the fiberscope, bring the He-Ne laser beam to the center of the end face of the optical fiber with the X and Y axis adjustment screws. (Note that the laser beam on the left side is the one reflected in the rear side of the branch mirror.)

3 Tighten the lock nut to secure the X and Y axis adjustment screws. Look through the fiberscope and confirm that the He-Ne laser beam is applied to the center of the optical fiber.



LASER49.PCX

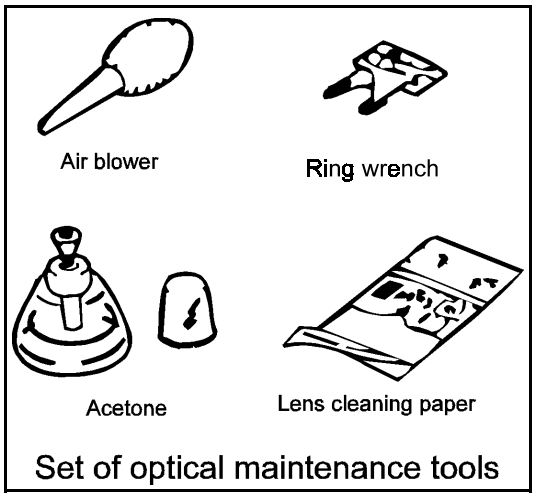
Fiberscope Image

SECTION 2: OPTICAL PARTS

Maintenance Tools

To service the optics, you will need a special set of tools and materials, equivalent to the one shown opposite.

CAUTION: Prepare an air blower, ring wrench, acetone and lens cleaning paper for cleaning the optical parts. Do not use any other tools or chemicals.



LASER52.PCX

Optical Part Removal and Replacement

CAUTION: Unlike most machined parts, optical parts can no longer be used if they are scratched or burned. Accordingly, handle them very carefully.

NOTE: When optical parts, other than the laser beam input unit, require maintenance, contact Unitek Miyachi Corporation.

Laser Beam Input Unit Removal and Replacement. To remove and replace the laser beam input unit titled: ***Ghost/Fundamental Guide Beam Determination***.

1 Remove the laser beam input unit from the laser head.

2 Remove the screw ring.

3 Press two sheets of lens cleaning paper to the lens holder.

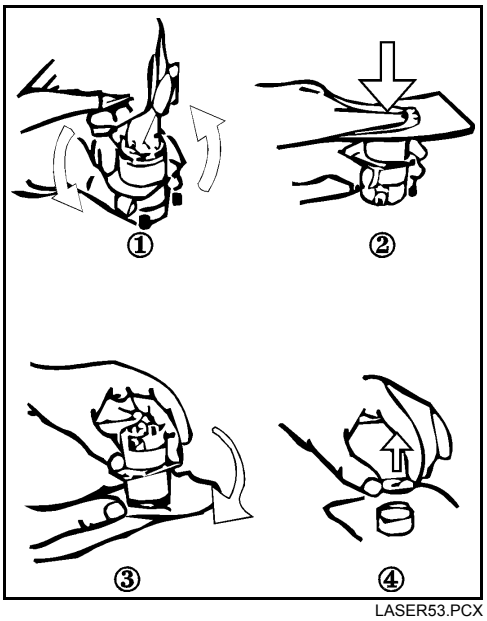
4 Slowly turn the laser beam input unit so that the cleaning paper is under the unit.

5 Carefully place the laser beam input unit on a table on top of the lens cleaning paper.

6 Carefully lift up the laser beam input unit. (If the lens cannot be removed, shake it gently up and down.)

7 Remove the collar, lens and Teflon ring one by one from the laser bean input unit. Hold the lens by both its sides and place it on the cleaning paper.

8 To replace the optical parts, reverse the removal procedures. **CAUTION:** Contaminants may adhere to the optical parts during replacement. Therefore, check them again after they are installed.



LASER53.PCX

Remove & Replace Laser Beam Input Unit

Cleaning the Optical Parts

Contaminant Removal. To remove dirt, dust and other contaminants adhering to the parts:

1 Hold the optical parts horizontally by the sides.

2 Blow off any dirt and dust with optical grade compressed air.

3 Shine fluorescent light onto the cleaned parts to confirm that no dirt or dust remains.

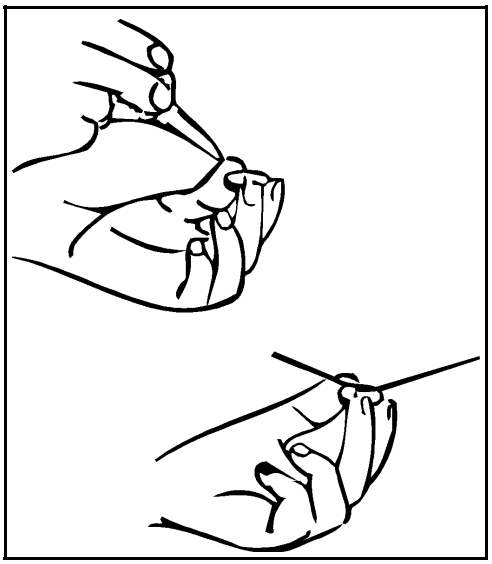
Cleaning the Optical Parts (continued)

Fogging and Stain Removal. To remove fogging or staining:

1 Hold the optical parts horizontally by the sides.

2 Place a drop of acetone on the center of the cleaning paper.

3 Place the wet part of the cleaning paper onto each optical part. (If there is a gap between the paper and a part, the part will not be cleaned evenly.)

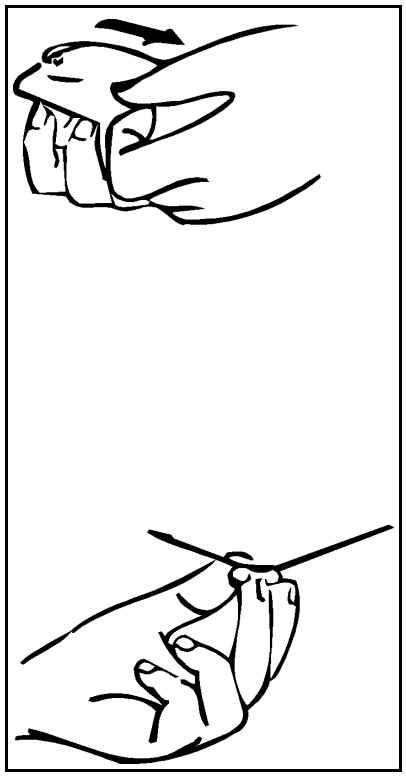


LASER54.PCX

Wet The Cleaning Paper

4 Holding one end of the cleaning paper, wipe each optical part by pulling the cleaning paper across it at a constant speed from one side to the other. (If there is a gap between the cleaning paper and optical parts while being wiped or if any liquid acetone remains at the trailing edge of the cleaning paper when wiping is completed, the optical parts may not be cleaned evenly.)

5 Shine fluorescent light onto the cleaned parts to confirm that no dirt or dust remains.

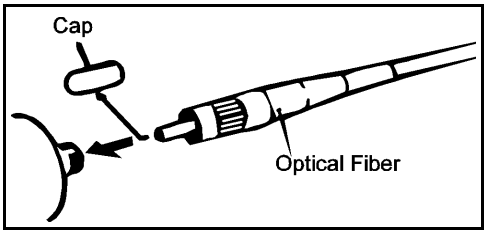


LASER55.PCX

Cleaning Optical Parts

Cleaning the Optical Fiber. To clean the optical fiber:

1 Remove the optical fiber from the connector.



Laser56.pcx

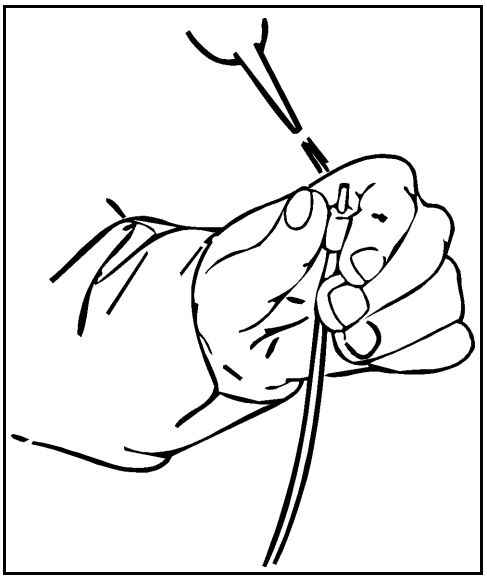
Disconnect Optical Fiber

2 Blow the dust off the end face of the optical fiber with optical grade compressed air.

3 If dust cannot be removed by performing Step 2 above, lightly wipe the fiber with the cleaning paper. **CAUTION:** To avoid scratching the end face, do not press the cleaning paper by finger against the end face of the fiber.

4 Check the end face for dust and staining.

NOTE: We recommended the use an end face checker to check the end face of the optical fiber for flaws, dust and burns.



LASER57.PCX

Blow Dust From Fiber

SECTION 3: POWER SUPPLY

Backup Battery Replacement

To replace the backup battery:

1 Turn off the main power.

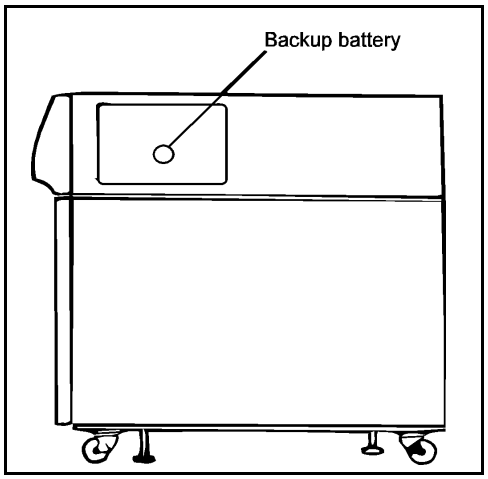
2 Remove the right top cover of the body.

3 Cut the band of the battery on the main board with wire cutters.

4 Disconnect the used battery from the connector and connect a new battery.

5 Pass a new band through the hole on the board, then secure the battery in position.

6 Install the right top cover of the body.



LASER58.PCX

Location of Backup Battery

Fuse Replacement

CAUTION: Rectify the cause of the blown fuse before replacing it.

To replace the fuses:

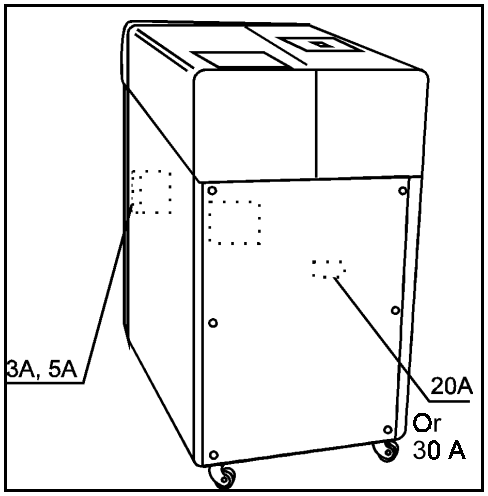
1 Turn of the main power.

2 Remove the right side panel or rear panel from the body.

3 The 3 A and 5 A fuses are located on the board (ME-1694B) fixed to the rear side of the circuit breaker. The 20 A fuse (LW51/52) or 30 A fuse (LW100) is located on top of the transformer on the rear side.

4 Replace the blown fuse with a new one.

5 Install the right side panel or the rear panel.



Location of Fuses

SECTION 4: TROUBLESHOOTING

Unit malfunctions are indicated in the program unit display as follows. Up to four malfunctions can be indicated in one screen.

The
screen shows four examples of trouble indications by their trouble code number (E01: through E04:) and their trouble definition. Check the definitions and rectify the troubles according to the following table. **NOTE:** After rectifying the trouble, push the TROUBLE RESET button.

Code No.	Indication by Program Unit	High Voltage	Trouble Output	Remedy
00	COMMUNICATION LINE ERROR	--	--	Communication problems between the laser power supply and the program box. Increase the distance between the communication line and the noise source.
01	POWER SUPPLY COVER OPENED	OFF	ON	Install the power supply cover or tighten the cover screws.
02	HEAD COVER OPENED	OFF	ON	Install the laser head cover and lamp replacement cover.

Code No.	Indication by Program Unit	High Voltage	Trouble Output	Remedy
03	HIGH TEMPERATURE OF COOLANT	OFF	ON	The flow rate of cooling water is too low or the temperature is too high. Open the cooling water supply valve further. If the draining pressure is high, lower the resistance of the draining path. If the setting of the temperature controller is changed, return it and turn on power again.
04	LOW TEMPERATURE OF COOLANT	--	ON	If the ambient temperature is low, some time will be required to raise the de-ionized water temperature after the power is turned on. After the temperature controller setting is changed, if it takes a long time to raise the deionized water temperature to the set range, return the setting and turn on the power again.
05	LOW FLOW RATE OF COOLANT	OFF	ON	The deionized water flow rate is low. The water filter or the wire screen in the oscillator is clogged. Replace the water filter or clean the wire screen.
06	LOW LEVEL OF COOLANT	OFF	ON	Deionized water volume is insufficient. Add deionized water.
07	OVERHEAT OF PUMP	OFF	ON	The cooler pump is over-loaded. Check the deionized water route for a problem.

Code No.	Indication by Program Unit	High Voltage	Trouble Output	Remedy
08	DEIONIZE TROUBLE	OFF	ON	Purity of the deionized water is low. Allow the cooler to operate for 30 to 40 minutes. If this trouble still occurs, replace the ion-exchange resin cartridge.
09	SIMMER TROUBLE (Auxiliary discharge trouble.)	OFF	ON	Check the flash lamp for a mal-function. If faulty, replace it. Purity of the deionized water may be low. Refer to 08: DEIONIZE TROUBLE.
10	EMERGENCY STOP (Emergency stop is applied.)	OFF	ON	An emergency stop signal is input. Close the emergency stop signal input circuit of EXT-I/O or release the emergency stop switch at the remote control box.
11	CHARGE TROUBLE	OFF	ON	Too much time is required to charge the capacitor in the laser power supply or the charging voltage is abnormally high. Check to see if the capacity of the input power and power cable are insufficient. Check the 20 amp power supply fuse. If it is blown, replace it.
12	RATE OVER (Duty cycle is too high.)	OFF	ON	A start signal is input before charging is completed. Increase the input interval of the start signals or increase the time from the change of condition to the input of the start signal. If possible, input the start signal after a READY signal is received.

Code No.	Indication by Program Unit	High Voltage	Trouble Output	Remedy
13	MAIN SHUTTER TROUBLE (Resonator shutter malfunction.)	OFF	ON	A laser start signal is input while the resonator shutter is opening or closing. Increase the time from input of the shutter open/close signal to the input of the laser start signal.
14 15 16 17	BRANCH SHUTTER 1 TROUBLE BRANCH SHUTTER 2 TROUBLE BRANCH SHUTTER 3 TROUBLE BRANCH SHUTTER 4 TROUBLE	OFF OFF OFF OFF	ON ON ON ON	A laser start signal is input while the branch shutter or time branch unit is in operation. Lengthen the time from the input of the beam selection signal to the input of the laser start signal.
18	NO LIGHT	--	ON	Confirm that the resonator shutter is closed. Confirm that the energy is less than 0.5 J.
19	OVER LIMIT OF LASER POWER	--	ON	Change the upper limit setting.
20	UNDER LIMIT OF LASER POWER	--	ON	Change the lower limit setting or replace the lamp.
21	OVER LIMIT OF PEAK POWER	--	ON	Change the upper limit setting.
22	UNDER LIMIT OF PEAK POWER	--	ON	Change the set value or replace the lamp.
23	PHASE TROUBLE (3-phase power input is out of range)	OFF	ON	Check the connection of the R, S and T wires of the 230 VAC 3-phase input power.
24	MEMORY TROUBLE	--	ON	Replace the memory backup lithium battery (refer to Section 3 in this chapter).

Code No.	Indication by Program Unit	High Voltage	Trouble Output	Remedy
25	SET ERROR (Over limit of maximum power.)	--	--	Input power (voltage, time and repetition) is exceeding the capacity. Schedule setting will reset back to the previous setting.
29	BANK ALARM (Capacitor bank problem.)	OFF	ON	Thermal protection may occur when the change of schedule is too frequent. Increase the time interval between the schedules.
30	NO CURRENT (No lamp current.)	OFF	ON	Lamp current was not detected after the start signal is initiated. Check the lamp for damage.
31	GTR TROUBLE (Power device problem.)	OFF	ON	Lamp current is detected without the start signal. Possible power supply failure.
32	LASER START IS NOT READY	--	--	The start signal was initiated before the completion of the charging of the capacitor bank. Increase the time intervals between the start signal.

SECTION 5: PARTS LISTS

Accessory Kits

An accessory kit is supplied with the LW51/LW52/LW100 laser units, as listed in the following table. The part number for the LW51/LW52 accessory kit is 4-60268-01. The part number for the LW100 accessory kit is 4-60269-01.

Accessory Kit Contents

Part	Number	Qty
Braided hose, 10 meters	050-230	1
Cartridge wrench	451-082	1
Fiber optic grommet	L3-02155	4
Fiber scope	FOS-02 / FOS-03	1
Fuse, 20 amp, 660 V (LW51/LW52 only)	330-077	1
Fuse, 6 amp, 250 V, 3AG	330-044	1
Fuse, 30 amp, 700 V (LW100 only)	330-084	1
Fuse, 3 amp, 250 V, 3AG	330-083	1
Hand pump	PH-10	1
Hex ball driver, 3 mm	770-036	1
Hex ball driver, 5 mm	770-038	1
Hex ball driver, 2.5 mm	770-035	1
Hose clamp	245-096	4
Label, Laser, Danger	425-098	1
Label, Laser, P-1048, LM45	425-147	1
Label, Danger, Laser	425-131	1
Label, Laser, Danger	425-097	1

Spare Parts Kits

Spare parts kits are obtainable from Unitek Miyachi in three levels, as follows:

LW51/52, Level I, Kit PN 08-637-01

LW51/52, Level II, Kit PN 08-637-01-01

LW51/52, Level III, Kit PN 08-637-01-02

LW100, Level I, Kit PN 08-636-01

LW100, Level II, Kit PN 08-636-01-01

LW100, Level III, Kit PN 08-636-01-02

Spare Parts Kit Contents

Part	Part No.	Qty	Kit Level
Caster, 65 mm	760-002	4	III
Circuit breaker, W/GF1 (LW51/LW52)	240-056	1	III
Circuit breaker, W/GF1 (LW100)	240-057	1	III
Control PCB assy	ME-1703	1	III
Control PCB assy	ME-1737	1	III
Deionized water filter	4-60081-01	1	I, II, III
Deionized water cartridge	4-60082-01	1	I, II, III
Deionized water heater	4-60037-01	1	III
Door latch	30016459	1	II, III
Fan, 95 cfm, 120 V	305-025	3	II, III
Flash lamp assy, with clips	4-60200-01	1	I, II, III
Flow sensor	LD-20-PATAAA	1	III
Flow switch	4-60036-01	1	II, III

Part	Part No.	Qty	Kit Level
Fuse, 6 amp, 250 V, 3AG, quick-blo	330-044	1	I, II, III
Fuse, 30 amp, 700 V (LW100)	330-084	1	I, II, III
Fuse, 3 amp, 250 V, 3AG, quick-blo	330-083	1	I, II, III
Fuse, 20 amp, 700 V (LW51/LW52)	330-077	1	I, II, III
He-Ne aiming laser	4-60022-01	1	III
Keyswitch	S-9-90-B-1	1	II, III
Lamp glass pipe	4-35086-01	1	I, II, III
Laser water pump	32P121	1	III
Laser header, 10 circuit	250-331	1	III
Laser power detector	4-60153-01	1	III
Laser main PCB assy	4-60056-01	1	III
Laser trigger PCB assy	4-60057-01	1	III
Laser capacitor PCB assy	4-60058-01	2	III
Laser SSR PCB assy	4-60059-01	1	III
Laser PCB assy	ME-1715A	1	III
LCD display module	270-037	1	III
O-ring, silicon rubber	4-60020-01	3	I, II, III
O-ring, silicon rubber	4-60019-01	1	I, II, III
O-ring, 7 mm (LW51/LW52)	4-60017-01	2	I, II, III
O-ring, 12.5 mm	4-60018-01	2	I, II, III

Part	Part No.	Qty	Kit Level
O-ring, 9 mm (LW100)	570-154	2	I, II, III
Plug, male, 4 conductor	520-120	4	III
Power supply, 12 V	525-002	1	III
Power supply, 24 V	525-001	1	III
Receptacle, female, 4 conductor	550-074	4	III
Relay, DPDT, 5 amp, 220 VAC	555-114	1	II, III
Relay, DPDT, 3 amp, 24 VDC	555-115	1	II, III
Relay, 3PST	555-112	1	II, III
Relay, with overload	555-111	1	II, III
Relay, phase control	555-116	1	II, III
Relay, SPST, NC, 24 VDC	G7HN-1B	2	II, III
Rotary solenoid, with connector	4-60041-01	1	III
Rotary solenoid	4-60039-01	2	III
Rotary solenoid, with connector	4-60040-01	1	III
Sensor assy PCB	LP-0026C	1	III
Sensor assy PCB	LP-0046	1	III
Solenoid valve, 2 way	720-133	1	III
Switch, snap action	680-320	2	II, III
Switch guard	680-319	1	II, III
Switch, pushbutton	680-317	2	II, III

Part	Part No.	Qty	Kit Level
Switch, emergency	680-316	1	II, III
Switch, interlock	680-171	10	II, III
Switch, momentary, 1 amp	680-318	1	II, III
Temperature controller	4-60035-01	1	III
Terminal, female, 1 mm	253-072	16	III
Terminal, male	253-071	16	III
YAG rod, 10 mm x 110 mm (LW100)	4-60287-01	1	III
YAG rod glass pipe	4-35087-01	1	I, II, III
YAG rod, 8 mm x 112 mm (LW51/LW52)	4-60028-01	1	III

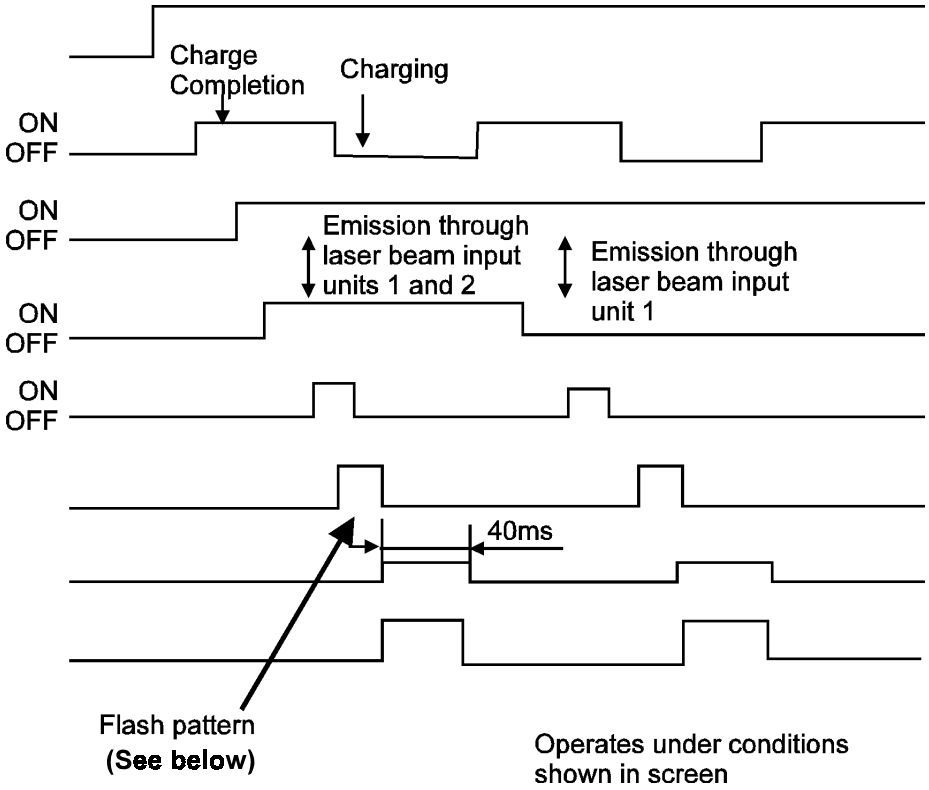
APPENDIX A
TECHNICAL SPECIFICATIONS

Item	Specification	
Laser Head	Average Power	LW51/LW52: 50W
		LW100: 100W
	Pulse Energy @ 10ms	50 Joules
	Pulse width:	0.3 to 20.0 msec (0.1-msec steps)
	Pulse repetition rate:	1 to 50 PPS
	Oscillation Wavelength:	1.064 µm (1,064 nanometers)
	Beam diameter:	LW51/LW52: 8mm
		LW100: 10mm
	Resonator shutter:	With open/closed sensor
	Positioning guide light:	Built-in visible laser unit (630-640nm, 5mW)
Power Supply	Source power:	230 VAC ±10%, 3-phase, 50/60 Hz, 12 A
	Set voltage:	LW51/LW52: 150 to 510 VDC in 1 volt
		LW100: 150 to 500 VDC in 1 volt steps
Laser Controller	Condition setting:	16 combinations of the following items can be set: C Charging voltage (A and B for the LW52 and LW100) C Pulse width (flash 1, cool 1, flash 2, cool 2, flash 3 for the LW52 and LW100) C Upper and lower limits of power monitor and alarm (energy monitor [J], average power monitor [W]) C Repetition rate and number of repeat shots.
	Counter:	C 8-digit total shot counter C 8-digit good shot number

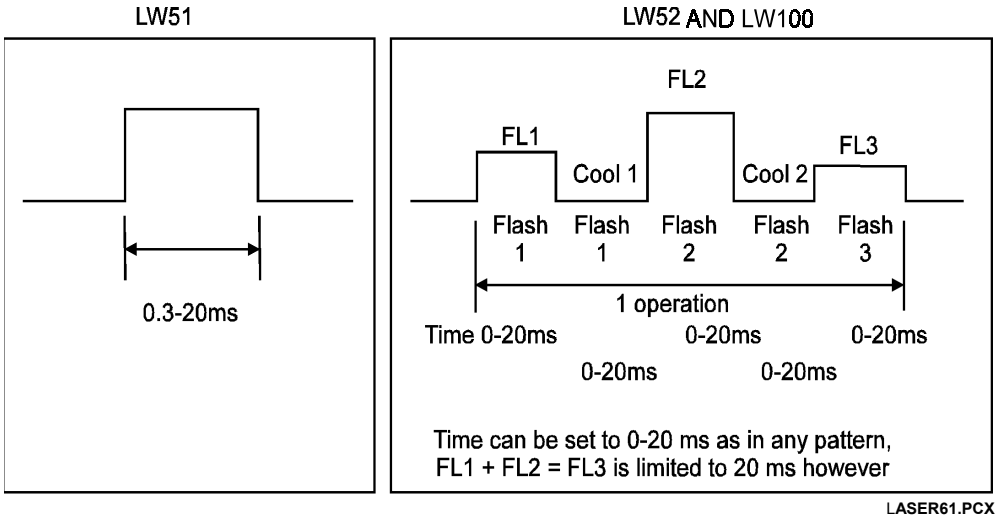
Item	Specification	
	Alarm Indication:	Messages are indicated in the liquid crystal display
	Remote Operation:	Remote operation can be performed through a standard 3-meter (10-foot) cable.
Cooler:	Heat Exchange Method:	Exchange Water - D.I. (Deionized) water or steam-distilled water
	Required Chilled Water:	• Pressure: 1-3 kg/cm^2 (1-3 bar) • Flow Rate: 8 liters/min • Temp: 5-25°C (40 - 95°F)
	Hose Inner Diameter:	15 mm
Coolant Medium: D.I. water or steam-distilled water. Provides water cooling for the laser rod	2 Gallons. **Note:** Use only deioniozed water or steam-distilled water as a coolant medium. Laser action on steam-distilled water will deionize it and control its purity (electrical resistivity).	
Dimensions:	Height: Width: Depth:	1,030 mm (40.5 in.) 550 mm (21.6 in.) 1,060 mm (41.7 in.)
Weight:	LW51:	250 kg (550 lb)
	LW52:	255 kg (560 lb)
	LW100:	250 kg (550 lb)

APPENDIX B
TIMING DIAGRAMS

PROGRAM UNIT IN OPERATION, TWO SIMULTANEOUS BRANCHES



FLASH PATTERN



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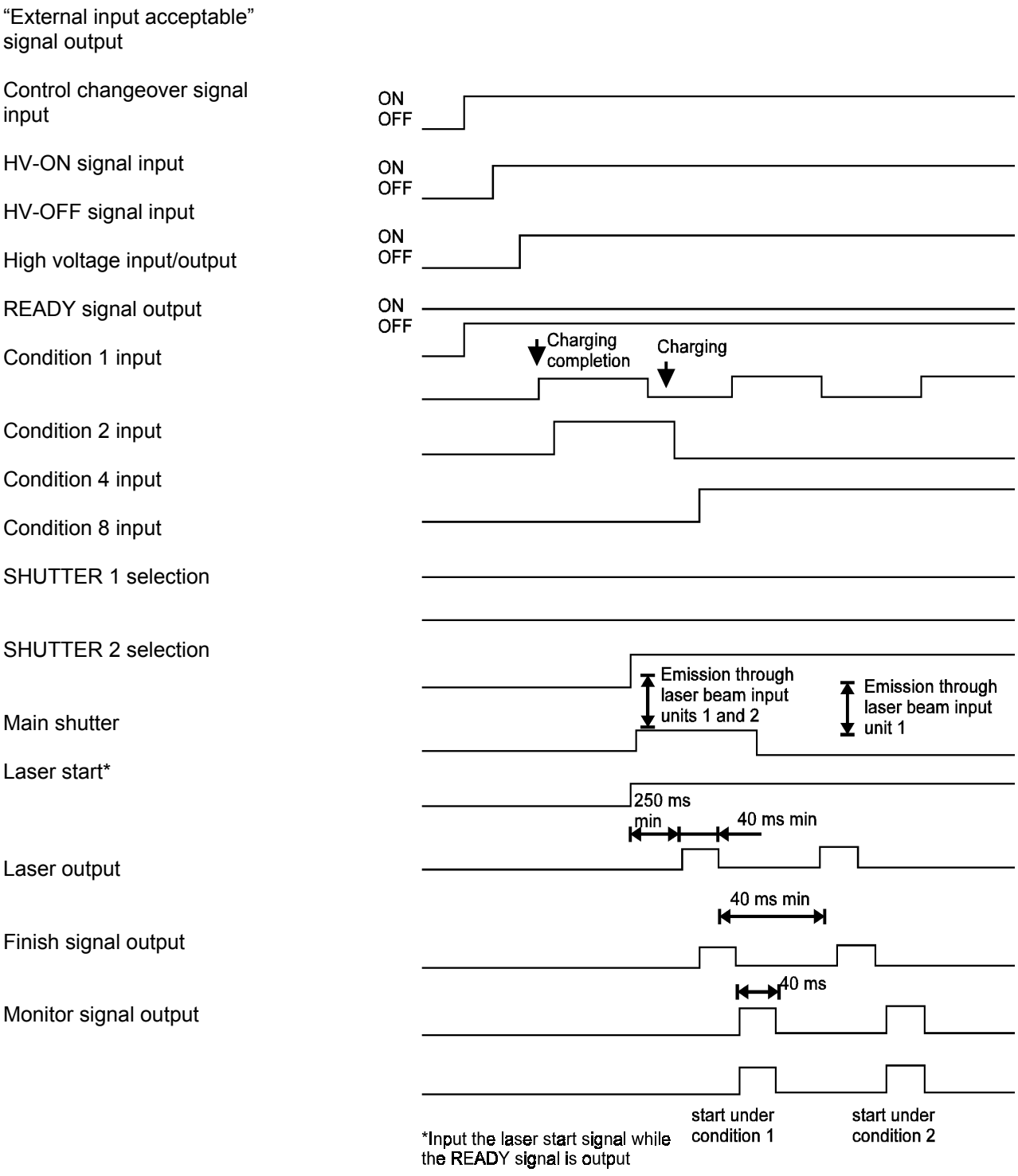
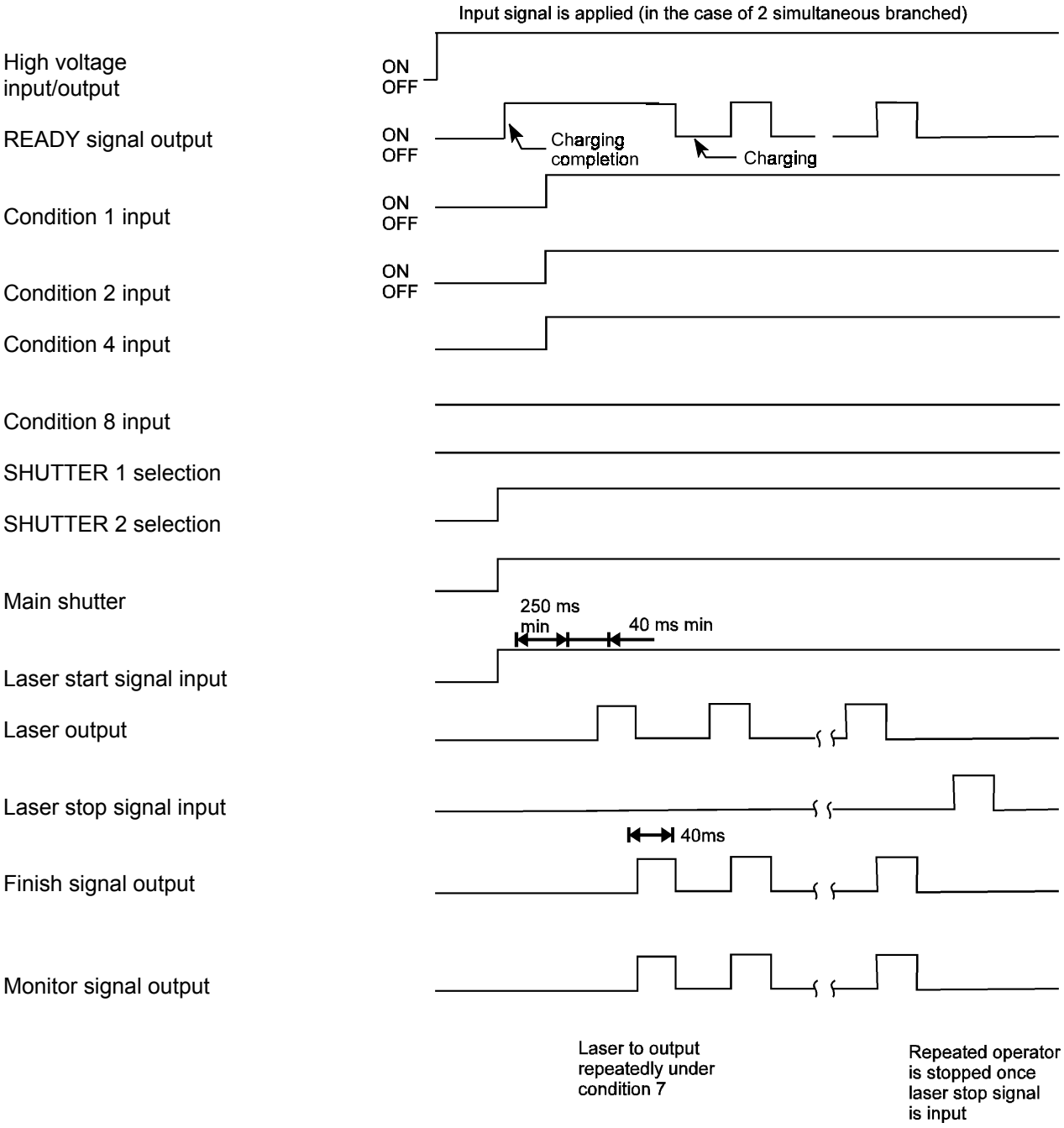
External Input Signal Applied, Two Simultaneous Branches



Repeat Operation, Two Simultaneous Branches



APPENDIX C
EXTERNAL COMMUNICATIONS SPECIFICATION

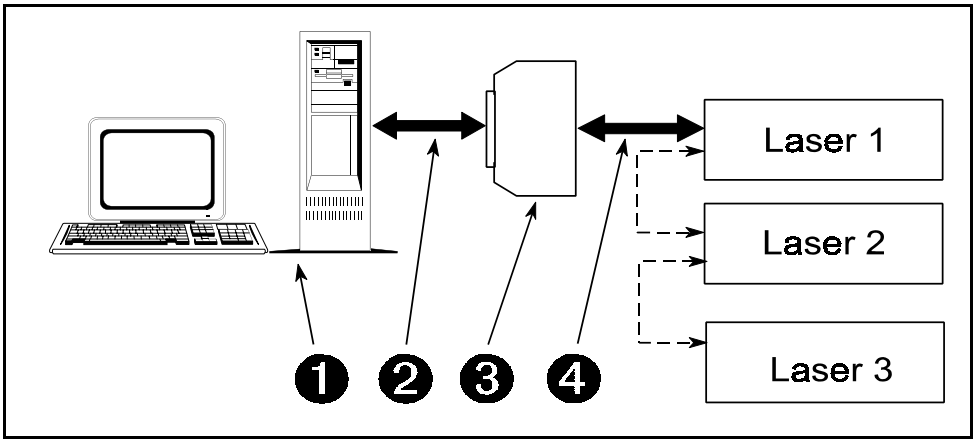
EXTERNAL COMMUNICATIONS SPECIFICATION

1. Introduction

An RS-485 interface is used for reading and setting schedules; and monitoring data and status of the LW51, LW52 and LW100 Laser Unit from an external computer.

2. Connections

To connect a host PC to the laser or several lasers:

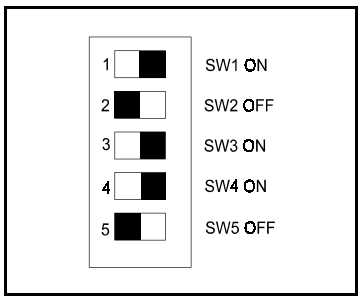


Ø **Host Computer**

Ù **Serial Cable.** Connects between the host computer serial port and the RS-232/RS-485 converter (Ú). Depending on the serial port to be used, the cable may be terminated as either:

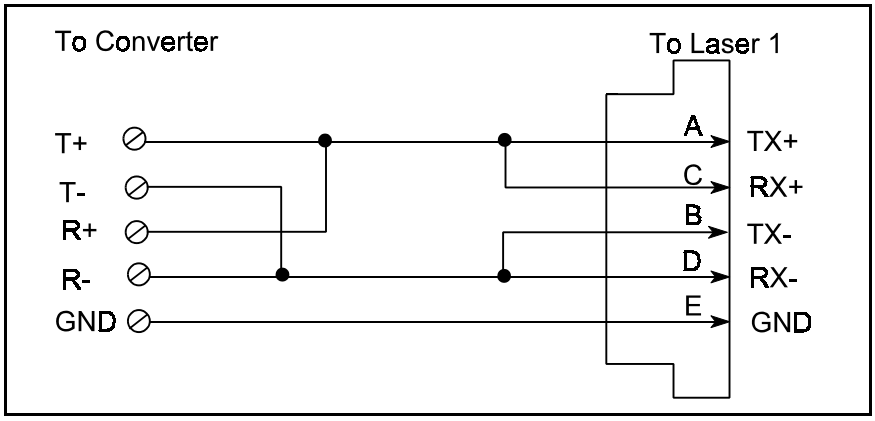
- C Standard female 9-pin to female 25-pin, or
- C Standard female 25-pin to female 25-pin.

Ú **RS-232/RS-485 Converter.** The converter is a Telebyte Model 285. The manufacturer may be contacted at 1-800-835-3298. The converter DIP switch settings for this application are as illustrated at the right.



Û **Receive/Transmit Cable.** This custom cable may be fabricated by the user or supplied by Unitek Miyachi. The cable schematic is shown below:

3. Data Transfer



(1) Type: Conforms to RS-485, in an asynchronous, full-duplex party line.

(2) Baud Rate: 9600 bps

(3) Data Format:

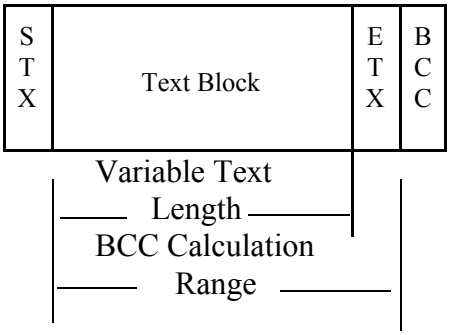
- Start bit : 1
- Data bit : 8
- Stop bit : 2
- Parity bit : 1 (even parity)

(4) Character code: ASCII

(5) Communication control code:

Command Code	Hex Value	Description
STX	02H	Start of Text
ETX	03H	End of Text
EOT	04H	End of Transmission
ENQ	05H	Enquiry
ID•ENQ	50H•30H•05H	Identification Enquiry
ACK	06H	Acknowledge
ID•ACK	54H•31H•06H	Identification Acknowledge
NAK	15H	Not Acknowledge

(6) Text Format



(7) BCC Calculation: BCC is the binary coded check sum. It is calculated by adding all bytes after STX and through ETX as listed in the following example C-program:

```
#include <stdio.h>

#define STX   0x02
#define ETX   0x03

char command[300];

/*
   calbcc: used to calculate BCC and concatinate
           BCC to the end of the string.
```

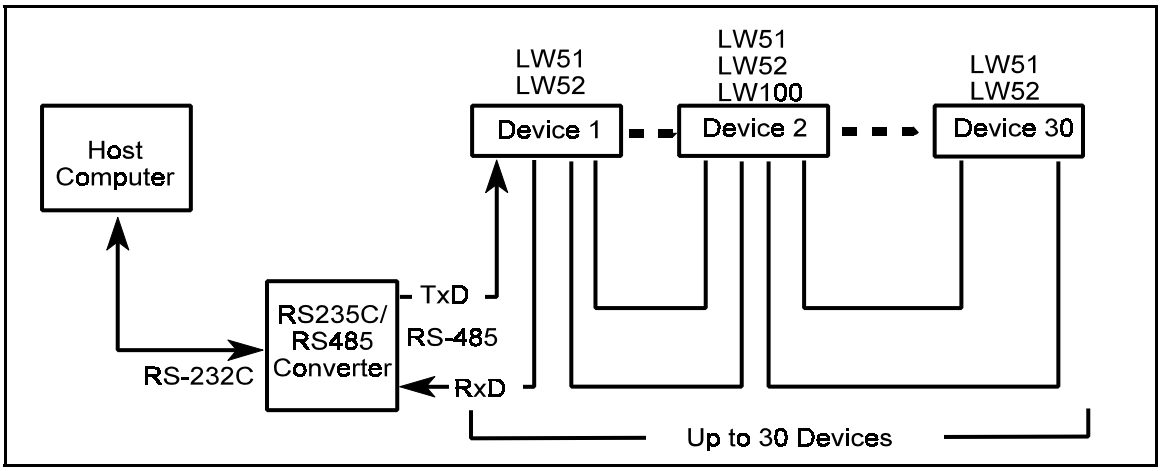
```
   NOTE:   printf statement is only to help debugging.
*/

char calbcc(bf)
char  *bf;
{
   char bcc;
   int n;

   printf("Command: %02X ", bf[0]);

   bcc = 0;

   for (n = 1; ; n++)
       {
       printf("%02X ", bf[n]);
       bcc ^= bf[n];
       if (bf[n] == ETX)
          break;
       }

   printf(" BCC: %02X\n", bcc);
   bf[++n] = bcc;
]

main()
{
   /*
      Following statement compose a command string to read
      Repeated PPS of schedule 5
   */

   sprintf(command,
      "%c%02d%s%02d%02d%c",    /* String Format               */
```

```
      STX,                      /* Start of transmission code  */
      0,                        /* Network Number = 0          */
      "R",                      /* Code for reading the data   */
      5,                        /* Schedule Number = 5         */
      4,                        /* Data No = 4 (Repeated PPS)  */
      ETX);                     /* End of transmission code    */

   calbcc ( command );

   /*
      Following statement compose a command string to read
      the status of shutters.
   */
   sprintf( command,
      "%c%02d%s%c",             /* String Format               */
      STX,                      /* Start of transmission code  */
      0,                        /* Network Number = 0          */
      "RS",                     /* Code for reading status     */
      ETX);                     /* End of transmission code    */
   calbbc( command );

   /*
      Following statement compose a command string to set schedule 1
      the pulse width to 2.0 ms.
   */
   sprintf( command,
      "%c%02d%s%02d%02d%3d%c", /* String Format               */
      STX,                      /* Start of transmission code  */
      0,                        /* Network Number = 0          */
      "W"                       /* Code for reading status     */
      1,                        /* Schedule Number = 1         */
      1,                        /* Data No = 1 (pulse width)   */
      20,                       /* Data value = 20 92.0 msec)  */
      ETX);                     /* End of transmission code    */

   clbcc( command );
}
```

4. Configuration

NOTE 1: Each device number is set by NETWORK # on the LW51/LW52/LW100 panel.

NOTE 2: Do not assign the same network number to more than one device. If you do, a data collision will occur in the communication lines and the units will not operate properly.



To change the network number:

1. Press the MENU key until the STATUS screen appears.
2. Use the arrow keys to move to the SERVICE MODE field.
3. Use the [+] to change to ON.
4. Press the ENTER key to enter the SERVICE MODE screen.
5. Use the [+] and [-] keys to change the network number.
6. Press the ENTER key to save the network number.
7. Press the MENU key to exit the SERVICE MODE screen.

5. Contents of Each Command

1.	Data Setting	Code: W

Host Computer Side	STX	CH1	CHO	W	SH1	SHO	DT1	DTO	:	data	ETX	BCC		
LW51 LW52 LW100													CH1 CHO ACK	or CH1 CHO NAK

(1) CH1 and CH0 are network numbers, where CH1 = number of tens and CH0 = number of units.

(2) SH1 and SH0 are schedule numbers, where SH1= number of tens and SH0 = number of units.

(3) DT1 and DT0 are data numbers, where DT1 = number of tens and DT0 = number of units.

(4) For data numbers, refer to Section 6, *Contents of Set Data and Monitor Data*.

(5) If the set data is within the setting range, [ACK] is returned. If the set data is out of the setting range, [NAK] is returned.

(6) For data common to all schedules, set the schedule number to [99].

(7) If the data number is set to [99], write the data in one line, as follows:

(Data No. 1), (Data No. 2), Data No.3), ---, (Last Data No.)

Enter a comma (,) between data, excluding the monitor values (Total count, GOOD count, energy monitor value, peak power monitor value).

(8) Before the Data Setting command is sent, the laser must be set to communication line control. Refer to the WS Command (Command No. 3, item (3)).

2.	Reading the data	Code: R

Host Computer Side	STX	CH1	CHO	R	SH1	SHO	DT1	DTO	ETX	BCC	
LW51 LW52 LW100	STX	data							ETX	BCC	

(1) CH1 and CH0 are network numbers, where CH1 = number of tens and CH0 = number of units.

(2) SH1 and SH0 are schedule numbers, where SH1 = number of tens and SH0 = number of units.

(3) DT1 and DT0 are data numbers, where DT1 = number of tens and DT0 = number of units.

(4) For data numbers, refer to Section 6, *Contents of Set Data and Monitor Data.*

(5) For data common to all schedules, set the schedule number to [99].

(6) If the data number is set to [99], read the data in one line, as follows:

(Data No. 1), (Data No. 2), (Data No. 3), ---, (Last data No.)

Enter a comma (,) between data.

3.	Setting the status, control mode and schedule number.	Code: W S

Host Computer Side	STX	CH1	CHO	W	S	SH1	SH0	cnt	s1	s2	s3	s4	s5	s6	s7	ETX	BCC		
LW51 LW52 LW100																		CH1	CH0	ACK	or	CH1	CH0	NAK

(1) CH1 and CH0 are device numbers, where CH1 = number of tens and CH0= number of units.

(2) SH1 and SH0 are schedule numbers, where SH1 = number of tens and SHO = number of units.

(3) cnt is the control mode, where:

0: Panel Control

1: External Control

2: Communication Line Control

EXT. I/O	Control mode from communication line		
	0: Panel Control	**1: External Control**	**2: Communication Line Control**
External Control OFF	Panel Control	External Control	Communication Line Control
External Control ON	External Control		

(4)

s1:	HV:	0 = OFF	1 = ON
s2:	He-Ne:	0 = OFF	1 = ON
s3:	Main (Resonator) Shutter:	0 = OFF	1 = ON
s4:	Branch Shutter 1:	0 = OFF	1 = ON
s5	Branch Shutter 2:	0 = OFF	1 = ON
s6	Branch Shutter 3:	0 = OFF	1 = ON
s7	Branch Shutter 4:	0 = OFF	1 = ON

(5) To change the control mode, insert spaces for SH1, SH0, and S1 through S7. For example, to change to Communication Line Control, send:

CH1	STX	CH0	W	S			2							ETX	BCC
Two Spaces				L	,	,		,	,	,	,	,	,	,	7 Seven spaces

4.	Reading the status	Code: R S

Host Computer Side	STX	CH1	CH0	R	S	ETX	BCC												
LW51 LW52 LW100	STX	SH1	SH0	cnt	s1	s2	s3	s4	s5	s6	s7	rdy	ETX	BCC					

(1) CH1 and CH0 are network numbers, where CH1 = number of tens and CH0 = number of units.

(2) SH1 and SH0 are schedule numbers, where SH1 = number of tens and SH0 = number of units.

(3) cnt is the control mode, where:

0: Panel Control
1: External Control
2: Communication Line Control

(4)

s1:	HV:	0 = OFF	1 = ON
s2:	HeNe:	0 = OFF	1 = ON
s3:	Main (Resonator) Shutter:	0 = OFF	1 = ON
s4:	Branch Shutter 1:	0 = OFF	1 = ON
s5:	Branch Shutter 2:	0 = OFF	1 = ON
s6:	Branch Shutter 3:	0 = OFF	1 = ON
s7:	Branch Shutter 4:	0 = OFF	1 = ON

(5) rdy is the READY state, where:

0: Laser start impossible
1: Laser start possible

5.	Laser start command	Code: $

Host Computer Side	STX	CH1	CH0	$		0		ETX	BCC											
LW51 LW52 LW100											CH1	CH0	ACK	or		CH1	CH0	NAK		

(1) CH1 and CH0 are network numbers, where CH1 = number of tens and CH0 = number of units.

(2) If the laser can be started, [ACK] is returned. If the laser cannot be started, [NAK] is returned to the host computer. Causes preventing laser start are as follows:

a. An error has occurred.

b. HV is turned off.

c. The capacitor has not been charged to the set voltage.

6.	Laser stop command	Code: $

Host Computer Side	STX	CH1	CH0	$		9		ETX	BCC											
LW51 LW52 LW100											CH1	CH0	ACK	or		CH1	CH0	NAK		

(1) CH1 and CH0 are network numbers, where CH1 = number of tens and CH0 = number of units.

(2) If the laser can be stopped, [ACK] is returned. If the laser cannot be stopped, [NAK] is returned to the host computer. Causes preventing laser stop are as follows:

a. An error has occurred.

b. HV is turned off.

c. The laser has not been started.

7.	Error reset command	Code: C 0

Host Computer Side	STX	CH1	CH0	C	0	ETX	BCC	
LW51 LW52 LW100								
							CH1	CH0	ACK

(1) CH1 and CH0 are network numbers, where CH1 = number of tens and CH = number of units.

(2) After receiving this command, the laser unit is released from the error schedule.

8.	Total count reset command	Code: C 1

Host Computer Side	STX	CH1	CH0	C	1	ETX	BCC	
LW51 LW52 LW100								
							CH1	CH0	ACK

(1) CH1 and CH0 are network numbers, where CH1 = number of tens and CH0 = number of units.

(2) After this command is received, the laser unit resets the total counter to 0.

9.	GOOD count reset command	Code: C2

Host Computer Side	STX	CH1	CH0	C	2	ETX	BCC	
LW51 LW52 LW100								CH1 CH0 ACK

(1) CH1 and CH0 are network numbers, where CH1 = number of tens and CH0 = number of units.

(2) After this command is received, the laser unit resets the GOOD counter to 0.

10.	Reading an error	Code: R T

Host Computer Side	STX	CH1	CH0	R	T	ETX	BCC										
LW51 LW52 LW100	STX	E1	E0	,	E1	E0	----------						E1	E0	ETX	BCC	

(1) CH1 and CH0 are device numbers, where CH1 = number of tens and CH0 = number of units.

(2) E1 and E0 are error numbers, where E1 = number of tens and E0 = number of units. All error numbers are transmitted. If it is normal, the error number is set to [00].

6. Contents of Set Data and Monitor Data

(1) System Setup for LW51, LW52, and LW100

Data No.	Item	Data Range
01	CONTROL NO.	0000 - 9999
02	PROGRAMMED DATE	YYYYMMDD (year, month, date)
03	Total count	00000000 - 99999999
04	GOOD count	00000000 - 99999999

NOTE: YYYY: 0000 - 9999, MM: 01 - 12, DD: 01 - 31

NOTE: The values of Data Nos. 03 and 04 are monitor values. These numbers can be read but not changed.

(2) Data under each schedule for LW51, Schedule No. 00 - 15

Data No.	Item	Data Range
01	Pulse width.	003 - 200 (0.1ms)
02	Voltage	150 - 500 (V)
03	Number of dummy shots	00 - 99
04	Repeated PPS	00 - 99
05	Number of repeated shots	000 - 999
06	Upper limit setting of energy monitor	000 - 999 (x 0.1J)
07	Lower limit setting of energy monitor	000 - 999 (x 0.1J)
08	Upper limit setting of peak power monitor	0000 - 9999 (x 0.01KW)
09	Lower limit setting of peak power monitor	0000 - 9999 (x 0.01KW)
10	Energy monitor value	000 - 999 (x 0.1J)
11	Peak power monitor value	0000 - 9999 (x 0.01KW)

NOTE: The values of Data Nos. 10 and 11 are monitor values. These numbers can be read but not changed.

NOTE: The values of Data Nos. 08, 09 and 11 are recognized as spaces and have no meaning.

(3) Data under each schedule for LW52 and LW100, Schedule No. 00 - 15

Data No.	Item	Data Range
01	Time for FLASH 1	003 - 200 (x 0.1ms)
02	Time for COOL 1	003 - 200 (x 0.1ms)
03	Time for FLASH 2	003 - 200 (x 0.1ms)
04	Time for COOL 2	003 - 200 (x 0.1ms)
05	Time for FLASH 3	003 - 200 (x 0.1ms)
06	Voltage selection for FLASH 1	0 - 1 (0 = A 1 = B)
07	Voltage selection for FLASH 2	0 - 1 (0 = A 1 = B)
08	Voltage selection for FLASH 3	0 - 1 (0 = A 1 = B)
09	Charging voltage A	150 - 500 (V)
10	Charging voltage B	150 - 500 (V)
11	Number of dummy shots	00 - 99
12	Repeated PPS	00 - 99
13	Number of repeated shots	000 - 999
14	Upper limit setting of energy monitor	000 - 999 (x 0.1J)
15	Lower limit setting of energy monitor	000 - 999 (x 0.1J)
16	Upper limit setting of peak power monitor	0000 - 9999 (x 0.01KW)
17	Lower limit setting of peak power monitor	0000 - 9999 (x 0.01KW)
* 18	Energy monitor value	000 - 999 (x 0.1J)
* 19	Peak power monitor value	0000 - 9999 (x 0.01KW)

NOTE: The values of Data Nos. 18 and 19 are monitor values. These numbers can be read but not changed. The values of Data Nos. 16, 17 and 19 are recognized as spaces in the data string and have no meaning.

7. Error List

No.	Error
00	Normal
01	Power supply cover open
02	Laser head cover open
03	Cooling water temperature high
04	Cooling water flow rate low
06	Cooling water level low
07	Pump error
08	Conductivity error
09	Preliminary discharge error
10	Emergency stop
11	Charging error
12	Duty cycle too high
13	Main shutter error
14	Branch shutter 1 error
15	Branch shutter 2 error
16	Branch shutter 3 error
17	Branch shutter 4 error
18	No lights
19	Laser power upper limit error
20	Laser power lower limit error
21	Peak power upper limit error
22	Peak power lower limit error
23	3-phase input error
24	Memory error

PC-9801, Turbo C
Prepared by Turbo C on an NEC Computer

```
/* ML-2331A maintenance service program */
/* '92. 6. 21 */

#include <stdio.h>
#include <conio.h>
#include <dos. h>
#include <graphics.h>

#define CTLC  ('C' - 0x40)
#define CR          0x0d
#define BS         0x08
#define STX        2
#define ETX        3
#define EOT        4
#define ENQ        5
#define ACK        6
#define NAK        0x15

#define YES        0
#define NO           1
#define OK           2
#define NG           3
#define TIMEOUT      0X800

#define S10DT    0x30
#define S10CS    0x32

char rs[64*99*2];
char tx_buf[64*99*2];
char id[2];
int tx_cnt;
int tx_cntl;


main()
{
        char c, *bfx, *bfy, *bfz, text;
        int x, y, n;
        bfx = "¥00200W9999:0000,19920625¥003";
        bfy = "¥00200W1599:123,300,00,00,000,999,000,9999,0000¥003";
        bfz = "¥002001599:010,020,030,040,050,0,1,0,300,250,11,12,013,014,015,0016,0017¥003";

        /* initiates 18251 */
        _CL = 0x0e;       /*rs232c command */
        _DL = 1;          /* ch0 initialize function */
        _BX = 0xfc08;   /* 8 bits, 2 stop, even pari, xoff, 9600 baud */
        geninterrupt(0xdc);
```

```
p0:     c = 0;
        clrscr();
        gotoxy(1,1);
        cprintf("ML-2331A/ML-2332A (RS-485 monitor   '92. 7. 1)   exit... ^C   network # ...
e");

p1:     gotoxy(1,3);
        cprintf("input NETWORK # ( 00 ~ 30 ) ");
        c=getch()
        if ((c >= '0')&&(c <= '9')){
                id[0] = c;
                putch(c);
        }
        else

                goto p1;
        c=getch();
        if ((c >= '0')&&(c <= '9')){
                id[1] = c;
                putch(c);
        }
        else
                goto p1;

p2:     gotoxy(1,4);
        cprintf("NETWORK # = [5c%c], id[0], id[1]);
        gotoxy(1,6);
        cprintf("input command");
        gotoxy(1,8);
        cprintf("[X];write test data (control # /date)");
        gotoxy((1,9);
        cprintf("[Y]:write test data  (schedule No. 15 :1bank)");
        gotoxy(1,10);
        cprintf("[Z]:write test data (schedule No. 15 :2bank)");
        gotoxy(1,11);
        cprintf("[R]:read data   [RS]:read status [RT]:read trouble");
        gotoxy(1,12):
        cprintf("[W]:write data   [WS]:write status [$]:laser start");
        gotoxy(1,13);
        cprintf("[CO]:trouble reset [C1]:total.count reset [C2]:good.count reset");
        gotoxy(1,15);
        cprintf("command type ? ["); clreo();
        x = wherex(); y = wherey();
        n = 3;
        gotoxy(x,y);
        rs_clr();                       /* rs[0~0xoff] '0' clear */
        rs[0] = STX;  rs[1] = id[0];  rs[2] = id[1];
```

```
while (1){
        gotoxy(x,y);
        c = getch();
        if © == CTLC)
                exit(0);
        if © == CR)
                break ;
        if © == BS){
                --x;
                gotoxy(x,y);
                cprintf(" ");
                --n;
        }
        else {
                putch(c);
                rs[n] = c;
                ++n;
                ++x;
        }
}
if ((rs[n-1] == 'E') || (rs[n-1] == 'e'))
        goto p0;
if ((rs[n-1] == 'X') || (rs[n-1] == 'x')){
        sprintf(rs, "%s",bfx);
        rs[1] = id[0]; rs[2] = id[1];
        goto p3;
}
if ((rs[n-1] == 'Y') || (rs[n-1] == 'y')){
        sprintf(rs, "%s",bfy);
        rs[1] = id[0]; rs[2] = id[1];
        goto p3;
        }
        if ((rs[n-1] = 'Z') || (rs[n-1] == 'z')){
                sprintf(rs,"%s",bfz);
                rs[1] = id[0]; rs[2] = is[1];
                goto p3;
        }
        cprintf("]");
        rs[n] =ETX;
p3      tx_cnt = set_bcc(rs);                   /* set bcc data */
        gotoxy(1,20); clreol(); /* spase */
        gotoxy(1,21); clreol();
        gotoxy(1,20); cprintf("send character [");
        for (n=0; rs[n] l= ETX; n++)
                putch(rs[n]);
        putch(rs[n]); cprintf("]  ");
        tx_ndat(rs, tx_cnt);                    /* send */
```

```
        text = rx_text();                       /* receive data */
        gotoxy(1,22); clreol(); /* spase */
        gotoxy(1,23); clreol(); /* spase */
        gotoxy(1,22); cprintf("receive character [");
        if (text == NG)
                goto p2;
        for (n=0; (rs[n] != ETX) && (rs[n] != ACK)
                && (rs[n] != NAK) && (rs[n] != '@'); n++){
                  c = rs[n] & 0x7f;
                  putch(c);
        }
        putch(rs[n]); cprintf("]");
        goto p2;
}


d_set(xc, yc, cnt, t)
char xc;
char yc;
char cnt;
char t;         /* rs[] top address */
{
        char c, x, n;

        gotoxy(xc,yc);
        for (n=0; n < cnt; ){                   /* control no. */
                x=wherex();
                c = getch();
                If ((c >= '0')&&(c <= '9')){
                        putch(c);
                        rs[t+n] = c;
                        ++n;
                        ++x;
                }
                If © == CR)
                        return;
                Gotoxy(x,yc);
        }
}


d_set1(xc, yc, cnt, t)
char xc;
char yc;
char cnt;
char t;         /* rs[] top address */
```

```
{
        char c, x, n, m;

        gotoxy(xc,yc);
        m = 0;
        for (n=0; n < cnt; ){                   /* control no. */
                x=wherex();
                c = getch();
                If ((c >= '0')&&(c <= '9')){
                    putch(c);
                    rs[t+m] = c;
                    If (n==1){
                        ++n;
                        ++x;
                    }
                    ++m;
                    ++n;
                    ++x;
                    }
                    if © == CR)
                        return;
                    gotoxy(x,yc);
        }
}


/* rs[] display the contents */
dsp_rs(t, n)
char t; /* top address */
char n; /* data length */
{
        char i;
        for (I=0; i<n; I++)
                cprintf("%c",rs[t+i]);
}


/* rs[] display the contents with decimal point */
dsp_rsl(t, n)
char t; /* top address */
char n; /* data length */
{
        char i;
        for (I=0; i<n; i++){
                if (i == 2)
                    cprintf(".");
                cprintf("%c".rs[t+i]);
```

```
        }
}


/* set bcc. Value of return is number of data */
set_bcc(bf)
char bf[];
{
        char bcc;
        int n;
        bcc = bf[1];
        for (n = 2; bf[n] != ETX; ){
                bcc ^= bf[n];
                ++n;
        }

        bcc ^= bf[n];
        ++n;
        bf[n] = bcc;      /* n = tx_cnt */
        return n;
}


/* transmit data until ETX is found */
tx_text()
{
        int n;
        rts_on();
        for ( n=0; rs[n] != ETX; n++)
                rsout(rs[n]);
        rsout(rs[n]);                           /* send bcc */
        rts_off();
}


/* transmit context of BF for ENT */
tx_ndat(bf, cnt)
char bf[];
int cnt;
{
        Int n;
        rts_on();
        for ( n=0; n <= cnt; n++)
                rsout(bf[n]);                   /* send data */
        rts_off();
}
/* transmit id code */
```

```
tx_id(c)
char c;
{
        rts_on();
        rsout(id[0]);    /* ID code */
        rsout(id[1]);
        rsout(c);        /* ENQ / ACK */
        rts_off();
}

/* transmit RENEWD program */
tx_update()
{
p0;     tx_id(ENQ);                                  /* send id enq */
        if (rx_idack() == NG)                        /* wait id ack */
                goto p0;
        tx_buf[0] = rs[0];                           /* STX */
        tx_buf[1] = '+';                 /* + */
        tx_buf[2] = rs[2];                           /* p */
        tx_buf[3] = rs[3];                           /* s */
        tx_buf[4] = rs[4];                           /* s */
        tx_buf[5] = ETX;
        set_bcc(tx_buf, tx_cntl);        /* bcc and tx_cntl set */
        tx_ndat(tx_buf, tx_cntl);        /* send +pss */
        if (rx_idack() == NG)                        /* wait id ack */
                goto p0;
        tx_ndat(rs, tx_cnt);                         /* send text */
        if (rx_idack() == NG)                        /* wait id ack */
                goto p0;
}

/* receive until ETX is found */
rx_text()
{
        int n, m, ex;
        unsigned int time;
        char bcc;
        n = 0;
        ex = 0;
        gotxy(1,17);clreol();
        time = 0;
        while(1){
                If (time == TIMEOUT)
                        break;
                ++time;
                If (getsts()) {
                        if (getch() == 'E')
```

```
                        return NG;
                }
                if (getrssts()) {                       /* receive data check */
                        rs[n] = rsin();
                        time = 0;
                        if (ex == 1)
                                break;  /* bcc */
                        if (rs[n] == ETX)
                                ex = 1;
                        if (rs[n] == ACK) || (rs[n] == NAK))
                                break;
                        if (rs[n] == '0')
                                break;
                        ++n;
                }

}
cprintf("receive end !!!");
if (time == TIMEOUT){
        if (rs[n-1] == ETX)
                return OK;
        else {
                cprintf("  (time over)");
                return NG;
        }
        }
        if (ex != 1){
                if (rs[n] == ACK) || (rs[n] == NAK) || (rs[n] == '0'))
                        return OK;
                else
                        return NG;
        }
        bcc = rs[1];
        for (m=2; m < n; m++)
                bcc ^= rs[m];
        if (rs[n] I= bcc)
                return NG;
        return OK;
}
        /* receive id_ack */
        rx_idack()
        {
                char n, bf[3], c;
                cprintf(" wait ID ACK !!!");
                for (n=0; n<3; ){
                        if (getsts()) {
                                c = getch();
```

```
                        if © == CTLC)
                                exit(0);
                }
                if (getrssts()) {  /* receive data check */
                        bf[n] = rsin();
                        ++n;
                }
        }
        if ((bf[0] == id[0]&&(bf[1] == id[1]&&(bf[2] -- ACK))
                return OK;
        return NG;


}

/* clear 256 byte on rs */
rs_cir()
{
        int n;
        for (n=0; n < 0xff; n++)
                rs[n] = '0';
}

/* RTS on */
rts_on()
{
        char type;
        type = 'R';
        if (type == 'T')
                outport(SIOCS, 0x07);           /* RTS 0 */
}

/* RTS off */
rts_off()
{
        char c;
        while((inport(SIOCS) & 0x04) == 0){  /* txemp ? */
                if(getsts() {
                        c = getch();
                        if© == CTLC)
                                exit(0);
                }
        }
        outport(SIOCS, 0x27);           /* RTS 1 */
}

/* get console status */
```

```
getsts()
}
        _AH = 0x0b;     /* function 0bh */
        geninterrupy(0x21);
        _AH = 0

}

/* get rs232c status */
getrssts()
{
        _CL = 0x0e;     /* rs232c command */
        _DL = 0;        /* ch0 rx data get */
        _BX = 0xf808;   /* 7bits, 2 stop, even pari, xoff, 9600 baud */
        geninterrupt(0xdc);
}


/* read a rs232c data */
rsin()
{
        _AH = 0x03;     /* function 03h */
        geninterrupt(0x21);
        _AH = 0;

}
        /* write a data to rs232c */
        rsout(c)
        char c;
        {

                _AH = 0x04;     /* function 04h */
                _DL = c;
                geninterrupt(0x21);
}
```

EXTERNAL COMMUNICATION CHART

Code	Description	Text Construction – Host Side	Laser Response			
W	Data Set	STX CH1 CH0 W SH1 SH0 DT1 DT0 : Data ETX BCC	CH1 CH0 ACK	Or	CH1 CH0 NAK	Written data is out of range or control is not External Communication.
R	Data Ready	STX CH1 CH0 R SH1 SH0 DT1 DT0 ETX BCC	STX Data ETX BCC	Or	CH1 CH0 NAK	Schedule No. Or Data No. is out of range.
W S	Status Control Mode – Set Schedule No.	STX CH1 CH0 W S SH1 SH0 cnt s1 s2 s3 s4 s5 s6 s7 ETX BCC	CH1 CH0 ACK	Or	CH1 CH0 NAK	Cannot set status or anything but External Communication Control.
R S	Status Control Mode – Read Schedule No.	STX CH1 CH0 R S ETX BCC	STX SH1 SH0 cnt s1 s2 s3 s4 s5 s6 s7 rdy ETX BCC			--
$ 0	Laser Start Command	STX CH1 CH0 $ 0 ETX BCC	CH1 CH0 ACK	Or	CH1 CH0 NAK	HV is off, voltage not reached set level, during trouble or other than External Communication Control.
$ 9	Laser Stop Command	STX CH1 CH0 $ 9 ETX BCC	CH1 CH0 ACK	Or	CH1 CH0 NAK	HV is off, voltage not reached set level, during trouble or other than External Communication Control.
C 0	Trouble Reset Command	STX CH1 CH0 C 0 ETX BCC	CH1 CH0 ACK	Or		HV is off, voltage not reached set level, during trouble or other than External Communication Control.
C 1	Total Count Reset Command	STX CH1 CH0 C 1 ETX BCC	CH1 CH0 ACK	Or		HV is off, voltage not reached set level, during trouble or other than External Communication Control.

NOTES FOR EXTERNAL COMMUNICATIONS CHART

C Control Code in hexadecimal:

ACK: 06H NAK: 15H STX: 02H ETX: 03H BCC: Block Check Code STX: 1 byte horizontal even parity by ETX except STX.

CH1 = Unit No. 10 digit SH1 = Schedule No. 10 digit DT1 = Data No. 10 digit E1 = Error No. 10 digit (Transmit all error numbers. When no errors, E1 and E0 = 0.)

CH0 = Unit No. 1 digit SH0 = Schedule No. 1 digit DT0 = Data No. 1 digit E0 = Error No. 1 digit

C Status (0 = Off, 1 = On):

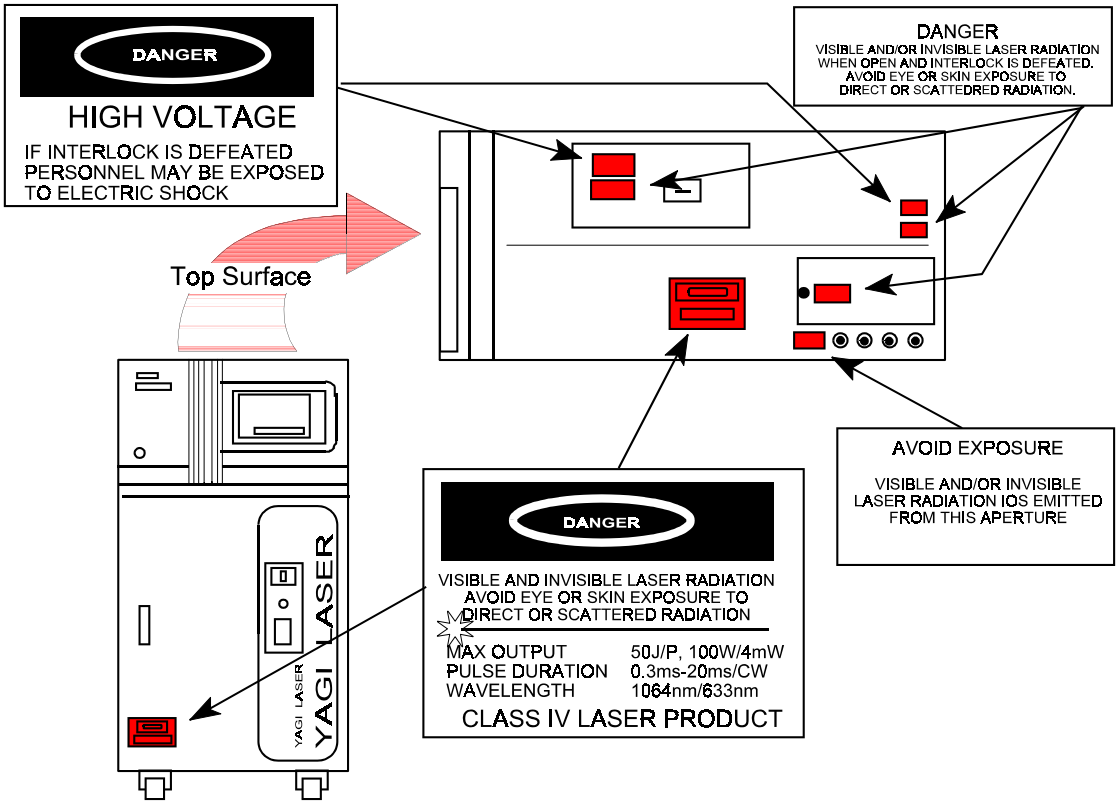
cnt = Control Mode (0: Panel Control, 1: External Control, 2: Communication Line Control, 3: Maintenance)

s1 = HV s2 = He-Ne s3 = Main Shutter s4 = Branch Shutter 1 s5 = Branch Shutter 2 s6 = Branch Shutter 3 s7 = Branch Shutter 4

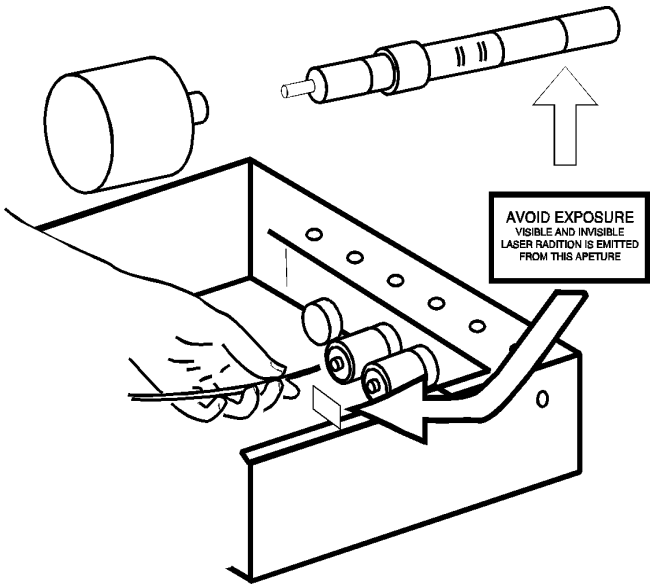
rdy = Ready State (Read only. Goes on when ready to start the laser.)

APPENDIX D
LABEL LOCATIONS

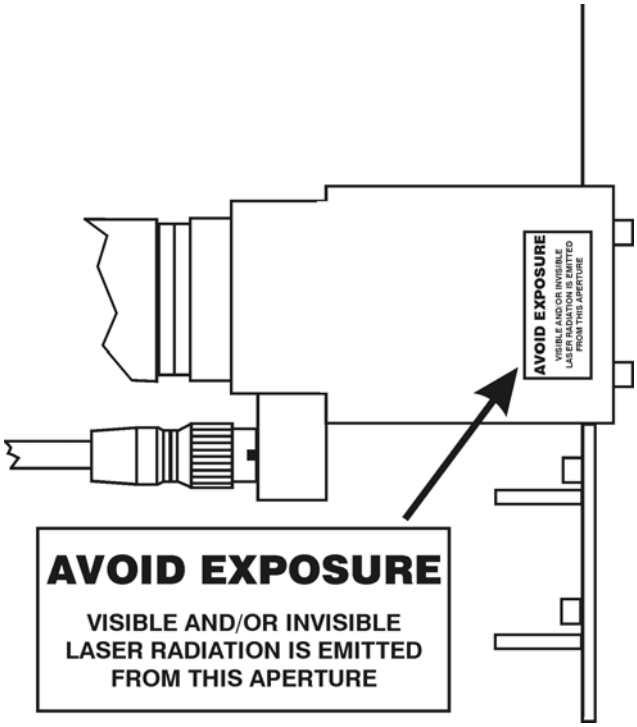
External Danger and Aperture Label Locations: LW100 (Typical)



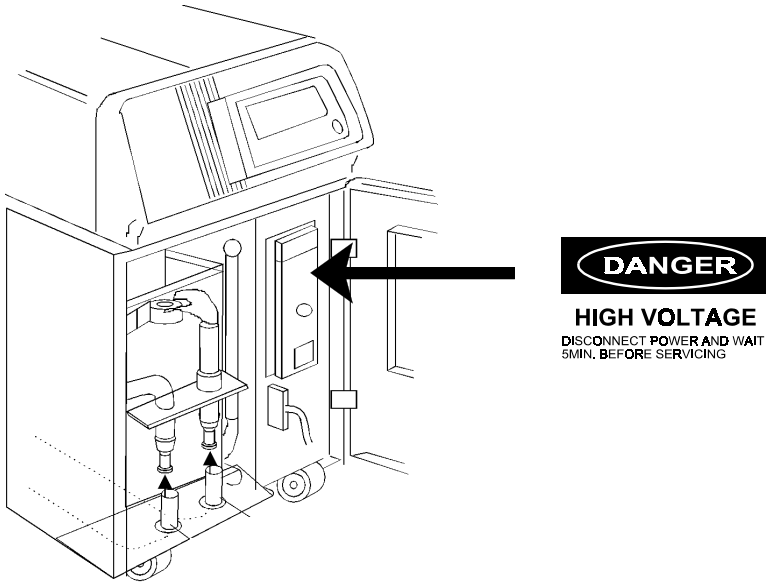
Input End of Optical Fiber



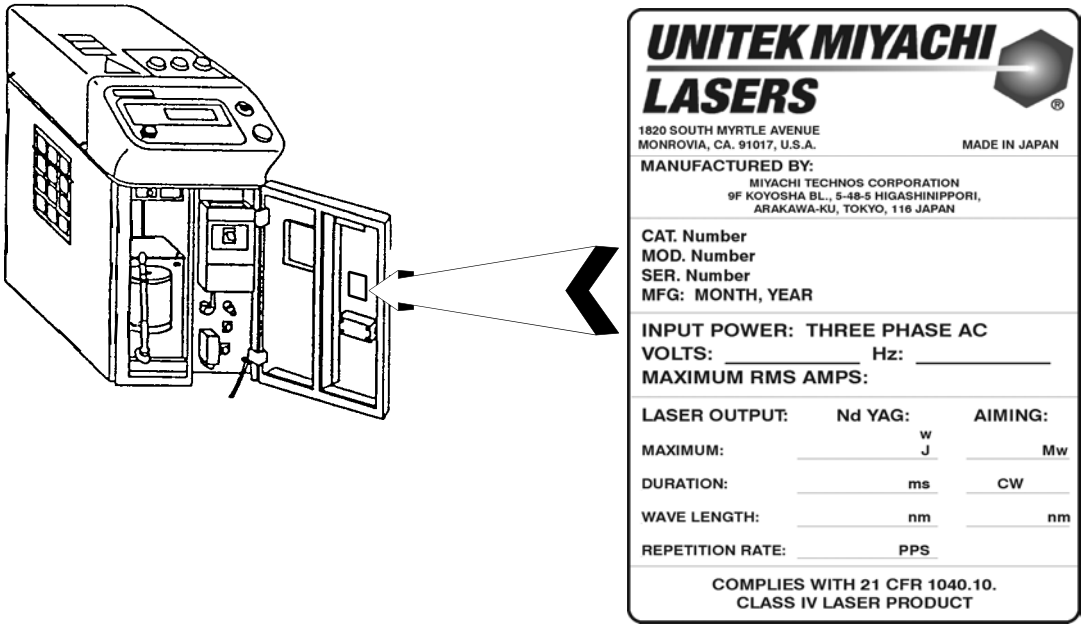
Standard Focus Module



Programming Unit

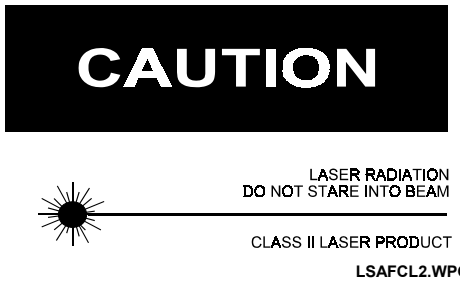


Inside Front Door

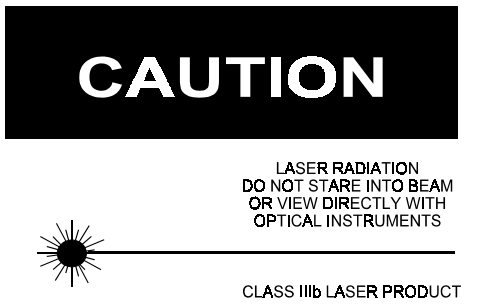


Warning Label Summary

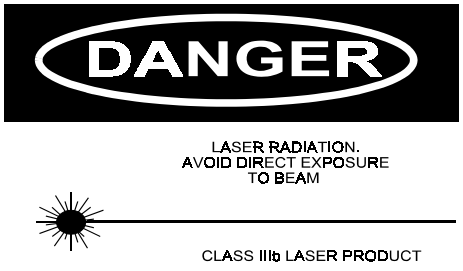
Radiation Hazard Labels



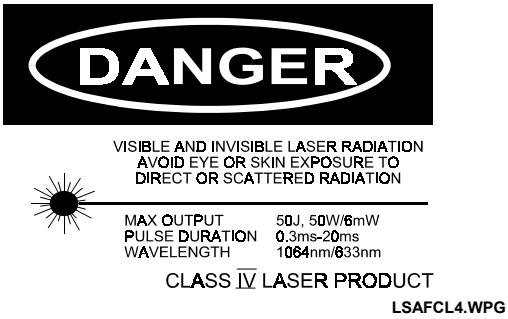
LSAFCL2.WPG



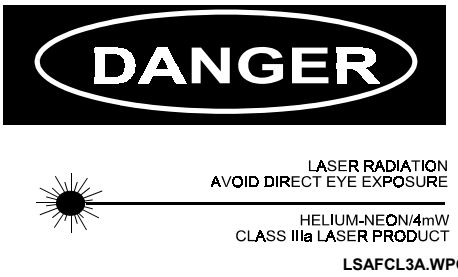
LSAFCL3B.WPG



LSAFLRAD.WPG



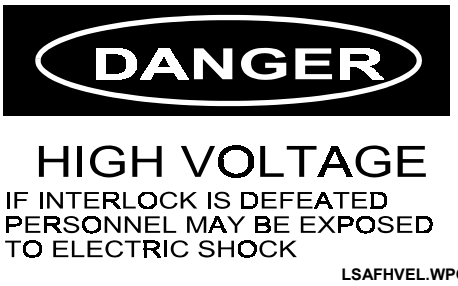
LSAFCL4.WPG



LSAFCL3A.WPG

LSAFRAD.WPG

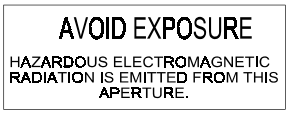
Electric Shock Hazard Labels



LSAFHVEL.WPG

LSAFHVSV.WPG

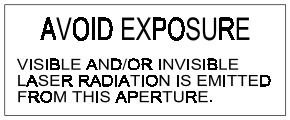
Aperture Labels



LSAFAVEX.WPG

LSAFAVX1.WPG

LSAFAVX2.WPG



LSAFEXP.WPG

Labels for Noninterlocked Protective Housings

LSAFSTRE.WPG

LSAFXP1.WPG

LSAFEXP2.WPG

LSAFEXP3.WPG

LSAFEXP4.WPG

LSAFEXP5.WPG

Labels for Interlocked Protective Housings

DO NOT REMOVE THIS PLATE EXCEPT FOR LASER BEAM AXIS ADJUSTMENT. HIGH VOLTAGE WILL BE SHUT OFF WHEN THIS PLATE IS REMOVED.

LSAFCAUT.WPG

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