Laser Photonics, Inc.

LN203/LN203C
NITROGEN/OPTIONAL DYE LASER

Operator's Manual

P/N 7011-0034 Rev. A

December 1997

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LASER PHOTONICS, INC.
Scientific Product Warranty

LASER PHOTONICS, INC. (LPI), hereinafter, the "Company", warrants to the original purchaser, that the instrument sold hereunder is free from defects in material and workmanship under normal usage for a period of one (1) year from the date of shipment (*see the following page for warranty of consumables*). The Company will replace, at is own expense, all broken or defective parts during the period for which such part is warranted (excluding consumables). Equipment returned to the Company for warranty repair requires prior authorization from Laser Photonics Customer Service. The Company will pay freight charges (ground services only) for all warranty repairs.

Defects or breakage due to negligence, tampering, abuse of the instruments, or intrusion of the instrument by other than Company personnel or their authorized representative shall not be warranted. The Company shall not be liable for consequential or incidental damage caused by normal wear and tear or exposure to contaminated environments. Contamination includes: dust, graphite (from pencils), soot, lint, dew (city water below dew point), tobacco smoke, oils (including fingerprints), condensible vapors, e.g., resin, smoke, outgassing from products generated when the beam strikes partial absorbers such as optic mounts, o-rings, rubber pads ("footprint" surfaces). Please note that "blow off" dust generated at the aperture in an under-coupled or misaligned oscillator can move to contaminate the optics on both sides of the aperture.

The Company strongly recommends that the laser chassis be kept closed. When the top covers must be removed, the laser chassis should be inside a polyethylene clean tent or laminar flow bench. Before opening the beam line, wipe down the laser and table using a lint-free wiper moistened with alcohol. Do no set open containers of liquid (e.g., coffee cups or dye cuvettes) on or in the laser chassis. Where warranty labels/seals exist, authorization from Laser Photonics Customer Service must be obtained prior to breaking the seals. Failure to do so voids the warranty.

The buyer expressly agrees that the instrument has been selected BY THE BUYER as a proper design, size, fitness, and capacity; and the buyer is satisfied that the instrument is suitable and fit for the buyer's purposes.

Consumables

All consumables are warranted for ninety (90) days, except as noted below.

Flashlamps	Thyratrons
Arc Lamps	D.I. Cartridges/Filters
Tubes	

Pulsed YAG Lasers

Flashlamps are warranted free of defects in material or workmanship for 5,000,000 shots or 90 days, whichever comes first. Warranty replacement of flashlamps will be charged on a pro-rated basis based on the number of shots actually fired.

Continuous Wave Solid-State Lasers

Arc lamps are warranted free of defects in material or workmanship for 200 hours or 90 days, whichever comes first.

Sealed Gas Lasers

- Model LN300 Sealed Tube - warranted to be at least 50% of rated power after 100,000,000 shots or one (1) year, whichever comes first.
- CO_2 Sealed Tubes - warranted to be at least 80% of rated power after 2,000 hours or one (1) year, whichever comes first.
- Thyratron (Model LN300) - warranted for ninety (90) days.
- Thyratron (UV Series) - warranted for ninety (90) days.

Deionizer Cartridges/Filters

Deionizer Cartridges are warranted free of defects in materials and workmanship for a period of ninety (90) days.

THIS WARRANTY IS EXPRESSED IN LIEU OF ALL OTHER WARRANTIES, EXPRESSED OR IMPLIED, AND THE COMPANY DISCLAIMS ANY WARRANTY OR MERCHANTABILITY OR OF FITNESS FOR A PARTICULAR PURPOSE. NO OTHER OBLIGATIONS OR LIABILITIES ARE ASSUMED BY THE COMPANY.

Prior to the return of a unit, or any portion thereof, the Laser Photonics Service Department must be consulted to avoid unnecessary shipping. If return of the equipment is deemed necessary, a Return Material Authorization (RMA) number will be assigned. This number must be recorded on the outside of the shipping container and on the packing list.

Laser Photonics, Inc.
Customer Service Department
12351 Research Parkway
Orlando, Florida 32826

Telephone: (407) 281-4103
(800) 624-3628
Facsimile: (407) 281-4114 or 380-3479

INTRODUCTION

The LN203/LN203C is an ultraviolet wavelength (337.1 nm) nitrogen laser which combines thyratron triggering with high pressure, sub-nanosecond "strip line" operation.

Thyratron triggering delivers pulses of uniform energy at precisely timed intervals. This feature provides accurate synchronization with events occurring on a nanosecond time scale.

The atmospheric pressure (TEA) design greatly simplifies operation and provides high power compared to sub atmospheric units.

The higher power derives from the generation of shorter pulses - subnanosecond vs. nanosecond.

The simplified operation is due, in part, to the absence of any vacuum system components such as pumps, pump exhaust systems, gas manifolds, linkages and connections. The strip line channel design is of the fast charge/fast discharge type. This is essential as its stored energy must be deposited in the channel within a fraction of a nanosecond to produce high power laser pulses.

Command charging provides "on demand" high voltage just before each pulse. This extends component lifetime by reducing average voltage levels. There is also a provision for convenient remote status checks and remote function control.

Each accessory dye laser module(optional) is suited to particular requirements:

- The LD1S module provides broad band tuning across the range of visible wavelengths by interchange of dye solutions.

- The LD2S provides narrow band (0.5 - 1.0 mm), continuously lined output from 357-710 nm.

Section I.
SAFETY

OVERVIEW

All persons operating the Laser Photonics, Inc. LN203/LN203C Nitrogen/Optional Dye Laser, and all persons in the vicinity of the laser must be aware of the hazards of laser beams. All personnel should carefully review the safety precautions listed in this chapter before operating the laser.

When recommended safety measures are consistently adopted and practiced, potential hazards are minimized. Most laser-related accidents and injuries are operator-caused due to inexperience or carelessness.

This section will review some safety considerations, precautions, and warnings related to the use of the Laser Photonics, Inc. LN203/LN203C Nitrogen/Optional Dye Laser system.

SAFETY CONSIDERATION SUMMARY

- Only qualified personnel should operate the laser system.
- Equip the work area with a UL approved fire extinguisher in case of equipment or material fire.
- Wear safety glasses or goggles when operating the laser for extended periods of time.*
- Do not look directly into the laser beam.
- Do not expose skin to laser beam for extended periods of time; skin burns could result. Extended exposure may also cause photochemical injury to skin.
- A high voltage safety (cover) interlock is located on the rear panel of the laser. Removal of the top access panel is required only for servicing and will automatically break the interlock. Lethal high voltages and currents exist inside the laser while it is operating. Only qualified service technicians should defeat the safety interlock. Any interlock interruption will required the high the high voltage enable switch to be re-engaged.
- A remote safety interlock connector is located on the rear panel, and requires continuity for the laser to operate. Laser Photonics recommends the use of this interlock in all cases when the possibility of accidental exposure to the beam exists. Ideally, remote continuity is provided to the connector only when all access doors to the laser containment room are closed.
- Read this document, in its entirety, before operating the laser system.

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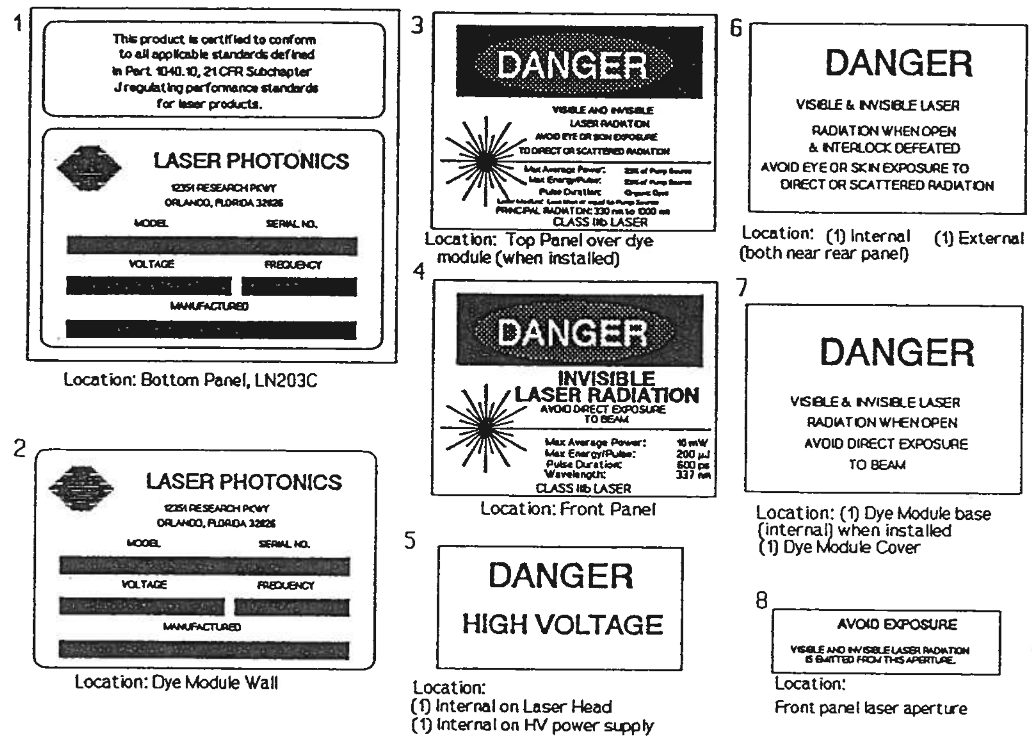
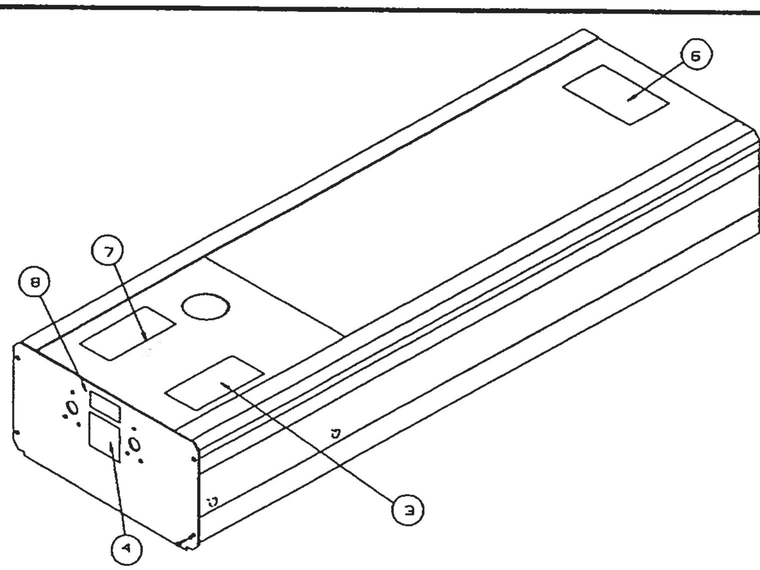
*Consult the *Handbook of Laser Science and Technology (Vol. I.), Section G: Laser Safety* for more information.

LABELS AND SAFETY FEATURES

In compliance with the U.S. Code of Federal Regulations Title 21:21 CFR Subchapter J, Part 1040.10, this laser produce has incoproated the required safety features: keyswitch, mechanical beam shutter, panel lights, remote interlock and cover interlock. In addition, in compliance with the above the following labels have been affixed to this product.

Figure 1-1. Warning Labels/Locations





Section II.
SYSTEM DESCRIPTION

OVERVIEW

The LN203/LN203C Nitrogen Laser and Optional Dye laser system specifications are described below. Brief descriptions of nitrogen laser characteristics, dye lasers, overall optical, and system layout are discussed in this section.

SYSTEM SPECIFICATIONS

Item	*Description*	**Optional**	
	LN203/LN203C	LD2S	LD1S
• Spectral Output (nm)	337.1	357-710	357-950
• Spectral Bandwidth (nm)	0.1	1-3	10-30
• Pulsewidth (ps FWHM)	600	300-500	300-500
• Energy/Pulse (μJ)	100	Dye dependent	dye dependent
• Conversion Efficiency (%)	N/A	15 @ 500 nm	20 @ 500 nm
• Energy/Stability (%) @ 10 hz	3	3	3
• Peak Power (kW)	167		
• Repetition Rate (maximum) (Hz)	50	50	50
• Maximum Average Power (mW)	5	dye dependent	dye dependent
• Beam Dimensions (hor. x ver.) (mm)	5.5 x 3.1	2.5 mm at exit	2.5. mm at exit
• Beam Divergence hor x ver. (mrad) (half-angle)	6.2 x 2.5	2**	2**
• Flow Rate (L/min) @ 10 hz	1.51		
• Trigger In	TTL		
• Trigger Out	TTL		
• Command Jitter (nm)	± 2		
• Input voltage	110 V; 60 Hz		
• Dimensions (in.) L X W X H)	28.5 x 8.5 x 5.25	(LN203C)	
• Dimensions (in.) L X W X H)	21.5 x 8.5 x 5.25	(LN203)	
• Dimensions (cm) (L X W X H)	71.3 x 21.3 x 13.3	(LN203C)	
• Dimensions (cm) (L X W X H)	54.6 x 21.3 x 13.3	(LN203)	
• Weight (lbs)	20		
• Weight (kg)	9		

** < 1 with CL20.

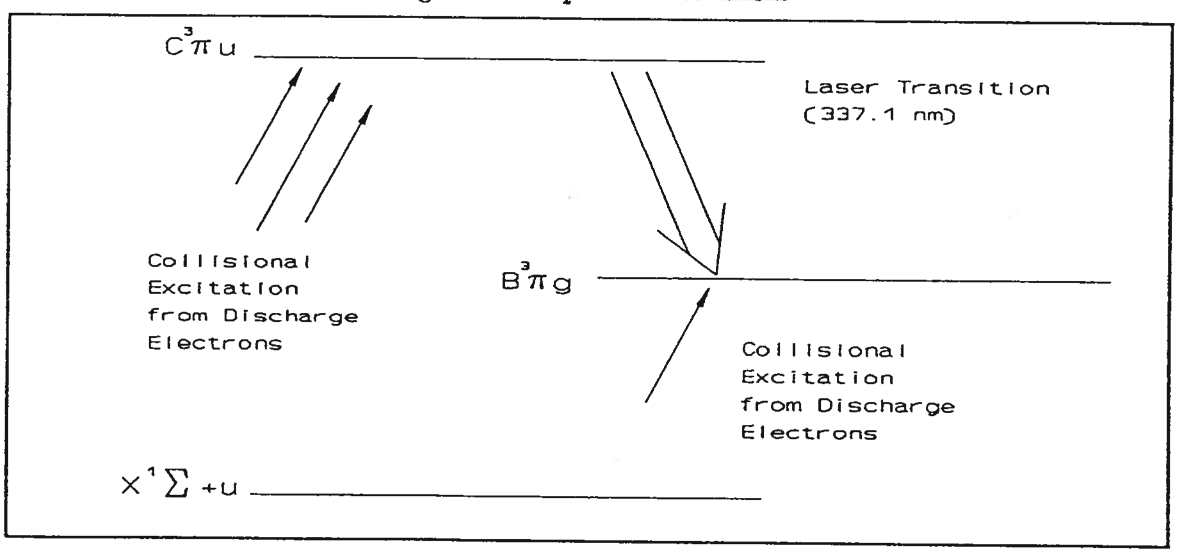
NITROGEN LASERS

Nitrogen lasers are unique, high peak power devices, producing ultraviolet light at 337.1 nm. Although the terminal state of the laser transition is metastable, and the upper level is extremely short-lived, this three-level laser (the third level is the ground state) can exhibit extremely high gain. In fact, the laser is capable of "super radiant" performance, requiring no mirrors. Most nitrogen lasers, however, have mirrors to enhance and direct the super radiant output *(See Figure 2-1. "N_2 Laser Mechanism".)*

The mechanism, which allows the high gain population inversion between the two upper levels ($C^3\pi u$ and $B^3\pi g$) of the N_2 molecule, is the enhanced free electron collisional rate for the $C^3 m\pi u$ state excitation is comparison to the lower $B^3\pi g$ state excitation. Although the $B^3\pi g$ state is metastable, there can still be gain very early in time, before the lower state is greatly populated. This property of the N_2 molecule is the reason the laser pulses are extremely short ($<$10ns).

As a result of the short inversion time for the N_2 laser, special high speed electrical circuits are required. The two basic types are the capacitor transfer method and the "Blumlein" method *(see Figure 2-2. "Excitation Circuits for the N_2 Laser")*.

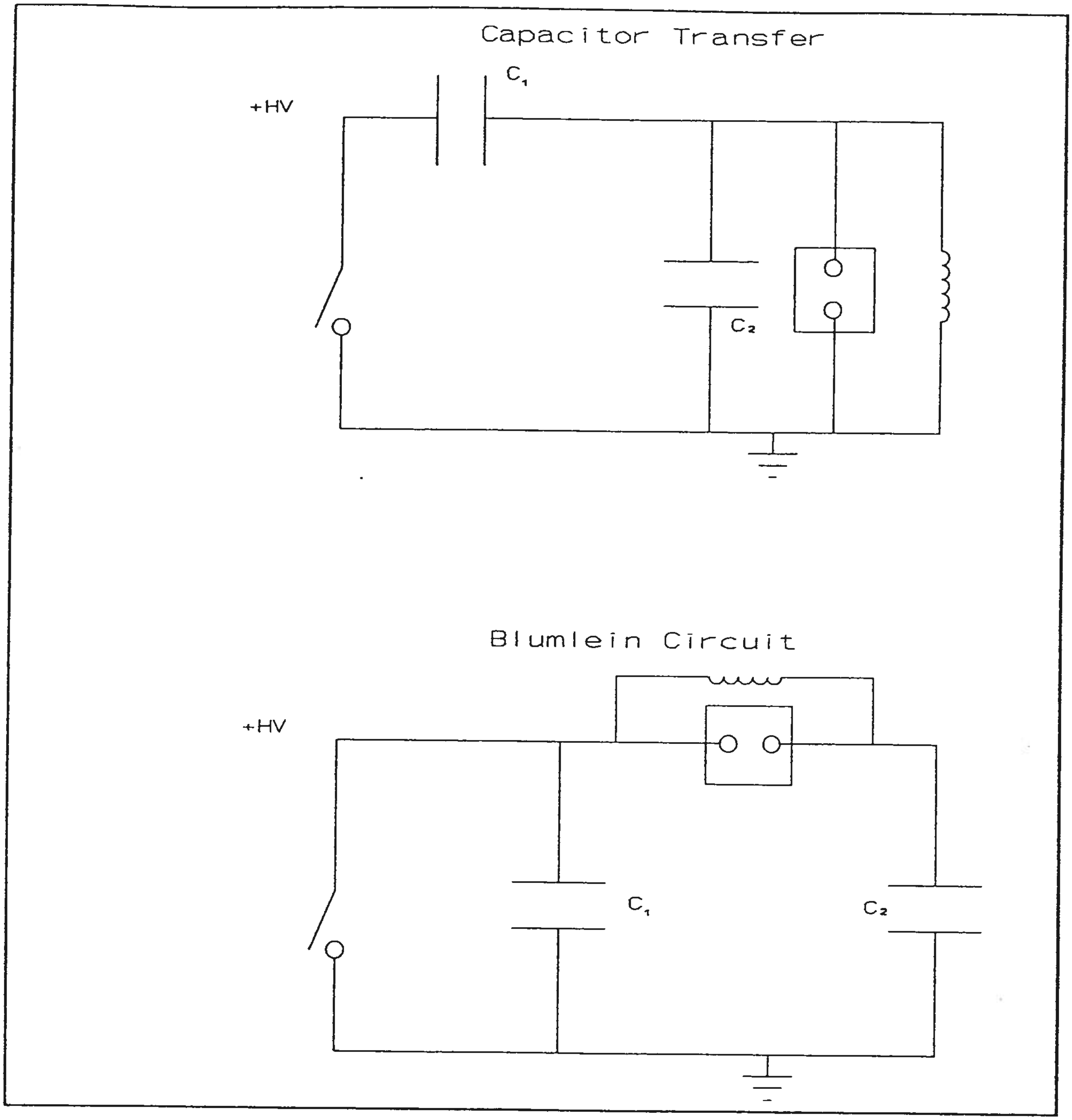
Figure 2-1. N_2 Laser Mechanism



Transfer Method

In the transfer method,the high voltage source charges the main storage capacitor, while the switching element isolates the secondary capacitor and laser channel from the high voltage. When the switch is closed, the charge on C_1 is transferred to C_2. The faster C_2 is charged, the higher the overvoltage reached, before the gas has sufficient time to break down. Both loops must have sufficiently low inductance to transfer the charge quickly. This constraint is especially important for the secondary loop since C_2 is the main contributor of energy to the laser channel. Typically, this type of circuit can product pulse durations of 5-10 ns. shorter pulses are possible only with careful design.

Figure 2-2. Excitation Circuits for the N_2 Laser



Blumlein Method

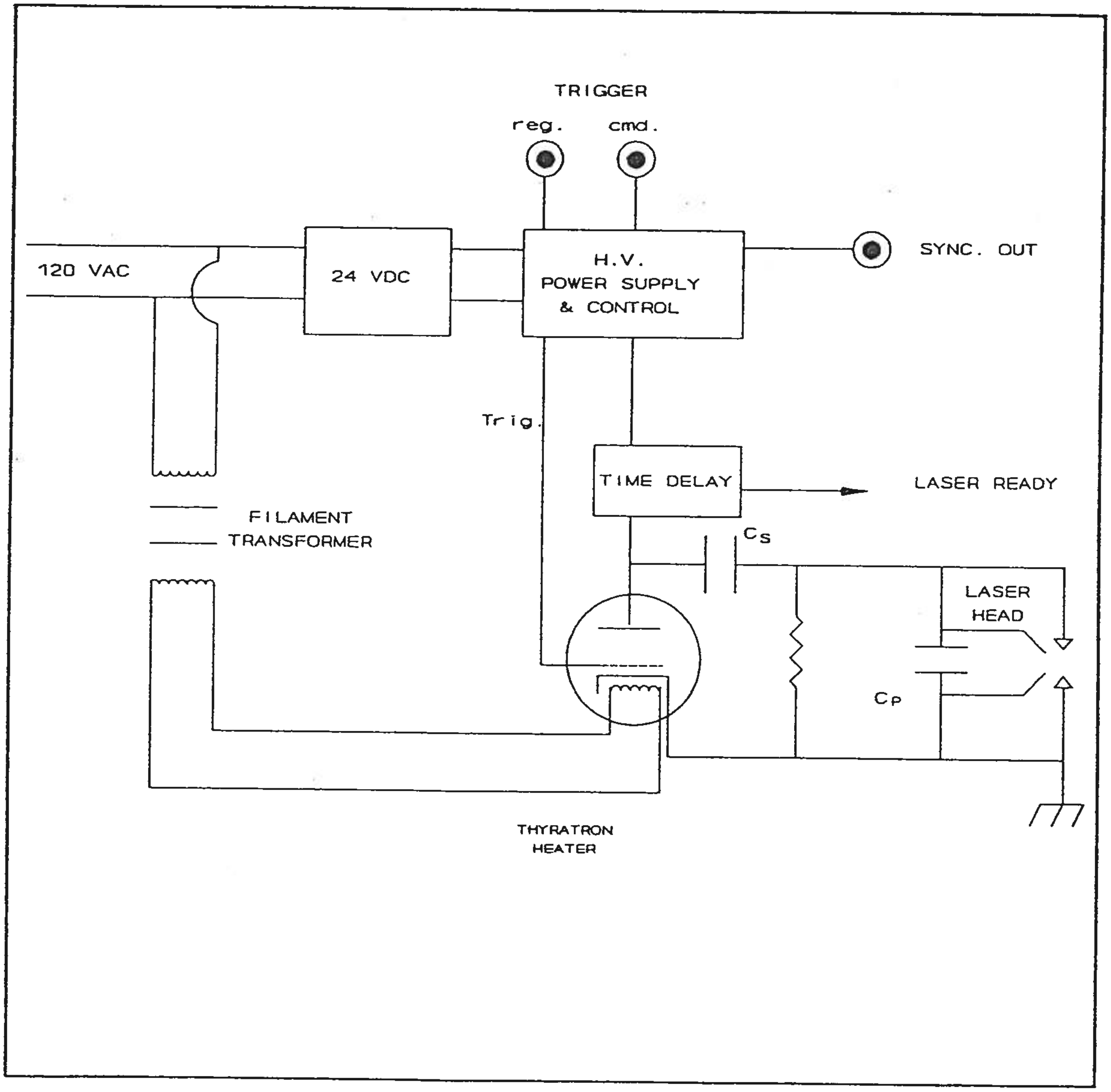
In the Blumlein method, both capacitors C_1 and C_2 are initially charged in parallel to the applied high voltage potential, while the laser channel electrodes are effectively shorted by an inductive lead. When the switch is triggered, the capacitor C_1 is rapidly shorted through the switch. Because of the inherent inductance in the loop, damped oscillation occurs such that voltage reversal occurs on C_1 and C_2. This equivalent potential can be nearly twice the applied potential. The Blumlein method can produce pulses typically from 1-5 ns.

In general, the Blumlein method is well-suited to Transverse Electric Atmospheric (TEA) N_2 lasers, since the gain for these lasers can be only sustained for about 1 ns. In comparison, the capacitor transfer method is sufficiently fast for sub-atmospheric N_2 laser, for which gain can typically be sustained for up to 10 ns. With special (strip-line) design considerations, the transfer method can also be applied to TEA N_2 lasers, such as the LN203/LN203C. The transfer technique has the further advantage of increased reliability since the laser channel and secondary capacitors do not have to be maintained statically at a increased high voltage potential.

Major Components

A system layout for the LN203/LN203C is shown below (*see Figure 2-3. "LN203/LN203C System Layout"*). The major components of the laser are the DC power supply - which powers most of the laser, the high voltage module, and control circuitry board, and the laser head which includes tube and capacitors. A filament supply powers the thyratron heater directly from the AC line. The thyratron is the switching element for this capacitor transfer circuit and is triggered by a high voltage signal from the control board.

Figure 2-3. LN203/LN203C System Layout



DYE LASERS

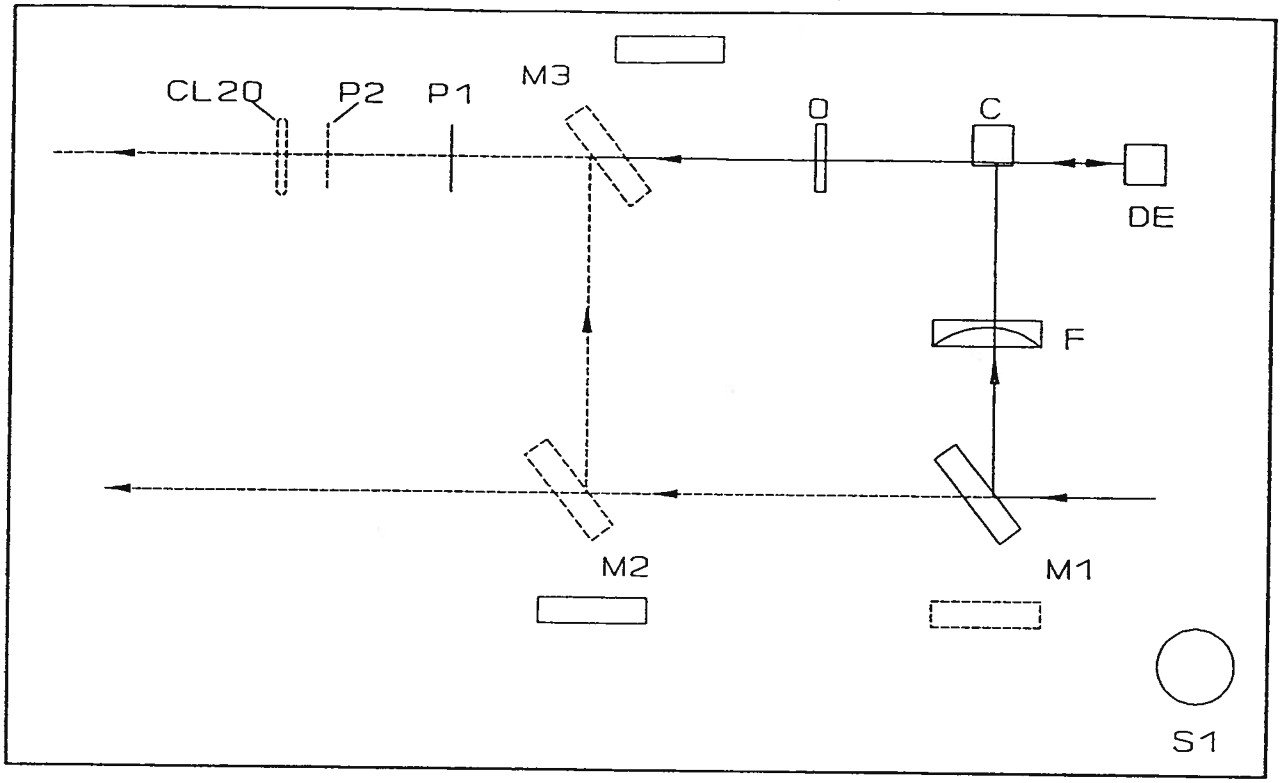
The LN203 consists of strickly a UV nitrogen laser. The LN203C consists of a UV nitrogen laser and optional dye laser module combination. The 337.1 nn nitrogen laser is operable, and its beam accessible, with or without a dye module installed. The modules use the nitrogen laser beam as the pump source, and can be installed, removed, or replaced when required. (LN203C Only)

The nitrogen laser wavelength is fixed, but the modules offer variable wavelengths. The mechanism for this tunability feature is based on the unique emission properties of certain organic liquid dyes when irradiated with an intense UV source such as the LN203/LN203C laser. The dye laser emits broadband radiation within the overall gain curve of the dye (LD1S), or radiation spectrally narrowed within the gain curve (LD2S).

Dye Module Components

Component	Description	Function
M1	High Reflectivity Turning Mirror	Turns nitrogen laser beam 90° to pump dye module. Mount is rotatable to allow nitrogen beam throughput.
M2, M3	Beam Steering Mirrors	Steers nitrogen laser beam through dye beam aperture. Allows option for collinear beams.
F	Plano-Cylindrical Lens	Focuses 337.1 nm nitrogen beam into dye cell.
C	Quartz 1 cm Square Dye Cell Cuvette and Agitator.	Contains the laser dye. Tilted to minimize internal feedback. The magnetic stirrer agitates the dye.
DE	Cavity Dispersive Element	Provides spectrally dispersed feedback to the gain medium. LD1S option uses mirror (zero dispersion). LD2S option uses Littrow type grating and sine bar.
O	Cavity Output Coupler	Provides feedback to the gain medium; optically aligned with DE.
P1	Spatial Beam Filter	Improves dye beam quality. Filters out amplified spontaneous emission.
P2 (Optional)	Spatial Beam Filter	As above. Included with CL20 option.
CL (Optional)	Plano Convex ½ diameter collimating lens	Collimates dye beam. Threads into collar located on front panel.
S1	Dye Stirrer Toggle Switch	Powers the magnetic stirrer in the dye cuvette.

Figure 2-4. Dye Module Optical Layout



Section III.
INSTALLATION

OVERVIEW

Instructions given of the following pages of this manual provide safe, step-by-step procedures to be followed in setting up and operating the laser.

PRE-INSTALLATION PROCEDURES

First, remove the laser from the packing case and visually inspect for shipping damage. If no damage is apparent, proceed. Otherwise, contact a Laser Photonics, Inc. representative immediately so that the proper claims may be filed with the shipping agent. Save the packing crates - lasers returned for servicing should be repackaged in these boxes. Shipping damage resulting from improper packaging by the customer will be repaired at the customer's expense.

DYE MODULES INSTALLATION/REMOVAL

The following procedure should be used when installing or removing a module from a Laser Photonics LN203C nitrogen laser/dye laser.

1. Ensure the power line cord is disconnected. Remove the sliding lid and module lid. If a module has not already been installed, the removal of the module lid requires the removal of the top access screw and the stand-off beneath it.

2. The front panel has the two beam apertures. Remove the four screws holding it in place, and set the panel aside.

3. Grasp the aluminum bottom panel and slide out through the exposed front of the laser.

4. Carefully turn the laser on one side so that the bottom of the laser is now exposed. Remove the two screws holding the module to the back side of the laser. Now carefully turn the laser on this front side, and remove the remaining two screws holding the module to the front panel.

5. Reposition the laser (carefully) with the top up.

6. To remove a module, first disconnect the power connector, then grasp the front of the module chassis and slide it out the front.

7. To install a module, insert the module into the side panel grooves (see *Figure 3-1. "Module Installation and Removal"*). Slide the module until the mounting holes match and insert the four screws to secure using the procedure listed in step 4, above. Plug the module power connector into the receptacle provided beneath the LN203C chassis.

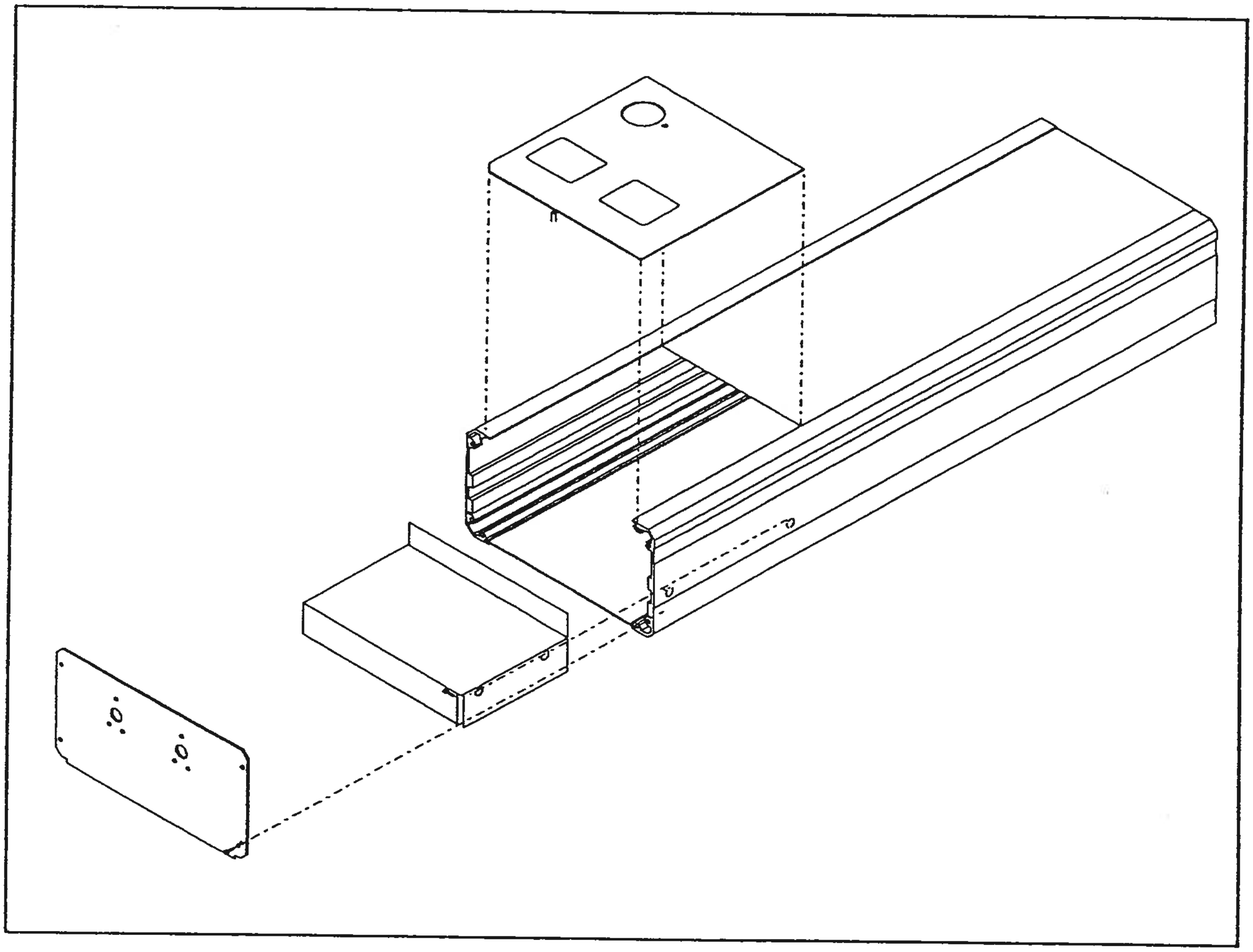
8. Replace the aluminum bottom panel.

9. Replace the front panel and secure with the four screws.

10. If a module has not already been installed.

    a. Turn the dye stirring motor ***ON***.
    b. Ensure the main turning mirror, M1, is rotated to the steering position; mirror should self locate automatically when correctly positioned.
    c. Install the new small lid which accompanies the module.
    d. Replace the sliding lid over the nitrogen laser. If friction is severe, loosen the front panel, slide the lid in, and resecure the front panel.

Figure 3-1. Module Installation and Removal



Section IV.
SYSTEM OPERATION

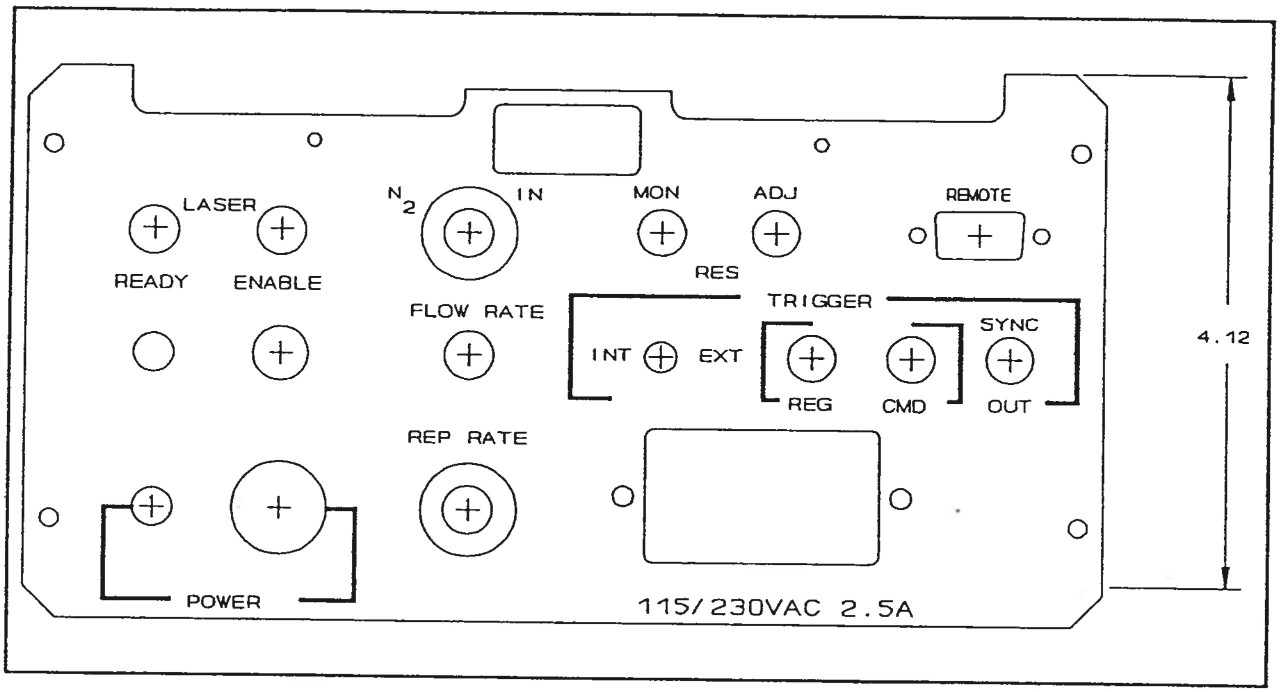
OVERVIEW

It is important that this section is read thoroughly. A clear understanding of the laser operating controls will minimize any initial difficulties when attempting to power the unit. In addition, the operating instructions should be read carefully before turning on the unit for the first time.

CONTROLS FOR OPERATION

All of the controls to operate the laser are conveniently located on the rear panel of the laser (*see Figure 4-1. "Control Panel"*).

Figure 4-1. Control Panel



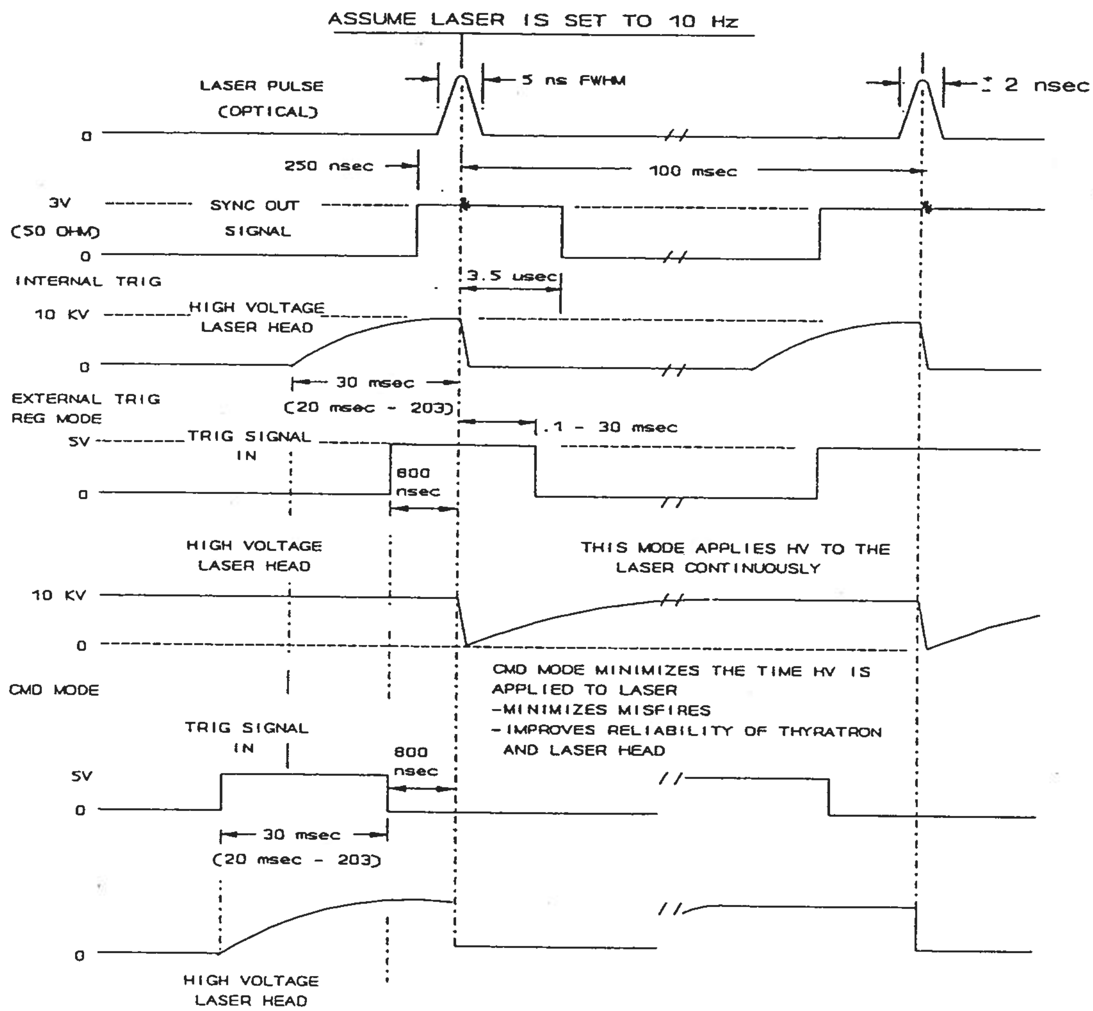
Control	*Description*
POWER (Switch)	This keyswitch provides AC power to the system (but does not energize the laser), activates a five minute delay circuit for the high voltage, and supplies current to the thyratron heater. The key cannot be removed with ***POWER*** on.
POWER (LED)	Illuminates when the ***POWER*** keyswitch is activated to indicate AC power to the system.
VAC RECEPTACLE	Standard IEC "mains" connector. It contains a replaceable fuse and a small voltage selection board that allows 120/240 VAC selection.
LASER READY	Illuminates (green) after the five minute warm-up time, indicating that the laser is ready to be fired.
LASER ENABLE (switch)	To activate firing, the ***ENABLE*** switch must be raised toward the enable position, and released. This switch will prevent automatic restart due to remote interlock, cover-interlock or main electrical power interruption. The enable switch must be reactivated after any interruption. To terminate lasing, the operator may either depress the ***ENABLE*** switch or de-energize the entire system via the keyswitch. In the latter case, the delay circuit will be activated upon reenergizing. Always deactivate the switch before making any cable connections to the rear panel. When a dye module is installed, this switch also controls power to the dye stirring motor.
LASER ENABLE (LED)	Illuminates (red) when the laser is enabled. This light indicates laser operation and the presence of high voltage.
TRIGGER IN/EXT	(generated from the laser circuit) or external trigger source coupling. A special locking device prevents inadvertent switching. The switch lever must be pulled in order to alter its position.

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

REP RATE	This potentiometer controls the repetition rate of the laser The internal trigger mode will allow a range of approximately 1-50 Hz, depending on the setting. In ***EXTERNAL TRIGGER*** mode, this control is disabled.

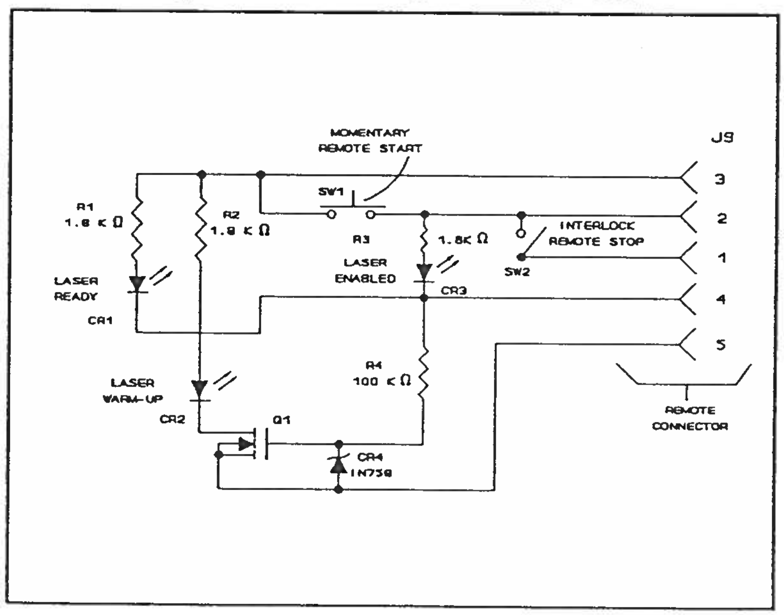
Control	*Description*
TRIGGER REG/CMD	When the trigger source is in the ***EXTERNAL*** position, the BNC trigger input (co-axial cable connector) can be either regular (***REG***) mode or command (***CMD***) mode. *See Figure 4-2 for more detail on the timing signals.*
REG	In regular mode, a positive TTL type input signal (5V) will fire the laser on the rising edge of the input pulse. In this mode, the laser high voltage is continuously applied to the laser head components, allowing the laser to fire immediately upon triggering (approximately 800 nsec delay). This mode is most useful for synchronization.
CMD	In this mode, the laser high voltage is not activated until a "rising edge" 5 volts signal appears at the connector. The laser is configured to fire on the "falling edge" of the signal. (A 30 ms wide pulse is required for achieving full charge.) This mode should be used when synchronization with another device is not required but external triggering is required, (i.e., very low repetition rates). In contrast to regular mode, command mode minimizes the time that static high voltage is held on the laser head, thus improving long term reliability of the head components (thyratron, capacitors, etc).
TRIGGER SYNC OUT	Outputs a TTL type signal approximately 250 ns before the laser optical pulse is emitted.

Figure 4-2 Timing Diagram



Control	*Description*
REMOTE	This multi-pin connector input allows remote interlock control, as well as remote status check and remote high voltage enable. If the connection between pins 1 and 2 is interrupted, the high voltage will be automatically disabled, and re-enabling is required to re-activate the laser. This is the normal interlock feature. In addition, pins 3 and 5 can be monitored and controlled with a remote auxiliary circuit. Referring to *Figure 4-3. "Remote Operation Schematic"*, only a few components are required to remotely monitor or enable the laser.
RES MON	This jack is intended as a convenience for maintenance. The monitor voltage corresponds to the thyratron reservoir voltage and can be measured with a standard DVM. ☞ **WARNING!** DO NOT MEASURE THE RESERVOIR VOLTAGE WHEN THE LASER IS OPERATING OR METER DAMAGE MAY OCCUR. The reservoir voltage setting at the time of factory testing is documented on the test sheet.
RES ADJ	This control permits adjustment of the reservoir voltage for the thyratron and is mainly intended as a convenience for maintenance. A locking device is normally used on the control to ensure the reservoir voltage is not altered inadvertently.

Figure 4-3 Remote Operation Schematic



Control	*Description*
N_2 IN	This is the inlet port for connecting the nitrogen gas. Laser Photonics recommends a purity of 99.995%. Always ensure the hose fitting is tight.
FLOW RATE	Located below the N_2 in gas port, this needle (metering) valve allows fine adjustment of the gas flow rate to the laser head. Each repetition rate requires an adjustment in the flow rate for optimum performance. Flow rate can be best optimized if the laser energy is monitored at the same time.

Table 4-1.

FLOW CHART		
Repetition Rate	Approximate Flow Rate SCFH	LPM
1	1	0.47
5	2	0.94
10	2.5	1.18
20	4	1.88
30	5	2.35
40	6	2.82
50	7.5	3.53

COVER INTERLOCK	A cover interlock switch is located between the top panel and the rear control panel. In the event the top panel is removed for servicing, the cover interlock will be disrupted, thus disabling the laser.
BEAM SHUTTER	A push-pull aperture shutter is located on the beam exit aperture panel., i.e, the panel located at the opposite end of the cabinet from the control panel. Both the dye laser and nitrogen laser apertures are closed by the shutter.
CUVETTE ACCESS PORT	Located near the exit aperture and permits cuvettes to be inserted into, or removed from, the dye laser. During operation, the access port is covered by a movable port cover.
DYE AGITATOR POWER ON	A small toggle switch is located on the base of the dye laser module near the beam input aperture. When in the *ON* position, the dye stirrer motor is activated. If only the nitrogen laser beam is required, it is advisable to switch the motor *OFF*.

OPERATING INSTRUCTIONS

General

- Position the laser on a stable platform. Position the output aperture in the desired direction and use safeguards to ensure that the laser beam cannot directly contact any personnel. Ensure that the beam aperture is closed.
- Connect the AC line cord between the laser and the wall plug.
- Connect a regulated gas line to the ***N_2 IN*** port at the back of the laser. Set the pressure to 80-90 psi (550 KPA), or if a flow meter is available, consult the flow chart in "*Controls for Operation*" on page 4-1. A lower inlet pressure can normally be used if the laser is to be operated at the repetition rates lower than 50 Hz. Keep the gas tank valve closed until the laser is to be operated.
- Insert the key into the keyswitch.
- Plug the remote interlock connector into the remove receptacle, and ensure continuity.
- Turn the key switch to the right and energize the laser. The power light will illuminate.
- Wait approximately five minutes until the green ***READY*** light is illuminated and check that the turning mirrors of the dye module do not intercept the nitrogen beam. This would prevent beam exit from the cabinet.
- Open the gas tank valve and adjust the gas flow needle valve according to the flow chart.
- Turn the ***TRIGGER TOGGLE*** switch to the ***INTERNAL*** position.
- Adjust the ***REP RATE*** control to the desired position. (Repetition rate may be monitored from the ***SYNC OUT BNC*** connector.)
- Raise the ***ENABLE*** toggle switch toward the ***LASER ENABLE*** label. The laser will begin firing.
- Open the beam aperture when ready and view the effect on a fluorescent card placed a few centimeters from the aperture.

☞ WARNING! DO NOT LOOK INTO THE FRONT APERTURE OF THE LASER HEAD UNDER ANY CIRCUMSTANCES!

Dye Laser Module Operating Instructions (LN203C/Dye Laser Only)

To initiate lasing activity within the dye laser, please follow these dye laser module operating instructions:

1. Prepare the appropriate dye mix according to the chart on page A-1. Dyes supplied by the factory will normally be pre-measured in 50 cc bottles. Simply add 50 cc of the appropriate solvent into the bottle. Secure the bottle cap and shake vigorously until no solid or crystalline particulates are visible at the bottom of the bottle.

2. Place a clean magnetic stir agitator inside a 1 cm x 1 cm square quartz cuvette. Using an eye dropper, carefully fill the cuvette (dye cell) to just below the top. Secure the plastic cap tightly. If required, shake the cell until the agitator is positioned with the flat side on the bottom.

3. Ensure all sides of the dye cell are clean, preferably polished with lens tissue.

4. After checking the nitrogen laser is operating satisfactorily, disable the high voltage.

5. Slide the dye cuvette access port cover open.

6. Insert the dye cuvette into the port, and push down until it is secured. Slide the dye cuvette access port to the closed position.

7. Set the repetition rate for 10 Hz or less.

8. Open the beam shutter and place a white card or screen in front of the laser beam path. Exercise due caution (*see Section I. "Safety"*).

9. Enable the high voltage.

10. Adjust the repetition rate appropriately.

Note: Periodically, the dye module top panel may need to be removed (e.g., for cleaning, etc.). Laser Photonics, Inc. strongly recommends the laser be de-activated (high voltage disabled) before removing the top panel. Since there is a risk of exposure to scattered radiation from the pump beam inside the module, only qualified service personnel should operate the laser with the top panel removed.

Tuning

LD1S Module

Output wavelength is tuned by changing dye types. Each type will provide a broadband output centered about the labelled dye wavelength number. Refer to the tuning curves of the LD2S as a guide for wavelength emission characteristics.

LD2S Module

Output wavelength is indicated by the inch micrometer setting. The wavelength in nanometers corresponds to the number of thousandths of an inch displayed on the micrometer. Please consult the following, "*How to Read Inch Micrometers*". The tuning characteristics are shown on the specification sheets.

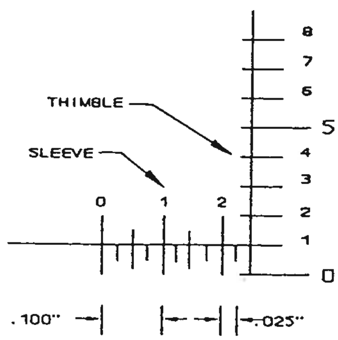
Precautions

Always ensure dye cell surfaces are clean. Never touch the sides of the cell. If necessary, isopropyl alcohol or an equivalent solvent should be used for cleaning.

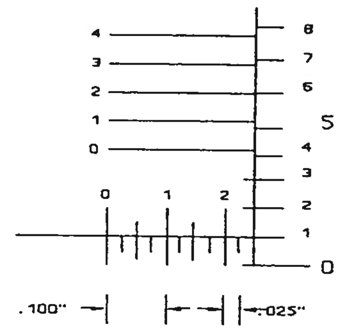
☞ WARNING! ADJUSTMENTS TO DYE MODULES AS DETAILED IN SECTION V. MAY INVOLVE EXPOSURE TO IIIb RADIATION. THESE SERVICE ADJUSTMENTS, IF NECESSARY, ARE TO BE PERFORMED BY QUALIFIED PERSONNEL ONLY!

HOW TO READ INCH MICROMETERS***

TO THOUSANDTHS OF AN INCH



TO TEN-THOUSANDTHS OF AN INCH



SLEEVE: The micrometer sleeve is divided into forty equal parts. Each part or division is indicated by a vertical line. Each vertical line represents one-fortieth of an inch or .025", and, each fourth line is marked by a longer line and a number which designates one hundred-thousandths.

More simple, the line marked "1" represents .100", the line marked "2" represents .200" and so forth.

THIMBLE: The thimble is divided into twenty-five equal parts, and, one complete rotation of the thimble coincides with the smallest division on the sleeve. Thus, the division on the thimble is one-twenty-fifth of .025" or .001".

READING EXAMPLE:

1. *Note that the thimble has stopped at a point beyond "2" on the sleeve indicating .200" (see illustration above.)*
2. *Note that one additional line visible between the graduation numbered "2" and the edge of the thimble, indicating .025".*
3. *Line numbered "1" on the thimble coincides with the center line of the sleeve. It means additional one-thousandth of an inch.*

(1)	Reading on the Sleeve	.200"
(2)	No. of lines between "2" and the edge of the thimble	.025"
(3)	Thimble line corresponding to the centerline of the sleeve	.001"
	TOTAL READING	.226"

To read to one ten-thousandth requires an additional scale called the "Vernier" scale, named after the Inventor, Pierre Vernier.

In the case of a regular micrometer, the vernier consists of ten divisions, marked on the sleeve, which are spaced within nine divisions of the thimble scale.

Each division on the vernier, therefore, is one tenth shorter than that of the thimble's, thus representing .0001".

READING EXAMPLE:

1. *Read to the thousandth of an inch in the same manner as shown on the left.*
2. *The vernier on the sleeve reads to one tenth of a thousandth of an inch, or .0001".*
3. *To read the vernier, find which line on the vernier scale coincides with a line on the thimble and read the number off the vernier scale. It is important to note that when finding the vernier (ten-thousandth) reading, the correct figure is ALWAYS taken from the number at the vernier scale and NEVER from the thimble.*
4. *Note that the vernier line numbered "2" coincides exactly with a thimble lin8e indicating .0002".*

(1)	Reading on the Sleeve	.200"
(2)	No. of lines between "2" and the edge of the thimble	.025"
(3)	Thimble has passed .001" line on the Sleeve	.001"
(4)	Vernier line coinciding exactly with a Thimble Line	.0002"
	TOTAL READING	..2262"

***Excerpt from Mitutoyo Measuring Instruments Catalog No. 6000, p. 26.

Section V.
MAINTENANCE

OVERVIEW

The LN203/LN203C nitrogen laser and companion dye laser modules are designed for minimal maintenance. To ensure optimum system performance, only a few simple procedures are recommended.

LN203/LN203C

Check pulse energy and thyratron reservoir voltage periodically. Record the readings in a lab book, together with the estimated shot count. A copy of this record should be included with the unit in case it is returned to Laser Photonics for service. The thyratron voltage should not exceed 6.8 volts. The laser channel is aligned at the factory. However, severe temperature changes can slightly alter the alignment. If adjustment is ever required, use the three plastic alignment screws at the rear of the laser channel to re-optimize beam quality and pulse energy. Follow all labeled precautions and warnings when accessing the laser head. Only qualified personnel should access the head. Normally, the unit should be returned to the factory if re-alignment is required.

LD1S, LD2S

Replace the dye solutions frequently for optimum energy and beam quality. Each dye has its own characteristic photochemical properties. Thus, some dye solutions will require more periodic replacement than others. In addition, solvents evaporation will alter the dye concentration. Periodically, check that the dye cuvettes are filled to the top.

Clean the cuvettes frequently. Fingerprint oils are highly absorptive at UV wavelengths, yet cannot be seen easily in visible light.

For the LD2S, check wavelength calibration frequently. Any adjustment of the dye module output coupler can change calibration.

For both modules, visually inspect the condition and orientation of the dye laser; stir agitator periodically. Re-orient the agitator as necessary. The flat side should be on the bottom.

Section VI.
TROUBLESHOOTING

OVERVIEW

This section covers basic troubleshooting of the LN203/LN203C. The questions listed below are common problems that can be solved by the operator. This section also includes instructions on how to return parts for both warranty and nonwarranty service.

TROUBLESHOOTING

Problem: ***Power light does not illuminate.***

Action:

- Check that the AC power cord is connected to an active AC socket.
- Ensure that the keyswitch is in the *ON* position.
- Check the fuse.

Problem: ***Laser Enable light does not illuminate***

Action:

- Check that the remote interlock connector is providing continuity.
- If the top cover is removed, ensure that the cover interlock is providing continuity. *Only qualified service personnel should remove access panels.*
- Check that the green ***READY*** light is illuminated. A five minute time delay from "power on" is required before green light will illuminate.

Problem: ***No laser output.***

Action:

- Check that, in the case of external trigger source selection, a trigger source is provided. Otherwise, maintain internal trigger selection.
- Ensure that the beam aperture is open.
- Check the N_2 gas pressure and flow rate.

SERVICE RETURN INSTRUCTIONS

Warranty

Please obtain prior authorization before returning a product for warranty repair or service. Please call (407) 281-4103 or fax (407) 281-4114 to obtain a return authorization number (RMA).

- A product subject to warranty repair should be returned freight prepaid to:

LASER PHOTONICS, INC. *12351 RESEARCH PARKWAY* *ORLANDO, FL 32826* *RMA # _________*

Note: Please Show RMA number on shipping label and packing list.

- Repack the product carefully using the original shipping carton. Insert a description of the malfunction inside the packing case.

- Do not ship back cuvettes containing liquid dye (to prevent the risk of spillage).

- Please submit a malfunction report with the following information:
  - Buyer's name; company affiliation; date
  - RMA number
  - Return shipping address
  - Telephone number where contact can be made
  - Original purchase date and purchase order number (if known)
  - Laser model and serial number
  - Describe briefly how the laser was used, including the operating environment
  - Describe malfunction

Non Warranty

Follow the instructions listed above for products covered under the warranty.

APPENDIX A. DYE LIST

MODEL #	ORDER #	DYE	MOLECULAR WEIGHT (gm)	CONCENTRATION (M)	SOLVENT	WEIGHT (mg) PER 50 CC	WAVELENGTH (NM) PEAK	RANGE
7A365	P0076-9018	BPBD	354	4.0x10-3	TOLUENE	70.9	365	357-395
7A366	P0076-9026	PBD	298	5.0x10-3	TOULUENE/ETHANOL (50/50)	74.6	366	360-386
7A386	P0076-9034	BBQ	675	2.5x10-3	TOULUENE/ETHANOL (50/50)	84.4	386	373-399
7A400	P0076-9042	PBBO	347	5.0x10-3	TOLUENE/ETHANOL (70/30)	8.7	400	391-411
7A406	P0076-9059	DPS	332	1.2x10-3	P-DIOXANE	19.9	406	396-416
7A421	P0076-9067	BIS-MS13	310	1.2x10-3	P-DIOXANE	18.3	421	411-430
7A425	P0076-9075	S-420	562	1.8x10-3	METHANOL	50.6	425	408-453
7A437	P0076-9083	C-440	175	5.0x10-3	ETHANOL	43.8	437	427-457
7A447	P0076-9091	C-450	217	1.0x10-2	ETHANOL	108.6	446	428-465
7A457	P0076-9109	C-460	231	1.0x10-2	ETHANOL	115.7	457	440-478
7A470	P0076-9117	C-480	255	1.0x10-2	ETHANOL	127.7	470	2453-495
7A481	P0076-9125	C-481	285	2.0x10-2	P-DIOXANE	285.6	481	460-518
7A500	P0076-9133	C-500	257	1.0X10-2	ETHANOL	128.6	500	473-547
7A520	P0076-9141	C-485	257	1.0x10-2	ETHANOL	128.6	520	490-560
7A536	P0076-9158	C-540A	309	1.0x10-2	ETHANOL	154.7	536	515-583
7A579	P0076-9166	R-590	479	5.0x10-3	ETHANOL	119.8	579	568-603
7A609	P0076-9174	R-610	479	5.0x10-3	ETHANOL	119.8	609	594-643
7A644	P0076-9182	R-640	591	5.7x10-3	ETHANOL	168.5	644	620-673
7A660	P0076-9190	CV670/R590	362/479	2.5x10-3/3.3x10-3	ETHANOL	45.3/30.0	660	641-687
7A665	P0076-9299	DCM	303	5.0x10-3	DMSO	75.8	665	655-700
7A696	P0076-9208	NB690/R610	418/479	3.8x10-3/8.0x10-4	ETHANOL	79.4/46.0	696	683-710
7A735	P0076-9257	HIDC	510	5.0x10-3	DMSO	127.5	735	710-775
7A750	P0076-9215	OX725	424	5.0x10-3	DMSO	106.0	750	720-770
7A775	P0076-9224	OX750	470	5.0x10-3	DMSO	117.5	775	760-800
7A800	P0076-9232	DOTC	512	5.0x10-3	DMSO	128.5	800	785-825
7A850	P0076-9240	DTTC	544	5.0x10-3	DMSO	136.0	850	830-870
7A870	P0076-9265	HITC	536	5.0x10-3	DMSO	134.0	870	825-890
7A925	P0076-9273	IR-125	774	5.0x10-3	DMSO	193.5	925	890-945
7A960	P0076-9281	IR-140	779	5.0x10-3	DMSOI	194.8	960	940-990

Appendix B. - N_2 & DYE LASER LITERATURE

1. "Pulsed UV Nitrogen Laser: Dynamical Behaviour", P. Richter et al, Appl. Optics, Vol. 15, No. 3, March 1976, p. 756.

2. "Cascade Population Mechanism in Nitrogen Lasers", L. Scaffardi et al, L.E.S. Mathias and J.T. Parker, Appl. Optics, Vol. 24, No. 1, Jan. 1985, P.22.

3. "Stimulated Emission in the Band Spectrum of Nitrogen", Appl. Phys. Lett. Vol. 3, p.16 (1963).

4. "Pulsed Molecular Nitrogen Laser Theory", E.T. Gerry, Appl. Phys. Lett., Vol. 7, p. 6-8, July 1965.

5. "UV TEA Laser with 760-Torr N_2, E.E. Bergmann, Appl. Phys. Lett., Vol. 28, No. 3, January 15, 1976, P. 84.

6. "Ultraviolet Gas Laser at Room Temperature", H.G. Heard, Nature (london) 200, P. 667, 1963.

7. "Dye Lasers". Ed: F.P. Schafer, Springer - Verlag, New York, 1977 (TA1690.S33) (Text).

8. "Lasers: Physics, Systems, and Techniques". Ed: W.J. Firther and R.G. Harrison, Published by Scottish Universities Summer School in Physics, 1983 (TA 1673.S38). (Text).

9. "Lasers and Light". Readings from Scientific American, San Francisco, W.H. Freeman (1969) (QC 351.L35).

10. "Laser, Supertool of the 1980's New Haven". Ticknor and Fields, 1982 (TA1675.H3).

Appendix C. 220 V OPERATION

1. Remove the power cord from the laser plug receptacle.

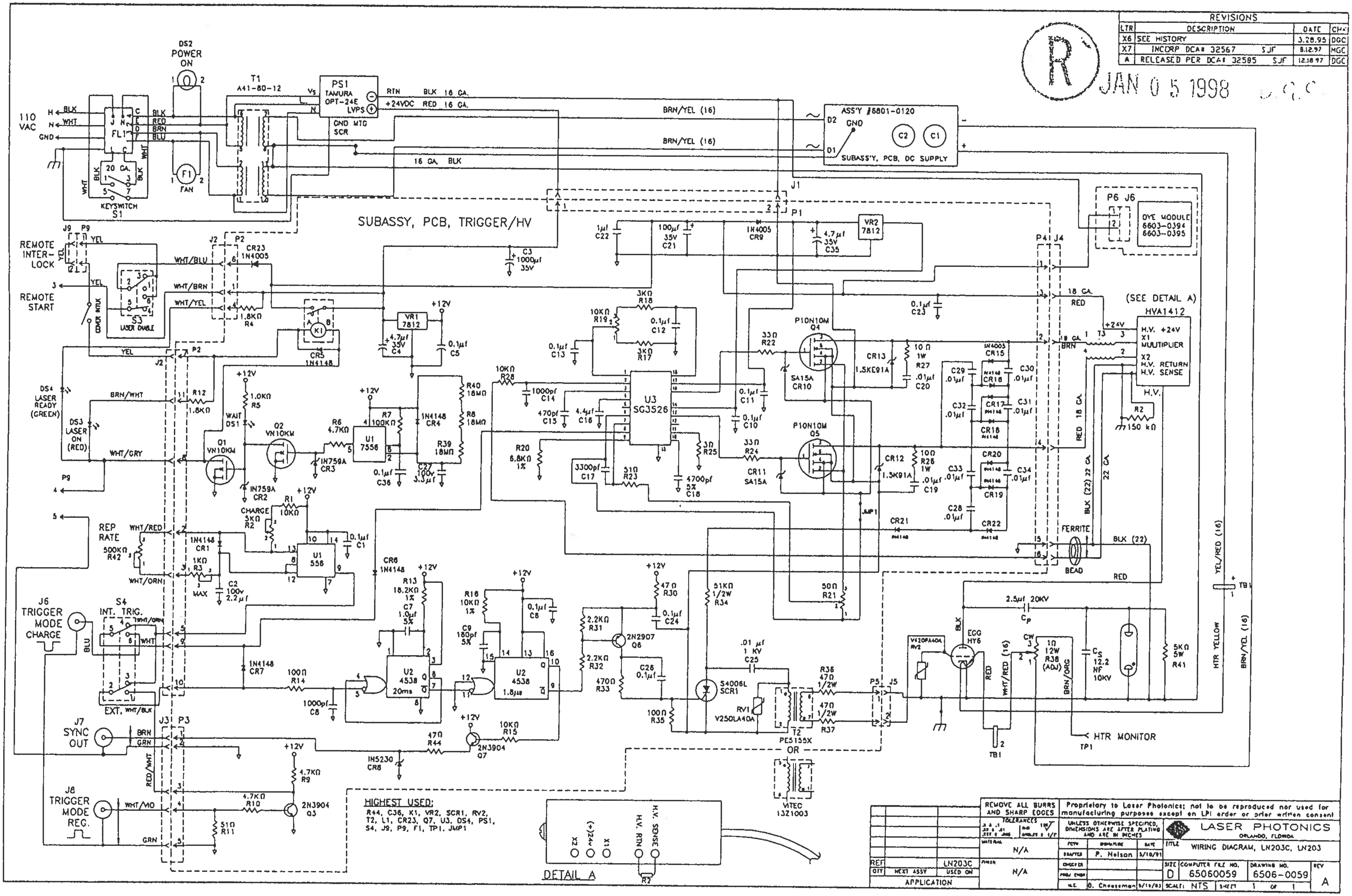
2. Slide the clear plastic fuse cover to the left to expose the fuse.

3. Remove the fuse by using the fuse puller.

4. Remove the printed circuit board located beneath the fuse holder. To do this, firmly grip the printed circuit board at one end with a pair of needle nose pliers and pull. By alternately pulling at either end, the board will eventually become dislodged.

5. Re-insert the board such that the desired voltage level is legible (120 V or 240 V are the only allowable choices. The laser will not function if any other voltage is chosen).

6. Install the fuse and replace the fuse cover.


REVISIONS
LTR | DESCRIPTION | DATE | CHK
X6 | SEE HISTORY | 3.28.95 | DGC
X7 | INCORP DCA# 32567 SJF | 8.12.97 | MGC
A | RELEASED PER DCA# 32585 SJF | 12.18.97 | DGC
R
JAN 0 5 1998
110 VAC
DS2 POWER ON
T1 A41-80-12
PS1 TAMURA OPT-24E
KEYSWITCH S1
ASS'Y #6801-0120 SUBASS'Y, PCB, DC SUPPLY
SUBASSY, PCB, TRIGGER/HV
REMOTE INTER-LOCK
REMOTE START
S3 LASER DISABLE
DS4 LASER READY (GREEN)
DS3 LASER ON (RED)
REP RATE
J6 TRIGGER MODE CHARGE
S4 INT. TRIG.
EXT.
J7 SYNC OUT
J8 TRIGGER MODE REG.
P6 J6
DYE MODULE 6603-0394 6603-0395
(SEE DETAIL A)
HVA1412
H.V. +24V X1 MULTIPLIER
X2 H.V. RETURN H.V. SENSE
U3 SG3526
FERRITE BEAD
HTR MONITOR TP1
HTR YELLOW
HIGHEST USED:
R44, C36, K1, VR2, SCR1, RV2, T2, L1, CR23, Q7, U3, DS4, PS1, S4, J9, P9, F1, TP1, JMP1
DETAIL A
X2 (+)24v X1 H.V. RTN H.V. SENSE
REMOVE ALL BURRS AND SHARP EDGES
Proprietary to Laser Photonics; not to be reproduced nor used for manufacturing purposes except on LPI order or prior written consent
LASER PHOTONICS ORLANDO, FLORIDA
TITLE WIRING DIAGRAM, LN203C, LN203
DRAFTER P. Nelson 5/10/91
O. Cheeseman 5/10/91
SIZE D
COMPUTER FILE NO. 65060059
DRAWING NO. 6506-0059
REV A
SCALE: NTS
SHEET 1 OF 1
LN203C
NEXT ASSY USED ON
APPLICATION
N/A

GLOSSARY:
Terms Used with Laser Systems

Term	*Description*
Photocoagulation	Tissue coagulation caused by light (laser).
Photodisruption	Creating an acoustical shock wave, through Q-switching or mode-locking, to gently "snap" apart membranes. This is a "cold cutting" technique with laser. Ophthalmologists use the Q-switched Nd:YAG to photodisrupt an opacified posterior capsule secondary to cataract surgery.
Photon	The quantum of electromagnetic energy, generally regarded as a discrete particle having zero rest mass or no electric charge.
Picosecond	10^{-12} seconds. Longer than a femtoseconds but shorter than a nanosecond. Associated with mode-locked ophthalmic Nd:YAG lasers.
Plane	A surface containing any straight line through any two of its points.
Plasm	The fourth state of matter in which electrons have been stripped off the atoms. The extremely high internal temperature expands rapidly, setting up an acoustical shock wave. Usually experienced as a lightning bolt (plasma) and resulting thunderclap (shock wave).
Plasma Shield	The ability of plasma to stop transmission of laser light.
Plastic Surgery and Dermatology	Excision of benign, malignant, and/or highly vascular tumors; operations in highly vascular areas such as scalp or tongue; operations involving infected or necrotic tissue, aesthetic plastic procedures, removal of tattoos, Moh's surgery, vaporization of basal cell carcinoma, condyloma acumulata, and removal of plantar warts.
Pockel's Cell	An electro-optical crystal used to achieve a Q-switch.
Population inversion	A state in which a substance has been energized, or excited, so that more atoms or molecules are in a higher given excited state than in a lower resting state. This is a necessary prerequisite for lasing action.
Power	The rate of energy delivery expressed in watts (joules per second).
Power Density	The strength of intensity of the laser beam; measured in watts/square centimeter; determined by the watts delivered at the tissue site and the spot size of the beam at the tissue surface.
Precise	Exact or sharply defined.
Proximal	Near the point of attachment or origin.
Pulse	A discontinuous burst of laser as opposed to a continuous beam. A true pulse achieves higher peak powers than that attainable in a continuous wave output - usually pulsed in microseconds or shorter. (See also gated pulse.)
Pulse Mode	Operation of a laser when the beam is intermittently on in fractions of a second.
Pulsed	A transient amplification or intensification of a wave characteristic of a system, followed by a return of equilibrium or steady state.
Pumped Medium	The energized laser medium.
Pumping	The process of supplying energy to the laser medium.
Q	Quality factor of resonator (energy storage); the ratio of total stored energy to the energy (removed) per cycle; the number of cycles to energy depletion.

GLOSSARY:
Terms Used with Laser Systems

Term	*Description*
Ablation	Volume removal of material by vaporization.
Absorption	Uptake of light energy by tissue, converting into heat.
Absorption coefficient	Factor describing light's ability to be absorbed. Optical properties of different material alters the absorption coefficient.
Acetic Acid	CH_3COOH; a clean colorless liquid with a pungent odor miscible with water or alcohol; a component of vinegar.
Acetone	CH_3COOH_3; a colorless, volatile, extremely flammable liquid, miscible with water; used as a solvent and reagent.
Activate	To start activity or motion in a device or material.
Active Medium	(laser Medium) The material used to emit the laser light.
Aiming Beam	A HeNe (or other visible light source) used as a guide light. Used coaxially with infrared or other invisible light.
Align	To adjust the components of a system for proper interrelationship.
Alternating current	AC; electric current that flows in one direction and then in the opposite direction.
Amplifiers	A device which acts upon an incoming signal (input) to increase or amplify it.
Amplitude	The maximum height of a wave. Implies power.
Angstrom (Å)	A unit of length equal to one hundred millionth (10^{-8}) of a centimeter.
Anode	The primary source of positive charges in a laser.
Argon	A gas used as a laser medium. It emits blue/green light at 488 and 515 nm.
Articulated	A configuration in which relative motion is allowed to occur between parts, usually by means of a hinged or sliding joint or joints.
Atom	The basic unit of any chemical element. It is composed of a dense, positively charged nucleus orbited by negatively charged electrons.
Attenuation	The decrease in energy as a beam passes through an absorbing or scattering medium.
Bandpass	A specification which defines the wavelengths which a device will transmit.
Bandwidth	Defines the wavelength range over which a signal exists.
BBO	Beta Barium Borate. A (frequency doubling) crystal which converts an incident range of visible wavelengths to an ultraviolet range at one half the incident wavelengths.
Beam	A concentrated, nearly unidirectional flow of photons, or a like propagation of electromagnetic or acoustic waves.
Beam Diameter	The distance between diametrically opposed points in the cross section of a beam.
Beveled	The angle between one line or surface and another line or surface; a sloping surface or line.

Term	Description
Binoculars	Any optical instrument designed for use with both eyes to provide depth of field focus.
Biostimulation	The use of a low-power (usually milliwatts) laser, to stimulate metabolic activity on a subcellar level; experimentally used for pain relief and wound healing.
Calibrate	To determine the settings of the control devices so that a system will operate or perform within certain limits.
Carbon	C; a nonmetallic chemical element that occurs in many inorganic and in all organic compounds.
Carbon Dioxide	CO_2; A colorless, odorless, tasteless gas about 1.5 times as dense as air.
Cathode	The primary source of negative charges in a laser.
Cautery	Achieving hemostasis of bleeding vessels, usually by heat from laser, or electro-surgical units. Contrasts with laser-induced protein coagulation.
Centimeter	cm; a unit of length equal to 0.01 meter or 0.3937 inch. (1 inch = 2.54 cm).
Chromophore	Optically active (colored) material in tissue which acts as the target for the laser light.
Circuit	A path or group of interconnected paths capable of carrying electric currents.
Circuit Breaker	An electromagnetic device that opens a circuit automatically when the current exceeds a predetermined value.
Coagulation	Destruction of tissue by heat without physically removing it.
Coating (Optical)	A surface additive of an optical component to achieve a desired effect; e.g., an anti-reflective coating to reduce surface reflection.
Coherence	Orderliness of wave patterns by being in phase in time and space.
Coherent Radiation	Radiant electromagnetic energy of the same wavelength and with definite phase relationships between different points in the field.
Collimation	Waves or rays traveling in a nearly parallel direction, with negligible divergence.
Combiner Mirror	The mirror in a laser which combines two or more laser beams of different wavelengths into a coaxial beam, i.e., CO_2 and HeNe beams.
Contact Probe	Synthetic ceramic material, like sapphire, used with laser fibers to allow touch of tissue with the probe, intensifying its effects and allowing cutting, vaporizing, or coagulation if tissue at relatively low powers and high degree of control.
Continuous Wave	Laser beams with a continuous flow of photons.
Cornea	The transparent anterior portion of the outer coat of the eye covering the iris and pupil.
CW	Continuous Wave
Debris	Fragments arising from disintegration.
DHE	Dihematoporphyrin Ether. A photosensitizing agent used in photodynamic therapy (PDT). DHE is a more refined form of HpD.
Dichroic Filter	Filter that allows selective transmission of colors

Term	Description
Diffraction	The bending of a light beam as it passes near an object.
Diffuse	To transmit and scatter light particles through a translucent material.
Diopter	An optical instrument that allows field of view adjustment.
Direct Current	DC; electric current which flows in one direction only.
Distal	Located away from the point of origin or attachment.
Distortion	To change from the original or usually shape or character of signals or objects.
Divergence	The amount of spread of a laser beam with distance travelled, usually measured in milliradians.
Dosimetry	Measuring the amount (joules) of light energy delivered to tissue.
Doubling Crystal	An optical crystal which generates radiation at a wavelength of one-half of that of the incident radiation.
Dovetail	A horizontal and/or vertical mounting bracket on a microscope to accommodate accessories.
Electricity	Physical phenomenon involving electric charges and their effects when at rest and when in motion.
Electromagnetic Radiation	The flow of energy consisting of orthagonally vibrating electric and magnetic fields lying transverse to the direction of propagations.
Electromagnetic Spectrum	The span of frequencies (wavelengths) considered to be light from radio & t.v. waves to gamma and cosmic rays.
Electron	Negatively charged particle of an atom.
Emission enable	Any radiation of energy by means of electromagnetic waves. To allow an activity which would otherwise be suppressed.
Endoscope	An instrument inserted into the body through an orifice (either therapeutic or surgical) that allows viewing and manipulation of tissue. May be rigid or flexible.
Energy	Potential forces, capacity for vigorous action expressed in Joules (watts/second).
ENT Surgery (ears, nose and throat)	Surgery performed in the ears, nose and throat area including laryngeal papillomatosis, polyps, nodules, polyposis, hemangioma, hyperkeratosis, cordal lesions, cordectomy, repair of stenosis and webs, excision of benign lesions, excision of malignant lesions of oral cavity, and dermatological, intranasal and major head and neck surgery.
Excimer	"Excited Dimer." A gas mixture used as the basis of lasers emitting ultraviolet light.
Excitation	The state of increased internal energy of an atom or molecule gained when an electron assumes a large orbit after the absorption of light energy.
Excited State	The state of an atom or molecule after the absorption of energy.
Excited State Lifetime	The length of time during which an excited state exists.
Extinction Length	The thickness of a substance in which 98% of the incident energy is absorbed.
Femtosecond	10^{-15} second. Shorter than a picosecond or a nanosecond.

Term	*Description*
Fiberoptics	A system of flexible quartz or glass fibers with internal reflective surfaces that pass light through thousands of glancing reflections. Many hundred or thousands of individual fibers are needed to transmit an image, but only single fibers are used to transmit laser light during treatment.
Field of View	The area which can be viewed through an optical instrument.
Filter	That which passes as output a portion of the input; as of an optical or electrical signal; a discriminator.
Fine Focus	The most precise ability to move an optical lens toward or away from an object to obtain the sharpest possible image of the object.
Fixed	Firmly in position; unmovable.
Fluorescence	The process by which an atom or molecule on decaying from an excited state emits light energy. Also known as spontaneous emission.
Focal Length	The distance from the focal point of a lens or curved mirror to the lens or mirror surface.
Focal Point	The point to which rays that are initially parallel to the axis of a lens, mirror, or other optical system are converged or appear to diverge.
Focus	The point or small region at which rays converge or appear to diverge; to move an optical lens toward or away from an object to obtain the sharpest possible image of the object.
Frequency	The rate of occurrence of an event; the symbol, f; units per second or Hertz (*see "Wave Equation"*).
Frequency Doubling	The action of doubling the frequency of a signal (halving the wavelength).
Fuse	An expandable device for opening an electric circuit when the current therein becomes excessive.
Gated Pulse	A discontinuous burst of laser light, made by timing (gating) a continuous wave output - usually in fractions of a second.
Gaussian Curve	Normal Statiscal curve showing a peak with even distribution on both sides. May either be a sharp peak with steep sides, or a blunt peak with shallower sides. Used to show power distribution in a beam. The concept is important in controlling the geometry of the laser impact.
Grating	An optical device consisting of a number of closely space grooves or lines which has the ability to break up or resolve in incident light beam into its constituent
Gross Focus	The first of two focusing systems that moves an optical lens toward or away from an object to obtain the sharpest possible image of the object.
Ground	A conducting path between an electric circuit or equipment and the earth, or some conducting body serving in place of the earth.
Ground State	The energy state to which an atom or molecule returns an excited state and in which it is most often found.
Harmonic Generation	The production of signals at frequencies which are multiples of the frequency of an original signal (*see "Frequency Doubling"*).

Term	*Description*
Helium	He; a colorless, odorless, tasteless, inert gaseous element used in laser media.
Hemostasis	The arrest of a flow of blood; the stopping or slowing of circulation.
HeNe	Helium Neon. A laser-producing, low-power (milliwatts). Used as a guide light for infrared lasers, or experimentally for biostimulation.
Hertz	Hz; unit of frequency; also know as cycles per second.
Hologram	A three-dimensional picture made by interference patterns created by the coherence of laser light. Created as transmission, reflection or integral holograms.
Horizontal	Being in a plane perpendicular to the gravitational field, that is, perpendicular to a plumb line, at a given point on the earth's surface.
HpD	Hematoporphyrin Derivative. A photosensitizing drug used with photodynamic therapy as a treatment for cancer.
Illumination	The density of lighting on a surface.
Impact Size	The size crater or width of incision left by a laser impact. Related to spot size of the beam, except impact size varies depending on how the energy is applied.
Infrared	*See "Spectrum"*.
Infrared Radiation	Electromagnetic radiation with a wavelength that lies in the range of 0.7 microns to 1 micrometer.
Intensity	The strength of amount of a quantity; the power transmitted by a light wave across a unit area perpendicular to the wave.
Intermittent	Stopping and starting at intervals.
Ionizing Radiation	Radiation commonly associated with X-Ray, that is of a high energy enough to cause DNA damage with no direct, immediate thermal effect. Contrasts with non-ionizing radiation of surgical lasers.
IR	Infrared (*see "Spectrum"*).
Irradiance	See Power Density.
Jitter	The uncertainty of a specification during operation of timing signals.
Joule	A unit of energy. Laser powers are sometimes described in joules per second. A power of one (1) per second is known as one (1) watt as is the rate of energy delivery.
Joystick	A device for moving the CO_2 and Helium Neon laser beams with a microscopic beam delivery attachment.
KTP	Potassium Titanyl Phosphate. A crystal used to change the wavelength of a Nd:YAG laser from 1060 nm (infrared) to 532 nm (green).
Laser	A light source which produces narrow, directional, intense and monochromatic ("pure color") beams. Light amplification by the stimulated emission of radiation.
Laser Energy Source	The mechanism - either heat, chemical, electrical or laser radiation— which initiates and supports lasing action.

Term	*Description*
Laser Head	The laser medium, together with mechanical supports, optical components and electrical connections from which laser radiation is emitted.
Laser Medium	(Active Medium) material used to emit the laser light and for which the laser is named.
Laser Plume	Smoke, vapor, and airborne particles that are the by-products of CO_2 laser vaporization.
Laser Pump	See laser energy source.
Lens	A curved piece of ground and polished or molded material, usually glass, used for the refraction of light.
Light	Electromagnetic radiation with wavelengths capable of causing the sensation of vision.
Loupes (magnifying)	Small magnifying glasses set in eye pieces.
Magnification	A measure of the effectiveness of an optical system in enlarging or reducing an image.
Metal Vapor Lasers	A class of lasers using vaporized metal as the laser medium, such as the copper vapor emitting yellow light at 578 nm and gold vapor emitting red light at 630 nm. These are usually high frequency pulsed systems.
Metastable state	The state of an atom, just below a higher excited state, which an electron occupies momentarily before destabilizing and emitting light.
Meter	The fundamental unit of length (equivalent to 39.37 inches) in the metric system; a device designed to measure, indicate, record, or regulate power, etc.
Methanol	CH_3OH; a colorless, toxic, flammable liquid miscible with water either, and alcohol.
Micromanipulator	Device attached to a microscope that controls delivery of the laser beam into the microscopic field of view. In non-ophthalmic surgery are most commonly used with CO_2 lasers, then with Argon & KTP, and least with Nd:YAG lasers.
Micrometer	(μm) Limit of
Microprocessor	A digital chip (computer) that operates and monitors some lasers.
Microscope	An instrument through which minute objects are enlarged by means of a lens or lens system.
Millimeter	(mm); a unit of length equal to one-thousandth of a meter or 0.00394 inch.
Milliradian	A unit of angular measure used to describe beam divergence, one thousandth of a radian.
Minimal Thermal Effect	When CO_2 is absorbed in water and minimizes conductivity of heat.
Mirror	A surface which specularly reflects a large fraction of incident light.
Mode	A term used to describe how the power of a laser beam is distributed within the geometry of the beam. Also used to describe the operating mode of a laser such as continuous or pulsed.

Term	*Description*
Mode-Locking	A process similar to Q-switching except that the pulses produced are even shorter (about 10^{-12} seconds) and energy in short trains of pulses instead of singularly. It is usually achieved with a dye cell.
Molecule	A group of atoms held together by chemical forces; the smallest unit of matter which can exist by itself and retain all its chemical properties.
Monochromatic	Consisting of electromagnetic radiation having an extremely small range of wavelength; having only one color.
Monochromaticity	The state in which laser waves are the exact same length.
Nanometer	Abbreviated nm--measure of length. One nm equal 10^{-9} meters, and is the usual measure of light wavelength. Visible light ranges from about 400nm in the purple to about 760 nm in the deep red.
Nanosecond	10^{-9} (one billionth) of a second. Longer than a picosecond or a femtosecond, but shorter than a microsecond. Associated with Q-switched ophthalmic Nd:YAG lasers.
National Center for Devices and Radiological Health	Section of U.S. Government Department of Health and Human Services that regulates the laser industry.
Nd:YAG	Neodymium:Yttrium Aluminum Garnet. The crystal used as a laser medium to produce 1064 nm light.
Necrosis	The pathologic death of living tissue.
Neodymium	The rare earth element that is the active element in a Nd:YAG laser.
Neon	Ne; a rare, inert gaseous element occurring in the atmosphere. It is colorless, but glows reddish-orange in an electric discharge.
Nitrogen	N_2; a gaseous, colorless odorless element.
Nonlinear Effect	Not a normal, linear temperature rise induced by laser. Refers to the plasma "spark" and snap created by the Q-switched Nd:YAG laser.
Nuclear	The positively charged core of an item.
Objective	The first lens or lens system through which light passes in an optical system.
Optical Breakdown	Plasma formation by stripping electrons off atoms/molecules. Caused by high laser energy densities and used to create a "spark." Used in ophthalmology with Q-switched or mode-locked Nd:YAG lasers to cut membranes.
Optical Cavity	(Resonator) Space in between the laser mirrors where lasing action occurs.
Optics	Components of an optical instrument designed to assist sight.
Output Coupler	The partially transmissive mirror that allows laser output from the optical cavity.
PDT	Photodynamic Therapy. The use of photosensitizing drugs, activated by certain pure colors of light produced by the laser, to achieve selective tissue destruction. Its current major use is investigational as a selective treatment for cancer.
Phase	Waves are in phase with each other when all the troughs and peaks coincide and are "locked" together. The result is a reinforced wave in increased amplitude (brightness).

Term	Description
Q-Switching	Switching the "quality" of a resonator, producing very high peak powers (millions of watts) but for very short bursts (nanoseconds) - frequently achieved with a Pockel's cell. This creates a "sparking" and shock wave effect. (See photodisruptors, plasma, and mode-locking.)
Quartz	SiO_2; a colorless, transparent rock-forming mineral with vitreous luster; the most abundant and widespread of all minerals.
Quartz Fiber	Beam delivery material for the Nd:YAG laser.
Radian	A unit of angular measure which is the ratio of the divergence distance to the travel distance of a light beam.
Radiation	The energy transmitted by waves through space or some medium; also known as electromagnetic radiation or radiant energy.
Radio Frequency	Any frequency in the range within which radio waves are transmitted.
Reagent Grade	Any substance used in a chemical reaction to detect, measure, examine, or produce other substances; a very pure chemical.
Reflect	To throw or bend light from a surface.
Refraction	The bending of a light beam as it passes from one medium to a different one.
Repetition Rate (Rep Rate)	The rate of occurrence of a particular event; pulses per second; Hertz.
Resonator	The chamber that allows oscillation of the light waves back and forth at the speed of light.
Rotate	To turn or spin on an axis.
Scientific Notation	A method of numerical comparison and manipulation based on multiples of 10, e.g., $10 \times 10 \times 10 = 1000 = 1 \times 10^3$; and $2500 = 2.5 \times 10^3$
Shutter	A mechanical device that cuts off a beam of light by opening and closing at different rates of speed.
Signal	A specific anticipated, detectable event, e.g., a laser pulse.
Spectral Line	A specific wavelength, usually with a defined line width.
Spectral Range	A defined continuum of wavelengths; e.g., G80 to 720 nm.
Spectral Region	A specific continuum of wavelengths; e.g., the visible 400-760 nm, VIS
Spectrum	The characteristic group of wavelengths radiated by a substance; spectral output; a group of wavelengths with a common basis, e.g., groups or ranges adjacent wavelengths; infrared wavelengths.
Spot Size	The mathematical measurement of a focused laser spot. In a TEMoo beam it is the area that contains 86% of the incident power. This is the "optical" spot size and does not necessarily indicate the size of the laser crater that will be made. The latter is the impact size.
Stability	The consistency over time of a given signal.
Sterilize	To render free from bacteria or other microorganisms.

Term	*Description*
Stimulated Emission	The process of excited state decay with photon emission induced by the interaction with another like photon.
Superpulse	An operating mode on the CO_2 laser describing a fast pulsing output (250-1000 times per second), with peak powers per pulse higher than the maximum attainable in the continuous wave mode. Average powers of superpulse (speed of tissue removal) are always lower than the maximum in continuous wave.
Switch	A device used to break or open an electrical circuit or to divert current from one conductor to another.
Target Site	Tissue that is aimed or fired at with the laser beam.
TEM	An acronym for T (transverse) E (electromagnetic) M (mode).
Thermal Effect	Impact of heat on tissue or cell matter.
Thermal Necrosis	Death of tissue or cell matter due to thermal impact.
Thermal Relaxation Time	The rate at which a structure can conduct heat. When pulse times of a laser are shorter than the time required for heat to spread out of a target, the heat damage will be confined to that target.
Tunable Dye Laser	A laser using a jet of liquid dye, pumped by another laser or flashlamps, to produce various colors of light. The color of light may be tuned by adjusting optical tuning elements and/or changing the dye used. Common medical applications are with the 630 nm continuous wave red, and the pulsed 577 nm yellow and 504 nm green.
Vertical	At right angles to the horizon; extending perpendicularly from a plane; upright.
Volt	V; the International System unit of the electric potential and electromotive force, equal to the difference of electric potential between two points on a conducting wire carrying a constant current of one ampere when the power dissipated between the points is one watt.
Watt	W; unit of power in the International System equal to one joule per second.
Wave Equation	The equation which relates the wavelength and frequency of wave motion to its speed of propagation. In the case of light waves, $c=f\lambda$; where c, the speed of light, has been measured as (approximately) $3x10^8$ m per second or $3x10^{17}$ nm per second. F, the frequency (number of wave per second); λ, the wavelength. A light source emitting 300 nm wavelength light would, therefore, do so at a frequency of $f \cdot \frac{c}{\lambda} = \frac{3x10^{17}}{300} = 1x10^{15}$ *cycles per second*
Wavelength	Distance between two points of corresponding phase in consecutive cycles.
X-Ray	A very short wavelength of light, producing ionization effects commonly associated with radiation hazards. Not a problem with surgical laser units.