LASER IONICS

INNOVATION • QUALITY
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OPERATION, MAINTENANCE AND SERVICE INSTRUCTIONS

SERIES 1400, RAINBOW AND "B" SERIES GAS-ION LASER SYSTEMS WITH MODEL 851/851B POWER SUPPLY

JUNE 1992
(REVISION B)

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PREFACE

This instruction manual has been prepared to provide the user with information required to operate and perform routine maintenance on Laser Ionics gas-ion laser systems. These systems are comprised of Models 1400, Rainbow, and B Series laser heads with Model 851 or 851B power supply. It is recommended that all equipment operators and maintenance personnel familiarize themselves with the information in this manual prior to operating the laser system or performing any system maintenance.

Center of Devices and Radiation Health (CDRH) warning logotypes, similar to that shown here, appear on each laser. They indicate the CDRH classification and certify that the output power of the laser will not exceed the power level printed on the logotype.

WARNING

HIGH VOLTAGE

IS USED IN THE OPERATION

OF THIS EQUIPMENT

DEATH ON CONTACT

MAY RESULT IF OPERATING PERSONNEL

FAIL TO OBSERVE SAFETY PRECAUTIONS

BE CAREFUL TO AVOID CONTACT WITH HIGH-VOLTAGE CIRCUIT CONNECTIONS WHILE CHECKING OR SERVICING THIS EQUIPMENT.

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SECTION 1
SAFETY AND COMPLIANCE

1.1 SAFETY ISSUES

This safety section should be thoroughly reviewed prior to operating the Laser Ionics laser systems described in this manual. Safety precautions contained herein and throughout the manual must be carefully followed to ensure that all personnel who operate or maintain the laser are protected from accidental or unnecessary exposure to laser radiation.

Hazards associated with lasers generally fall into the following categories:

1. Exposure to visible or invisible laser radiation which may result in damage to the eyes or skin.

2. Exposure to chemical hazards such as particulate matter or gaseous substances released as a result of laser material processing, or as a byproduct of the lasing process itself.

3. Electrical hazards inherent in the laser power supply or laser head and associated circuits. Some high power lasers operate at extremely high voltages (600 volts or more). Death or serious injury may result from contact.

4. Secondary hazards such as:
   - High acoustical noise levels
   - Pressurized lamps, cylinders, hoses, etc.
   - Moving parts in parts handling systems
   - EMI/RFI emissions from faulty equipment
   - Pressurized liquids and gases

It is recommended that you obtain a copy of ANSI Z136.1, American National Standard for the Safe Use of Lasers, published by the American National Standards Institute (ANSI), 1430 Broadway, New York, NY 10018, (212) 354-3300. This publication is a comprehensive guide to the safety compliance standards required of laser users. While ANSI is a non-government agency, and has no enforcement authority, OSHA, the Occupational Safety and Health Administration uses ANSI Z136.1 as its laser safety standard. Therefore, ANSI Z136.1 does, in effect, carry the full authority of Federal Regulations. Additional information can be obtained from the Laser Institute of America, 12424 Research Pkwy., Orlando, FL 32826, (407) 380-1553.

1.2 RADIATION SAFETY CONSIDERATIONS

— CAUTION —

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

Laser Ionics certifies that all lasers described in this manual comply with safety requirements for class IV lasers as established by the United States Government in Title 21, Code of Federal Regulations, Subchapter J, (21 CFR). Laser Ionics has designed the following engineering controls into their lasers in compliance with 21 CFR and to ensure the safety of the laser user. Any modification or use of these lasers which changes, disables, or violates the functions of these engineering controls invalidates the Class IV certification of the laser and can be a violation of Federal Regulations.

1. KEYSWITCH — A keyswitch is provided on the power supply to enable operation of the laser. The actual function of this switch is to make control power available to the system. The keyswitch is designed so that the key is removable only in the OFF position. This assures that the use of the laser is controlled and prevents use by unauthorized personnel.

2. PROTECTIVE HOUSING — The optical cavity of the laser is completely covered by an aluminum housing which is interlocked to

the power supply such that power to the laser will be shut down immediately when the housing is removed. The laser beam is enclosed within this housing until it exits through the safety shutter. The laser should never be operated with the protective housing opened, removed or displaced and the interlock system defeated. The only exception to this is when service is being performed on the laser head by QUALIFIED personnel.

3. REMOTE CONNECTOR — This connector is a BNC female type and is located on the rear of the power supply. It is also referred to by its designation, J3. It provides a means of connecting an external interlock such as a switch on the door to the room containing the laser. This could be used to control access to the laser operating area and prevent accidental exposure to laser radiation. Opening the contacts of the switch will cause the power supply to immediately shut down, thereby terminating the lasing action. The power supply is shipped with a male plug which closes the contacts.

4. EMISSION INDICATOR — An illuminated emission indicator is located on the front panel of the power supply. Another is located on the laser head near the laser beam output port. A third is located on the remote control module, if installed. These emission indicators illuminate when the master keyswitch is turned on. Since there is a timer circuit in the power supply which delays the application of power to the laser tube for 30 seconds after the "POWER ON" switch has been depressed, these indicators warn of impending lasing action. The emission indicators remain on as long as the keyswitch is in the ON position.

5. BEAM ATTENUATOR (SAFETY SHUTTER) — A mechanical shutter is located on the output aperture end of the laser head. When closed, it prevents laser radiation from escaping from the optical cavity. The shutter is closed by pushing the shutter knob in towards the beam aperture.

6. LOCATION OF CONTROLS — Controls for operation of the laser are located so that exposure to laser radiation is not required during operation.

7. WARNING LABELS — Certification and warning labels are affixed to the laser to assure the user that it complies with 21 CFR, to provide information on the radiation output of the laser, and to warn the user against accidental exposure to laser radiation. Figure 1-1 identifies the labels and depicts where they are located on the laser system.

8. OPERATION AND MAINTENANCE — Instructions for safely operating and maintaining the laser are provided in this manual.

9. MAXIMUM OUTPUT POWER — The maximum output power accessible from each model laser is given in Figure 1-2.

10. LASER BEAM PATH — Figures 1-3 and 1-4 illustrate the laser beam path for the gas-ion laser systems.

1.3 PROTECTIVE EYEWEAR

It is recommended that laser-safe eyewear which has the capability of attenuating specific laser wavelengths be worn at all times when operating Laser Ionics' lasers. Since Laser Ionics manufactures argon, krypton, neon and mixed gas ion lasers, it is not possible to attenuate all possible wavelengths with a single unit of eyewear. Such a device would attenuate almost the entire visible spectrum. Eyewear specific to the type of laser being operated should be used. It is important to safety that protective eyewear be worn when servicing the laser while emitting radiation with the head cover removed.

Laser eyewear may be obtained from:

Glendale Optical Company, Inc.
130 Crossways Park Drive
Woodbury Park, NY 11797
(516) 921-5800

Fred Reed Optical, Inc.
P. O. Box 1336
Albuquerque, NM 87103
(505) 265-3531

Rockwell Associates, Inc.
P. O. Box 43010
Cincinnati, OH 45243
(513) 271-1568

Spectra Optics
12317 Gladstone Avenue
Sylmar, CA 91342
(818) 361-0949

These references are provided as a service to our customers. This does not constitute an endorsement by Laser Ionics of the products supplied by any of the named companies.

WARNING LABEL LOCATION AND IDENTIFICATION

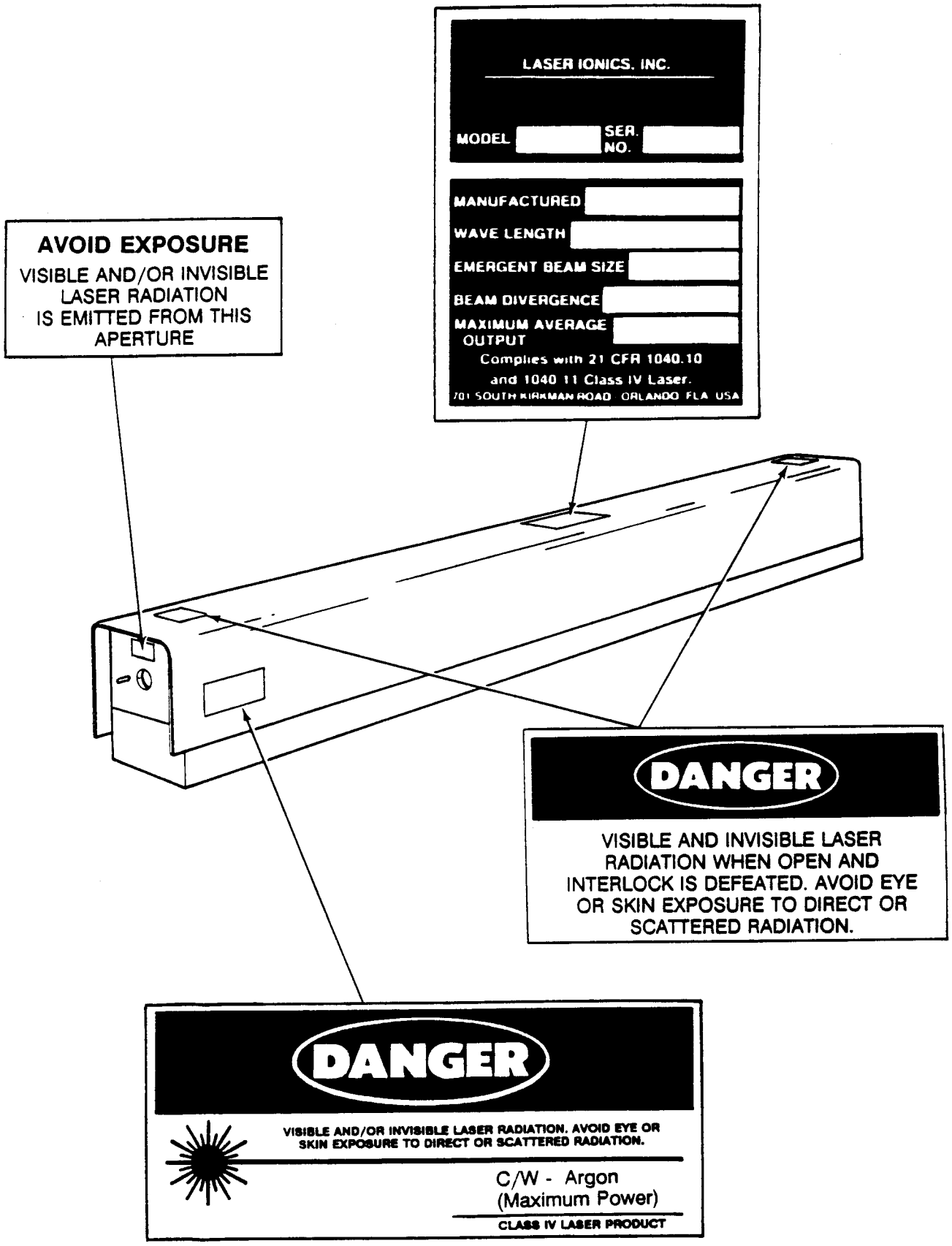

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Figure 1-1 Warning Label Location and Identification (Sheet 1)

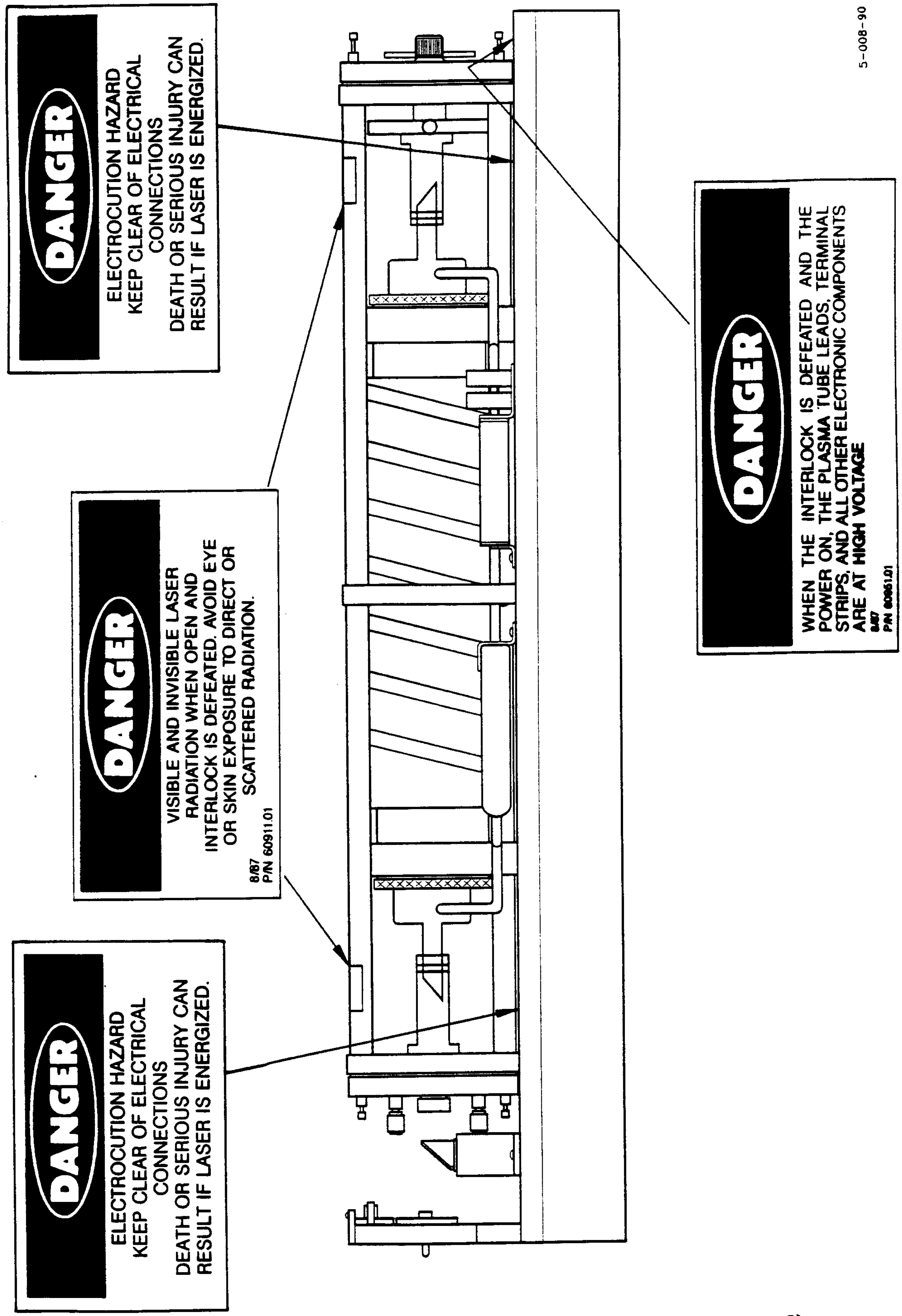

Figure 1-1 Warning Label Location and Identification (Sheet 2)

MODEL 1400

ARGON		KRYPTON		MIXED GAS	
Model	Max. Power (Watts)	Model	Max. Power (Watts)	Model	Max Power (Watts)
1400-2A	2.5	1400-1K	2.0	1400-1AK	2.5
1400-5A	9	1400-2K	3.8	1400-2AK	5.0
1400-10A	16	1400-3K	6.0	1400-3AK	9
1400-15A	24	1400-4K	8.2	1400-4AK	12
1400-20A	29	1400-5K	11.0	1400-6AK	14
1400-25A	36				

Figure 1-2 Maximum Power Levels and Danger Sign (Sheet 1)

NEON LASER

MODEL 1400

MODEL	MAX POWER (WATTS)
1400-1N	3
1400-05N	2

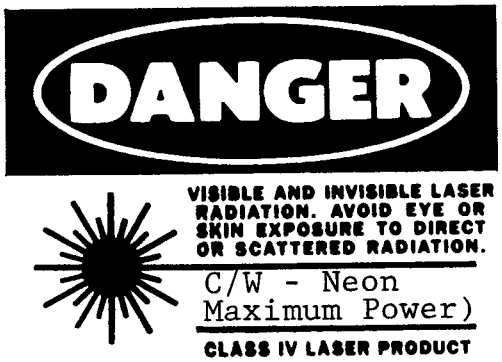

Figure 1-2 Maximum Power Levels and Danger Sign (Sheet 2)

ULTRA HIGH POWER ION LASERS

B SERIES

ARGON		KRYPTON		MIXED GAS	
Model	Max. Power (Watts)	Model	Max. Power (Watts)	Model	Max. Power (Watts)
MB-50A	76	MB-50K	20	MB-50A/K	30
RB-25A	38	RB-25K	16	RB-25A/K	22
PB-15A	26	PB-15K	12	PB-15A/K	16

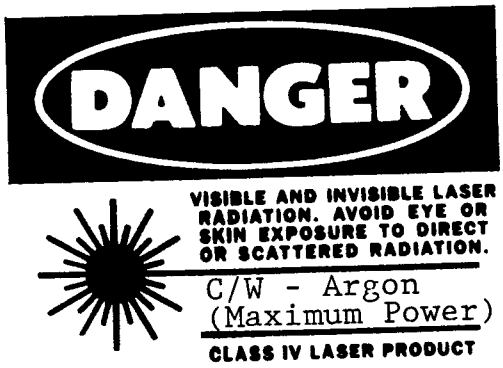

Figure 1-2 Maximum Power Levels and Danger Sign (Sheet 3)

LASER BEAM PATH

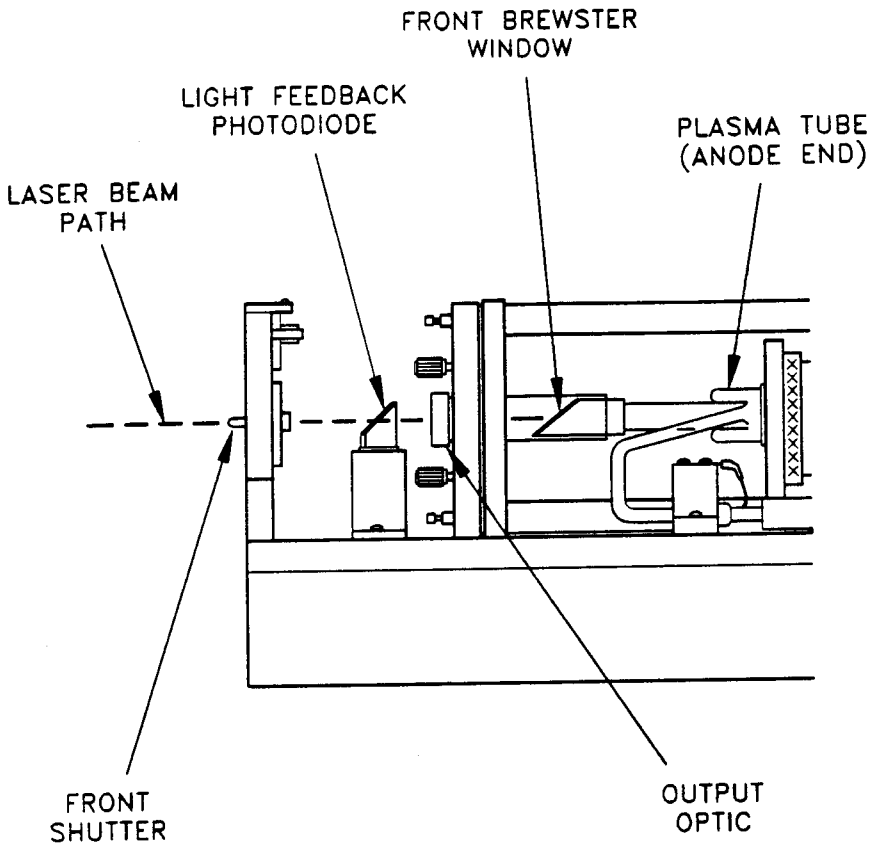

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Figure 1-3 Laser Beam Path

LASER BEAM PATH

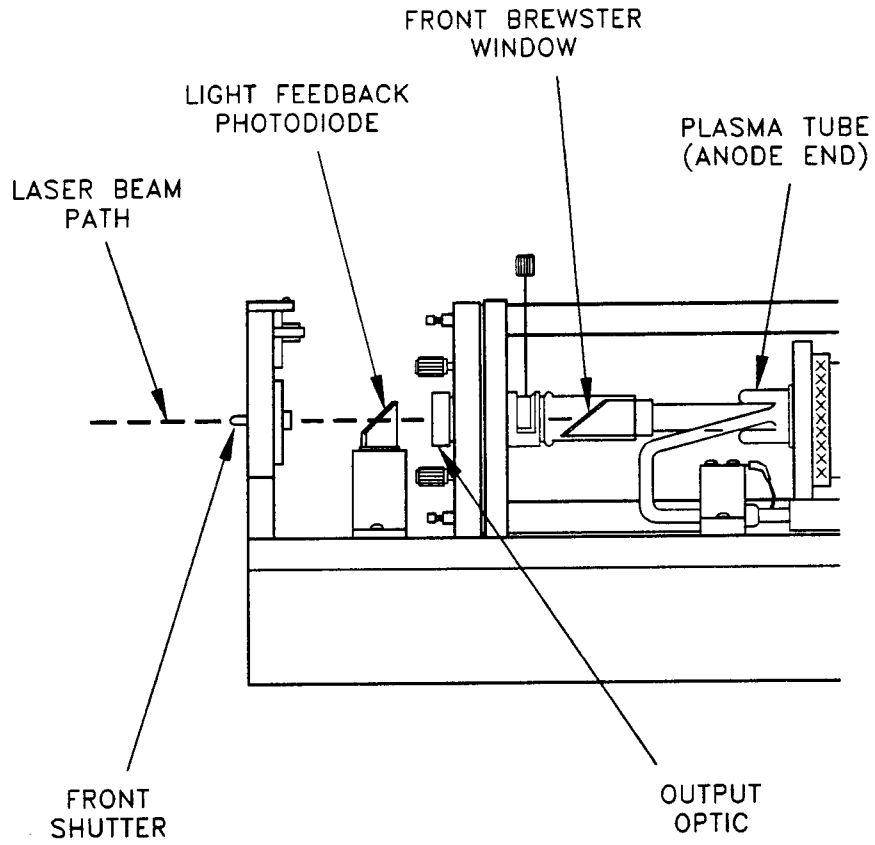

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Figure 1-4 Laser Beam Path With Aperture Assembly

1.4 ELECTRICAL SAFETY CONSIDERATIONS

Gas-ion lasers, by their nature require significant amounts of electrical power to operate. Gas-ion laser power supplies, therefore, are to be considered high power electrical devices and contain electrical voltages lethal to human beings. The following recommendations should be considered mandatory for safe operation and/or service of gas-ion lasers.

1. Disconnect the main power source before working on any electrical equipment.

2. Since power supplies contain energy storage devices, always allow at least ten minutes for filter capacitors to fully discharge through their internal bleeder resistors. Use a voltmeter to determine if any residual voltage exists before working on equipment.

3. The usual reason for working on electrical equipment is that something has gone wrong. Always assume that the safety features of the equipment have failed, and check each component as if it was still energized until you are satisfied that it is safe.

4. Should it be necessary to work on equipment that is energized, use only approved, insulated tools.

5. Do not connect any portion of the power supply circuitry to chassis ground. Circuit common (DC negative) is at a high potential to chassis ground. Attempting to operate the power supply with circuit common connected to chassis ground may damage the power supply.

   Positive personnel protection, however, requires that the chassis ground be securely connected to earth ground through the green wire in the incoming power cable. This ground should be positively confirmed at the time of installation and periodically reconfirmed thereafter. (This is an item to check during periodic maintenance.)

6. Use only test equipment with ungrounded circuitry and grounded chassis. If this is not possible, the test equipment must be isolated through the use of an isolation transformer. Confirm isolation with an ohmmeter before energizing the equipment. If the DC power supply circuitry is grounded through the use of test probes or similar technique and the power supply is energized, damage could occur to the power supply and/or the test equipment. Serious injury to the personnel operating the test equipment is a very real possibility.

7. **NEVER** work alone on energized high voltage equipment of any kind. Always have an associate in the immediate vicinity who is familiar enough with the equipment to place it in a safe condition and has been trained to administer first aid for electrical shock.

8. Read and adhere to warnings and cautions inserted in applicable locations in this manual.

1.5 CERTIFICATION OF COMPLIANCE

Laser Ionics certifies that the Series 1400, Rainbow and B series lasers comply with the requirements of Title 21, Code Federal Regulations, Subchapter J, for Class IV laser products. Verification of compliance may be obtained from:

Director
Office of Compliance (HFZ-300)
Center for Devices and Radiological Health
Food and Drug Administration
8757 Georgia Avenue
Silver Springs, MD 20910

Telephone: (301) 427-8228

SECTION 2
INSTALLATION

2.1 GENERAL

Laser Ionics lasers are designed to operate under conditions found in the majority of industrial and research settings.

2.1.1 Site Planning

Your laser will operate more effectively if the following guidelines are followed:

1. Provide a stable, relatively flat work surface for mounting the laser.

2. Operate the laser in an environment free from atmospheric contaminants.

3. Avoid installing the laser where direct or reflected radiation can be a damage to personnel or equipment. It is recommended that the site include highly diffuse walls and barriers for protection from reflected radiation. A facility interlock connector is provided to allow installation of special shutdown if deemed necessary.

2.1.2 Water Requirements

Provide clean cooling water, free from contaminants and materials in suspension. Cooling water flow must meet the requirements of Table 2-I. Tap water in most places is adequate. If an appropriate clean source is not available, install a particulate filter in the water supply line. A closed-loop chiller system is also an acceptable option. Contact Laser Ionics for assistance when selecting a chiller system.

2.1.3 Electrical Requirements

1. Install the laser as close to the wall electrical power source as possible. This will avoid large line-related electrical losses and voltage drops.

2. Provide a three-phase electrical power source with the voltage and amperage capacity specified in Table 2-II.

2.2 UNPACKING/RECEIVING INSPECTION

2.2.1 General

Laser systems are shipped in reusable containers. A T-handle wrench is included to open and lock the container holding the laser head. Do not lose this wrench.

> **- NOTE -**
>
> Retain all shipping containers and packing material. These will be required should it be necessary to ship the laser to another location or to return the laser to the factory for service.

The laser head container includes these items when a new laser is shipped:

- Technical Manual (2 copies)
- Laser head and umbilical assembly
- 20-foot cooling water hoses (2)
- Maintenance kit: Q-tips; Optical soap; Acetone bottle; Interlock banana plug; Power supply keys (2); Tube pumpdown keys (2); Optional purchased items.

The power supply and autotransformer (if required) are packed in separate re-usable containers.

2.2.2 Unpacking Instructions

Unpack and remove the laser system from the shipping and storage containers as follows:

1. Carefully open the laser head container and remove the flat wooden pieces which secure the laser head in place using the packing wrench.

2 Remove the foam packing around the laser head, and carefully lift the laser head straight up and out of the container.

Table 2-I Cooling Water Requirements

Frame Size	Model 1400	"B" Series
A	2.5	4.0
B	4.0	-
C	5.0	5.0
D	6.0	-
E	6.0	6.0

Cooling water in gallons per minute with inlet pressure at 45 - 60 psi. Temperature at 55°F-80°F.

Table 2-II Output Power and Electrical Service

		Output Power (Watts)			Recommended Three-Phase Service				
Model 1400		**Argon**	**Krypton**	**Mixed Gas**	**208 VAC 50 Amp**	**208 VAC 60 Amp**	**208 VAC 100 Amp**	**208 VAC 110 Amp**	**480 VAC 50 amp**
Frame Size	A	5.0	0.7	1.5	X				
	B	10.0	2.0	3.0		X			
	C	15.0	3.0	4.0		X			
	D	20.0	4.0	8.0					X
	E	25.0	5.0	9.0					X
B Series									
Frame Size	A	15.0	4.0	8.0		X			
	C	25.0	7.0	12.0			X		
	E	50.0	12.0	20.0				X	X

Note:

1. Recommended amperage for UV lasers is 20% higher than listed.
2. Phase to phase voltages must be within 2% of each other.

- CAUTION -

The quartz plasma tube runs the full length of the laser head and must not be subjected to extreme shock or vibration. Always support the laser head under each end and in the middle when handling.

3.Open the container holding the DC power supply and remove the packing. Lift the power supply up and out of the container.

4. Open the container holding the transformer. Remove packing and transformer. Exercise care when lifting the transformer enclosure. It has a fairly high center of gravity and can weigh 150 pounds or more.

2.2.3 Inspection

The shipping container has been designed to provide the safest, most secure transport possible. Damage can occur, however, if the container is subjected to rough handling during shipment. It is recommended that the laser head be inspected immediately after removing it from the shipping container as described below.

1.Inspect the exterior of the laser head for signs of damage.

2.Loosen the screws along the sides of the laser head rail. Remove the laser head cover and inspect the interior of the unit thoroughly for damage. The head cover might require a degree of upward force applied along the front edge of the cover to disengage the cover interlock banana plugs. Lift the cover slowly and carefully to avoid contacting the laser tube, or subjecting it to any physical shock when the interlock releases.

3.Inspect the getter located in the front of the ballast. See Figure (2-1) for the location of the getter. The getter plating should be a dark silver color on the interior of the quartz glass. If the getter is chalk-white in appearance, the laser tube has been broken and must be replaced. If the laser system is found to be damaged in any way, file a report with your shipper and notify Laser Ionics of the situation immediately.

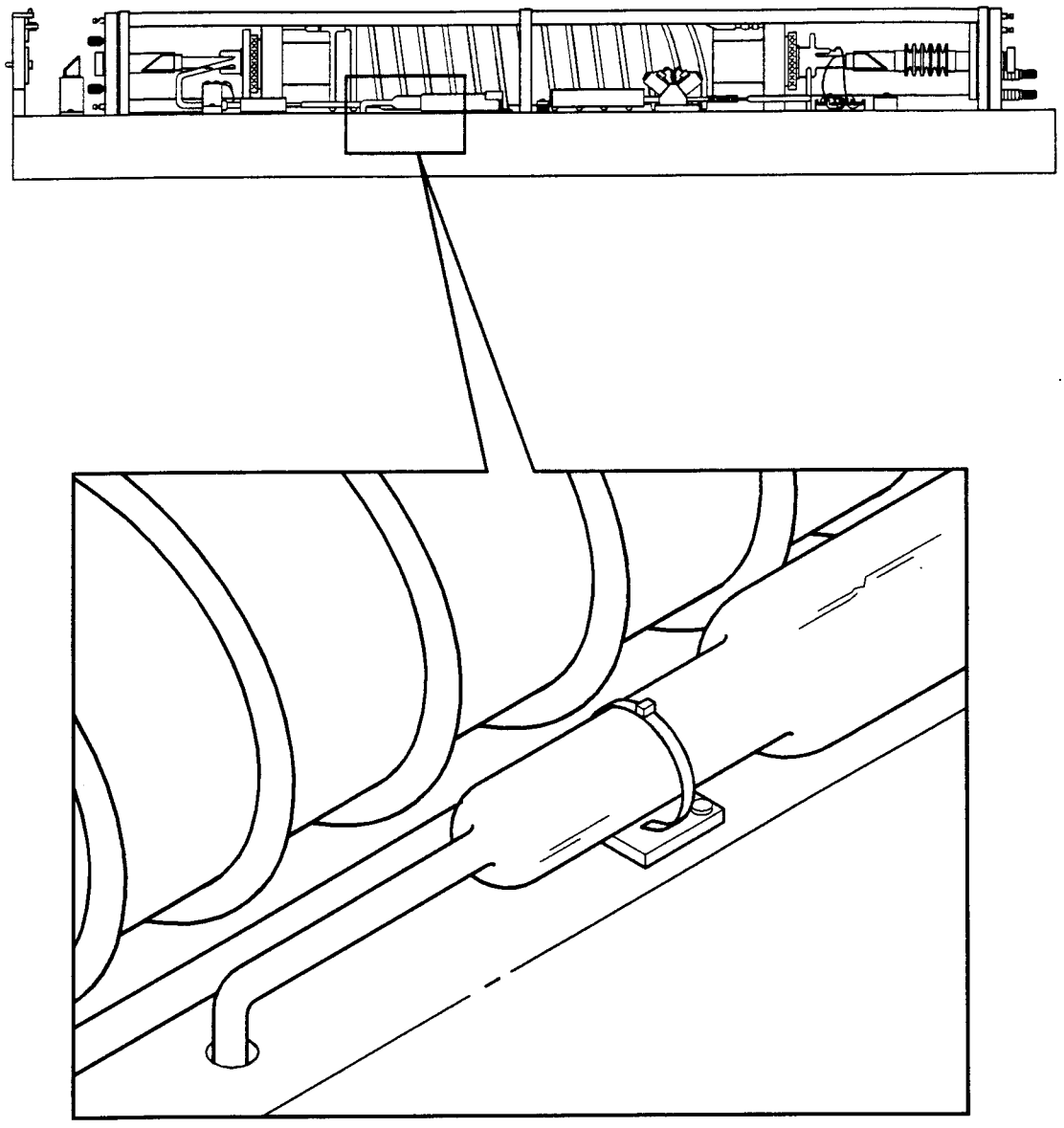

Figure 2-1. Getter Location

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SECTION 3
SYSTEM DESCRIPTION

3.1 SYSTEM OVERVIEW AND THEORY OF OPERATION

3.1.1 General

Laser Ionics lasers include argon, krypton, a mixture of argon and krypton gases, and neon gas. Each is available in several configurations and may be designated Model 1400, or B Series. Each of these laser systems is made up of two major components — a laser head and a DC power supply (Figure 3-1). The power supply includes an Electronics Unit (EU) and Remote Control Module (RCM), and may include an autotransformer.

Laser Ionics' lasers belong to the general class of gas ion lasers. The general operating principles are the same as those of sealed HeNe lasers, CO_2 lasers, and competing ion lasers. A DC potential difference is created between an anode and cathode in a sealed tube containing an inert gas (argon, krypton, neon, or mixtures of these) at a pressure of a few TORR (atmospheric pressure is equivalent to 760 TORR). The large voltage drop across the tube ionizes the gas atoms. A magnetic field, created by a solenoid which surrounds the tube, helps to organize the ionized gas into a plasma which flows down the center (bore) of the tube. Mirrors, one highly polished with a reflectivity usually greater than 99%, a second with a reflectivity of 85-99%, are mounted at either end of the laser tube to support a process termed Population Inversion. This process supports the continuous emission of laser energy. These principles are described in detail in many sources and will not be described further here. The following sections will, however, describe how general gas laser operating principles are implemented in a Laser Ionics laser.

3.1.2 Laser Head

The laser head (Figure 3-2) includes the tungsten-bore plasma tube assembly, a water-cooled solenoid which produces a magnetic field, and a thermally isolated graphite/invar resonator assembly.

The plasma tube (Figure 3-3) has a tungsten bore and quartz envelope. The tube is enclosed within an electromagnetic field produced by the solenoid assembly. When operating, ionized gas atoms flow between the anode and cathode located at opposite ends of the plasma tube.

Figure 3-4 shows the cooling water flow path for the laser head. Water passes through the cooling coil wrapped around the solenoid and in the annular region between the exterior of the tube envelope and the interior surface of the solenoid. Waste heat radiates from the tungsten bore to the annular flow region and is carried away by the cooling water.

Laser heads are available in five standard frame sizes, as shown in Figure 3-5. Laser output power and wavelengths depend primarily on the type of gas, frame size, tube internal characteristics, and optics.

3.1.2.1 Resonator Assembly

The resonator assembly consists of graphite rods with invar end caps positioned within aluminum sheaths; end and center plates; and mirror mount assemblies. The aluminum sheaths and plates form a rigid assembly fixed to the laser rail. The resonator rods are free to expand or contract, and move the mirror mounts along the axis of the rods in response to temperature effects. Graphite has been chosen as the rod material as its coefficient of thermal expansion is less than one part in 10 million. The distance between mirrors is termed the intracavity length. Limiting changes to intracavity length by limiting mirror displacement through effective resonator design is highly desirable. Since movement can cause changes to the output power and mode hopping during single frequency operation.

3.1.2.2 Tube Pressure Control

Gas pressure within the laser tube is controlled to provide optimum performance of the laser tube. If pressure becomes too high, output power can be affected and lasing terminated. Low pressure reduces power and can also cause overheating and severe damage to the laser tube. Tube pressure is also affected by tube voltage, solenoid field strength and tube current. Tube pressure cannot be read directly. Rather, the voltage

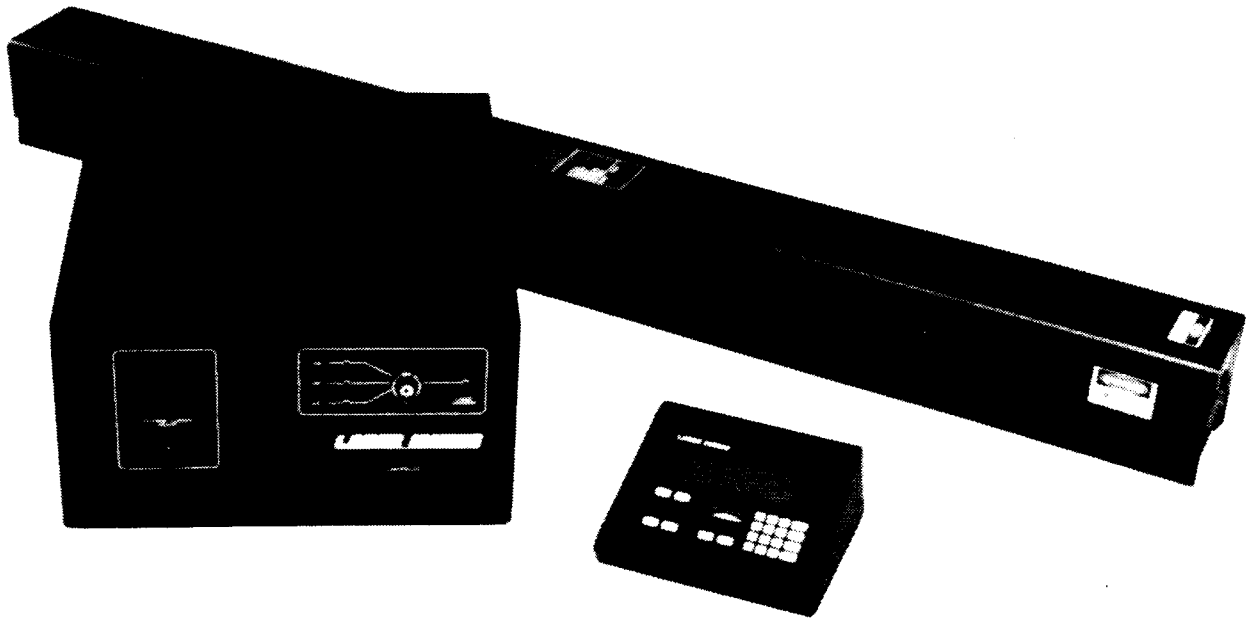

Figure 3-1 Ion Laser System

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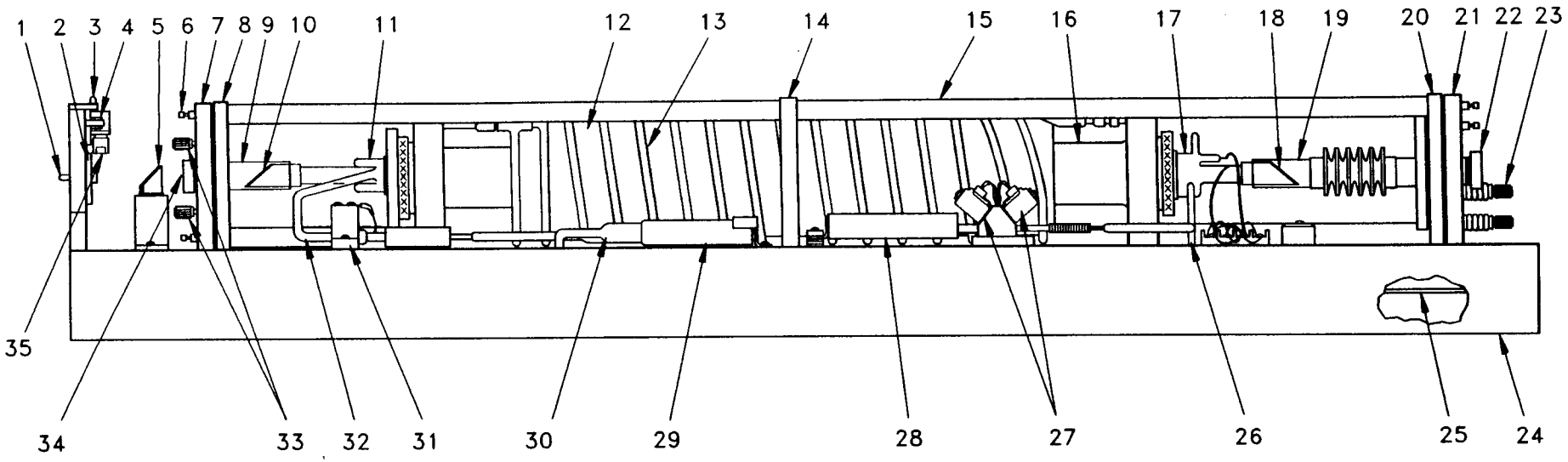

1. Front Shutter Knob
2. Front Shutter Plate
3. Emission Indicator
4. Head Cover Interlock
5. Light Feedback Photodiode
6. Front Mirror Coarse Adjustment
7. Front Mirror Mount
8. Front Resonator End Plate
9. Front Cavity Cover
10. Front Brewster Window
11. Plasma Tube (Anode End)
12. Field Solenoid
13. Solenoid Cooling Tubing
14. Resonator Center Support
15. Optical Resonator
16. Cathode Throat
17. Plasma Tube (Cathode End)
18. Rear Brewster Window
19. Rear Cavity Cover
20. Rear Resonator End Plate
21. Rear Mirror Mount
22. Rear Mirror Plate (Max R Optic)
23. Rear Mirror Fine Adjustment
24. Laser Head Rail
25. Head Configuration Module
26. Bypass (Cathode End)
27. Gas Refill Valves
28. Gas Reservoir
29. Balast
30. Getter Plating
31. Bypass Fault Detector
32. Bypass (Anode End)
33. Front Mirror Mount Fine Adjustment
34. Output Coupler Optic
35. Tube Pumpdown Keyswitch

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Figure 3-2 Component Identification for Gas-Ion Laser Head

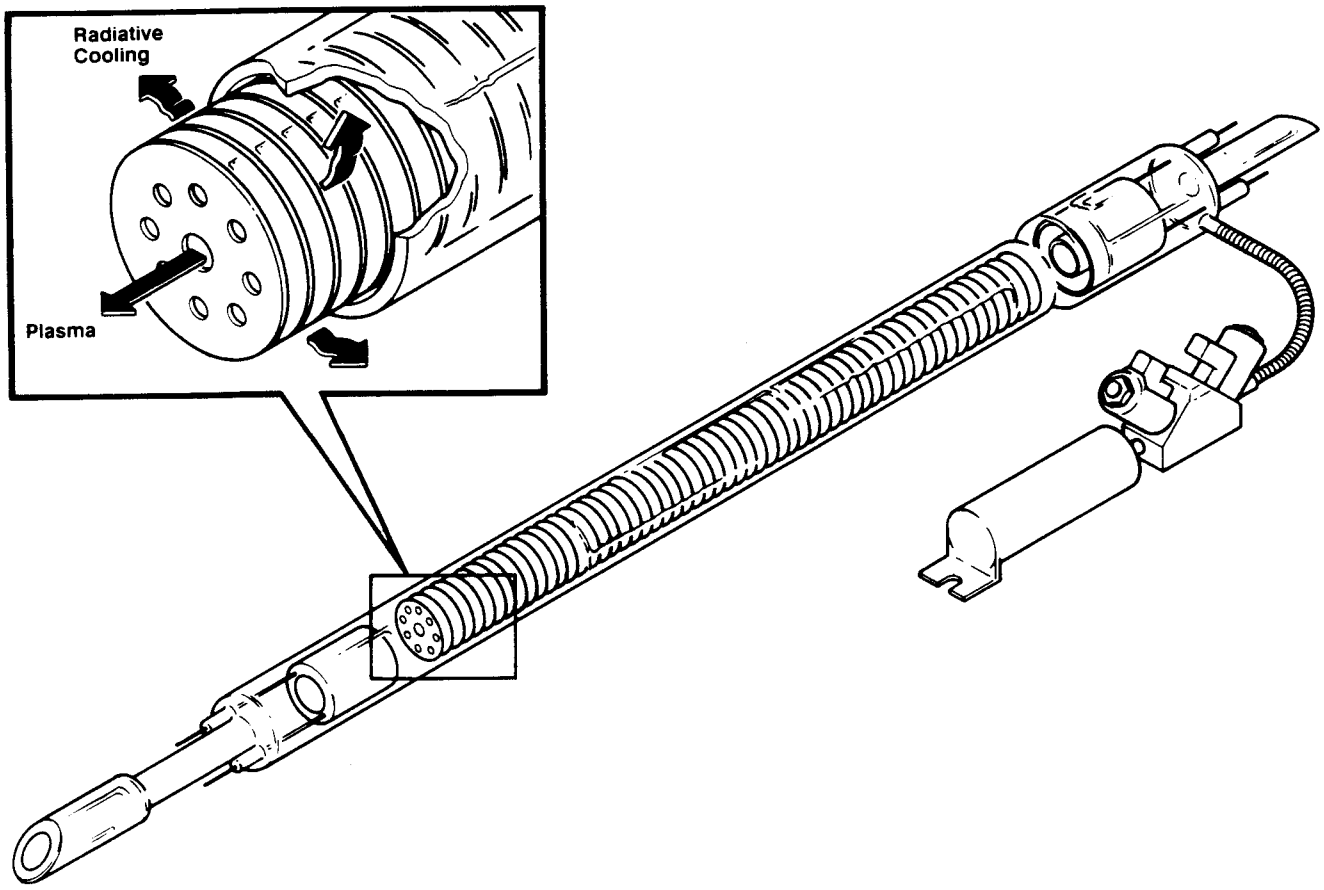

Figure 3-3 Radiatively-Cooled Tungsten Bore

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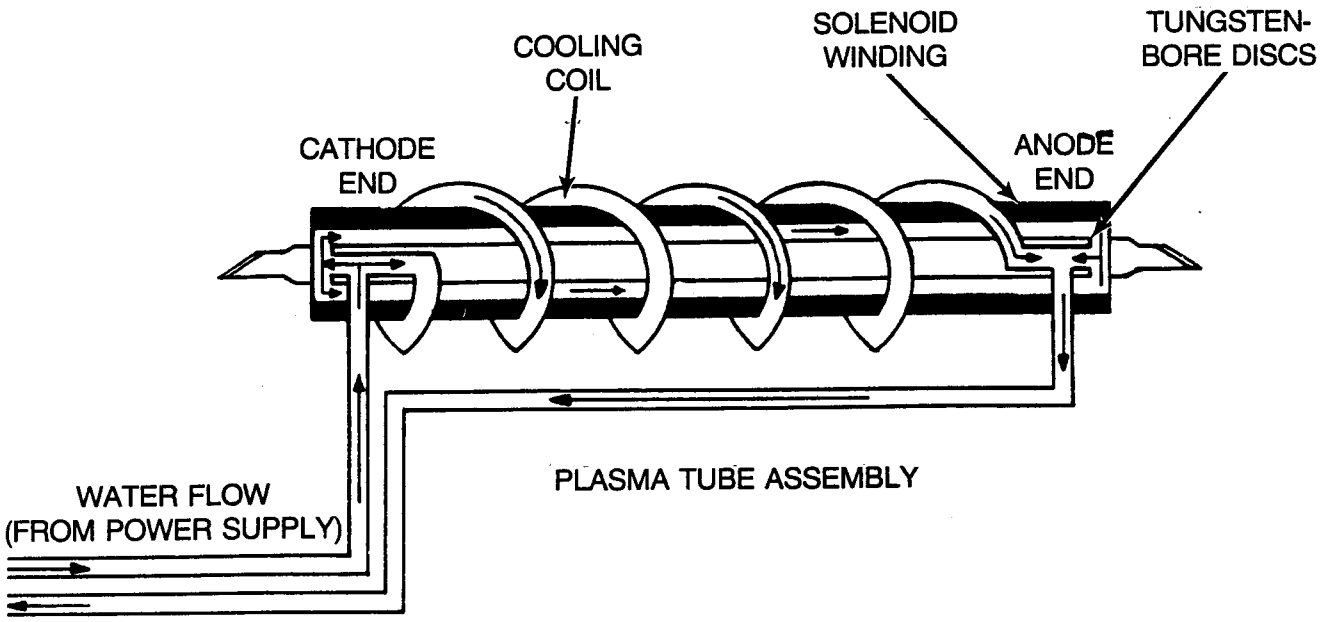

Figure 3-4 Tungsten-Bore Plasma Tube Assembly

FRAME

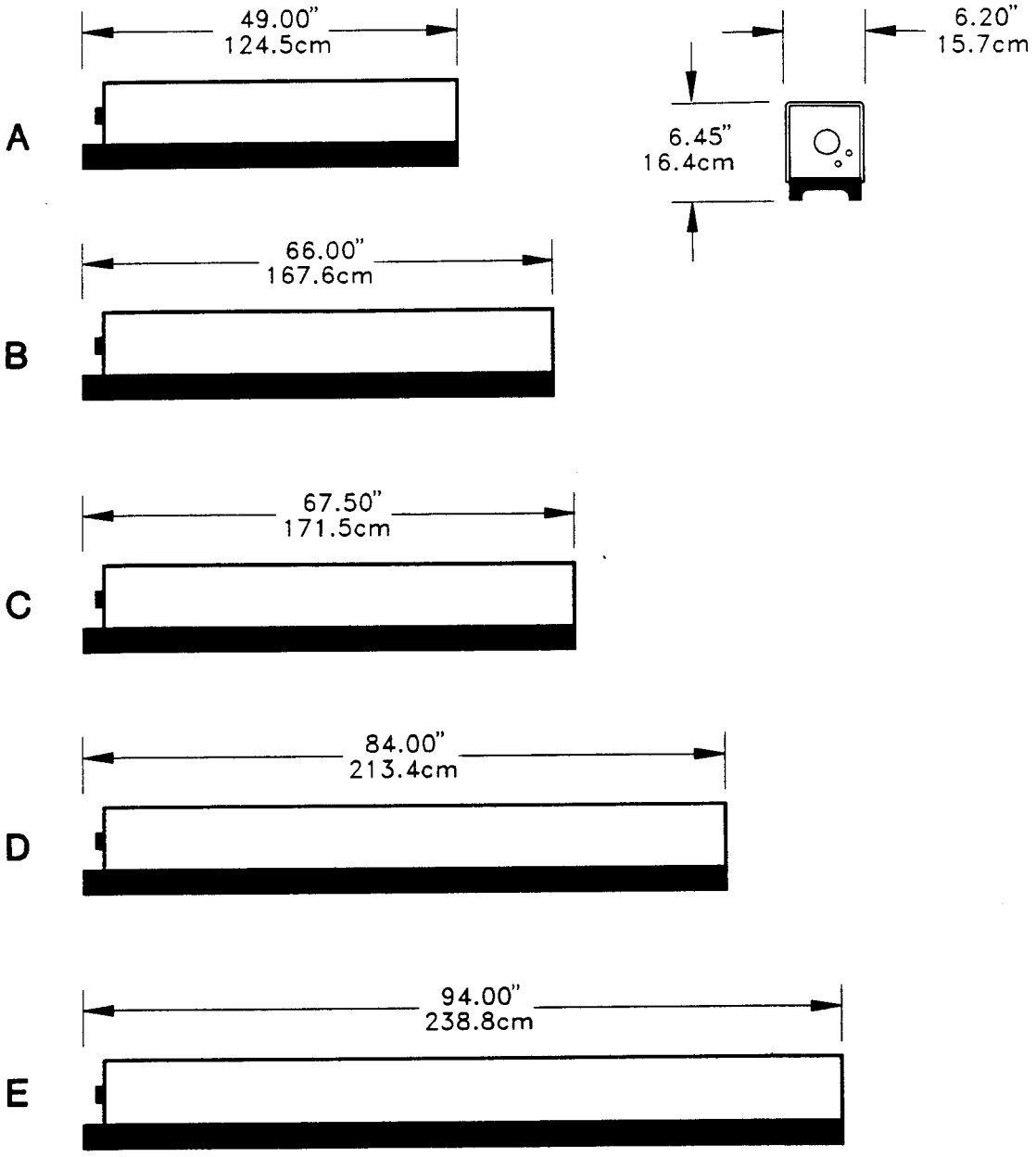

Figure 3-5 Laser Head Frame Sizes

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drop between the anode and cathode (tube voltage or ET) is monitored and interpreted as an indicator of tube pressure.

Ion lasers absorb gas over time, which causes tube pressure to drop. For this reason, the laser includes a reservoir with replacement gas which is used to restore pressure to the recommended value. This is accomplished through use of the automated gas refill system, accessed through the FUNCTION (FCTN) menu on the Remote Control Module (see Section 5, Maintenance). Excessively high pressure is corrected in a similar method by use of a tube pumpdown feature. This allows removal of a small amount of gas from the tube (see Section 6, Laser Head Service).

3.1.2.3 Radiatively-Cooled Tungsten Bore Tube

The tungsten bore quartz tube (Figure 3-3) contains the ionized gas flow in the form of a plasma. Tungsten discs confine the plasma flow to the small center hole, termed the tube bore. Outer holes allow return of gas for a full cycle of flow. An external bypass line allows additional return flow. The tube is radiately cooled, with excess heat radiated from the plasma to a water-cooled annular region between the outer tube wall and inner surface of the solenoid.

3.1.2.4 Photodiode Assembly

The photodiode assembly, mounted on the laser rail near the output optic, samples the laser output beam and measures its power. A small fraction of the beam is deflected downward into a photodetector located within the assembly housing. The detector electronics convert light into an output voltage signal, amplify this signal and transmit it to the power supply. Scaling factors are used to create a display of output power on the Remote Control Module.

— NOTE —

Model 1400 ultraviolet lasers [1400- (UV)] include both visible and ultraviolet photodiode assemblies. The assembly must be switched when changing from visible to UV optics and *vice versa*. See the Appendix for UV operation if your laser includes this option.

When in CURRENT MODE, the photodiode assembly measures output power and transmits this information to a microprocessor where the output power readout is generated. When operating in POWER (light) MODE, the assembly output is used as a part of a feedback circuit to adjust current instantaneously in order to maintain constant output power.

3.1.3 DC Power Supply

The Model 851 power supply (Figure 3-6) is a microprocessor controlled, line rectified, series-pass, linear design. Model 851 is a standard component of all Model 1400 laser systems produced after June 1991. It contains circuitry required to convert three phase AC line voltage to DC voltage required by the laser. It also includes all control and monitoring circuits needed to operate the laser system. The power supply uses three high speed microprocessors to control the laser system, monitor performance and store archival data.

Power supplies provided with B Series lasers are termed the Model 851B. The Model 851B is functionally the same as the Model 851 but includes some higher capacity components required by the B Series lasers. Model 851B power supplies are not compatible with Model 1400 series lasers.

3.1.3.1 Power Supply Electronics Unit (EU)

The Electronics Unit (EU) is enclosed in a 19-inch wide box. It is suitable for mounting on a table or in a standard 19" instrumentation rack when purchased with an optional rack mount kit. A cart-mounted version with the Electronics Unit mounted above an autotransformer, is also available. Controls required infrequently are mounted on the Electronics Unit so that it may be placed outside the general laser work area. An umbilical assembly, comprised of 9-foot (2.7 meter) long flexible conduits which contain the water hoses and electrical cables, connect the laser head and Electronics Unit. Dimensions of the power supply configurations are shown in Figure 3-7.

The Electronics Unit front panel includes the laser Master Keyswitch and Laser Emission Indicator. A Solenoid Field Strength Control is included as an optional feature on some units. LEDs are also provided to indicate whether all three phases of AC wall power are available to the power supply. The rear panel includes the water and power connections and the facility remote interlock connecter. The Electronics Unit is cooled by a fan mounted on the rear panel. Water flows within the supply

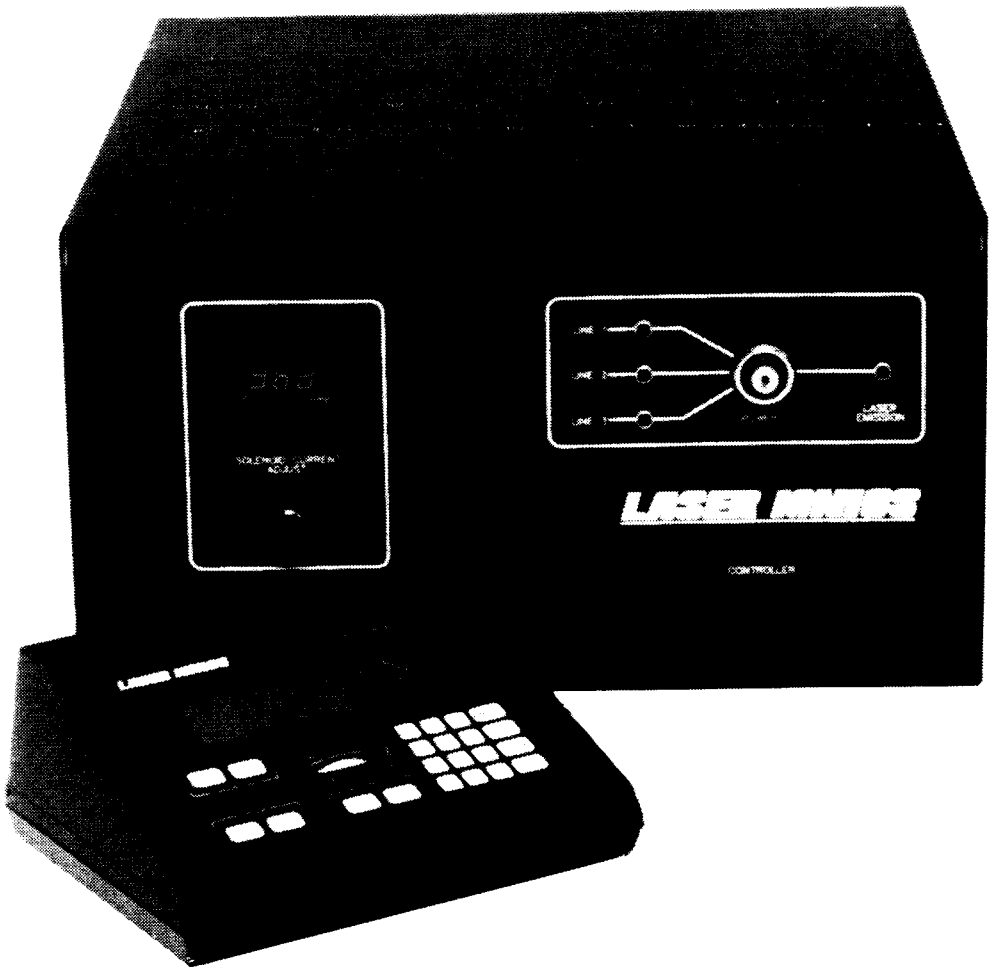


Figure 3-6 Model 851/851B Power Supply
(Table Mounted Version)

8-329-91

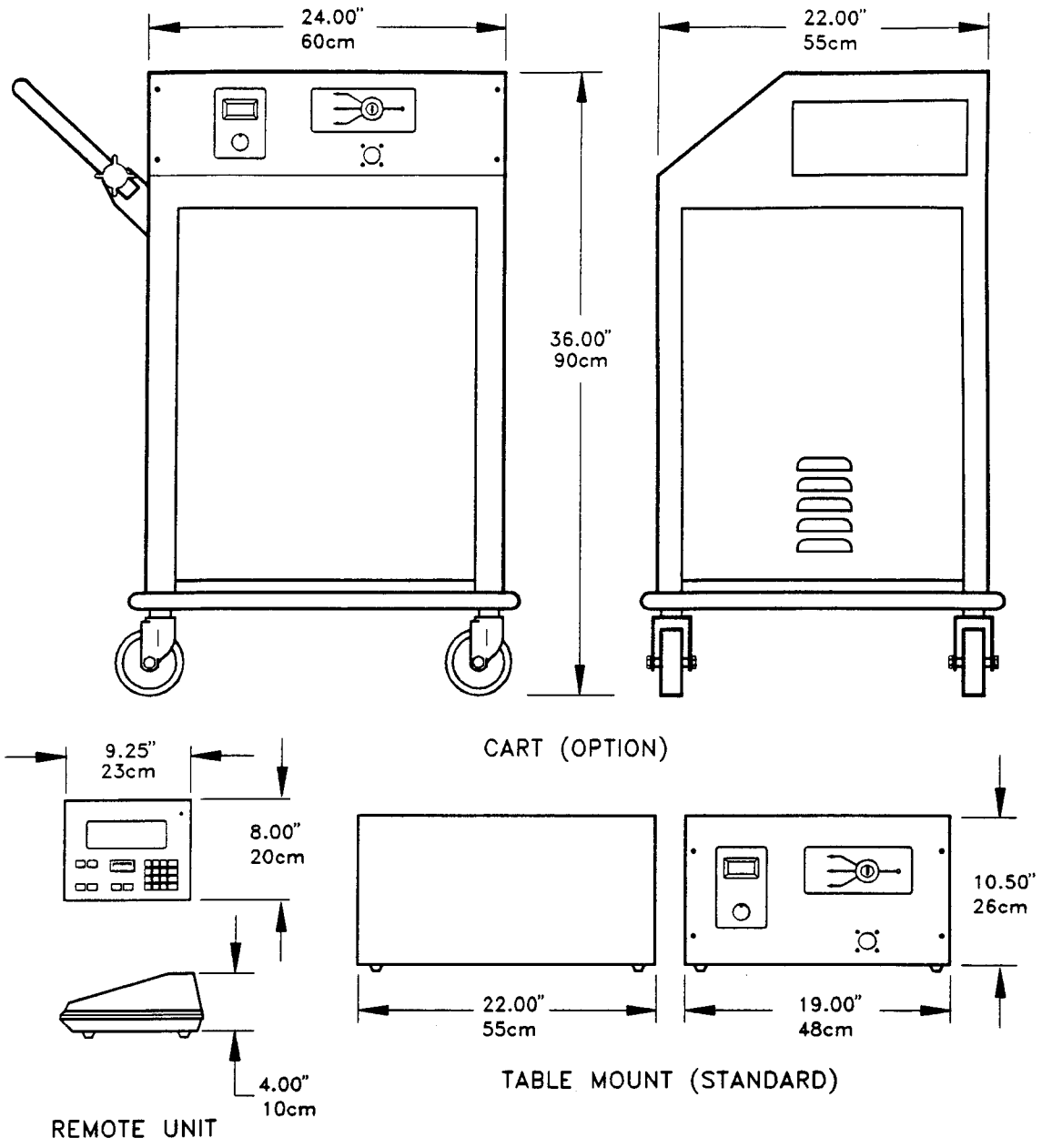


Figure 3-7 Power Supply Dimensions

through a single water block which mounts energy dissipating Field Effect Transistors. Start, control, and protection circuits are enclosed by the cabinet. Access panels for use by trained service technicians include the top cover, a side panel and a rear panel.

3.1.3.2 Remote Control Module (RCM)

The Remote Control Module is the primary user interface (Figure 3-6). It includes the Laser ON/OFF Power Switches, Mode Selection Switches, a relative power meter for peaking laser output, a keypad, and Liquid Crystal Display (LCD). The module serves as a terminal for controlling and monitoring the laser system. Some units include a keyswitch on the rear of the RCM which can be used to turn the power to the Electronics Unit ON or OFF. A 15-foot (4.5 meter) cable connects the module to the front panel of the Electronics Unit. Optional cables may be up to 300 feet in length. Also, a computer system with standard RS-232C serial interface or IEEE-488 interface may be used to operate the laser in lieu of the RCM. The optional RS-232 cable connects to the 8-pin connector on the front panel port of the Electronics Unit. The computer replaces the RCM in this installation.

The Remote Control Module is menu driven, providing real-time displays of key performance parameters. A system of menus can be accessed which provide additional information on operating values, shutdown signals and archival data.

3.1.3.3 Autotransformer

Since various lasers operate at different voltages, a three phase transformer (Figure 3-8) is supplied to adjust the available power line voltage to that required by the laser. The exception to this is that Model 1400 visible light, Frame A lasers do not require the transformer and can operate directly from a 208 to 240 VAC, three phase power source, if available. Electrical power is transferred from the power source to the autotransformer through a 12-foot (36 meter) cable, supplied with the laser. A cable from the power supply to the autotransformer includes wires for delivery of three phase power for the solenoid, the laser tube and the control circuits. The autotransformer is mounted in a box to protect personnel and equipment from injury or damage.

3.1.3.4 Power Circuits

The laser power circuits are depicted in Figure 3-9. Available three-phase power is supplied to the electronics unit either directly or through an autotransformer. The autotransformer converts line voltage into voltage required for the solenoid primary power circuit, the tube primary power circuit, and the utility power circuit.

1. Solenoid Primary Power: Solenoid voltage is applied across the solenoid and a controlling FET, wired in series. Water cooling of the FET dissipates excess energy. This circuit, and electronics of the Laser Control Assembly, control the current which can be applied to the solenoid, and the magnetic field strength. The circuit also sets the field strength to maximum level during the startup cycle.

2. Tube Primary Power: The tube primary power circuit includes a bank of 4-6 field effect transistors (FETs) which control the current applied to the tube. The Laser Control Assembly changes the tube current in response to operator and system initiated commands.

3. Utility Power: Electrical source power applied to a low voltage power supply furnishes ±5 VDC, ±15 VDC, and +24 VDC control power. Power is applied to the control circuits to activate the five control assemblies in the system card cage within the EU.

3.2 CONTROLS AND INDICATORS

Table 3-1 and accompanying figures explain the function of the laser system controls and indicators.

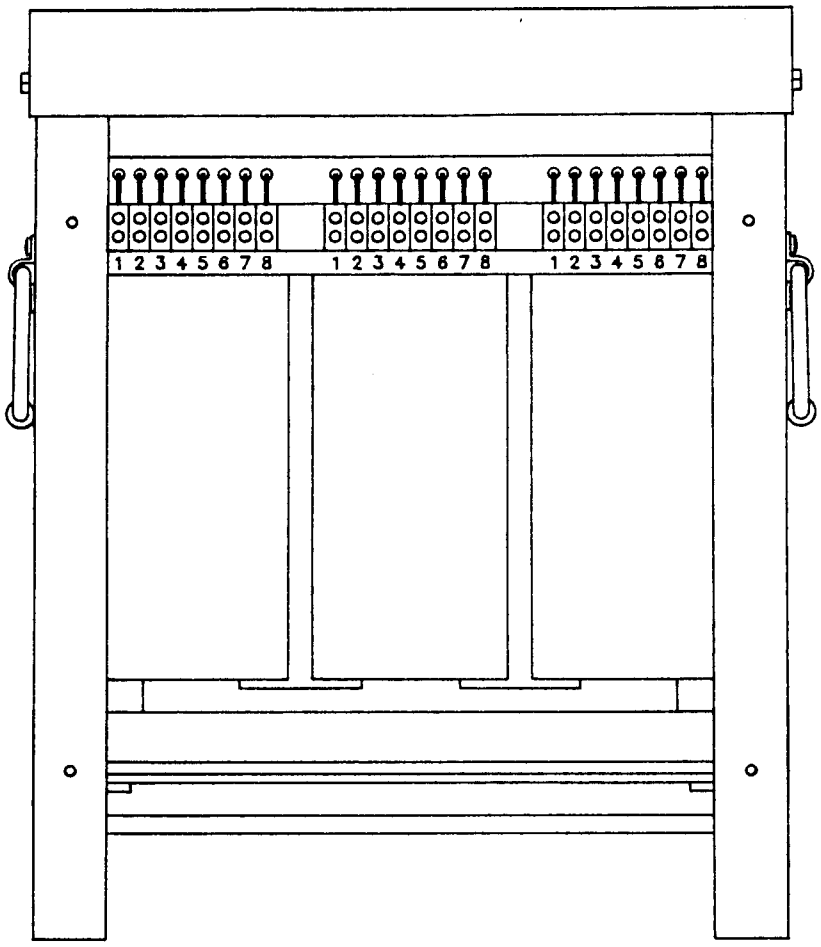


Figure 3-8 Typical Transformer Terminal Layout

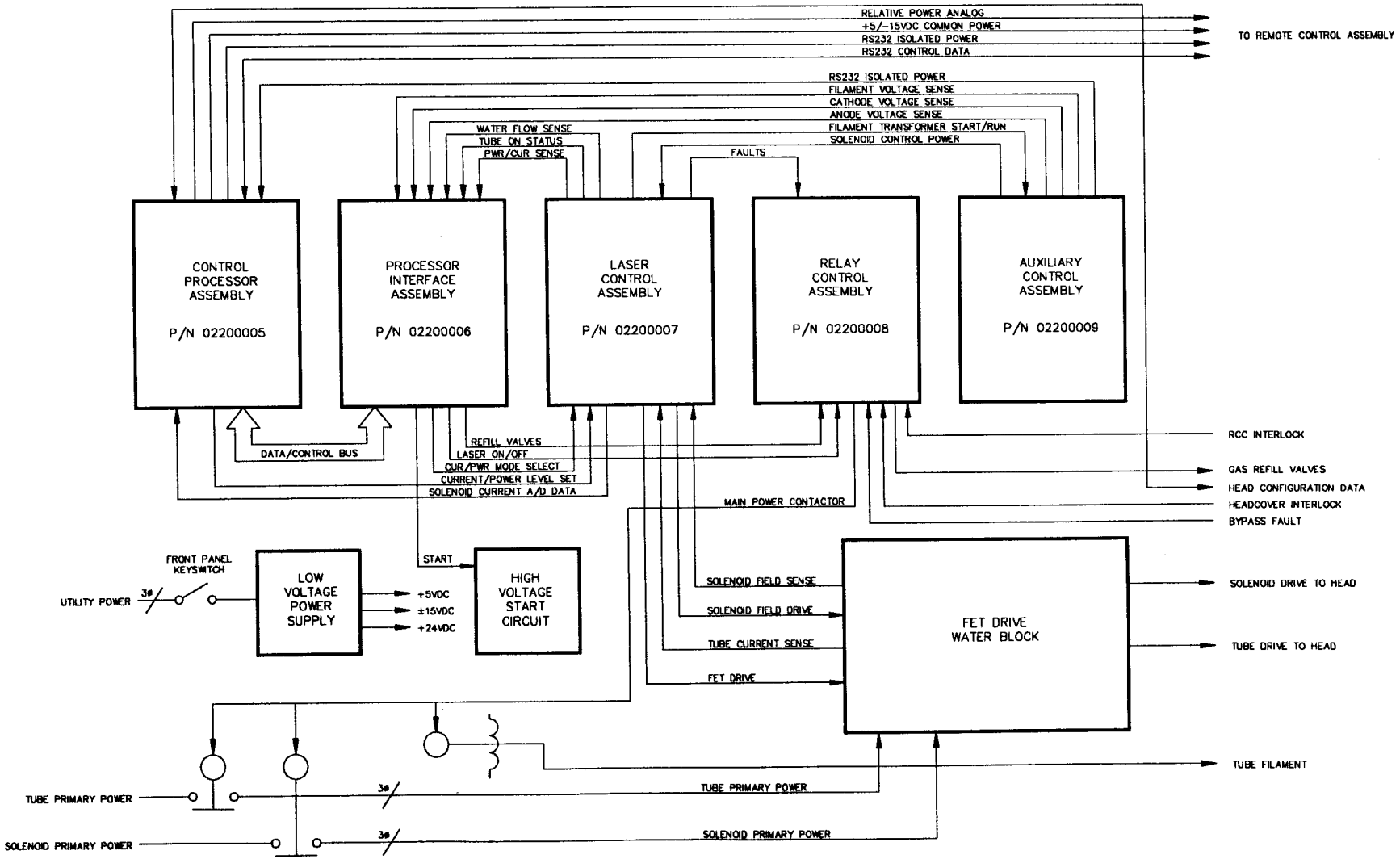
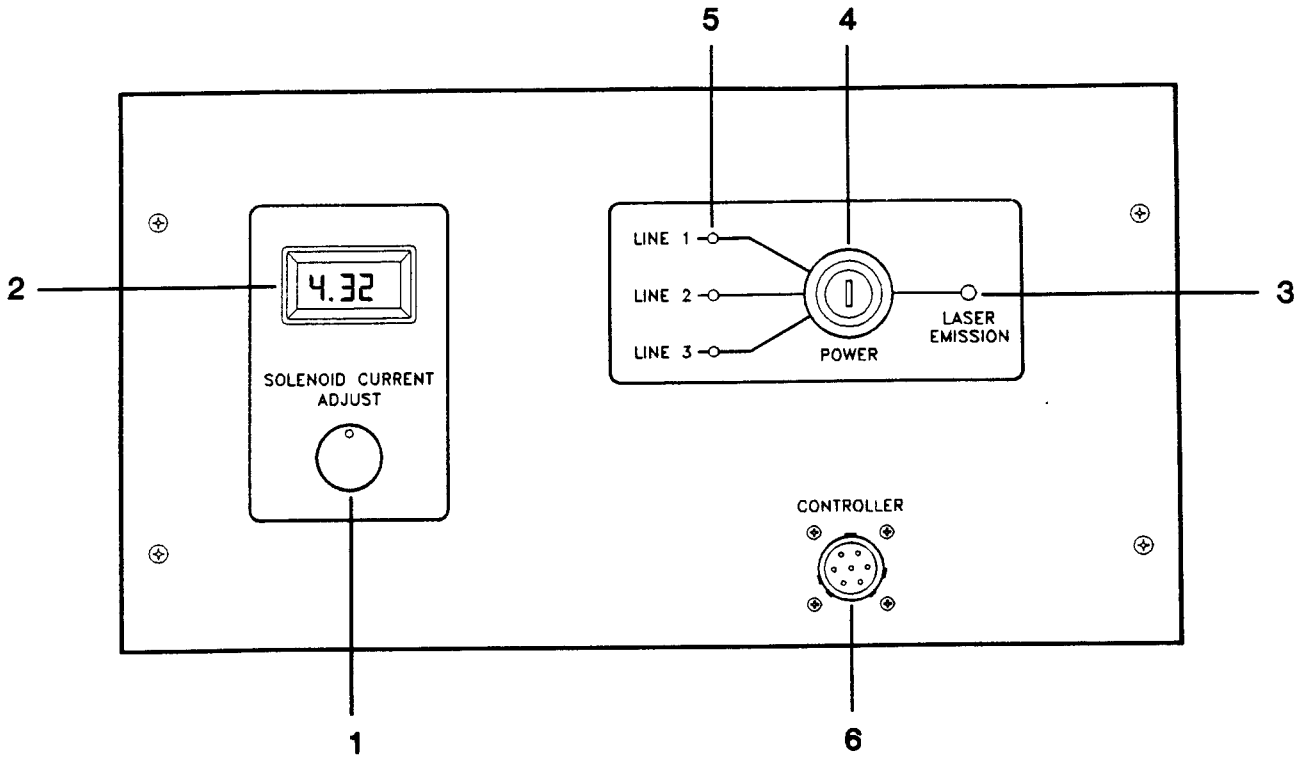


Figure 3-9 Laser Power Circuits

Table 3-I Controls and Indicators

Control/Indicator	Function
DC Power Supply Electronics Unit Front Panel (Figure 3-10)	
SOLENOID CURRENT* Adjustment Knob	Control for adjusting current flow to the solenoid. Used to adjust the magnetic field strength.
SOLENOID CURRENT Indicator*	Displays solenoid current in AMPS (0.00-9.99)
LASER EMISSION Indicator	Light illuminates when POWER KEYSWITCH is "ON". Indicates lasing is underway or imminent.
POWER KEYSWITCH	Two position keylock switch. Controls power to power supply electronic circuits. One-quarter turn clockwise, "on" position, energizes power supply and laser head circuits. (Front panel, laser head and RCM indicators will illuminate). Key can be removed only in "off" position. Turning key to "off" during operation will shutdown laser. NOTE: Some units include an additional keylock on the rear of the RCM. When present, this switch is wired in series with the POWER KEYSWITCH and must be "ON" in order to activate the laser with the EU POWER KEYSWITCH.
AC Power Bus Phase LED Indicators	Illuminate when service power for a phase is available to the laser system. Loss of an AC power line phase is indicated by a non-illuminated LED.
Controller Connector	Female connector for Remote Control Module cable or optional cable to computer interface.

*Optional Feature



1. Solenoid Current Adjustment Knob*
2. Solenoid Current Indicator, Digital* Display, AMPS (0.0-9.9)
3. Laser Emission Indicator
4. Power to Laser, Keyswitch
5. AC Power Bus Indicators
6. Controller Connector

*Optional Feature

Figure 3-10 Electronics Unit Front Panel

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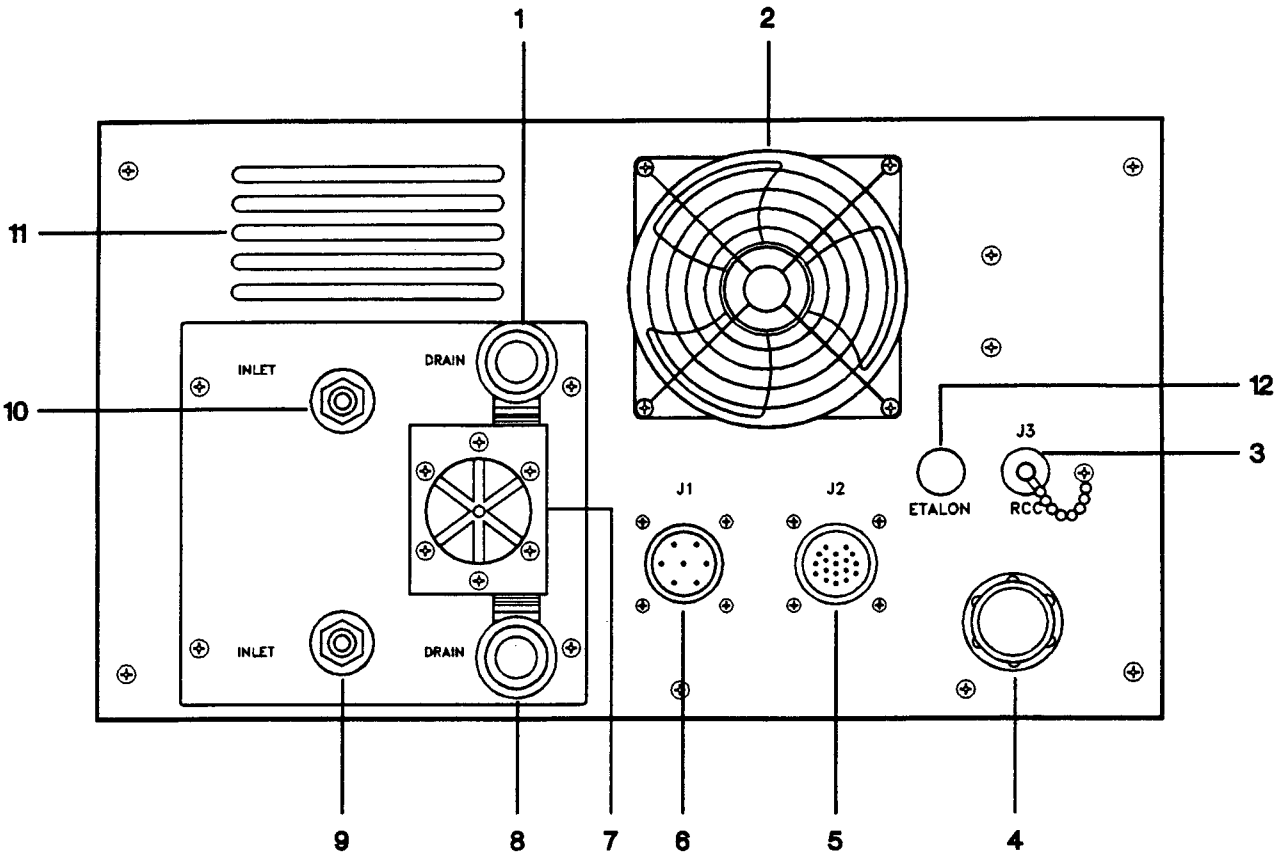
Table 3-I Controls and Indicators (Cont'd)

Control/Indicator	Function
DC Power Supply Electronics Unit Rear Panel (Figure 3-11)	
Cooling Water INLET Fitting	This is a female 1/2" quick disconnect fitting. It mates with the fitting on the 3/4" rubber hose supplied with the unit.
Cooling Water DRAIN Fitting	This is a 1/2" male quick disconnect fitting. It mates with the fitting on the 3/4" rubber hose supplied with the unit. This line must be routed to a drain with no backpressure.
Laser Head INLET Fitting	1/2" male quick disconnect fitting. It mates to the 3/8" hose which is part of the umbilical.
Laser Head DRAIN Fitting	1/2" female quick disconnect fitting. It mates with the remaining hose in the umbilical.
Flow Transducer	Magnetic generator type of transducer with visual port. The turbine spins in the direction of the arrows when cooling water is flowing.
Cooling Air Fan	Provides cooling air for internal components of the DC power supply.
Exhaust Vent	Provides positive venting of DC power supply cooling air.
Power Line Conduit	Plastic shell enclosing electrical power cables from EU to power source, either autotransformer or wall connection.
Umbilical Connector J1	Metal shell connector containing filament, solenoid, and laser tube power conductors.
Umbilical Connector J2	Metal shell connector containing control signal and interlock conductors to the laser head.
Remote Interlock Connector J3	BNC female with shorting cap for connection to customer facility interlock system (optional). If a remote interlock is not used the shorting cap must be in place for the system to operate.
Water Compartment Cover	Access panel for water-cooled heat sink assembly. Complete assembly can be removed intact through this cover.



1. Laser Head Drain Connector (from laser head)
2. Fan
3. Remote Interlock Connector
4. Power Line Conduit (to power source)
5. Connector, 34 Pin Control Cable (to laser head)
6. Connector, 7 Pin Power Cable (to laser head)
7. Flow Transducer
8. Cooling Water Drain Connector (to drain)
9. Cooling Water Inlet Connector (from water source)
10. Laser Head Inlet Connector (to laser head)
11. Air Vents
12. Etalon Temperature Adjustment Knob

Figure 3-11 DC Power Supply - Electronics Unit Rear Panel

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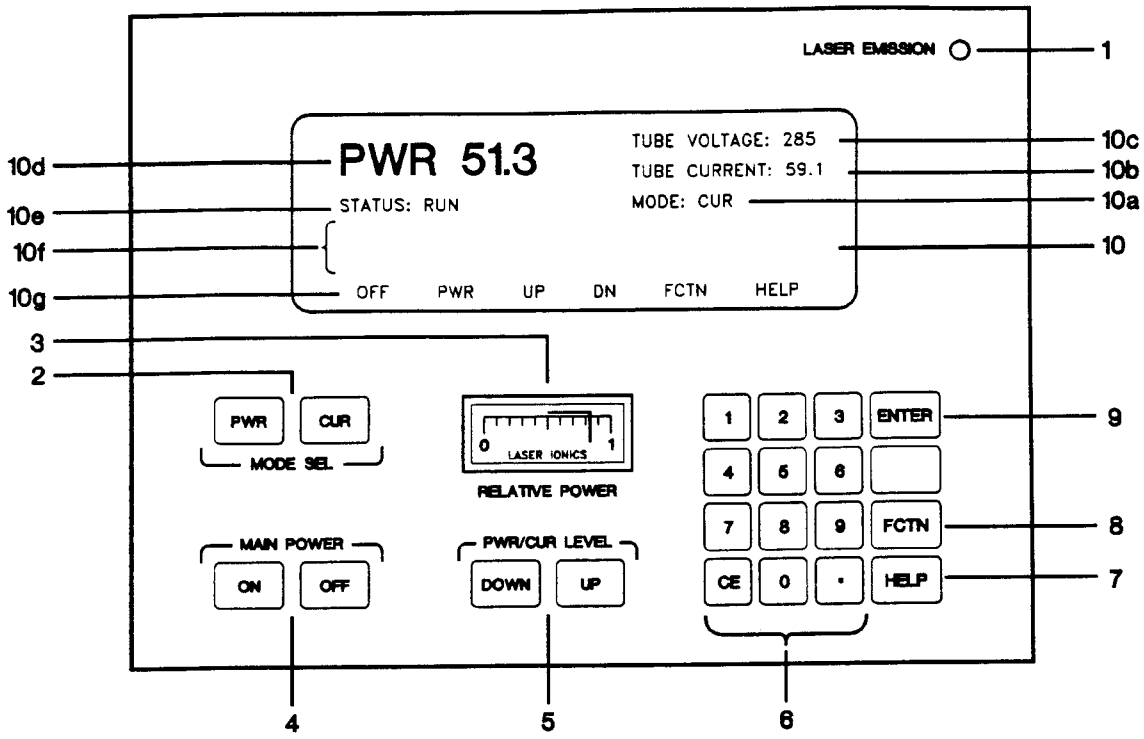
Table 3-I Controls and Indicators (Cont'd)

Control/Indicator	Function
	DC Power Supply Remote Control Module (Figure 3-12)
LASER EMISSION Indicator	Light illuminates anytime POWER KEYSWITCH is "ON". Indicates lasing is underway or imminent.
LASER MODE SELECTOR	Pushbutton for selecting POWER (PWR) or CURRENT (CUR) modes. In CURRENT mode, the microprocessor controller maintains tube current at the selected level. In POWER mode, the controller adjusts current in order to maintain laser power at the selected level.
RELATIVE POWER PEAKING Meter	Analog meter provided as an aid in aligning the laser mirrors. Used to adjust laser output to peak power. Scale is absolute, ranging from zero to maximum output at rated tube current.
LASER EMISSION Controls:	
ON	Depressing control with POWER KEYSWITCH "ON" and laser in STANDBY initiates automatic start sequence.
OFF	Depressing control shuts down laser or resets power supply after automatic shutdown.
LEVEL Control	Raises or lowers power if POWER mode is selected; raises or lowers current if CURRENT mode is selected.
DATA ENTRY KEYPAD	Provides capability to enter numerical data in response to prompts displayed on LCD.
HELP Key	Depressing key when HELP appears in commands available line of LCD causes HELP menu to be displayed.
FUNCTION (FCTN) Key	Depressing key when FCTN appears in commands available line of LCD causes FCTN menu to be displayed.

Table 3-I Controls and Indicators (Cont'd)

Control/Indicator	Function
DC Power Supply Remote Control Module Back Panel Controls (Not Shown)	
DISPLAY LIGHT Controls	Activates backlight capability for LCD
ON/OFF	
INTENSITY Control	Raises on lowers backlight illumination level.
POWER KEYSWITCH (Optional Feature)	Two position keylock switch present on some units. Controls power to power supply electronic circuits and is wired in series with keyswitch on the EU front panel. One-quarter turn clockwise, "ON" position, energizes power supply and laser head circuits if EU KEYSWITCH in "ON". (Front panel, laser head and RCM indicators will illuminate). Key can be removed only in "OFF" position. Turning key to "OFF" during operation will shut down laser.



1. Laser Emission Indicator
2. Laser Mode Control Selctor: Allows selection of either Power (PWR) or Current (CUR) mode.
3. Relative Power Peaking Meter, (Analog)
4. Laser Emission Controls: ON, initiates automatic start sequence for laser tube; OFF, shuts down laser or resets power supply after automatic shutdown.
5. Level Control: Raises or lowers power if power mode is selected; raises or lowers current if current mode is selected.
6. Data Entry Keypad
7. HELP Key: Causes HELP menu to be displayed when HELP is available. (See LCD)
8. Function (FCTN) Key: Causes FCTN menu to be displayed when FCTN is available. (See LCD)
9. ENTER Key: Primary data entry key.
10. Liquid Crystal Display (LCD), with normal operation (RUN) format selected.
    - 10a. Selected Mode - Power or Current
    - 10b. Tube Current, AMPS (0.0 - 99.9)
    - 10c. Tube Voltage, VOLTS (0 - 999)
    - 10d. Laser Output Power, WATTS (0.0 - 99.9)
    - 10e. Laser Status Indicator: RUN, STANDBY, AUTOMATIC SHUTDOWN, or START SEQUENCE
    - 10f. Message Area: Display area for system generated messages relating to shutdown commands, operational conditions, diagnostic information, graphics, etc.
    - 10g. Commands Available: Indicates which commands are available to user.

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Figure 3-12 Remote Control Module Controls and Display

Table 3-I Controls and Indicators (Cont'd)

Control/Indicator	Function
	DC Power Supply Remote Control Module (Figure 3-12)
ENTER Key	Depressing key in response to prompt causes system to respond as described on LCD.
LIQUID CRYSTAL DISPLAY (LCD)	Display area for laser control, status and archival information (Note: normal operating display is shown).
MODE SELECTED Display	Indicates MODE SELECTED (CURRENT or POWER).
TUBE CURRENT Display	Indicates TUBE CURRENT in AMPS (0.0-99.9) when laser is in RUN.
TUBE VOLTAGE Display	Indicates TUBE VOLTAGE in VOLTS (0-999) when laser is in RUN.
LASER OUTPUT POWER Display	Indicates LASER OUTPUT POWER in WATTS (0.0-99.9) when laser is in RUN.
LASER STATUS Display	Indicates present condition of laser: - RUN: Laser is emitting output - STANDBY: Laser is ready to initiate start sequence when "ON" is depressed - AUTOMATIC SHUTDOWN: Laser has been shutdown by monitoring and protection circuits - START SEQUENCE: ON has been depressed with laser in STANDBY. Automatic start sequence is underway.
MESSAGE AREA	Displays system generated messages relating to automatic shutdown, operational conditions, diagnostic information, and graphics, etc.
COMMANDS AVAILABLE Display	Indicates which commands are available to the user, depending on status of the laser. Commands include the following: ON or OFF - Laser Control PWR or CUR - Mode Select UP - Raise Power or Current DN - Lower Power or Current FCTN Menu HELP Menu

Table 3-I Controls and Indicators (Cont'd)

Control/Indicator	Function
Laser Head Front Shutter Plate (Figure 3-13)	
Shutter Control Lever	Opens or closes beam shutter. When the knob is pushed toward the center of the laser head, the shutter is CLOSED and the laser beam cannot be emitted. Sliding the knob toward the outside of the laser head will OPEN the shutter, allowing the laser beam to be emitted.
Emission Indicator	Light illuminates anytime the POWER KEYSWITCH is "ON". Indicates lasing is underway or imminent.
Tube Pumpdown Keyswitch	Keyswitch is used to ENABLE tube pumpdown procedure. Cover must be removed to allow insertion of key.
Head Cover Interlock Shorting Bar	A banana plug is provided which can be inserted into the interlock to bypass the head cover interlock and start the laser with the head cover removed. This is a service task.

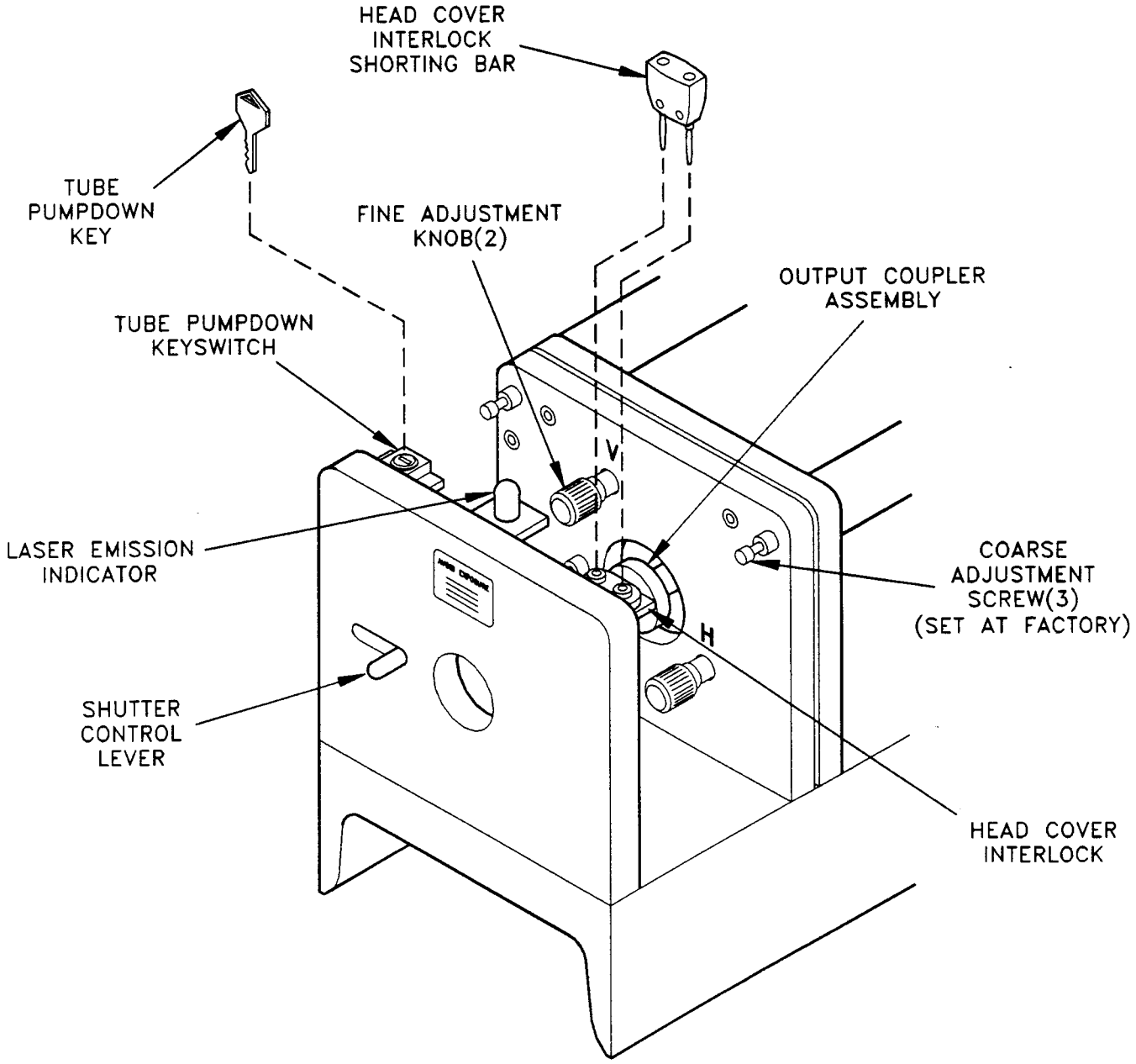

Figure 3-13 Laser Head Front Shutter Plate

Table 3-I Controls and Indicators (Cont'd)

Control/Indicator	Function
Laser Head Front Mirror Mount (Figure 3-14)	
Photodiode Assembly	Samples a minute amount of the output laser beam and converts it to an electrical signal that is sent back to the power supply where it drives the power meter and can control the power supply in POWER mode.
Vertical Fine Adjustment Knob	Provides a means for adjusting the output coupler in the vertical plane. Used to align the output coupler to the laser tube bore.
Horizontal Fine Adjustment Knob	Provides a means for adjusting the output coupler in the horizontal plane. Used to align the output coupler to the laser tube bore.
Tension Control Adjustment	Screws used to adjust the loading on the graphite resonator rods. Loading is preset at the factory. **DO NOT ADJUST.**

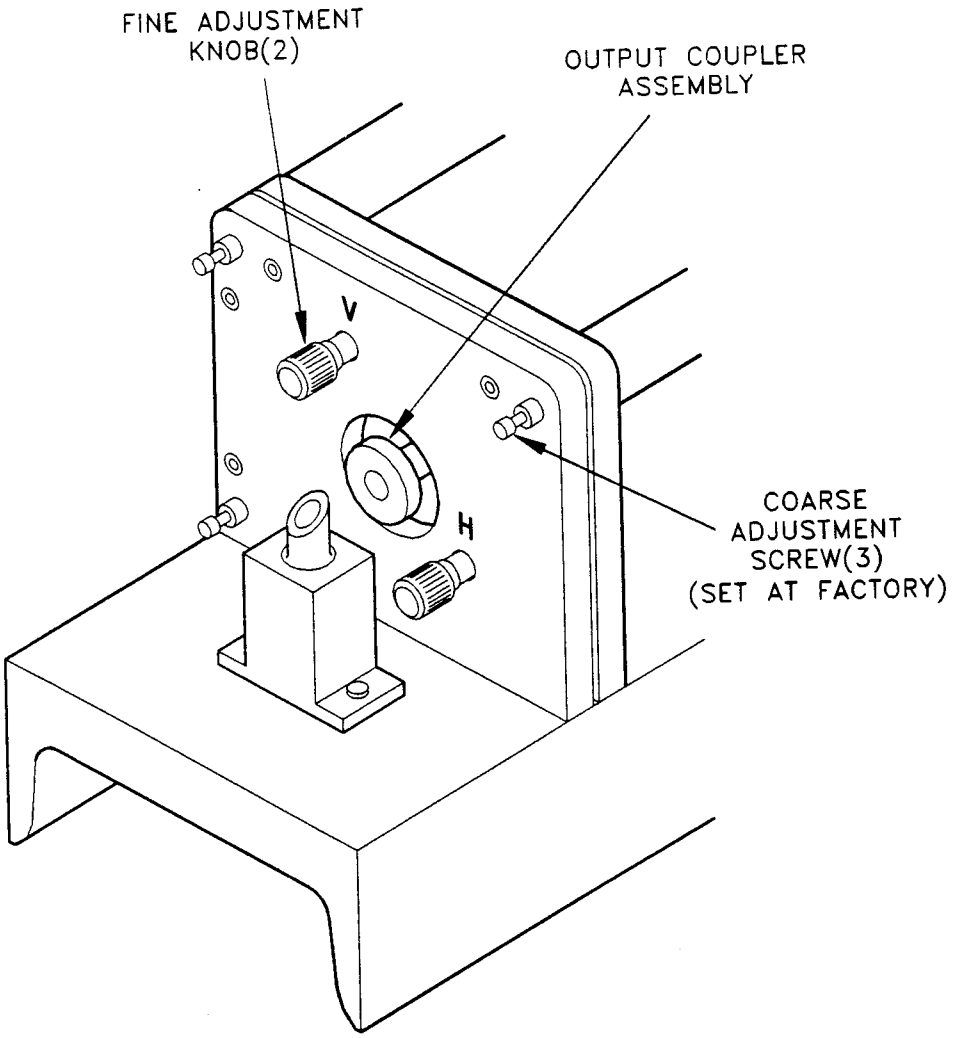

Figure 3-14 Front Mirror Mount

Table 3-I Controls and Indicators (Cont'd)

Control/Indicator	Function
Laser Head Rear Mirror Mount (Figure 3-15)	
Vertical Fine Adjustment Knob	Provides means for adjusting the maximum reflector rear mirror, or optional Littrow prism, (see Figure 3-14) in a vertical plane. Allows for alignment of the mirror to the bore of the laser tube. This is the wavelength selection knob when a littrow prism is installed.
Horizontal Fine Adjustment Knob	Provides a means for adjusting the maximum reflector rear mirror, or the optional Littrow prism, (see Figure 3-14) in a horizontal plane. Allows for the alignment of the mirror to the bore of the laser tube.
Tension Control Adjustment	Screws used to adjust the loading on the graphite resonator rods. Loading is preset at the factory. **DO NOT ADJUST**.

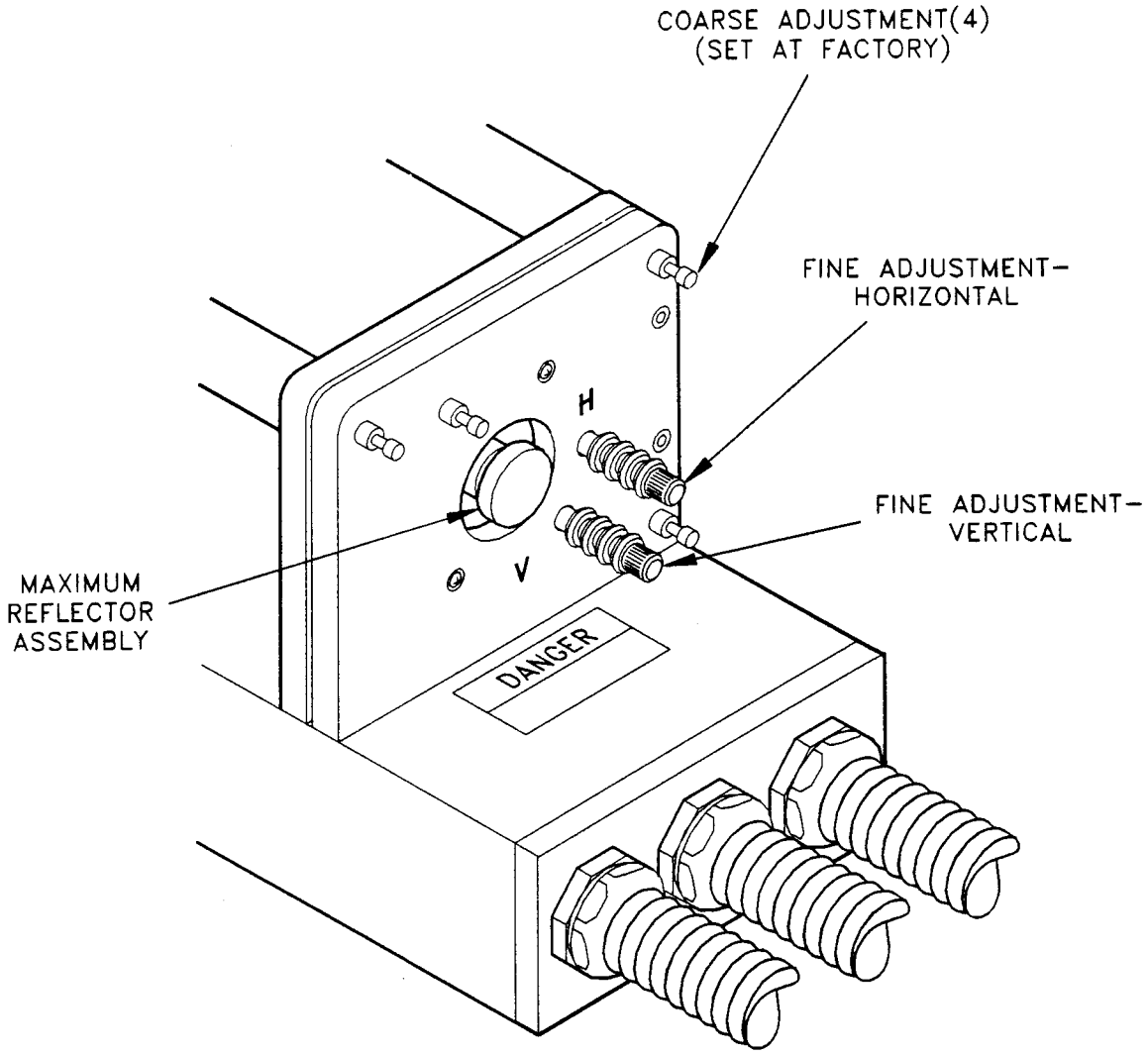

Figure 3-15 Rear Mirror Mount

3.3 CONTROL OF THE LASER SYSTEM

3.3.1 Control System Introduction

The Model 851 power supply includes three microprocessors which monitor the condition of the laser, provide control commands in response to system conditions or operator commands, and store and update certain archival information. The control system can also make diagnostic and other information available to the user. In addition to digital control, some functions are processed and controlled as analog signals. These include the Solenoid Field Control, Master Keyswitch, facility and head cover interlocks, peak power peaking meter, and Laser Emission indicator.

The Remote Control Module (RCM) and front panel controls of the Electronics Unit are the method by which the user operates the laser. The LCD display of the RCM presents system status to the user.

Figure 3-16 is a simplified block diagram of the system of LCD displays by which the laser is operated. The paths for access between each block are shown.

The Model 851 power supply is self calibrating. The correct values for key parameters, as verified by test of the particular laser head, are stored by the factory in ROM on a circuit board located on the underside of the laser rail. When the Master Keyswitch is placed ON, the laser head values are transferred to the power supply for control of the laser.

3.3.2 Pre-operational Checklist and Warnings

Turning the Master Keyswitch to the ON position initiates a series of pre-operational checks. Following display of a laser radiation warning display on the RCM, the Pre-operational checklist (Figure 3-17) will appear. Three conditions must be met in order to place the laser in STANDBY:

1. Water Flow, measured by the flow transducer on the rear of the Electronics Unit, must be within the range specified for this laser.

2. RCC Interlock must be satisfied, either by placing the shorting cap on BNC connector J3 on the EU rear panel, or by meeting local requirements established for satisfying a customer installed facility interlock.

3. Head Cover Interlock must be satisfied, either by placing the protective head cover on the laser head or by the shorting bar provided for service.

Failure to meet any pre-operational conditions will cause NO GO to be displayed. Depressing ENTER when NO GO is displayed provides an explanation of the Pre-operational fault. The condition must be corrected before the laser will go to STANDBY status.

3.3.3 Status Menus

Figure 3-18 depicts the four Status Menus and typical information available. These are explained as follows:

1. STANDBY: The laser can be placed in STANDBY by depressing ENTER when all pre-operational checks are "GO". Depressing ON changes mode to START SEQUENCE.

2. START SEQUENCE: A 30-second delay occurs between the time ON is depressed and initiation of a start pulse within the laser tube. "TIME UNTIL START: 30" is displayed on the start sequence Status Menu and the time will begin to count down. When the countdown reaches 0, the start circuit will fire for up to 5 seconds. If the laser does not start within 5 seconds, the laser will shut down automatically and the AUTOMATIC SHUTDOWN Status Menu will be displayed. Depressing OFF at any time during the start sequence returns the laser to STANDBY.

3. RUN: The RUN Status Menu is displayed when the start sequence has been successfully completed and the laser is lasing.

4. AUTOMATIC SHUTDOWN: The AUTOMATIC SHUTDOWN Status Menu is displayed when the laser has shut itself off since a condition has occurred which could either damage the laser or injure personnel. AUTOMATIC SHUTDOWN can occur when the laser is in STANDBY, RUN, or START SEQUENCE. The reason for the shutdown will be displayed in the message area. Correction of the condition must occur in order to return to STANDBY.

3.3.4 Function (FCTN)

FUNCTION is a group of information menus and operations which may be accessed when the laser system is in RUN, AUTOMATIC SHUTDOWN, or STANDBY MODES. These capabilities are available by pressing the FCTN (FUNCTION) key on the RCM, when FCTN is displayed on the

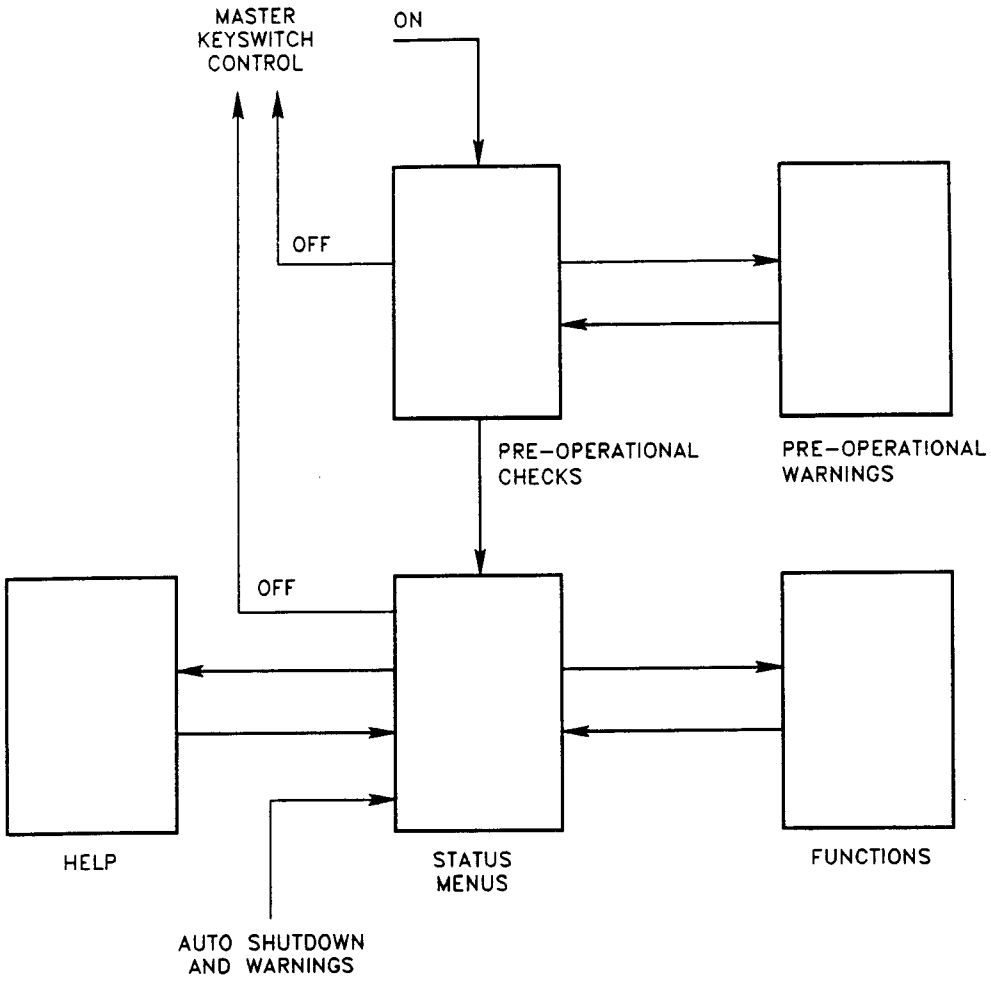

Figure 3-16 Block Diagram - LCD Displays

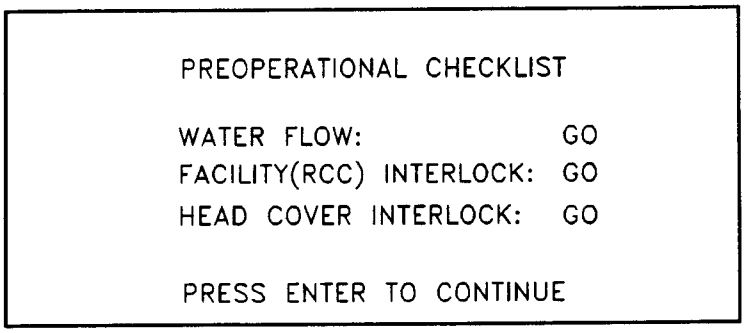

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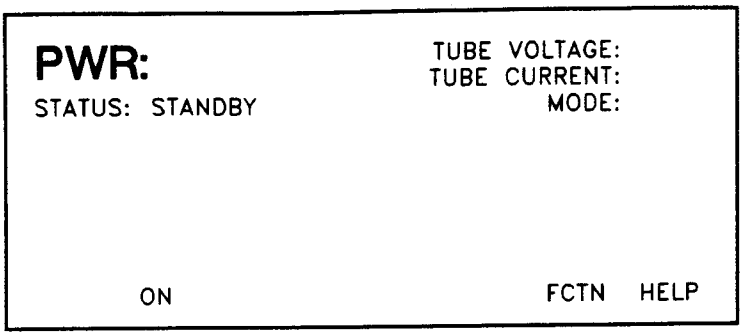
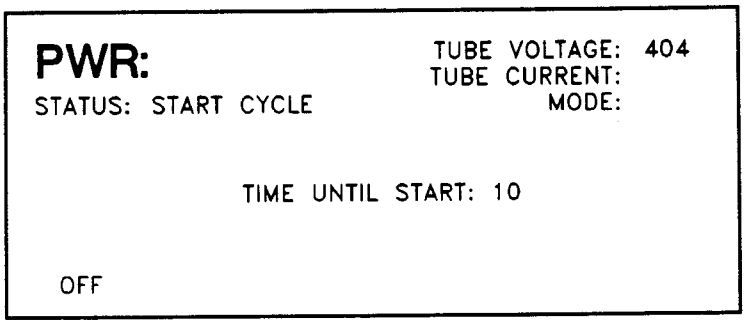
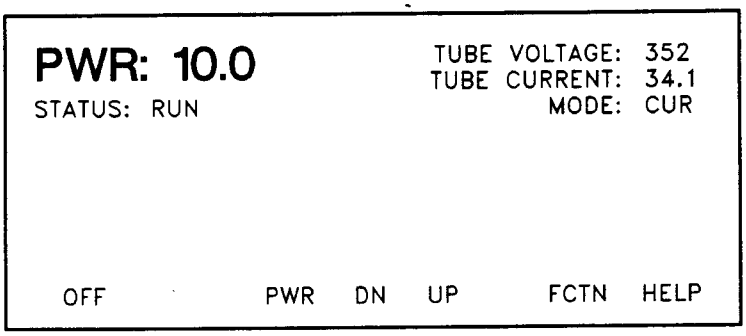
Figure 3-17 Pre-operational Checklist



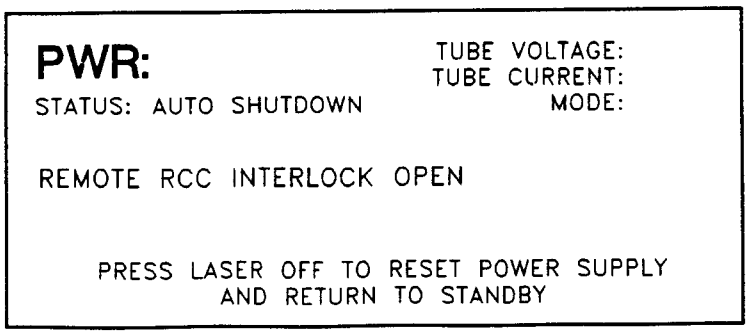
STANDBY MODE



START SEQUENCE MODE



RUN MODE



AUTO SHUTDOWN MODE

Figure 3-18 Status Menus

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COMMAND AVAILABLE line of the LCD. The FCTN Menu is shown in Figure 3-19.

FCTN data displays include the actual operating parameters specified for the individual laser system, which are programmed at the factory. Other data include the actual value for operating parameters and archival data which were in effect when the individual FCTN display was selected . Laser gas refill and pumpdown operations are also accessed through FCTN. Each capability is summarized as follows:

1. Laser Status: Information includes the following, measured at the time Laser Status is selected:

   . Tube Voltage (Volts)
   . Tube Current (Amps)
   . Solenoid Current (Amps)
   . Cooling Water Flow (Gallons Per Minute)

2. Pressure Check: Provides actual tube voltage (ET) and the tube voltage limits. Tube voltage is used as an indicator of laser tube pressure.

3. Etalon Control: When equipped with an etalon, the user may stabilize the etalon using the FCTN menu. An etalon heater is controlled (ON or OFF) from this menu. A temperature control knob on the back of the EU is used to raise or lower etalon temperature.

4. Laser Head Data: Three pages of information are available which describe the laser head presently connected to the power supply. All values except "Total Operating Hours" are set at the factory.

   . Solenoid Number
   . Date Manufactured
   . Model Number
   . Type of Gas
   . Rated Power (Watts)
   . Tube Current at Idle (Amps)
   . Power (Watts) at Idle
   . Maximum Tube Current (Amps)
   . Solenoid Current - upper and lower limits (Amps)
   . Tube Voltage - Limits (Volts)
   . Filament Voltage - Limits (Volts)
   . Anode Voltage - Limits (Volts)
   . Total Running Time (Hours)

5. Gas Refill: Presents instructions for adding gas to the laser tube when pressure is low. Gas Refill must be performed with this menu displayed (Section 5.0 Maintenance) and the laser running (RUN status).

6. Tube Pumpdown: Presents instructions for removing gas from the laser tube when tube pressure is high. Gas Refill must be performed with this menu displayed and the laser running (RUN status). This is a service function (Section 6.0 Service).

7. Level Save: Allows storage of pre-set lasing conditions. These include the mode of operation (Power or Current) and the magnitude of the controlling parameter. Examples would include Power Mode, 10.0 watts or Current Mode, 36.0 amps. Up to four values may be stored.

8. Level Restore: The Menu presents up to four previously programmed sets of values. These are selected from the menu by depressing the appropriate button.

9. Field Service: This function is reserved for factory trained personnel.

10. Exit FUNCTION: Depressing "O" on the keypad when the FCTN menu is displayed will cause the LCD to display the current Status Menu.

3.3.5 Help

The HELP capability of the laser system allows the operator to review key information on the operation and maintenance of the laser. HELP may be accessed when the status of the laser system is in RUN, AUTOMATIC SHUTDOWN, or STANDBY. HELP is available by pressing the HELP Key on the RCM, when HELP is displayed on the COMMAND AVAILABLE line of the LCD. The HELP menu is shown in Figure 3-19. The capabilities available through HELP are as follows:

1. Pre-operational Checklist: Selection of this capability causes a Pre-Op checklist menu to be displayed on the LCD. Definitions of the following are available

from this menu:

. Water Flow
. Remote (Facility) Interlock
. Head Cover Interlock

2. Interlocks/Faults: Selection of this capability causes a menu to be displayed. Definitions of automatic shutdown or warning messages may be selected from the menu. The following are included (see Section 4, 5 or 6 for fault information):

. Laser Head Cover Interlock
. Remote (Facility) Interlock
. Water Flow (High and Low)
. Water Temperature - High
. Solenoid Current (High and Low)
. Tube Bypass Fault
. Tube Voltage
. Overcurrent Fault
. Excess Power Dissipation
. Start Time Exceeded
. Anode (Power Supply Input) Voltage out of Range

3. Control Functions: Selection of this capability causes a menu to be displayed. Definitions of power supply control functions are available from the menu. These include the following:

. Solenoid Current Adjustment Knob
. Power Keyswitch
. Laser Mode Selector
. Analog Power Peaking Meter
. Laser ON
. Laser OFF
. Power/Current Level

HELP MENU

1. PRE-OP CHECKLIST
2. INTERLOCKS/FAULTS
3. CONTROL FUNCTIONS
4. PREVIOUS SCREEN

– PRESS NUMBER TO SELECT –

HELP MENU

FUNCTIONS (FCTN)

1. LASER STATUS	6. TUBE PUMPDOWN
2. PRESSURE CHECK	7. LEVEL SAVE
3. ETALON CONTROL	8. LEVEL RESTORE
4. HEAD DATA	9. FIELD SERVICE
5. GAS REFILL	0. EXIT FCTN

– PRESS NUMBER TO SELECT –

FUNCTION MENU

Figure 3-19 FCTN (FUNCTION) Menu

SECTION 4
OPERATION

4.1 SAFETY PRECAUTIONS

Every effort has been made to comply with the requirements of the Center for Devices and Radiological Health (CDRH) during the manufacture of this laser product. The pages of safety information included at the front of this manual should be reviewed when choosing an installation site. All CAUTIONS AND WARNINGS in this text and the safety summary of SECTION 1.0 must be read and understood prior to attempting to operate, maintain, or service the laser system. Particular attention should be given to selecting a site that can provide absolute isolation from unauthorized personnel entry. It is further recommended that the laser operating site be one that has been properly prepared with non-reflective or highly diffuse walls, or barriers that will provide optimum protection from reflected laser radiation.

4.2 SETUP OF THE LASER SYSTEM

Setup of the laser system requires the interconnection of the laser head, power supply, and interface transformer (if required), to each other, and the electrical and cooling water sources. Figure 4-1 depicts system and component interconnections. Setup the laser system as follows:

4.2.1 Cooling Water Connections

1. Place the laser head and power supply electronics unit (EU) on relatively flat, stable surfaces. The umbilical cable which connects the laser head to the power supply electronics unit is nine (9) feet (2.7 meters) long. Position the electronics unit so that the intake fan and exhaust vent located at the rear of the supply are not obstructed.

2. Connect the large plugs on the laser head umbilical to the receptacles labeled J1, J2 on the rear of the power supply EU (see Figure 3-11).

3. Connect the water lines in the laser head umbilical assembly to their respective fittings on the back of the power supply electronics unit. See Figure 4-2. These quick disconnect fittings connect to the upper of the two pairs of connections on the EU rear panel. Connect the male fitting to the connection labeled "DRAIN" and the female connection to the connection labeled "INLET".

4. Twenty foot (six meter) long rubber garden hoses are supplied with 3/4 inch garden hose female connections on one end and quick disconnects on the other end. The hose quick disconnects connect to the lower of the two pairs of quick disconnects located on the EU rear panel. See Figure 4-2. Connect the hose with the male fitting to the connection labeled "DRAIN". Connect the hose with the female fitting to the connection labeled "INLET".

5. Connect the rubber garden hoses to the water source and drain as shown in Figure 4-1.

6. Remove the covers from the laser unit.

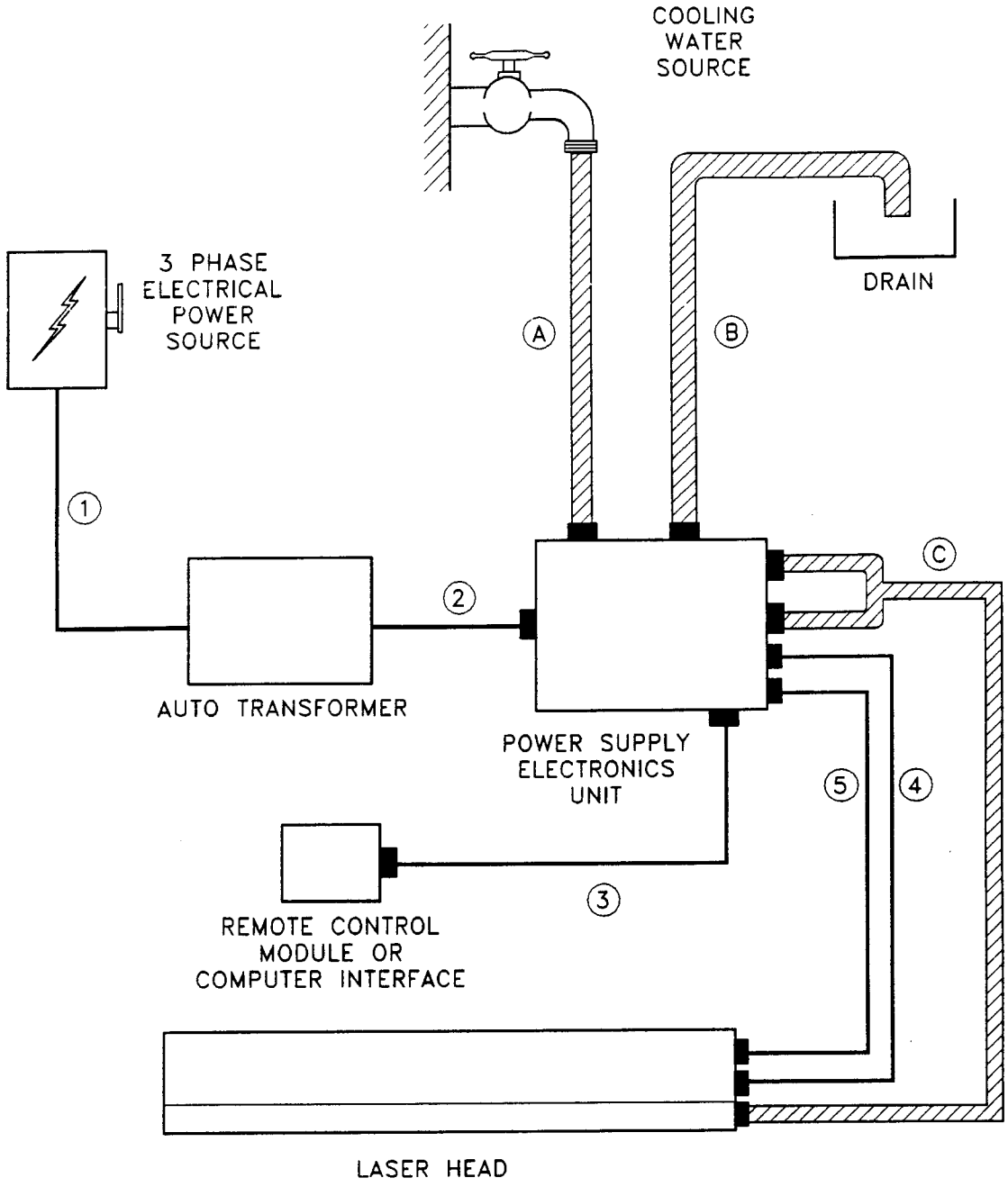
7. Turn on the coolant supply and check for flow through the laser unit. Check to see that the paddle wheel, visible through the rear of the water transducer, is turning. Examine each hose, fitting, and the laser head for leaks.

   NOTE: If the paddle wheel is not spinning either the water is not turned on, flow is blocked in some manner, or connections are backwards.

4.2.2 Electrical Connections (Autotransformer Required)

The following steps apply if an autotransformer has been supplied with the system by Laser Ionics.

1. Insure the autotransformer is not energized. Open the cover of the autotransformer. The terminals will



Electrical Cables

1. Main Power Cord
2. Power Supply Umbilical with 4 Conductor and 7 Conductor Cables
3. Controller Cable
4. Power Cable (7 Pin)
5. Control Cable (35 Pin)

Cooling Water Hoses

A. Inlet Hose (3/4 Inch)
B. Drain Hose (3/4 Inch)
C. Head Inlet/Drain Umbilical

8-322-91

Figure 4-1 System Interconnects

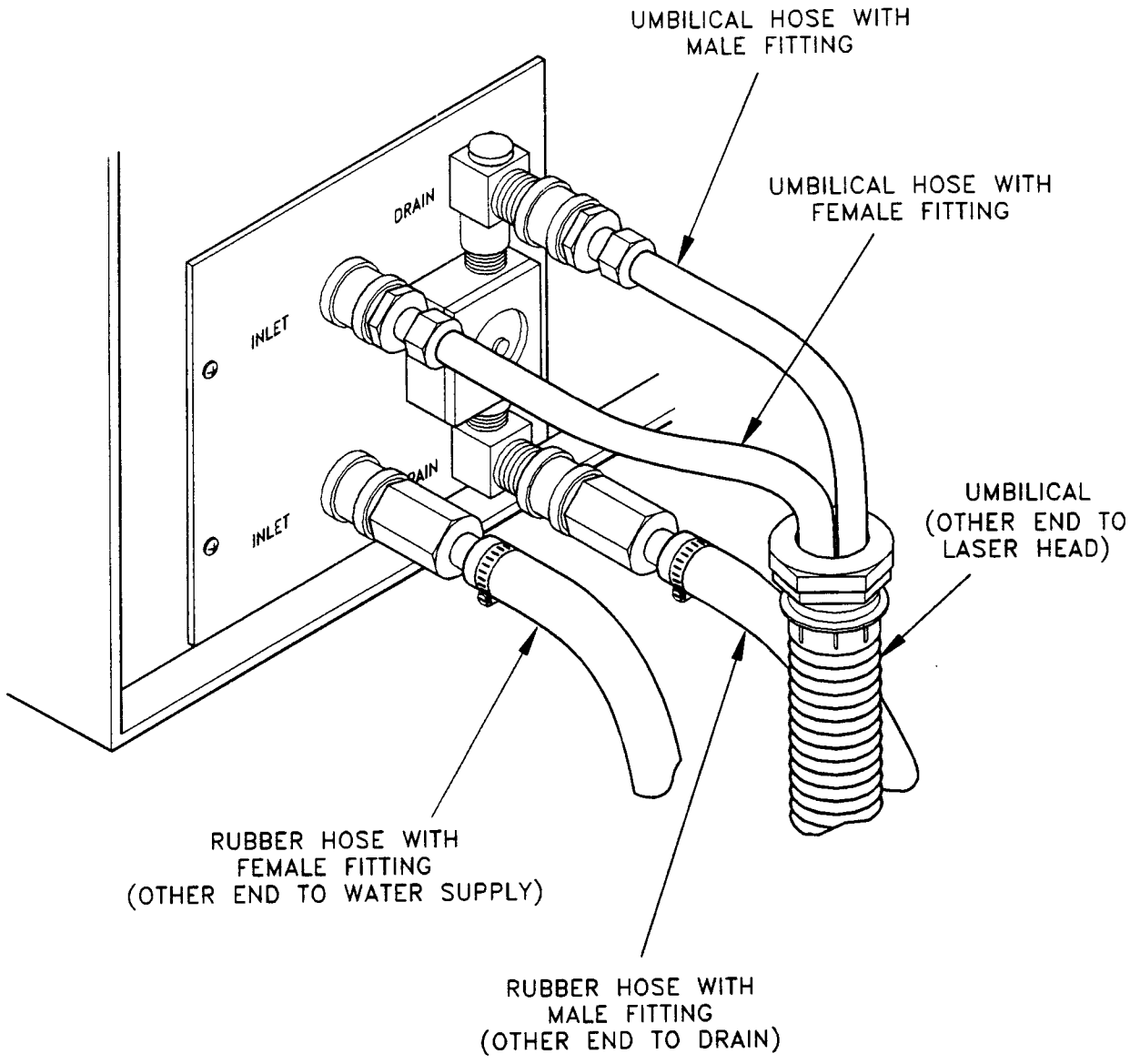


Figure 4-2 Cooling Water Connections

8-327-91

— WARNING —

Electrocution hazard is present when making electrical connections. Insure that the transformer is disconnected from the electrical power source when connecting the power supply to the autotransformer. Also insure that the electrical source is not energized when connecting the transformer electrical cable to the electrical power source. Failure to heed these warnings can result in death or serious injury.

appear as depicted in Figure 4-3. The power supply EU has all electrical power wires contained within a single flexible conduit umbilical, permanently attached to the EU rear panel. Four size 6 AWG wires supply power to the "tube" circuit and power supply "chassis ground". Six size 16 AWG wires supply power to the "field solenoid" and the "control" circuits.

2. The actual connection to the transformer depend upon the electrical power service voltage at the facility and the type/size of laser. There is a transformer diagram on the terminal board mounted to the top of the transformer, which shows the voltages available at each "tap". There are eight taps per phase for a total of 24 taps. All voltages are measured between phases, that is, a volt meter placed on any two #5 taps should read approximately 240 VAC. The "control" circuit wires will always be connected to the 240 VAC taps. The correct "field solenoid" and "tube" voltages will be found on the Final Test Data Sheet supplied with the system. Connect each wire to the appropriate tap.

— WARNING —

Be certain that the GREEN #6 wire is connected to earth ground. **This wire must not be connected to the windings of the autotransformer.** Failure to connect this wire to earth ground will result in a serious electrical hazard, and could result in injury or death.

3. Insure that the electrical power to the electrical source is de-energized. Connect the laser power cable (4 wires) to the transformer. Connect the other end of the power cable to the wall source.

4. After making all required connections to the transformer, be certain that the keyswitch on the power supply EU is OFF and the key removed. This step is recommended to prevent inadvertent operation of the laser. Turn on the electrical power to the transformer and very carefully measure all voltages. The voltages to the EU must be within +10, -5 volts of the value on the Final Test Data Sheet, and any set of three-phase voltages must be within ±1.5% of each other. If not, turn off the power and correct the situation, possibly by changing the connection to the transformer. It may be necessary to move up or down one tap. De-energize the wall power source prior to making any changes. It must be noted that if the incoming power connection is changed, the voltage at all other connections will change.

5. Repeat the voltage checks of Step (4) and if satisfactory, continue with operation. If satisfactory voltages cannot be obtained, contact Laser Ionics. Due to the wide variations possible in electrical power distribution systems, the voltages should be checked again with the laser running at rated current. If there is excessive sag in the power system, it may not be possible to achieve rated current and, consequently, rated output power. If this occurs, contact Laser Ionics.

4.2.3. Electrical Connections, Autotransformer Not Required)

The following steps apply when line voltages match those required by the laser, and an autotransformer is not necessary. This condition applies with some Frame A lasers. If in doubt whether or not an autotransformer is necessary for operation, contact Laser Ionics.

1. Once it is determined that an autotransformer is not required, it will be necessary to connect all wires to

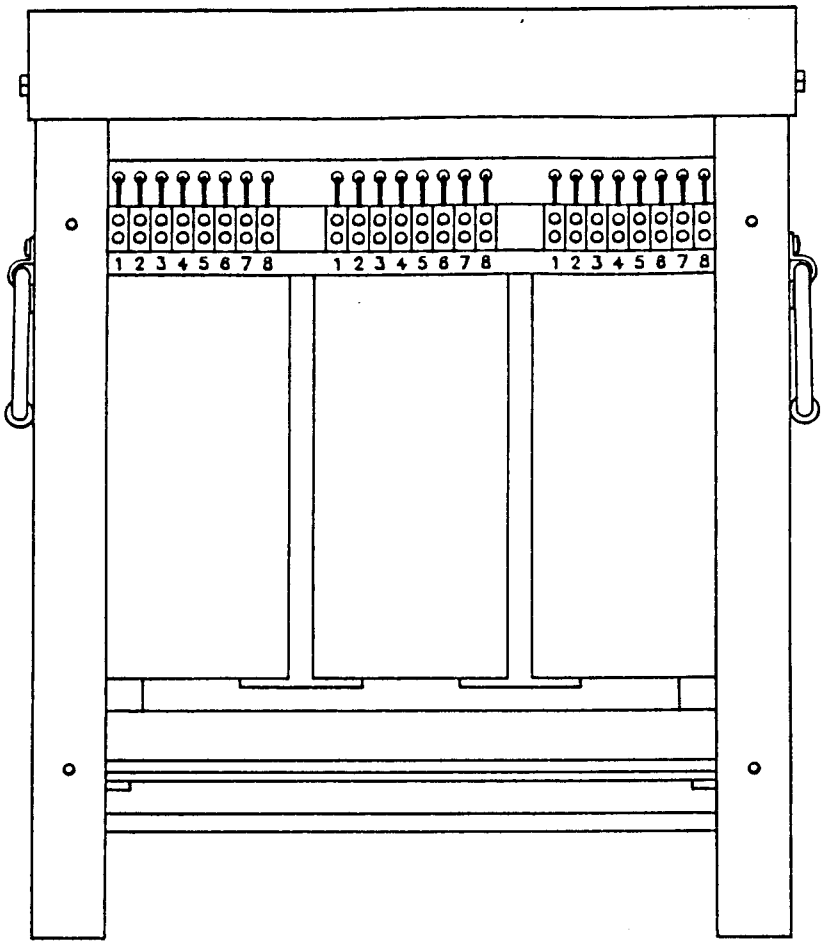


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Figure 4-3 Typical Transformer Terminal Layout

the utility electrical service. Each phase will have one (1) #6 and two (2) #16 wires connected to it. (The "control" and "field solenoid" circuits are over-current protected by fuses inside the power supply.)

2. The minimum input voltage to the system under this type of connection is 205 VAC. Voltage below 205 VAC may prevent the laser from starting or from achieving full power.

4-3. PRE-OPERATIONAL CHECKS

The following checks should be made prior to operating the laser:

1. Verify that the laser head cover and power supply cover and access panels are in place. There is a fail-safe interlock on the laser head cover. If the head cover is removed while the laser is operating, the laser will shut down. The laser cannot be started if the head cover is not securely in place.

2. Verify that the electrical cables and cooling water hoses have been installed and connected as described in Section 4-2.

3. Verify that the laser output shutter is closed to prevent inadvertent exposure of the laser beam to personnel and equipment.

4. If you are operating a Model 1400-(UV) laser in UV mode, insure that the correct photodiode assembly and optics are installed. See Appendix on UV operation.

4.4 SYSTEM OPERATING PROCEDURES

4.4.1 Start-Up

1. Verify that all three AC power LEDs are illuminated on the front panel of the electronics unit (EU).

2. Turn on cooling water flow. Check the water flow transducer on the EU rear panel as an indicator of flow. Visually inspect the laser system for leaks.

3. Turn the KEYSWITCH on the EU one-quarter turn clockwise. The LASER EMISSION indicators on the EU front panel, Remote Control Module (RCM) and laser head should all illuminate. The RCM display will now illuminate.

   NOTE: Adjust the lighting level and contrast on the RCM display as necessary with the BACKLIGHT and CONTRAST knobs on the rear of the RCM.

4. Press LASER OFF to reset electronics unit logic and safety circuits.

5. Observe results of automatic pre-operational checks on the RCM. Figure 4-4 shows the display with all checks "GO". Should an improper condition occur, "NO GO" will be displayed. In this case, press ENTER for an explanation. Correct the condition and press ENTER to obtain the updated status of preoperational checks. Press ENTER to proceed to Step 5 when all checks indicate "GO".

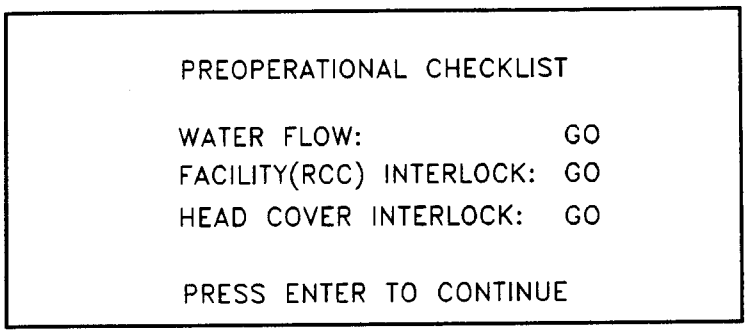
6. The laser is now in STANDBY. HELP and FCTN menus are now available. Any shutdown signals are reset at this time.

7. Press ON to initiate START CYCLE. The laser will display elapsed time, in seconds. The start pulse will be initiated at 30 seconds. The laser should light and transfer to RUN status. Should the laser not start, it will continue to initiate a start pulse until elapsed time is 35 seconds, at which time it will go to AUTOMATIC SHUTDOWN status.

   NOTE: The message "CHECK TUBE PRESSURE AT EACH START" will appear. This is a reminder for the operator to monitor tube pressure after starting the laser. PRESSURE MONITORING is accessed through FCTN.

8. When in RUN, key parameters are displayed on the RCM. All menus and control functions now available are also displayed.

9. While in CURRENT mode, raise the current to the maximum level and allow the laser to warm-up for about 2-5 minutes. Set SOLENOID FIELD CONTROL on the EU at the desired level.



8-339-91

Figure 4-4 Pre-Operational Checks

NOTE: Should adjustment of the mirrors be required to obtain peak power, follow these steps:

a. Remain in CURRENT mode
b. Adjust the rear mirror alignment using the fine adjustment knobs. Adjust the laser for peak power with one knob, and then adjust for peak power with the other knob.
c. If these procedures fail to achieve peak power, refer to sections of this manual covering cleaning of optical surfaces and alignment.

4.4.2 Normal Operation

1. Control the laser through the RCM as desired. Note that functions available to the user are displayed on the COMMANDS AVAILABLE line of the RCM.

   a. **MODE SELECT:** To change the mode, press PWR (power) or CUR (current) on the RCM.

   b. **LEVEL CONTROL:** To change laser output power, press DOWN or UP on the RCM. LEVEL CONTROL increases current until the upper limit for tube current is reached. Operating the laser above this limit will damage the laser tube and void tube warranty.

   c. **RELATIVE POWER:** Laser output can be adjusted using the fine adjustment knobs on the rear mirror mount. Place the laser in CURRENT mode and observe changes in power with the RELATIVE POWER peaking meter on the RCM.

   d. **KEYS:** Select FCTN or HELP when available, by depressing the appropriate key on the RCM. Menus for HELP and FCTN are self-explanatory.

   NOTE: Changing between UV and visible operation on Model 1400- -(UV) lasers requires changing the optics and photodiode assembly. Refer to the Appendix for operation.

2. Should a shutdown condition signal be sensed, the microprocessor-based control system will shutdown the laser and display AUTOMATIC SHUTDOWN status on the RCM. The reason for the shutdown will be shown in the RCM message area. Correct the condition and press LASER ON to reset the signal. This will return the laser to STANDBY status. Proceed with the start sequence (Step 5, above), as appropriate.

4.4.3 Shutdown

1. Press LASER OFF on the RCM.
2. Turn the KEYSWITCH on the EU one-quarter turn counterclockwise.

— CAUTION —

Cooling water must be allowd to flow for at least 15 minutes after shutdown. Failure to allow the laser to cool can result in damage to the laser and laser tube.

3. Allow the laser to cool for at least 15 minutes. At the end of this period, cooling water flow may be shut off.

   NOTE: Running cooling water through the laser when not operating is not recommended. Cooling water can condense on internal components and lead to corrosion or electrical damage to the system.

— WARNING —

High voltage may be present in the EU and autotransformer when the KEYSWITCH if OFF. De-energize the wall electrical source prior to maintaining or servicing these components. An electrocution hazard is present. Death or serious injury may result.

SECTION 5
MAINTENANCE

5.1 GENERAL

This section includes both preventive maintenance and corrective maintenance procedures. Preventive maintenance can be performed on a regularly scheduled calendar basis, on a schedule based on the number of operating hours, or performed in conjunction with corrective maintenance.

> **NOTE:** If you are operating a neon laser, be sure to refer to the Appendix on neon for any special maintenance instructions or warnings.

5.2 PREVENTIVE MAINTENANCE

Laser Ionics' gas-ion laser systems are designed such that they provide the most reliable and maintenance-free operation possible. However, due to the nature of lasers and associated equipment, some preventive maintenance is required. It is recommended that the laser system be used only in clean, dust-free environments, and proposed frequencies for preventive maintenance assume a clean environment. When conditions require equipment operation in areas containing a high level of airborne particles and/or exposure to the extremes of heat and humidity, more frequent preventive maintenance should be performed.

5.2.1 Records and Logkeeping

Figure 5-1 is the Test Data Sheet (TDS) provided with each laser tube. Important data on operating parameters are recorded on the TDS. This sheet should be retained with the laser. The Function Menu (FCTN) also provides head data, a listing of several key parameters important to proper maintenance of the laser.

Figure 5-2 is a log sheet which should be duplicated and used to develop a record of laser operation. Space is provided to record tube voltage (ET), Tube Current (IT), Solenoid Voltage, Power, and Comments. Use this sheet to record data on inspections, start-up, shut-down, and periodically during operation.

5.2.2 Daily Preventive Maintenance at Initial Start-Up of the Laser System

1. Turn on cooling water flow and inspect for proper cooling system operation per the requirements specified in Section 2 of this manual.

2. Verify that the incoming line voltage is correct. This is a very important check especially if temporary or portable power sources are used. If the system operates at a reduced input voltage it will not be able to achieve rated output power. If the system is operated at an increased input voltage, damage to the system may result with associated hazards to personnel.

3. Inspect the water fittings at the rear of the power supply for indications of condensation. Cooling water flow through the laser at temperatures below the dew point will cause condensation to buildup in this area, and indicate condensation is present inside the power supply and laser head. This can be a hazardous situation and cause damage to equipment or injury to personnel due to electrical shock. To correct this situation either raise cooling water temperature (up to 80°F) or dehumidify the environment. It is also recommended that cooling water not be allowed to flow through a shutdown laser for extended period in a humid environment.

5.2.3 Weekly Preventive Maintenance

With the laser shut down, remove the head cover and inspect the front and rear mirrors, Brewster windows, and any optional optics provided with the system for cleanliness. Refer to Section 5-4 for optical surface cleaning procedures if required.

FINAL TEST RUN TIME DATA SHEET PAGE 1 OF

DATE ———— MODEL ———— CUSTOMER ————————————

TUBE# ———— SOL# ———— P/S# ————

PINCH OFF DATA DATE ————

ET VDC ———— IT AMPS ———— SOL VDC ———— OUTPUT WATTS ————

LINE VOLTAGE INPUTS VAC

TUBE ———— FILAMENT ———— SOLENOID ————

POWER SUPPLY VOLTAGES

CONTROL VAC ———— FILAMENT VAC ———— SOLENOID VDC ————

ET VDC ———— AT IDLE ———— AMPS ET VDC ———— AT MAX ———— AMPS

CONTROL BOARD VDC: +15 ———— -15 ———— +12 ———— -12 ————

DATE	TIME	ET VDC	IT AMPS	SOL VDC	POWER WATTS	REFILL ↑ ↓	COMMENTS

Figure 5-1 Test Data Sheet

DATE	TIME	ET VDC	IT AMPS	SOL VDC	POWER WATTS	REFILL ↑ ↓	COMMENTS

Figure 5-1 Test Data Sheet (Cont'd.)

*ANODE AND CATHODE COVERS MUST BE PUT
BACK IN PLACE BEFORE STARTING THE LASER

CUSTOMER_____

PURCHASE ORDER_____

LASER IONICS, INC.
701 S. Kirkman rd.
Orlando, Fla. 32811
Tele 407-298-1561

ION FINAL TEST DATA

SERIAL NO._____
MODEL NO._____
INVOICE NO._____
SHOP ORDER NO._____
SOLENOID NO._____
SUPPLY NO._____

DATE__/__/__
CDRH COMPLIANCE []
NON COMPLIANCE []
POLARIZATION
VERTICAL []
HORIZONTAL []

OPTICS

_____MAX R__
_____OUTPUT__

_____
_____

OUTPUT	ARGON					KRYPTON				
	Watts Amps Aper Optic					Watts Amps Aper Optic				
	VIS					VIS				
	514.5					799.3				
	501.7					793.1				
	496.5					752.5				
	488.0					676.4				
	476.5					647.1				
	472.7					568.2				
	465.8					530.9				
	457.9					520.8				
	454.5					482.5				
						476.5				
	363.8					356.4				
	351.1					350.7				

DIVERGENCE:____MILLIRAD_____ NOISE(10HZ-2MHZ):LESS THAN_____ RMS

DIAMETER:____MM_____ STABILITY (BELOW 10HZ):+/-____%____

Figure 5-2 Data Log Sheet

VOLTAGE

INPUT_____VAC@_____AMPS	CONTROL_____VAC
SOLENOID_____VDC	+12 SUPPLY_____VDC
FILAMENT_____VAC	-12 SUPPLY_____VDC
PLASMA	
IDLE _____VDC@_____AMPS	+15 SUPPLY_____VDC
MAX _____VDC@_____AMPS	-15 SUPPLY_____VDC

CALIBRATION

POWER METER

PHOTODIODE_____mVDC@_____WATTS HIGH RANGE_____WATTS FULL SCALE
LOW RANGE_____WATTS FULL SCALE

PLASMA METERS

CENTER LINE_____VDC@_____AMPS CURRENT LIMIT_____AMPS

OVERCURRENT SHUTDOWN_____AMPS WATER PRESSURE SHUTDOWN_____GPM

REFILL VOLTAGE CHARGE_____VOLTS

OPTIONS:

KEYLOCK

R.C.C. [] BYPASS PROTECTION [] HEAD COVER INTERLOCK []
HEAD EMISSION INDICATOR [] SUPPLY EMISSION INDICATOR []

TUBE PRESSURE ALARM: AUDIBLE [] VISUAL []

PRESHIP

HEAD
CDRH LABELS [] OSHA LABELS [] L.I. LABELS [] ELECTRICAL CONNECTIONS []
HOSE CONNECTIONS []

POWER SUPPLY
OSHA LABELS [] L.I. LABELS [] DRAIN CONNECTIONS [] POWER CABLE []
HOSES [] 16 KVA XFMR [] 36 KVA XFMR [] _____XFMR

MANUAL
DATA SHEET [] SCHEMATICS [] OPTIONS SHEETS [] KEYS [] INTRLCK DEFEAT []
MAINTENANCE KIT []

TECH_____DATE__/__/__ QC_____DATE__/__/__
COMMENTS

Figure 5-2 Data Log Sheet (Cont'd)

5.2.4 Monthly Preventive Maintenance

1. With the laser system shut off, remove the laser head and power supply EU covers. Turn on cooling water flow and inspect all cooling hoses and fittings for any sign of deterioration and/or leakage. Tighten fittings if necessary. If any leakage is noticed in the laser head other than hoses or quick disconnect fittings, contact service personnel and correct the situation prior to operation. Operation in a high humidity environment, with cooling water below the dew point, will result in water condensation on various water-cooled parts of the laser system. Should this happen, the system is being operated **OUT OF SPECIFICATION** and the warranty is in jeopardy. This situation must be corrected, either by using warmer cooling water (less than 80 degrees Fahrenheit), or dehumidifying the environment.

2. Inspect for loose or missing hardware in the laser head and power supply. Tighten loose fasteners and replace missing hardware. This is a concern especially important when the laser is frequently transported from one location to another.

3. In areas where the cooling water is suspected to possess a high calcium content, inspect the cooling lines for calcium deposits. This can be accomplished by shutting off cooling water flow, separating a quick disconnect fitting, and inspecting its interior surfaces.

4. With the laser off, inspect external and internal surfaces of the laser head and DC power supply for cleanliness. Inform service personnel if cleaning is required as evidenced by obvious dirt on the optical surfaces or inability of the laser to meet specified output power.

5.3 CORRECTIVE MAINTENANCE

This section describes procedures to be followed to correct conditions which degrade laser performance.

5.3.1 Tube Voltage Monitoring and Gas Pressure Control

All ion lasers absorb gas over time. Absorption rates are sensitive to many factors. Cooling water temperature is a major factor in that lasers with high cooling water input temperatures [near 80°F (26°C)] will absorb at a higher rate than when temperatures are low. To restore the laser to the correct operating pressure, a gas refill reservoir and valve system is mounted on the laser rail (see Figure 3-2). If the system is inadvertently overfilled, service personnel can restore the laser to the correct pressure using the tube pumpdown procedure in Section 6.0.

Tube pressure is not measured directly. Tube voltage (ET), the DC potential difference between the anode and cathode, is read directly and used as an indicator of tube pressure. Pressure control is based on maintaining tube voltage within prescribed limits. The recommended range for ET for a particular laser tube is given on LASER HEAD DATA, and PRESSURE CHECK (if running), accessed through the FCTN Menu, and the Laser Test Data Sheet, provided in hard copy with the laser system.

Tube current and solenoid field strength affect ET, and must be set to prescribed values in order to accurately measure ET.

ET should be checked each time the laser is started, about five minutes after commencing operation. This allows gas pressure to stabilize. ET should also be checked prior to shutting down the laser, and periodically during operation. The correct frequency for checking ET will depend on the type of laser and duty cycle. Experience with the laser will help to determine the gas absorption rate and the correct frequency for monitoring.

— WARNING —

Failure to maintain tube voltage within the specified range on the Test Data Sheet can result in shutdown of the laser (Regulation Fault - FET Protection) or damage to the laser. Never operate with tube voltage below the specified ET limit, as presented on the RCM display (see 5.3.1.1). Incorrect operation will void the system warranty.

5.3.1.1 Tube Pressure Monitoring

To check ET (tube voltage, the indicator of tube pressure), perform the following:

1. With the laser in RUN, select the FCTN Menu. Depress the number on the keypad for PRESSURE CHECK.

Calling the PRESSURE CHECK Function when in RUN causes the microprocessor to place the system in CURRENT MODE and sets TUBE CURRENT to the idle value.

2. Compare the ACTUAL ET to the ALLOWABLE RANGE given on the RCM display.

3. If ET is below the ALLOWABLE RANGE, refer to Section 5.3.1.2, Tube Refill, below.

4. If ET is above the ALLOWABLE RANGE, contact service personnel to reduce tube pressure, as described in Section 5.3.1.3.

5. If ET is within the ALLOWABLE RANGE, proceed with normal operation.

5.3.1.2 Gas Refill

> **— WARNING —**
>
> This procedure does not apply to NEON LASERS. Refer to the NEON LASER Appendix for instructions on Gas Refill of Neon Lasers.

When Tube Voltage is below the correct range, the laser tube pressure is restored as follows:

1. With the laser in RUN, select the FCTN Menu. Depress the number on the keypad for GAS REFILL.

2. Depress FCTN to fill the tube. This will cycle both refill values, allowing a small measured amount of gas to flow from the reservoir to the laser tube.

3. Observe the increase in ET. ET should rise approximately 10 volts during the next five minutes. Refill is locked out for five minutes to allow gas pressure to stabilize.

4. After five minutes, check to insure ET is now within the correct range. Repeat Refill if necessary. If ET cannot be restored after performing the tube refill procedure two times, it is recommended that service personnel be contacted prior to proceeding.

5. Return to the Status Menu.

5.3.1.3. Reduction of High Pressure

Tube high pressure can result from over filling the tube during the GAS REFILL procedure. Laser tubes also outgas a small amount of argon or krypton gas on occasion, especially when operating conditions change or when the laser tube is new. If ET is no more than +15 volts above the upper limit for ET, when measured with the laser operating at idle current (PRESSURE CHECK), continued operation of the laser will generally bring the laser back to the normal operating range for ET. When ET is more than 15 volts above the upper range, the laser may not achieve specified power. However, operation at higher pressure than normal for short periods will not damage the system. If ET is above the specified range, perform the following:

1. Perform PRESSURE CHECK and record ET and time. Operate the laser as normal.

2. Perform PRESSURE CHECK after one hour operation. ET should be lower at this time and moving towards the normal range.

3. Continue to operate and check ET about once per hour.

4. As ET is lowered, normal range for full power will be restored. Should this not occur, within four hours, it is recommended that service personnel be contacted to perform the TUBE PUMPDOWN procedure in Section 6.0.

5.3.2 Cleaning of Exterior Surfaces on DC Power Supply and Laser Head

Standard cleaning practices and routines are permissible in regard to the exterior surfaces of the DC power supply and laser head. Insure the laser is de-energized at the wall power source prior to performing these procedures.

1. Clean exterior with a clean, damp cloth and mild detergent to remove smears and stains. Do not allow fluids, pastes, or contaminating material to enter connectors or vents.

2. Dust the interior of the DC power supply with a vacuum cleaner, low-pressure air (10-15 psi), or with a soft

brush. Observe all precautions associated with electrical equipment and delicate electronic components.

5.3.3 Cleaning of Optical Surfaces

— CAUTION —

* Do not touch any optical surface with bare, unprotected fingers. Use clean, unused fingercots.

* Do not wipe sand, dirt or dust from any optical surface with commercial wiping cloths or paper products. Use materials designated for use on precision optical surfaces only. Failure to comply could cause permanently scratched surfaces or coating deterioration.

— — —

NOTE: It is recommended that the mirrors and Brewster windows be cleaned during initial installation of the laser system. This experience will enable key operating/ maintenance personnel to visually define "normal" diffraction from clean optical surfaces.

1. Shut down the laser system and remove the head cover.

2. Remove the cavity covers from between the two front and rear mirror mounts and Brewster windows. Removal of these covers exposes the Brewster windows for cleaning.

3. Remove the optic hold-down caps from the threaded bezels on the front and rear mirror mounts.

4. Using a clean, unused high-quality Q-tip or clean, unused rolled-up sheet of lens paper, gently push the mirror out of its mount just far enough to grasp the mirror by its sides, then carefully slide it out of the mount.

5. Using dry nitrogen or compressed argon source, blow loose particles from optical surface(s).

6. Apply one or two drops of reagent-grade acetone to a fresh Q-tips or rolled-up sheet of lens paper. Shake off excess solvent (away from laser equipment).

7. Lightly lay the acetone dampened Q-tip or lens tissue on the surface to be cleaned and gently draw across the surface while carefully rotating the Q-tip or lens paper against the direction of travel. This practice prevents the coating on the optical surface from being scratched and precludes pressing any particles into the soft surface coating. Reinstall the mirrors.

   NOTE: Haze or smears remaining on optical surfaces require that the surface be recleaned. Use fresh cleaning materials when repeated cleanings are necessary.

8. To clean the two Brewster windows, perform Steps 5 through 7 above. Visually check cleaning results.

9. Replace the head cover and observe results. If the surfaces are not cleaned satisfactorily, as evidenced by low power, shut down the laser and repeat the cleaning steps above. Always use fresh, unused cleaning materials for all subsequent surface cleanings.

SECTION 6
LASER HEAD SERVICE

— CAUTION —

These tasks may require operation of the laser with the laser head cover or power supply panels removed and shorting bar in place. They should only be undertaken by trained service personnel since hazards exist from exposure to laser radiation and high voltage connections.

6.1 GENERAL

Optical components of the laser system were aligned and adjusted before shipment from the factory. Occasionally, however, handling and shipment can alter the alignment of one or more of the components. To properly "peak up" the laser to its maximum performance, it may be necessary to adjust the system using one of the following methods.

6.2 OPTICAL ALIGNMENT

To achieve optimum output power from the laser system, the mirrors within the optical cavity must be parallel to each other and the optical path of reflection must be aligned to the center of the tungsten disc bore.

6.2.1 Major Optical Allignment (Broadband Operation)

1. Shut down the laser system and disconnect power to the DC power supply.
2. Remove the covers from the laser head.
3. Install the interlock defeat shorting bar (provided with the laser system) on the laser head cover interlock switch.
4. Carefully remove the front and rear cavity covers from between the mirror mounts and the Brewster windows (see Figure 2-1).
5. Refer to Section 4.0 and start up the laser system.

— WARNING —

•During laser operation, two secondary beams are reflected off the Brewster windows. The direction of projection of these beams will be the axis of polarization of the laser head. The strength of these reflected beams is sufficient to cause permanent eye damage. Wear eye protection (laser goggles) suitable for rated output. Ensure laser output does not intercept observer personnel.

•When the laser covers are removed, hazardous voltages exist on exposed electrical leads from the laser head and on the terminal strips located on the laser head rail. Do not touch exposed leads or terminal strips with hands or fingers when performing optical alignment. Electrocution or serious injury can result from contact with electrical connections.

6. Set the tube current to a mid-range value while in **CURRENT** mode with the control on the RCM.
7. Bend a white 3"x5" index card into an "L" shape. Place the card in the opening between the front Brewster window and front mirror mount.
8. Adjust the card so that it completely blocks the light being emitted by the plasma tube from reaching the front mirror.
9. Locate the bright spot on the card which is caused by emissions of the

plasma tube. Lightly mark the center of that bright spot with a fine point felt tip marker.

10. Remove the 3"x5" card and punch a 1/16 inch diameter hole in the card at the marked spot.

— **NOTE** —

Patience and care in performing Step 11 through Step 13 will simplify the remaining alignment steps. See the Appendix on Neon lasers for slight variations in this procedure for neon ion lasers

— — —

11. Replace the card in the opening between the front Brewster window and front mirror mount and adjust it so the bright spot passes through the hole in the card and strikes the front mirror.

12. Observe the side of the card that faces the front mirror mount. Locate the bright spot on the card being reflected off the front mirror and onto the card.

13. On front mirror mount, adjust the Vertical and Horizontal adjustment controls until the spot on the front side of the card is superimposed over the 1/16 inch hole such that light is reflected off the front mirror and back down the laser bore.

14. Remove the 3" x 5" card.

15. On the rear mirror mount, remove the optic cap, optic shim, O-ring, and rear mirror. Set the parts aside for later installation (see Figure 6-1).

16. After removing the parts, observe the light radiated from the rear end of the laser on a white surface positioned approximately three to four feet in back of the laser head.

— **NOTE** —

It might be necessary to extinguish surrounding light to perform the next step.

17. The light radiated onto the white surface will appear as a large blue disc, with a small bright spot located somewhere within the disc. The small bright spot is the light reflected off the front mirror and back through the tube bore. If the bright spot cannot be located, Steps 11 through 13 above must be repeated.

18. Using the **VERTICAL** control on the front mirror mount, scan on the vertical axis to determine the points in the large blue disc where the bright spot disappears. Follow by scanning with the **VERTICAL** control as required to center the bright spot between these points.

19. Repeat Step 18 on the horizontal axis using the **HORIZONTAL** control. When this step is completed, the front mirror is roughly aligned with the center of the tube bore.

20. Reinstall the rear mirror in the mirror mount, inserting the surface containing the reflective coating first. Follow by installing the O-ring, optic shim, and optic cap (see Figure 6-1).

21. Perform Steps 7 through 13 at the rear end of the laser head and adjust the rear mirror. **DO NOT** move the axis adjustments previously set for the front mirror, or place the 3"x5" card between the front Brewster window and front mirror mount.

22. When the light reflected off the rear mirror is superimposed over the 1/16 inch hole in the card, scan the horizontal adjustment back and forth while slowly scanning with the vertical control. Lasing should occur during this scanning process when the rear mirror is aligned parallel to the front mirror.

— **NOTE** —

The major optical alignment (broadband operation) procedure is a time consuming task when first attempted, but with a little experience the procedure can be completed in a matter of a few minutes.

6.2.2 Optical-Path-to-Bore Alignment

Once lasing has commenced, alignment of optical path to the laser bore must be performed as follows:

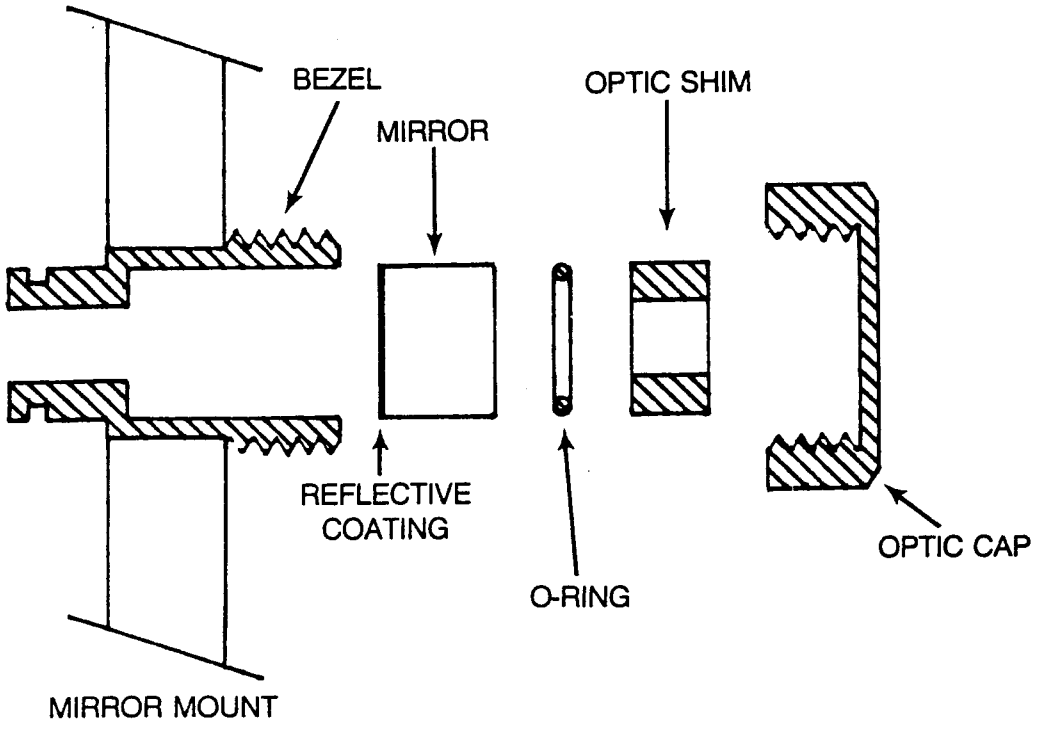


Figure 6-1 Mirror Mount, Exploded View

1. Adjust the rear mirror **HORIZONTAL** and **VERTICAL** controls to peak power and note the power level observed on the power meter on the DC power supply front panel.

2. Observe the beam. It should be centered on each Brewster window. If the beam is not centered, detune one axis at the front mirror mount in the direction required to move the beam toward the center of the rear Brewster window. Retune the same axis on the rear mirror mount in the opposite direction. Note the peak power level indicated on the power meter.

3. Detune the front mirror on the same axis, going in the same direction if the peak power increased; in the opposite direction if the peak power decreased. Retune the rear mirror and again observe the indicated peak power.

4. Repeat Steps 1 through 3 in one direction until the peak power which can be achieved by retuning the rear mirror begins to drop. At this point, repeat the same steps in the opposite direction until the output returns to the highest power level observed.

5. Repeat steps 1 through 4 on the remaining axis. When completed, the optical path will be aligned with the laser bore.

— NOTE —

This concludes the alignment procedures required for the basic Gas-Ion Laser Systems. Alignment procedures provided in Appendix B need only be performed if optional optic devices were purchased with the system. If optional optics were purchased, proceed to the appropriate installation and/or alignment task(s) without shutting down the laser system. Otherwise, perform Step 6.

6 .Shut down the laser system (Section 4.0), remove the interlock defeat shorting bar, replace the cavity covers, and reinstall the laser head covers.

6.3 GAS PRESSURE CORRECTION - GAS PUMPDOWN

To achieve maximum tube life, gas pressure should be maintained within the recommended band. Follow the procedure in Section 5.0 to verify that the tube voltage (ET) is above the operating range. If so, proceed with the tube pumpdown procedure.

If determined that the laser tube is in a high pressure state, and pressure is not restored to the normal range by the procedure in Section 5.3.1.3, the laser may be "Pumped Down" using the following procedure. It will be necessary to obtain approximately two liters of liquid nitrogen and fabricate a tray, as described below to perform this procedure. The function of the tray is to contain the liquid nitrogen in the immediate vicinity of the gas reservoir so that the temperature of the reservoir may be reduced enough that it will absorb gas from the laser tube.

1. Shut down the system and remove the head cover.

2. Remove the teflon screw in back of the refill system.

   ***Note:** Exercise caution not to lose the screw or any of the washers beneath the screw. Be sure to count the number of washers so that the same number is reapplied following this procedure.

3. Using a non-conductive material (i.e., cardboard, etc.), prepare a tray to fit the length of the gas-reservoir with sides measuring 5/8" in height.

4. Place the tray beneath the gas reservoir using extreme caution.

5. Insert the pumpdown key into the lock at the anode end of the laser. Turn 1/4 turn clockwise. This action enables tube pumpdown.

6. Install the shorting bar and start the laser. Call up the FCTN menu and select "TUBE PUMPDOWN".

7. Pour liquid nitrogen into the tray. Maintain flow at full level for approximately three minutes.

8. Initiate Tube pumpdown by pressing the command on the RCM. This

opens the valves for a brief period, allowing a small amount of gas flow into the reservoir.

CAUTION: If tube voltage rises, the reservoir is probably not cold enough. Cease the operation and continue to freeze the reservoir by pouring more liquid nitrogen on it.

9. Monitor the tube voltage closely. Continue to cycle the valve until tube voltage is near the middle of the recommended range.

10. Once the correct tube voltage has been achieved, exit TUBE PUMPDOWN and FCTN by depressing controls on the RCM. Turn the pumpdown enable keyswitch 1/4 turn counter-clockwise and remove the key.

11. Allow the gas reservoir to warm up to room temperature and remove the tray from beneath it.

12. Reattach the nylon screw. Use the original screw and replace all washers originally mounted on the system.

    Note: Substitute screws may cause damage to the unit. Use only the parts which came with the system.

13. Remove all moisture on or near the gas reservoir prior to starting the laser.

14. Observe Tube Voltage (ET) to make certain the refill valves are closed, and that gas is not allowed to leak back into the system. Gas pressure will stabilize about five minutes after completing the pumpdown procedure.

6.4 OPTICAL SURFACE SERVICE

— WARNING —

Never look down the laser bore. Always locate the secondary beams from the Brewster windows before looking into the laser cavity.

Proper inspection and maintenance of the front and rear mirrors and Brewster windows is critical to maintaining optimum laser performance and extended life of the optical components.

76.4.1 Cleaning of Optical Surfaces

— CAUTION —

•Do not touch any optical surface with bare, unprotected fingers. Use clean, unused fingercots.

•Do not wipe sand, dirt or dust from any optical surface with commercial wiping cloths or paper products. Use materials designated for use on optical surfaces only. Failure to comply could cause permanently scratched surfaces or coating deterioration.

— NOTE —

It is recommended that the mirrors and Brewster windows be cleaned during initial installation of the laser system. This experience will enable key operating/ maintenance personnel to visually define "normal" diffraction from clean optical surfaces.

— — —

1. Remove the cavity covers from between the two front and rear mirror mounts and Brewster windows. Removal of these covers expose the Brewster windows for cleaning.

2. Remove the optic caps from the threaded bezels on the front and rear mirror mounts.

— WARNING —

Use care to avoid touching the exposed high voltage leads located adjacent to the laser tube. Lethal voltages are present.

3. Using a clean, unused high-quality Q-tip or clean, unused rolled-up sheet of lens paper, gently push the mirror out of its mount just far enough to grasp the mirror by its sides, then carefully slide it out of the mount.

4. Using dry nitrogen or compressed argon source, blow loose particles from optical surface(s).

5. Apply one or two drops of reagent-grade acetone to a fresh Q-tips or rolled-up sheet of lens paper. Shake off excess solvent (away from laser equipment).

6. Lightly lay the acetone dampened Q-tip or lens tissue on the surface to be cleaned and gently draw across the surface while carefully rotating the Q-tip or lens paper against the direction of travel. This practice prevents the coating on the optical surface from being scratched and precludes pressing any particles into the soft surface coating.

— NOTE —

Haze or smears remaining on optical surfaces require that the surface be recleaned. Use fresh cleaning materials when repeated cleanings are necessary.

— — —

7. Reinstall the mirror and observe the results. If the surface is not cleaned satisfactorily, remove the mirror and repeat the cleaning steps above. Always use fresh, unused cleaning materials for all subsequent surface cleanings.

8. To clean the two Brewster windows, detune the front and rear mirrors as required to stop lasing, then perform Steps 4 through 6 above. Retune the mirrors, check cleaning results, and if results are good, shut down the laser system.

6.4.2 Brewster Window "Zapping"

Brewster window "zapping" is a method whereby electricity is used to remove internal contamination from the Brewster windows. Note that while there may be no visible contamination on the inside of the windows, there still could be enough contamination to cause operational problems such as poor color balance or loss of power. It might not be possible to see any visible improvement in window cleanness after performing the "zapping" process. Cleaning results must be verified as prescribed later in this procedure.

The following is the procedure recommended for Brewster window "zapping".

1. Carefully remove the rear cavity cover from the laser head, being certain to completely compress the bellows to clear and avoid scratching the Brewster window.
2. Carefully slide the front cavity cover over the neck of the plasma tube to expose the front Brewster window.

3. On the cathode end of the laser tube, gently disconnect the plastic tubing from the fitting on the cavity cover. Carefully remove the glass tube from the laser tube and place in safe area for later installation.

— CAUTION —

•Do not perform "zapping" procedure until laser is running at idle (CURRENT control set at its lowest value) and in CURRENT code. If this procedure is performed while running the laser at higher power, electical noise is produces that will cause the system to shut down and might result in damage to electonic components in the DC power supply.

•Do not allow the Tesla coil to arc to the surface of the mirror. Permanent damage to the mirror will result.

4. With the laser system operating at idle current and in CURRENT mode, place a plastic insulator card -- fabricated from a section of plastic or plexiglass measuring approximately 3 x 5 x 1/8 inches -- inside the resonator end plate between the Brewster window and the mirror. This insulator card will prevent the Tesla coil arc from jumping to the surface of the mirror, causing permanent damage. Note that if the distance between the Brewster window and the mirror of the system undergoing maintenance is two inches or more, the insulator card need not be used. However, to provide maximum protection for the mirror, the insulator card should be inserted.

— NOTE —

The Tesla coil is a tool powered by 110/220 Vac that is used to generate an electrical arc required to clean the Brewster windows. The Tesla coil can be purchased locally or can be ordered directly from Laser Ionics, Inc.

— — —

— CAUTION —

Avoid excessive motion of the "magic wand" against the Brewster window.

5. To prevent scratching the Brewster window, place the paper-backed side of the "magic wand" metal plate against the window.

6. Energize the Tesla coil and hold its tip approximately 1/2-inch over the center of the wand's metal plate to produce a single arc for no longer than 10-15 seconds.

7. Clean the external surface of the Brewster window as described in 6-4.1. This cleaning operation will remove any particles or other contamination that may have been introduced by the "magic wand". If the window is contaminated when laser power is brought up, it might get burned into the window causing permanent damage.

8. Verify cleaning results by observing the laser output power, and by examining the "mode" of the beam using a beam diagnostic system or a small lens to expand and project the beam onto a suitable flat viewing surface. The following characteristics should be observed at a point where the image is approximately one foot wide.

   a. The intensity of the light should be maximum in the center of the beam image and should taper off uniformly toward the edge.

   b. There should be no dark patches in the image. If the image is patchy or unstable, contamination still exists on the window interior and the "zapping" procedure must be repeated.

9. Install the cavity cover over the laser tube and reconnect the plastic tubing to the fitting on the glass tube.

10. Perform Steps 3 through 9 above on the Brewster window located at the anode end of the laser tube.

11. Install the covers on the laser head and return system to normal service.

APPENDIX A

SYSTEM SPECIFICATIONS

PERFORMANCE SPECIFICATIONS

MODEL 851/851B POWER SUPPLY

Type: Linear, line rectified, series pass

Input Voltage to Line	220 vac ± 10%[1]
Interface Transformer	440 vac ± 10%[2]
Current (depends on laser head rating)	25-85 Amperes
Frequency	47-63 Hz
Phase	3Ø, 3 wire w/ground
Weight	60 lb. (27 Kg)
Cooling	Air and water cooling
Interlock/Shutdown Indication	. Hi-Lo water flow . Covers PS/laser head . Facility (RCC) . Water temperature (high) · Solenoid current (high/low) · Tube bypass fault · Tube voltage · Overcurrent · Excess power dissipation · Start time exceeded · Anode voltage
Remote Capability	Full function remote with liquid crystal display
Diagnostic	Key parameters accessed through remote
Configuration	. Table model standard . Roll around cart with transformer optional
Construction	. Modular assembly . Ribbon cable control harness . PC boards in card cage

NOTES

1) For Argon lasers to 15 watts multiline output and Krypton and mixed gas lasers to 3 watts output and all B series lasers.
2) For Argon lasers 16 to 25 watts output and Krypton and mixed gas lasers 4 to 6 watts output.
3) Specifications subject to change without notice.

PERFORMANCE SPECIFICATIONS[1]

RAINBOW

Optical Output	.7 to 5 watts[2]
Resonator Structure	Graphite - Invar
Beam Diameter $1/e^2$ Points	1.5 - 1.9 mm
Beam Divergence[3]	.4 - .9 mRAD
Polarization	Vertical
Extinction Ratio	>100:1
Transverse Modes	Multi
Warm-up Time - Multiline	5 min.
Beam Pointing Stability[3]	<10 microRAD
Power Stability, Long-Term, Current Mode[5]	± 3%
Power Stability, Long-Term, Power Mode[5]	± .5%

NOTES

1) Specifications subject to change without notice.
2) Powers are multiline. Single line powers available on request.
3) In any 5 min. period after 30 min. warm-up.
4) Defined as the difference between the drain back pressure and the inlet pressure.
5) In any 30 min. period after 60 min. warm-up.

RAINBOW

ARGON		KRYPTON		MIXED GAS			
Model	Power (Watts)	Model	Power (Watts)	Model	Power (Watts)	Dim A (cm/in)	Weight (Kg)
A	5	K	.7	A/K	2.5	125/49	23

PERFORMANCE SPECIFICATIONS[1]

MODEL 1400

Optical Output	.5 to 25 watts[2]
Resonator Structure	Graphite - Invar
Beam Diameter $1/e^2$ Points	1.5 mm
Beam Divergence[3]	0.4 - 0.7 mRAD
Polarization	Vertical
Extinction Ratio	>100:1
Modes	TEM_{oo}
Warm-up Time	5 min.
Beam Pointing Stability[4]	<10 microRAD
Power Stability, Long Term, Current Mode[3]	± 2.0%
Power Stability, Long Term, Power Mode[3]	± 0.5%
Optical Noise, Current Mode	0.5% RMS
Optical Noise, Power Mode	0.3% RMS

NOTES

1) Specifications subject to change without notice.
2) Powers are multiline. Single line powers available on request.
3) In any 30 min. period after 60 min. warm-up.
4) In any 5 min. period after 30 min. warm-up.

MODEL 1400

ARGON		KRYPTON		MIXED GAS			
Model	Power (Watts)	Model	Power (Watts)	Model	Power (Watts)	Dim A (cm/in)	Weight (Kg)
1400-5A	5	1400-1K	.7	1400-1AK	1	124.5/49	23
1400-10A	10	1400-2K	2	1400-2AK	2	167.6/66	32
1400-15A	15	1400-3K	3	1400-3AK	3	171.5/67.5	38
1400-20A	20	1400-4K	4	1400-4AK	4	214/84	59
1400-25A	25	1400-6K	6	1400-6AK	6	239/94	60
NEON							
1400-1N	1					167.6/66	32
1400-05N	.5					124.5/49	23

PERFORMANCE SPECIFICATIONS[1]

B SERIES

Optical Output	1 to 50 watts[2]
Resonator Structure	Graphite - Invar
Beam Diameter $1/e^2$ Points	4.0 mm
Beam Divergence[3]	0.8 - 1.0 mRAD
Polarization	Vertical
Extinction Ratio	>100:1
Transverse Modes	Multi
Warm-up Time - Multiline	5 min.
Power Stability, Long Term, Current Mode[3]	± 2%
Power Stability, Long Term, Power Mode[3]	± .8%

NOTES

1) Specifications subject to change without notice.
2) Powers are multiline. Single line powers available on request.
3) In any 30 min. period after 60 min. warm-up.
4) In any 5 min. period after 30 min. warm-up.
5) Defined as the difference between the drain back pressure and the inlet pressure.
6) Measured two (2) meters from the beam aperture.

B SERIES LASERS

ARGON		KRYPTON		MIXED GAS			
Model	Power (Watts)	Model	Power (Watts)	Model	Power (Watts)	Dim A (cm/in)	Weight (Kg)
MB-50A	50	MB-50K	12	MB-50AK	20	239/94	60
RB-25A	25	RB-25K	8	RB-25AK	12	171.5/67.5	38
PB-15A	15	PB-15K	5	PB-15AK	8	124.5/49	23

APPENDIX B

OPTIONAL COMPONENT INFORMATION

APPENDIX B-1

LITTROW PRISM SERVICE

B-1.1 GENERAL

Littrow prisms are used to achieve single wavelength operation. The littrow prism replaces the maximum reflector optic at the rear of the laser head. Figure B-1-1 shows the relative position of the littrow, laser tube bore and output mirror. An angle is formed in the plane of the figure by a line drawn through the bore and a line parallel to the front of the prism within the plane of polarization. Changes to this angle, accomplished with the mirror mount fine adjustment knob, change the wavelength emitted by the laser.

B-1.2 LITTROW PRISM INSTALLATION AND ALIGNMENT

Figure B-1-2 shows the position of the littrow in the rear mount. Scribe marks on the mirror mount and littrow mount should be aligned when the littrow is inserted in order to operate correctly. The installation procedure is as follows:

— WARNING —

- During laser operation, two secondary beams are reflected off the Brewster windows. Ensure laser output does not strike personnel. **NEVER LOOK INTO THE BEAM.** The strength of these reflected beams is sufficient to cause permanent eye damage.
- When the laser covers are removed, hazardous voltages exist on exposed electrical leads from the laser head and on the terminal strips located on the laser head rail. Do not touch exposed leads or terminal strips with hands or fingers when performing optical alignment. Electrocution or serious injury can result from contact with electrical connections.

1. Optimize laser performance warm-up system and shutdown laser, remove the head cover and install the shorting bar. Start up the laser.
2. Remove rear mirror from the rear mirror mount and insert the littrow prism assembly in its place. Take care to align the scribe marks on the mirror mount with those on the littrow.
3. Note the two spots where the plasma radiation reflects off the Brewster windows and strikes a distant surface (ceiling, wall, etc.).
4. Rotate the prism in the mirror mount as required to align the spot from the ratiation reflected off the Littrow prism with the two spots from the Brewster windows. This action aligns the Littrow prism with the axis of laser polarization (see Figure B-1-1).
5. Secure the Littrow prism in place by tightening the setscrew located in the mirror mount threaded bezel.
6. If the laser is not lasing, slowly scan the Littrow prism by adjusting the mirror mount.

NOTE

Once satisfactory lasing has begun, the Littrow prism alignment task is complete, and the operator can proceed to the etalon installation and alignment procedure without shutting down the laser system, if planned. Otherwise, perform Step 7.

7. Shut down the laser, remove the shorting bar, and replace the head cover.

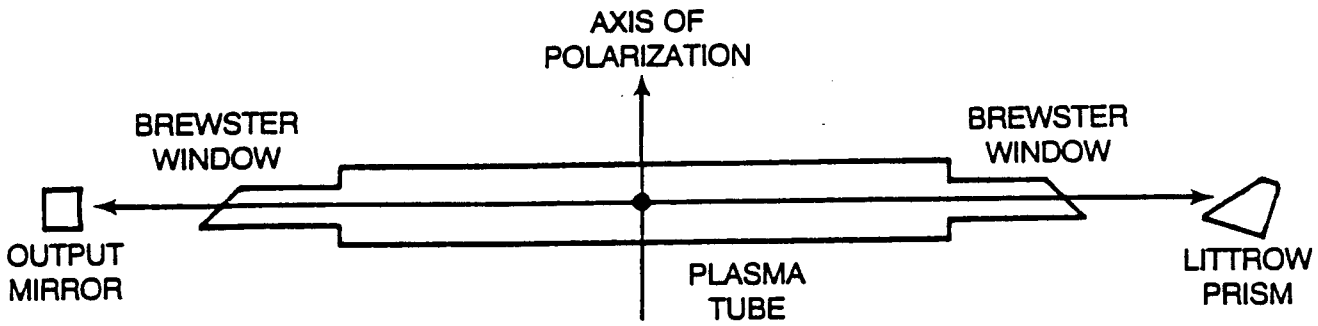


Figure B-1-1 Laser Polarization

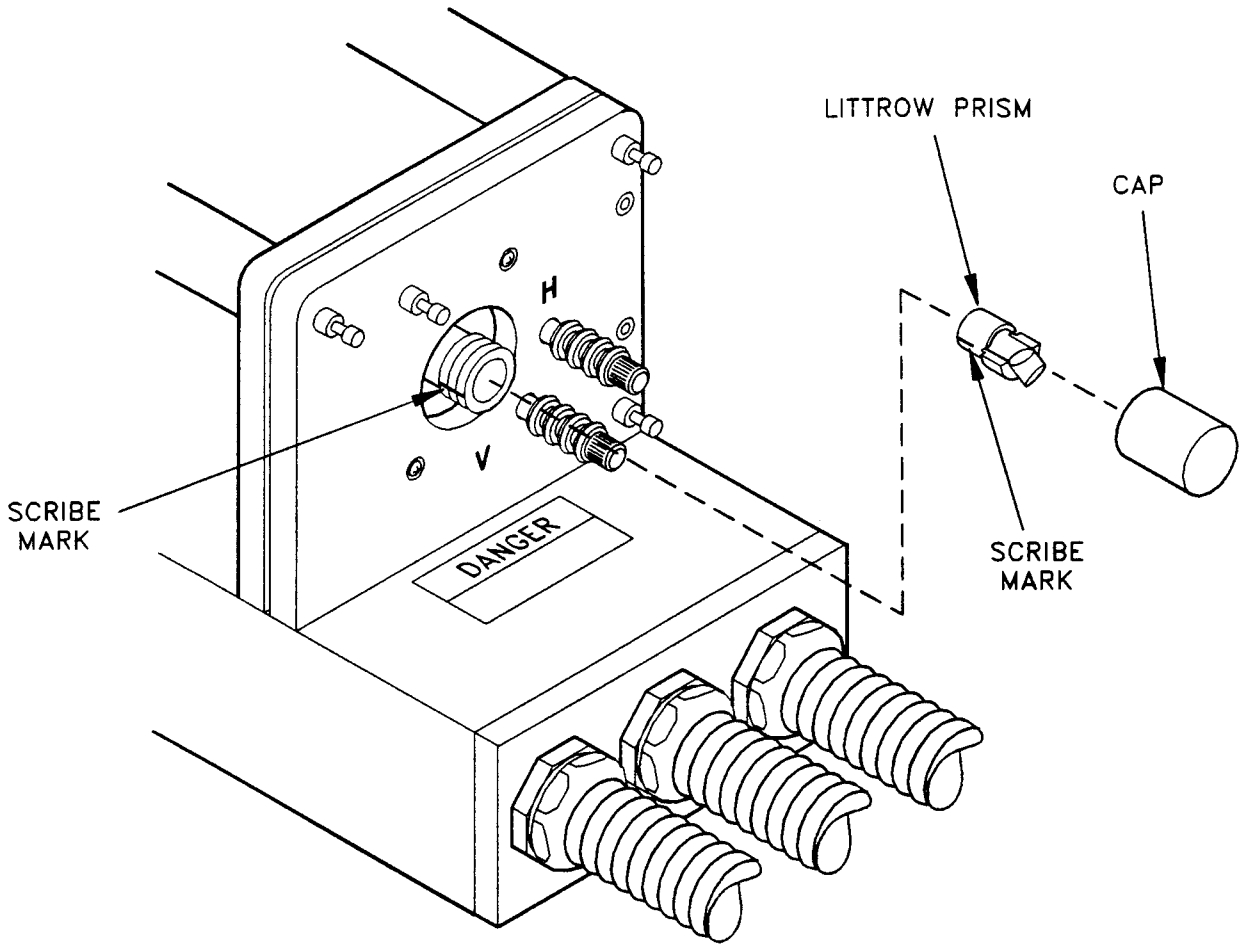


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Figure B-1-2 Littrow Prism Assembly Installation

APPENDIX B-2

ETALON INSTALLATION AND OPERATION

When optical-path-to-bore and littrow prism alignment have been completed and checked, and the system is lasing single-line with the littrow prism in place, installation of the optical etalon can be performed as described in the following paragraphs.

1. Shutdown the laser system and remove the head cover.

2. Install the etalon in the etalon mount located in front of the rear mirror mount. Be sure the etalon does not touch the Brewster window during installation. (See Figure B-2-1). Connect the oven controller cable.

3. Replace the head cover and start up the laser. Do not adjust the littrow prism or front mirror mount.

4. Activate the temperature controller by calling the etalon function through FCTN and the RCM. Turning on the oven will stabilize the etalon temperature in about 30 minutes.

5. If the laser is not lasing at this point, scan the etalon using the etalon vertical and horizontal adjustments on the rear mirror mount adjacent to the rear mirror adjustment controls. Continue to scan until lasing occurs.

6. When lasing occurs, continue scanning on one axis while observing the output power indication on the Remote Control Module power meter.

7. While scanning in one direction, one mode will cause lasing to stop and another mode, of higher or lower power level, will cause lasing to commence. Determine the highest power mode by scanning in both directions, then fine-adjust to that mode.

8. Perform Steps 5 and 6 on the opposite axis.

9. When the laser has been tuned to the highest power mode, detune the etalon on the axis equivalent to the axis of polarization until single-frequency operation is achieved.

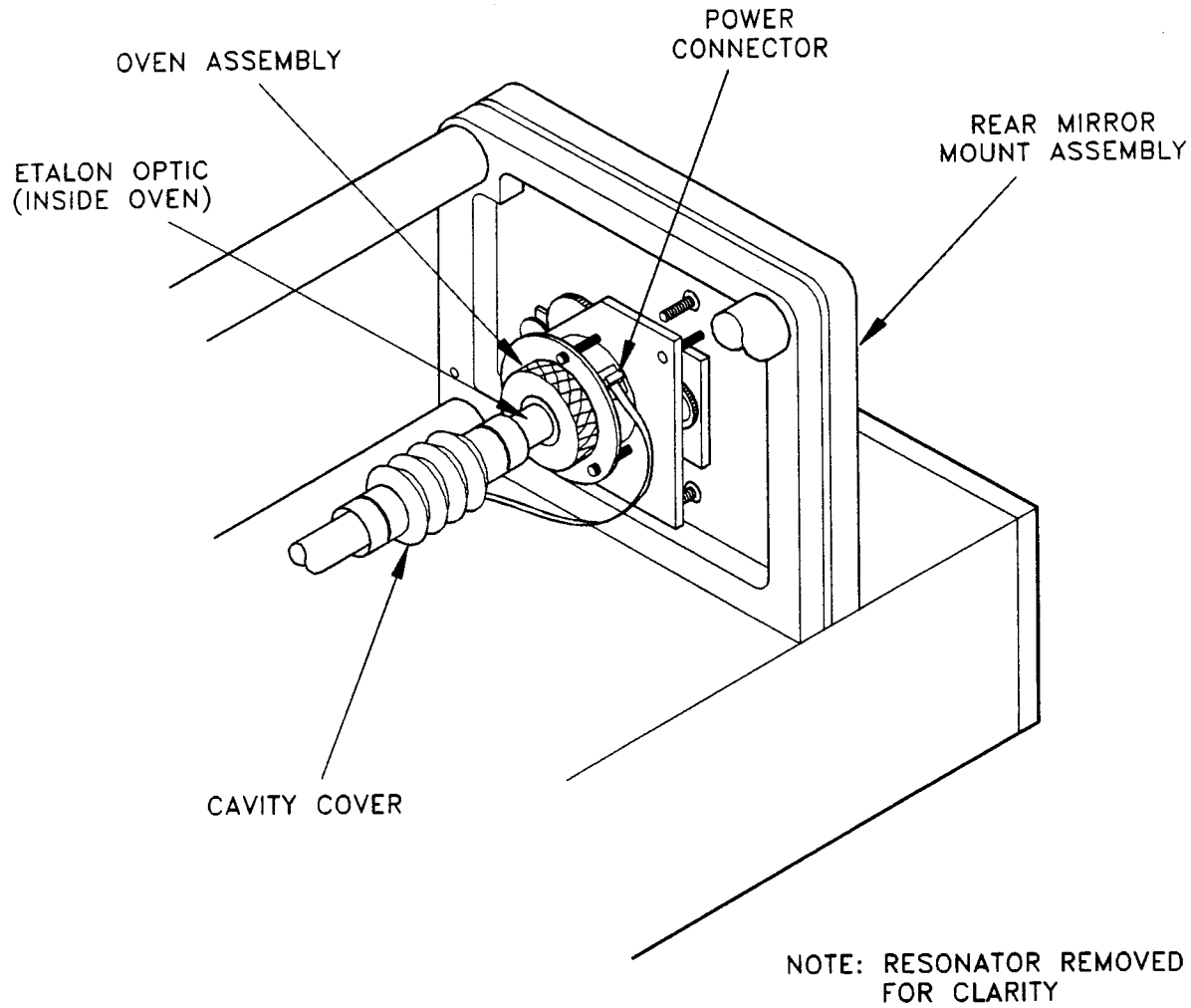


Figure B-2-1 Etalon Assembly

APPENDIX B-3

ULTRAVIOLET OPTICS

B-3.1 GENERAL

Argon and krypton ultraviolet lasers include special laser tubes designed to enhance ultraviolet output power. Ultraviolet and visible optics sets are both provided with the system. Two photodiode assemblies (Figure B-3-1), one for visible and one for ultraviolet operation, complete the system.

B-3.2 CHANGEOVER

When switching from ultraviolet to visible operations, and vice versa, the following procedure should be followed:

1. Shut down the laser system and remove the head cover.

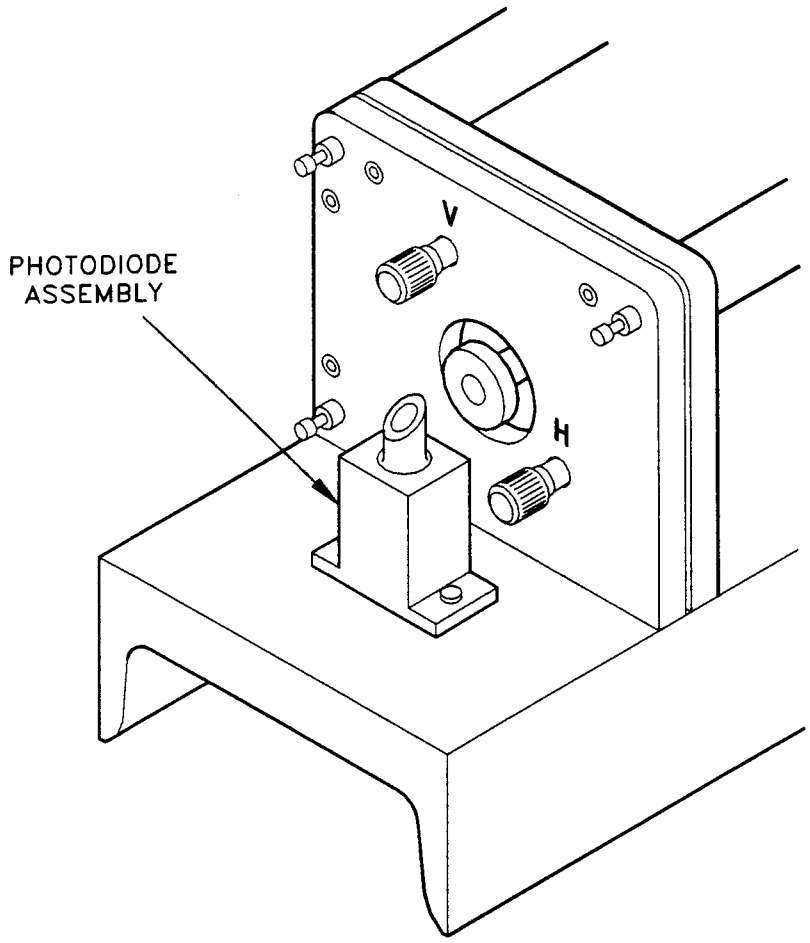
2. Clean the optics to be installed as described in Section 5-3. Remove the other optics set. Clean the brewster windows. Install the optics to be used.

3. Carefully remove the photodiode assembly by pulling it upwards. It is attached to the rail by a plug and socket connection. The photodiode assemblies are labeled as to whether they are designed for visible or ultraviolet operation.

NOTE

The photodiode assembly is tuned to particular power levels and wavelengths. Failure to use the correct assembly may affect the suppression of optical noise and cause inaccuracies in the measurement and display of output power on the Remote Control Module.

4. Remove the cover and follow normal start-up and operating procedures.



8-334-91

Figure B-3-1 Front Mirror Mount

APPENDIX B-4

RS-232 SERIAL INTERFACE

B-4-1 INTRODUCTION

The Model 851 Power Supply may be controlled through either the standard Remote Control Module or through any external device which provides an RS-232 interface. When using the RS-232 interface, the standard Remote Control Module must be disconnected and the optional RS-232 interface cable connected to the power supply front panel.

Using the RS-232 interface, Electronics Unit functions may be controlled and operating status interrogated by a remote computer system. A command or querry must always be initiated by the customer's equipment and must wait for the power supply to respond before a new command or querry issued. The power supply will not accept a second command or querry until it responds to the first nor will it initiate any communications.

All communications between the user's equipment and the power supply consists of ASCII data. Each command or interrogation must be terminated with a carriage return (0D hex). All responses from the power supply are terminated with a carriage return. (All line feeds, 0A hex, are ignored by the supply.)

Examples:

ON<CR>	(User command)
OK<CR>	(Power supply response)
?PWR<CR>	(User querry)
35.4<CR>	(Power supply response)

B-4-2 ELECTRICAL INTERFACE

An optional RS-232 interconnect cable is required in order to control the power supply by an external RS-232 control device. Use of any cable other than that specified by IOLIGHT voids all warranties and may cause serious damage to the power supply and user's equipment.

Table B-4-I provides a listing of pin assignments for the 25-pin RS-232 connector attached to one end of the optional RS-232 interconnect cable. RS-232 interface operation requires that the user's equipment be configured for 2400 BAUD, NO PARITY, 8 DATA BITS, and 1 STOP BIT. Data sent to the power supply is not echoed back to the user.

Table B-4-I. RS-232 Pin Assignments

Pin	Description
1	Protective ground
2	Transmitted data (data to power supply)
3	Received data (data from power supply)
7	Signal ground

The RS-232 interface is specified for operation at distances up to 50 feet. Operation at distances greater than 50 feet may be achievable in some circumstances but depends on the capabilities of the user's equipment, type of cable provided to user's equipment and the electrical noise levels within the immediate environment. Operation of the RS-232 interface at distances greater than 50 feet is not recommended.

B-4-3 USER COMMANDS/QUERRIES

The Model 851 Power Supply will respond to the following commands and querries. Any command sent to the power supply which is not listed will result in an error message response. Commands and querries must be in the exact format specified and must be in UPPER CASE text.

CUR

Name **CUR** - set tube current level in current control mode

Usage CUR=nn.n<CR>

Description Sets the tube current to nn.n Amperes. This command is executed only if the supply is in the current control mode. If this command is issued while the supply is in power control mode, an error message is returned. Tube current will not be permitted to exceed the maximum allowable tube current, nor will it be permitted to fall below the idle current specified for the head. For example, if the user commands the tube current to 50.0 Amps and the maximum allowable tube current is 35.0 Amps, the power supply will set the tube current to 35.0 Amps in response to the command.

Return Value OK<CR> - Normal return.

ERR nn... - See Table B-4-II for a description of error codes.

ETALON

Name **ETALON** - enables/disables etalon stabilization heater

Usage ETALON=ON<CR>
ETALON=OFF<CR>

Description Turns the etalon stabilization heater either ON or OFF. After the etalon stabilization heater is turned ON, the temperature of the etalon will stabilize within approximately 5 minutes and is then maintained at a level determined by the setting of the etalon temperature control located on the rear panel of the power supply electronics unit. Turning the etalon stabilization heater OFF will disable the etalon heater and the etalon temperature will drop to the ambient temperature within the laser head.

Return Value OK<CR> - Normal return.

FILL

Name **FILL** - activate tube refill cycle one time

Usage FILL<CR>

Description The FILL command places the laser in CURRENT control mode, sets the tube current to IDLE, measures the tube voltage, and if the tube voltage is less than the specified minimum, cycles the refill valves one time. If the tube voltage is within specification, this command will return without activating the refill valves. Once this command has been issued, further FILL

commands will be ignored for approximately 5 minutes while tube pressure and tube voltage stabilize. Issueing a FILL command will increase the tube gas pressure and increase the tube voltage approximately 10 volts at maximum current. The FILL command will place the laser in CURRENT mode and will set and leave the current at IDLE.

Return value OK<CR> - Normal return.

ERR nn... - See Table B-4-II for a description of error codes.

MODE

Name **MODE** - set the operating mode of the power supply

Usage MODE=CUR<CR>
MODE=PWR<CR>

Description Sets the power supply control mode to either current (CUR) or power (PWR). In current mode, the power supply regulates the current flowing through the tube and maintains constant current. In power mode, the power supply regulates the current flowing through the tube to maintain a constant output power level. If the power supply is in current mode, the command MODE=CUR will have no effect. Similarly, if the power supply is in power mode, the command MODE=PWR will have no effect.

If the power supply is in current mode and the output power is above the head's rated power when the MODE=PWR command is issued, the power supply will go into power control mode and will reduce the output power of the laser to the head's rated power.

Return value OK<CR> - Normal return.

ERR nn... - Returned if a fault or abnormal condition is detected during mode transition. See Table B-4-II for a description of error codes.

OFF

Name **OFF** - turn off laser emission/reset fault

Usage OFF<CR>

Description The OFF command turns off the tube and stops all laser emission. This command does NOT turn off power to the laser power supply. An OFF command must be issued after first applying power to the Electronics Unit before the laser may be started. It must also be issued after any fault is detected to reset the EU fault logic.

Return value OK<CR>

ON

Name **ON** - turns on the laser tube

Usage ON<CR>

Description The ON command initiates the 30-second laser ignition sequence. During this sequence, the following events take place:

1. Filament and Anode (High) voltage is applied to the tube.
2. Power supply is placed into the current control mode and the tube current is set for idle.
3. Solenoid field current is driven to maximum and the front panel solenoid field current control is disabled. The front panel control will remain disabled for approximately 3 minutes after tube start. At that time, control will be returned to the front panel solenoid field control.
4. Solenoid field current is measured. If the solenoid field current is less than the minimum required for start, the start sequence will be aborted and an error message returned.
5. Anode voltage is measured. If the anode voltage is less than the specified minimum or greater than the specified maximum for the head, the start sequence will be aborted and an error message will be returned. The error message indicates that the line voltage to the power supply is out of range.
6. All interlocks and prestart flags are checked. Any error condition will cause the start cycle to abort and an error code (ERR nn) return.
7. 30 seconds after the ON command is received, a start pulse will be applied to the tube. If the tube does not start within 5 seconds after applying the start pulse, the start sequence will be aborted and an error message will be returned. If the tube ignites when the start pulse is applied, an OK message will be returned.

Returned value

OK<CR> - Returned approximately 30 seconds after the ON command is issued and the tube is sucessfully started.

ERR nn... - Returned immediately upon detection of a fault or abnormal condition. Also returned if tube does not start within allowed time. See Table B-4-II for a description of error codes.

PWR

Name **PWR** - set output power level in power control mode

Usage PWR=nn.n<CR>
PWR=n.nn<CR>

Description Sets the output power level if the power supply is in power control mode. If the power supply is in current control mode, this command is ignored and OK is returned. If nn.n (or n.nn) exceeds the rated power of the laser head, the output power will be set at the laser head's rated output. If nn.n (or n.nn) is less than the power rating of the laser head at idle current, the power output of the laser will be set to the idle current power output level.

Returned value OK<CR> - Normal return.

ERR nn... - Fault or abnormal condition detected. See Table B-4-II.

?CUR

Name **?CUR** - report measured tube current

Usage ?CUR<CR>

Description Requests the power supply to measure and report the current through the laser tube. This query may be issued at any time. The value returned is the measure tube current in Amperes.

Return value nn.n<CR>

?ET

Name **?ET** - report tube voltage

Usage ?ET<CR>

Description Measures and reports the tube voltage in volts.

Return value nnn<CR>

?ETALON

Name **?ETALON** - report etalon heater status

Usage ?ETALON<CR>

Description Reports whether the etalon stabilization heater is on or off.

Return value ON<CR>
OFF<CR>

?FLOW

Name **?FLOW** - measure and report water flow rate

Usage ?FLOW<CR>

Description Measure and report the water flow rate through the power supply. The flow rate is reported as n.n gallons/minute.

Return value n.n<CR>

?HEAD

Name **?HEAD** - report programmed head data

Usage ?HEAD<CR>

Description Reads the head operating parameters stored within the head and sends the data back to the user according to the following structure:

n...n<CR>	-	Head serial number (solenoid number)
nn/nn/nn<CR>	-	Date of manufacture
a...a<CR>	-	Model number (10-character text field)
a...a<CR>	-	Type (ARGON, CRYPTON, etc)
nn.n<CR>	-	Power rating (in watts)
nn.n<CR>	-	Idle power (in watts)
nnn<CR>	-	Tube current limit (amps)
nn<CR>	-	Tube idle current (amps)
nn.n<CR>	-	Solenoid upper current limit (amps)
nn.n<CR>	-	Solenoid lower current limit (amps)
nnn<CR>	-	Tube voltage upper limit (volts at idle current)
nnn<CR>	-	Tube voltage lower limit (volts at idle current)
n.n<CR>	-	Filament voltage upper limit (volts)
n.n<CR>	-	Filament voltage lower limit (volts)
nnn<CR>	-	Anode voltage upper limit (volts before start)
nnn<CR>	-	Anode voltage lower limit (volts before start)
nnnnn.n<CR>	-	Cumulative elapsed time (hours)
hh<CR>	-	Head configuration (hex)

?INLK

Name **?INLK** - report interlock status

Usage ?INLK<CR>

Description This command causes the current status of the interlock chain to be reported. The interlock status is reported as two hexadecimal characters. The two hex characters represent a 8-bit status field with each bit corresponding to a particular interlock. A 0 in the bit field represents a closed (good) interlock condition. A 1 in the bit field represents an open interlock condition.

Bit	Interlock Description
7	Moisture Detector
6	Head Cover Interlock
5	Remote RCC Interlock
4	Excess FET Power Dissipation Detector
3	Water Temperature Detector
2	Water Flow Rate Detector
1	Tube Bypass Ignition Detector
0	Overcurrent Fault

Return value hh<CR>

?ISOL

Name **?ISOL** - measure and report solenoid field current

Usage ?ISOL<CR>

Description Commands the power supply to measure and report the solenoid field current in Amperes.

Return value nn.n<CR>

?MODE

Name **?MODE** - report power supply control mode

Usage ?MODE<CR>

Description Reports the current power supply control mode.

Return value
CUR<CR> - Power supply is in current control mode.
PWR<CR> - Power supply is in power control mode.

?PWR

Name **?PWR** - measure and report laser output power

Usage ?PWR<CR>

Description Commands the power supply to measure and report the laser output power in Watts.

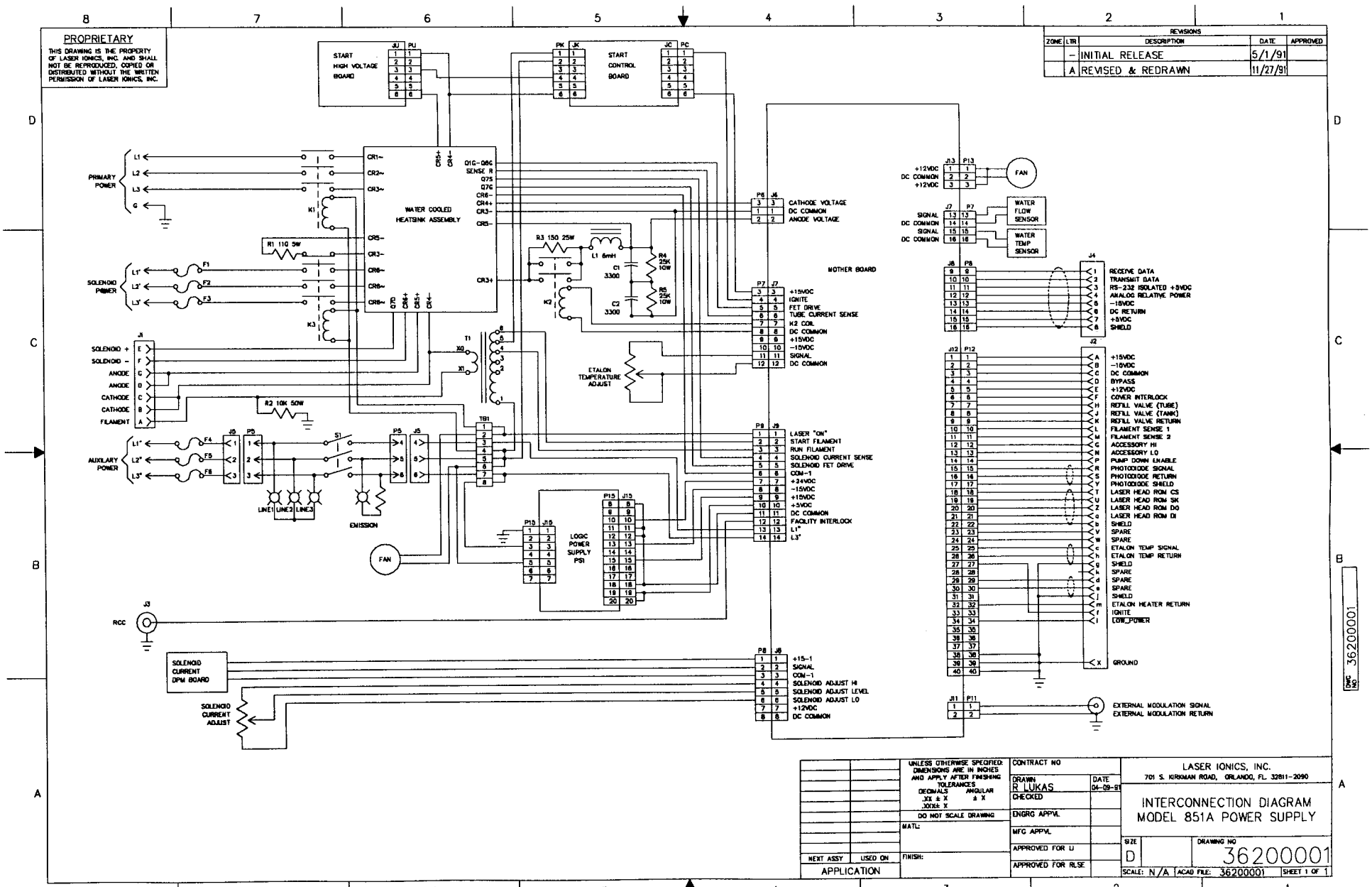
Return value
nn.n<CR> - If the rated power is >= 10.0 watts.
n.nn<CR> - If the rated power is < 10.0 watts.

Table B-4-II RS-232 Error Codes

ERR 01 - PRIMARY VOLTAGE LOW
ERR 02 - PRIMARY VOLTAGE HIGH
ERR 03 - SOLENOID CURRENT LOW
ERR 04 - SOLENOID CURRENT HIGH
ERR 05 - RESERVED
ERR 06 - TIMEOUT ON TUBE START
ERR 07 - POWER SUPPLY FAULT
ERR 08 - RESERVED
ERR 09 - RESERVED
ERR 10 - HEAD COVER INTERLOCK
ERR 11 - REMOTE RCC
ERR 12 - EXCESS POWER
ERR 13 - WATER TEMPERATURE
ERR 14 - WATER FLOW FAULT
ERR 15 - BYPASS IGNITION
ERR 16 - OVERCURRENT FAULT
ERR 17 - COMMUNICATIONS ERROR
ERR 18 - TUBE VOLTAGE TOO HIGH
ERR 19 - TUBE VOLTAGE TOO LOW
ERR 20 - ABSOLUTE TUBE VOLTAGE LIMIT EXCEEDED
ERR 21 - RESERVED
ERR 22 - CHECK INPUT VOLTAGE LEVELS
ERR 23 - CHECK WATER CONNECTIONS
ERR 24 - RESERVED
ERR 25 - TUBE CURRENT DROPOUT
ERR 26 - INVALID HEAD DATA
ERR 27 - INVALID COMMAND (RS-232)
ERR 28 - INVALID CHARACTER IN NUMERIC FIELD
ERR 29 - POWER CONTROL MODE ACTIVE. COMMAND IGNORED
ERR 30 - CURRENT CONTROL MODE ACTIVE. COMMAND IGNORED
ERR 31 - REFILL NOT REQUIRED
ERR 32 - TUBE REFILLED WITHIN LAST 5 MINUTES
ERR 33 - TUBE CURRENT LIMIT REACHED IN POWER MODE

APPENDIX C

SCHEMATIC DIAGRAMS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REVISIONS
ZONE | LTR | DESCRIPTION | DATE | APPROVED
– | INITIAL RELEASE | 5/1/91
A | REVISED & REDRAWN | 11/27/91
START HIGH VOLTAGE BOARD
START CONTROL BOARD
WATER COOLED HEATSINK ASSEMBLY
PRIMARY POWER
SOLENOID POWER
AUXILARY POWER
MOTHER BOARD
CATHODE VOLTAGE
DC COMMON
ANODE VOLTAGE
+15VDC
IGNITE
FET DRIVE
TUBE CURRENT SENSE
H2 COIL
DC COMMON
+15VDC
-15VDC
SIGNAL
DC COMMON
ETALON TEMPERATURE ADJUST
LASER "ON"
START FILAMENT
RUN FILAMENT
SOLENOID CURRENT SENSE
SOLENOID FET DRIVE
COM-1
+24VDC
-15VDC
+15VDC
+5VDC
DC COMMON
FACILITY INTERLOCK
L1*
L3*
LOGIC POWER SUPPLY PS1
FAN
WATER FLOW SENSOR
WATER TEMP SENSOR
RECEIVE DATA
TRANSMIT DATA
RS-232 ISOLATED +8VDC
ANALOG RELATIVE POWER
-18VDC
DC RETURN
+8VDC
SHIELD
+15VDC
-15VDC
DC COMMON
BYPASS
+12VDC
COVER INTERLOCK
REFILL VALVE (TUBE)
REFILL VALVE (TANK)
REFILL VALVE RETURN
FILAMENT SENSE 1
FILAMENT SENSE 2
ACCESSORY HI
ACCESSORY LO
PUMP DOWN ENABLE
PHOTODIODE SIGNAL
PHOTODIODE RETURN
PHOTODIODE SHIELD
LASER HEAD ROM CS
LASER HEAD ROM SK
LASER HEAD ROM DO
LASER HEAD ROM DI
SHIELD
SPARE
SPARE
ETALON TEMP SIGNAL
ETALON TEMP RETURN
SHIELD
SPARE
SPARE
SPARE
SHIELD
ETALON HEATER RETURN
IGNITE
LOW_POWER
GROUND
EXTERNAL MODULATION SIGNAL
EXTERNAL MODULATION RETURN
SOLENOID CURRENT DPM BOARD
SOLENOID CURRENT ADJUST
+15-1
SIGNAL
COM-1
SOLENOID ADJUST HI
SOLENOID ADJUST LEVEL
SOLENOID ADJUST LO
+12VDC
DC COMMON
EMISSION
LINE1 LINE2 LINE3
RCC
UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN INCHES AND APPLY AFTER FINISHING
TOLERANCES
DECIMALS .XX ± X .XXX± X
ANGULAR ± X
DO NOT SCALE DRAWING
MATL:
FINISH:
NEXT ASSY
USED ON
APPLICATION
CONTRACT NO
DRAWN R LUKAS
DATE 04-09-91
CHECKED
ENGRG APPVL
MFG APPVL
APPROVED FOR LI
APPROVED FOR RLSE
LASER IONICS, INC.
701 S. KIRKMAN ROAD, ORLANDO, FL. 32811-2090
INTERCONNECTION DIAGRAM
MODEL 851A POWER SUPPLY
SIZE D
DRAWING NO 36200001
SCALE: N/A
ACAD FILE: 36200001
SHEET 1 OF 1
DWG NO 36200001

REVISIONS				
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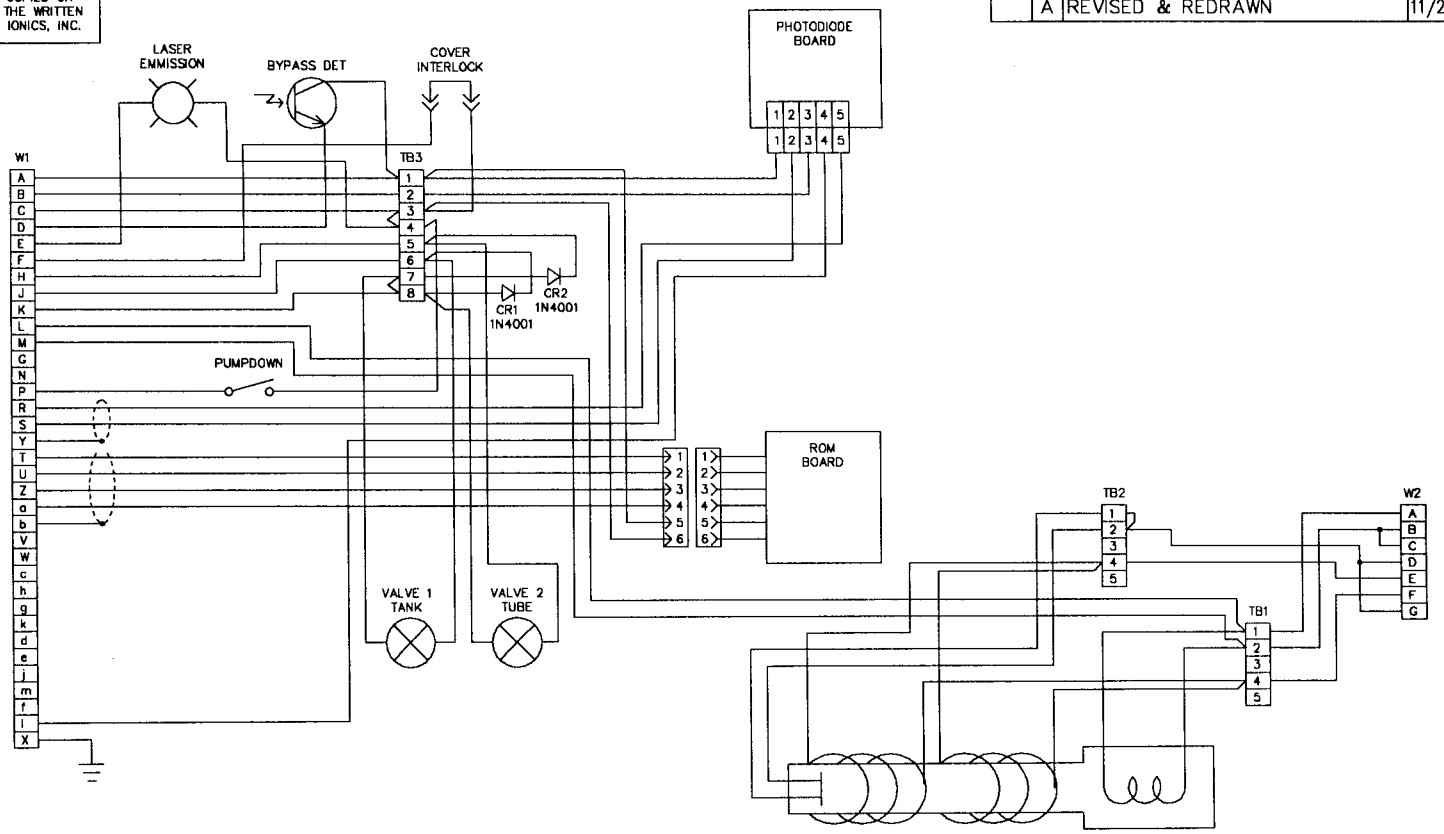
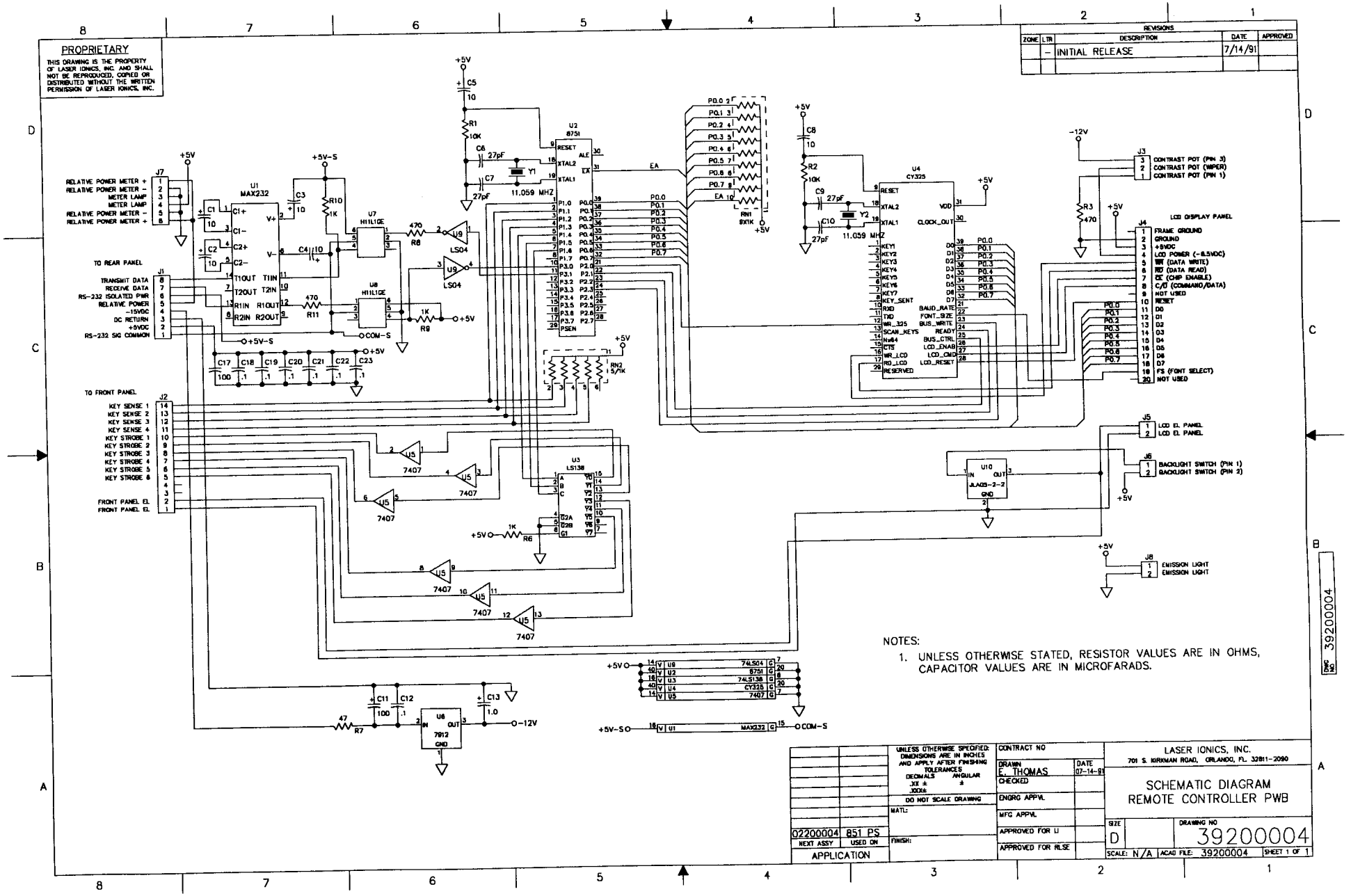
	–	INITIAL RELEASE		
	A	REVISED & REDRAWN	11/27/91	EKT



DWG NO 36200003

		UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN INCHES AND APPLY AFTER FINISHING TOLERANCES DECIMALS .XX ± N/A .XXX± N/A ANGULAR ± N/A	CONTRACT NO	LASER IONICS, INC. 701 S. KIRKMAN ROAD, ORLANDO, FL. 32811-2090
			DRAWN R LUKAS DATE 05-08-91	INTERCONNECTION DIAGRAM MODEL 1401 LASER HEAD
		DO NOT SCALE DRAWING	CHECKED	
		MATL:	ENGRG APPVL	
			MFG APPVL	
			APPROVED FOR LI	
NEXT ASSY	USED ON	FINISH:	APPROVED FOR RLSE	
APPLICATION				

SIZE C | DRAWING NO 36200003 | SCALE: N/A | ACAD FILE: 36200003 | SHEET 1 OF 1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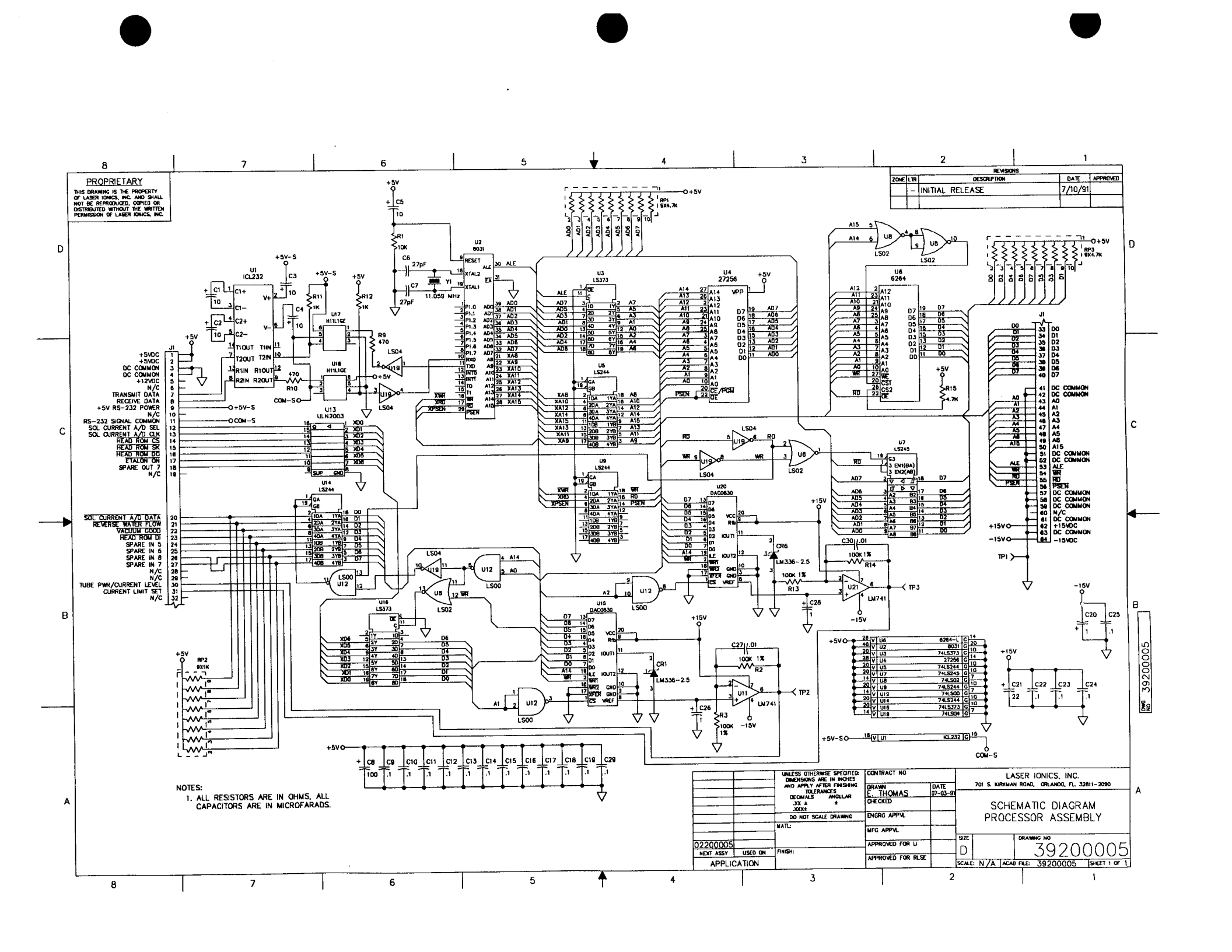
REVISIONS
ZONE | LTR | DESCRIPTION | DATE | APPROVED
– INITIAL RELEASE 7/14/91
U1 MAX232
U2 8751
U3 LS138
U4 CY325
U5 7407
U6 7912
U7 H11L1GE
U8 H11L1GE
U9 LS04
U10 JLA03-2-2
RN1 8X1K
RN2 5.7K
Y1 11.059 MHZ
Y2 11.059 MHZ
J1 TO REAR PANEL
J2 TO FRONT PANEL
J3 CONTRAST POT (PIN 3)
CONTRAST POT (WIPER)
CONTRAST POT (PIN 1)
J4 LCD DISPLAY PANEL
J5 LCD EL PANEL
J6 BACKLIGHT SWITCH (PIN 1)
BACKLIGHT SWITCH (PIN 2)
J8 EMISSION LIGHT
J7 RELATIVE POWER METER +
RELATIVE POWER METER –
METER LAMP
METER LAMP
RELATIVE POWER METER –
RELATIVE POWER METER +
TRANSMIT DATA
RECEIVE DATA
RS-232 ISOLATED PWR
RELATIVE POWER -15VDC
DC RETURN +5VDC
RS-232 SIG COMMON
KEY SENSE 1
KEY SENSE 2
KEY SENSE 3
KEY SENSE 4
KEY STROBE 1
KEY STROBE 2
KEY STROBE 3
KEY STROBE 4
KEY STROBE 5
KEY STROBE 6
FRONT PANEL EL
FRONT PANEL EL
NOTES:
1. UNLESS OTHERWISE STATED, RESISTOR VALUES ARE IN OHMS, CAPACITOR VALUES ARE IN MICROFARADS.
UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN INCHES AND APPLY AFTER FINISHING
TOLERANCES DECIMALS .XX ± .XXX± ANGULAR ±
DO NOT SCALE DRAWING
MATL:
FINISH:
02200004 NEXT ASSY
851 PS USED ON
APPLICATION
CONTRACT NO
DRAWN E. THOMAS DATE 07-14-91
CHECKED
ENGRG APPVL
MFG APPVL
APPROVED FOR LI
APPROVED FOR RLSE
LASER IONICS, INC.
701 S. KIRKMAN ROAD, ORLANDO, FL. 32811-2090
SCHEMATIC DIAGRAM
REMOTE CONTROLLER PWB
SIZE D
DRAWING NO 39200004
SCALE: N/A ACAD FILE: 39200004 SHEET 1 OF 1
39200004 REV A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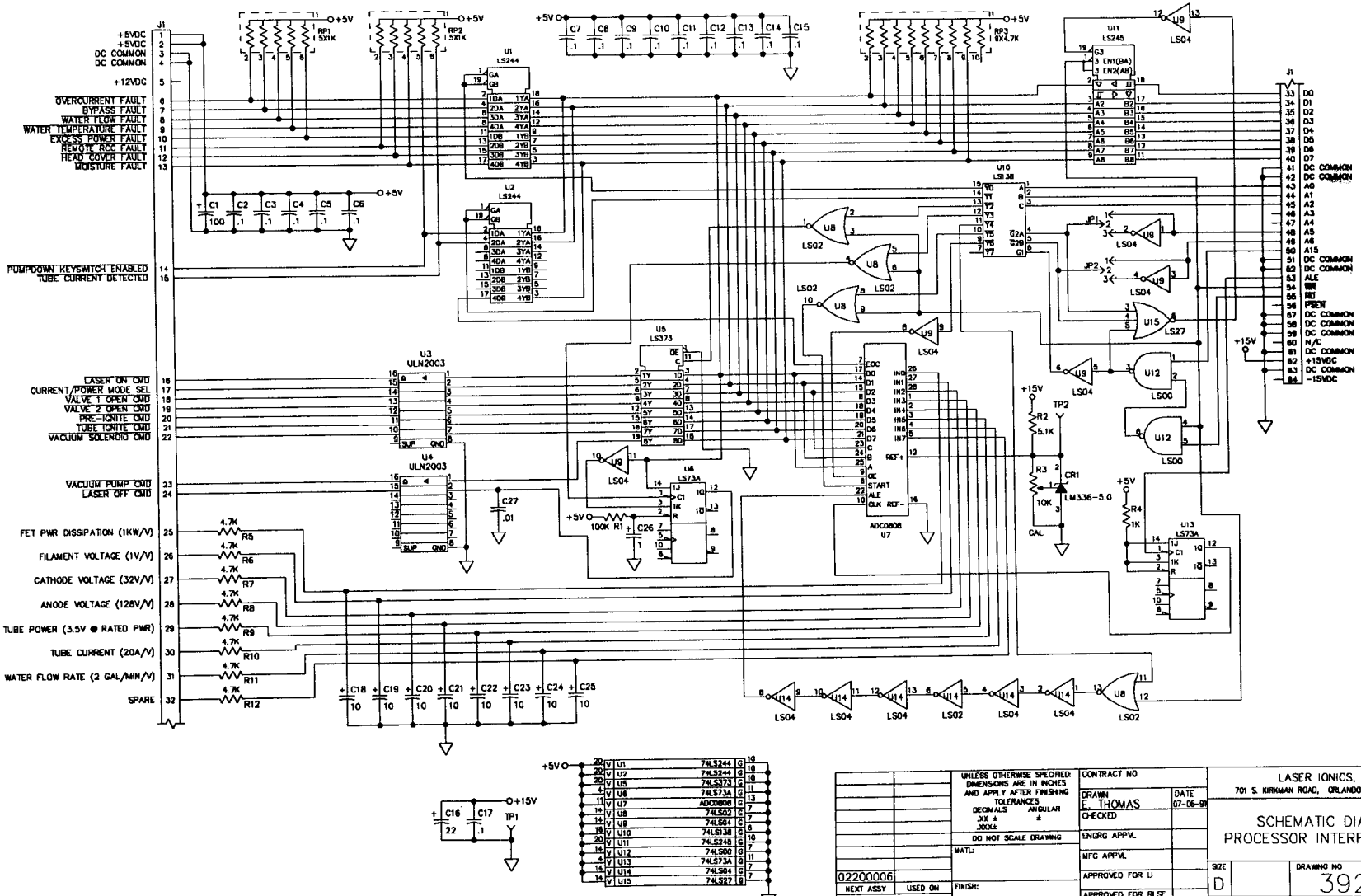
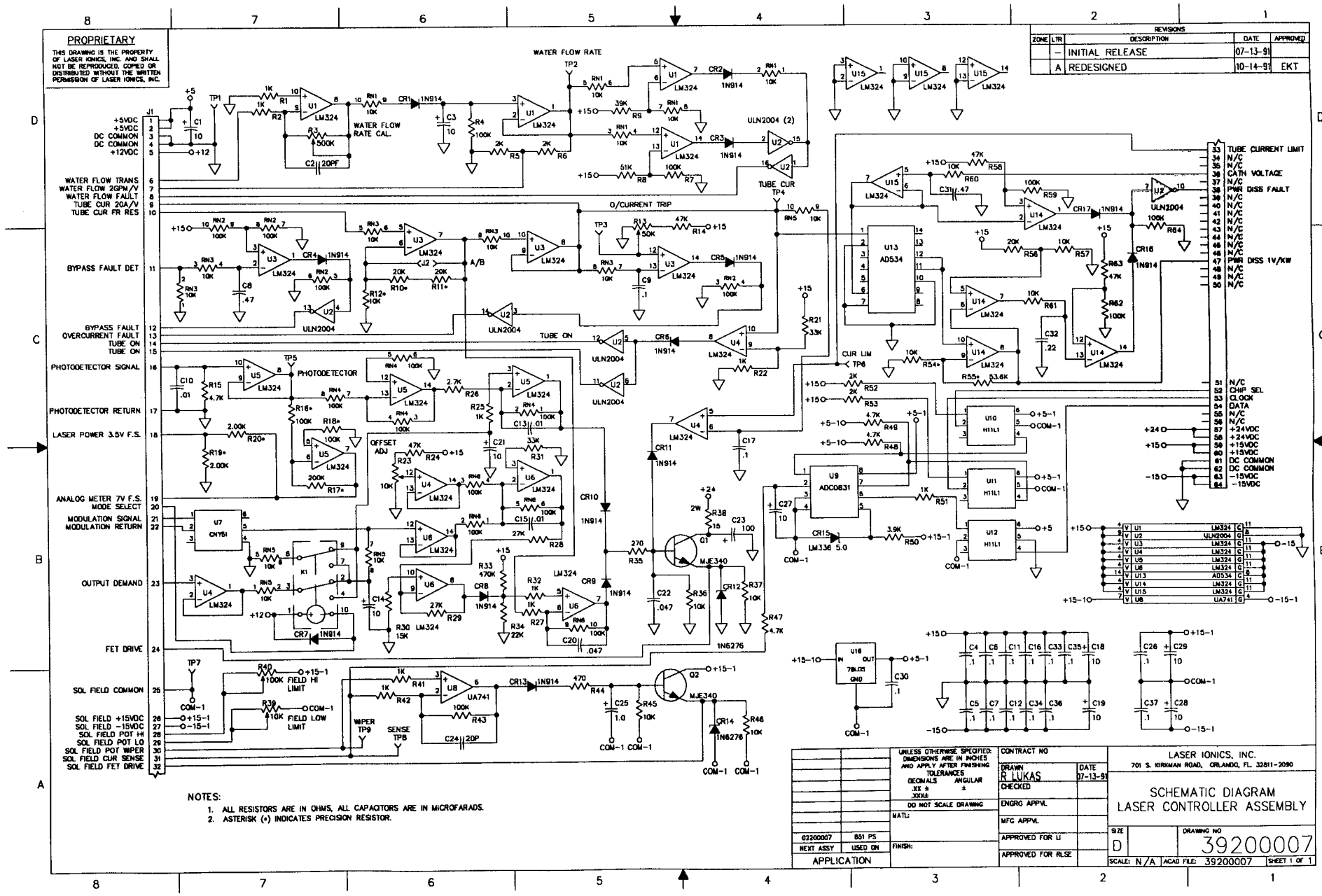
REVISIONS
ZONE LTR DESCRIPTION DATE APPROVED
- INITIAL RELEASE 7/10/91
NOTES:
1. ALL RESISTORS ARE IN OHMS, ALL CAPACITORS ARE IN MICROFARADS.
UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN INCHES AND APPLY AFTER FINISHING TOLERANCES DECIMALS .XX ± .XXX± ANGULAR ±
DO NOT SCALE DRAWING
MATL:
FINISH:
02200005
NEXT ASSY USED ON
APPLICATION
CONTRACT NO
DRAWN E. THOMAS DATE 07-03-91
CHECKED
ENGRG APPVL
MFG APPVL
APPROVED FOR LI
APPROVED FOR RLSE
LASER IONICS, INC.
701 S. KIRKMAN ROAD, ORLANDO, FL. 32811-2090
SCHEMATIC DIAGRAM
PROCESSOR ASSEMBLY
SIZE D
DRAWING NO 39200005
SCALE: N/A ACAD FILE: 39200005 SHEET 1 OF 1
DWG NO 39200005

REVISIONS				
ZONE	LTR	DESCRIPTION	DATE	APPROVED
	–	INITIAL RELEASE	7/7/91	



UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN INCHES AND APPLY AFTER FINISHING. TOLERANCES: DECIMALS .XX ± .XXX± ANGULAR ± DO NOT SCALE DRAWING	CONTRACT NO	LASER IONICS, INC. 701 S. KIRKMAN ROAD, ORLANDO, FL. 32811-2090	
	DRAWN E. THOMAS	DATE 07-06-91	SCHEMATIC DIAGRAM PROCESSOR INTERFACE ASSY
	CHECKED		
	ENGRG APPVL		
MATL:	MFG APPVL		
FINISH:	APPROVED FOR LI		SIZE D — DRAWING NO 39200006
02200006 NEXT ASSY / USED ON: APPLICATION	APPROVED FOR RLSE		SCALE: N/A — ACAD FILE: 39200006 — SHEET 1 OF 1

DWG NO 39200006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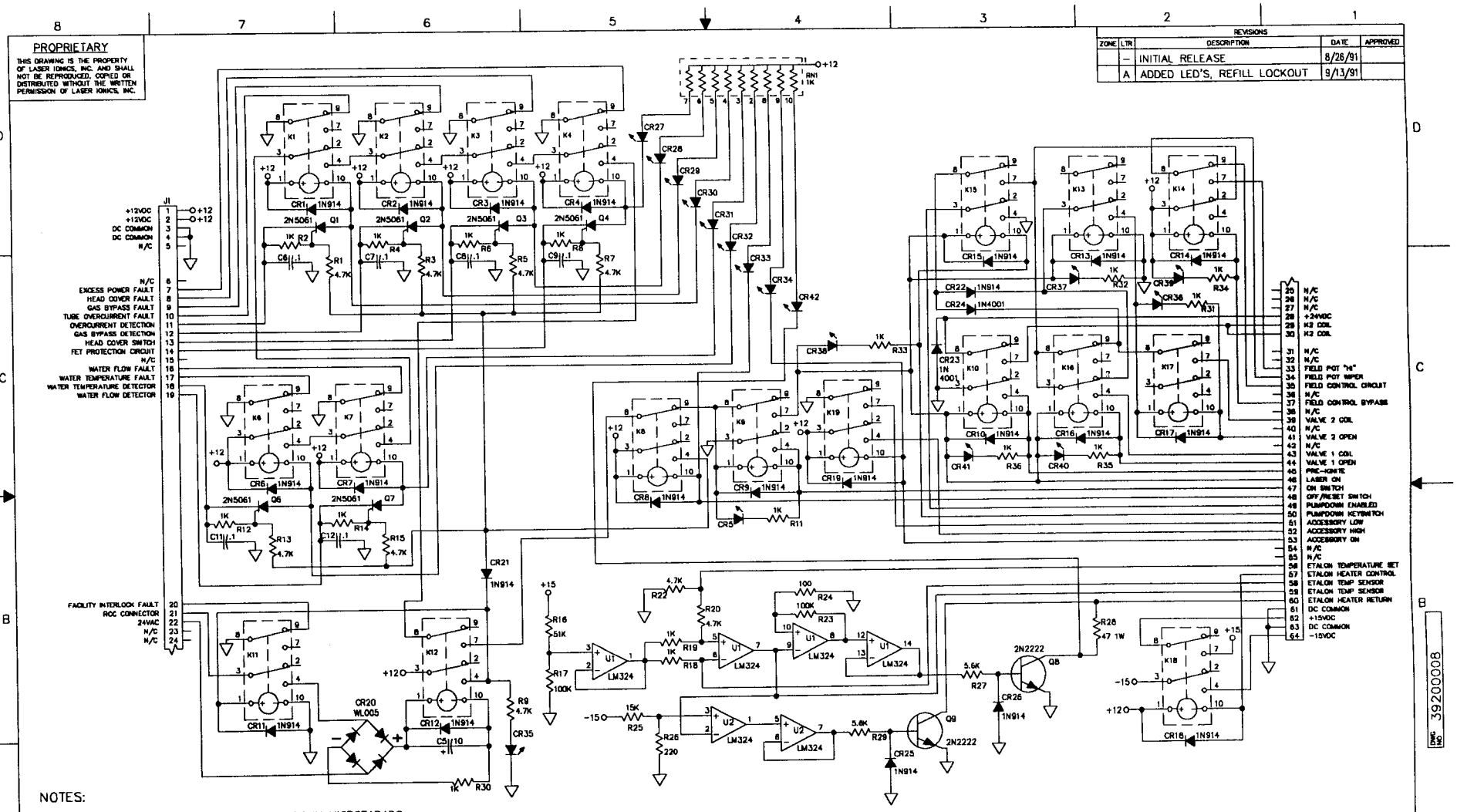
REVISIONS
ZONE LTR DESCRIPTION DATE APPROVED
– INITIAL RELEASE 07-13-91
A REDESIGNED 10-14-91 EKT
WATER FLOW RATE
WATER FLOW RATE CAL.
ULN2004 (2)
TUBE CUR
O/CURRENT TRIP
TUBE ON
CUR LIM
WATER FLOW TRANS
WATER FLOW 2GPM/V
WATER FLOW FAULT
TUBE CUR 20A/V
TUBE CUR FR RES
BYPASS FAULT DET
BYPASS FAULT
OVERCURRENT FAULT
TUBE ON
TUBE ON
PHOTODETECTOR SIGNAL
PHOTODETECTOR
PHOTODETECTOR RETURN
LASER POWER 3.5V F.S.
ANALOG METER 7V F.S.
MODE SELECT
MODULATION SIGNAL
MODULATION RETURN
OUTPUT DEMAND
FET DRIVE
SOL FIELD COMMON
SOL FIELD +15VDC
SOL FIELD -15VDC
SOL FIELD POT HI
SOL FIELD POT LO
SOL FIELD POT WIPER
SOL FIELD CUR SENSE
SOL FIELD FET DRIVE
FIELD HI LIMIT
FIELD LOW LIMIT
WIPER TP9
SENSE TP8
OFFSET ADJ
TUBE CURRENT LIMIT
CHIP SEL
CLOCK
DATA
+24VDC
+15VDC
DC COMMON
-15VDC
NOTES:
1. ALL RESISTORS ARE IN OHMS, ALL CAPACITORS ARE IN MICROFARADS.
2. ASTERISK (*) INDICATES PRECISION RESISTOR.
UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN INCHES AND APPLY AFTER FINISHING
TOLERANCES DECIMALS .XX ± .XXX± ANGULAR ±
DO NOT SCALE DRAWING
MATL:
FINISH:
02200007 851 PS
NEXT ASSY USED ON
APPLICATION
CONTRACT NO
DRAWN R LUKAS DATE 07-13-91
CHECKED
ENGRG APPVL
MFG APPVL
APPROVED FOR LI
APPROVED FOR RLSE
LASER IONICS, INC.
701 S. KIRKMAN ROAD, ORLANDO, FL. 32811-2090
SCHEMATIC DIAGRAM
LASER CONTROLLER ASSEMBLY
SIZE D
DRAWING NO 39200007
SCALE: N/A ACAD FILE: 39200007 SHEET 1 OF 1
DWG NO 39200007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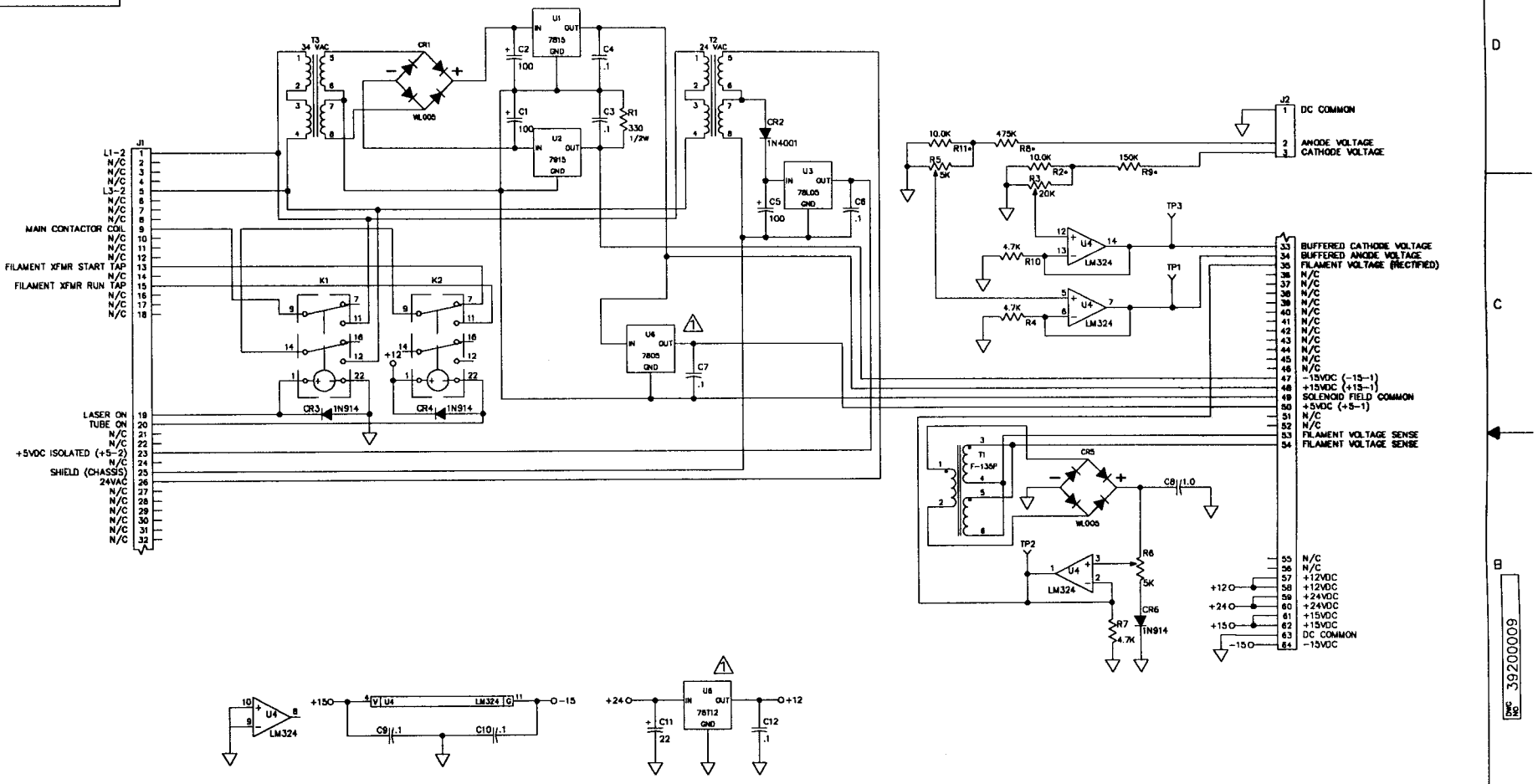
REVISIONS
ZONE LTR DESCRIPTION DATE APPROVED
– INITIAL RELEASE 8/26/91
A ADDED LED'S, REFILL LOCKOUT 9/13/91
+12VDC
+12VDC
DC COMMON
DC COMMON
N/C
EXCESS POWER FAULT
HEAD COVER FAULT
GAS BYPASS FAULT
TUBE OVERCURRENT FAULT
OVERCURRENT DETECTION
GAS BYPASS DETECTION
HEAD COVER SWITCH
FET PROTECTION CIRCUIT
WATER FLOW FAULT
WATER TEMPERATURE FAULT
WATER TEMPERATURE DETECTOR
WATER FLOW DETECTOR
FACILITY INTERLOCK FAULT
RCC CONNECTOR
24VAC
FIELD POT "HI"
FIELD POT WIPER
FIELD CONTROL CIRCUIT
FIELD CONTROL BYPASS
VALVE 2 COIL
VALVE 2 OPEN
VALVE 1 COIL
VALVE 1 OPEN
PRE-IONITE
LASER ON
ON SWITCH
OFF/RESET SWITCH
PUMPDOWN ENABLED
PUMPDOWN KEYSWITCH
ACCESSORY LOW
ACCESSORY HIGH
ACCESSORY ON
ETALON TEMPERATURE SET
ETALON HEATER CONTROL
ETALON TEMP SENSOR
ETALON TEMP SENSOR
ETALON HEATER RETURN
DC COMMON
+15VDC
DC COMMON
-15VDC
NOTES:
1. ALL RESISTORS IN OHMS, ALL CAPACITORS IN MICROFARADS
2. ALL RELAYS TYPE TQE-12D
3. Q5, R10, R21, C10, AND K5 NOT USED.
4. LAST REF. DES. USED: CR42, Q9, R36, C12, U2, AND K19.
UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN INCHES AND APPLY AFTER FINISHING
TOLERANCES
DECIMALS ANGULAR
.XX ± ±
.XXX±
DO NOT SCALE DRAWING
MATL:
FINISH:
G2200008 851 P/S
NEXT ASSY USED ON
APPLICATION
CONTRACT NO
DRAWN R. LUKAS DATE 08-26-91
CHECKED
ENGRG APPVL
MFG APPVL
APPROVED FOR U
APPROVED FOR RLSE
LASER IONICS, INC.
701 S. KIRKMAN ROAD, ORLANDO, FL. 32811-2090
SCHEMATIC DIAGRAM
RELAY CONTROL #1 ASSEMBLY
SIZE D
DRAWING NO 39200008
SCALE: N/A ACAD FILE: 39200008 SHEET 1 OF 1
DWG NO 39200008

REVISIONS				
ZONE	LTR	DESCRIPTION	DATE	APPROVED
	-	INITIAL RELEASE	5/25/91	



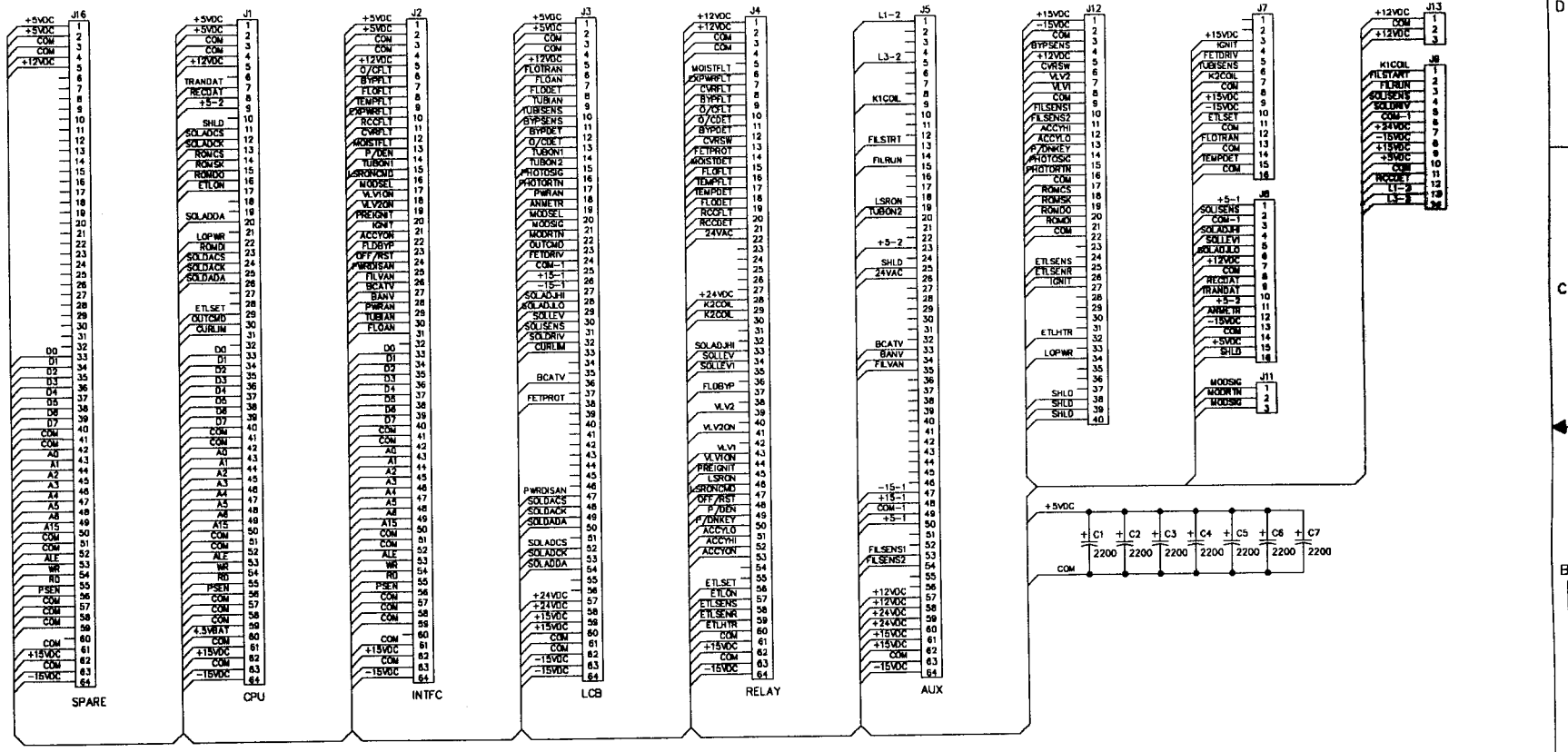
NOTES:

1. HEAT SINK REQUIRED
2. ALL RESISTORS IN OHMS
   ALL CAPACITORS IN MICROFARADS
3. ASTERISK (*) INDICATES PRECISION RESISTOR

		UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN INCHES AND APPLY AFTER FINISHING. TOLERANCES: DECIMALS .XX ± .XXX± ANGULAR ±	CONTRACT NO	LASER IONICS, INC. 701 S. KIRKMAN ROAD, ORLANDO, FL. 32811-2090
		DO NOT SCALE DRAWING	DRAWN R LUKAS DATE 05-29-91	SCHEMATIC DIAGRAM AUXILIARY CIRCUIT BOARD ASSY
		MATL:	CHECKED	
			ENGRG APPVL	
			MFG APPVL	
			APPROVED FOR LI	SIZE D DRAWING NO 39200009
		FINISH:	APPROVED FOR RLSE	SCALE: N/A ACAD FILE: 39200009 SHEET 1 OF 1
NEXT ASSY	USED ON	851 PS		
APPLICATION				

39200009

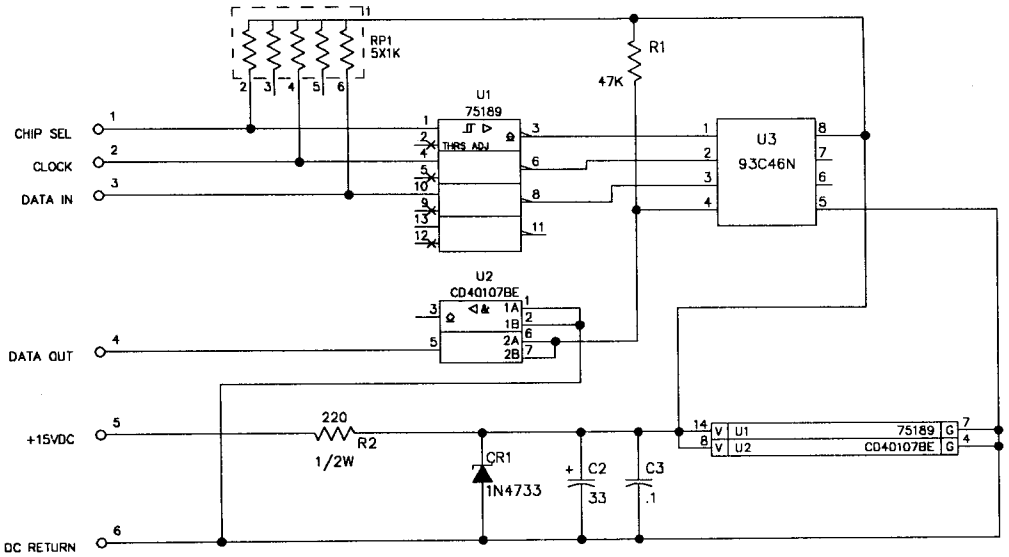
REVISIONS				
ZONE	LTR	DESCRIPTION	DATE	APPROVED



DWG 39200010

		UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN INCHES AND APPLY AFTER FINISHING. TOLERANCES: DECIMALS .XX ± X, .XXX ± X; ANGULAR ± X. DO NOT SCALE DRAWING	CONTRACT NO	LASER IONICS, INC. 701 S. KIRKMAN ROAD, ORLANDO, FL. 32811-2090
			DRAWN R LUKAS DATE 08-05-91	SCHEMATIC DIAGRAM MOTHERBOARD ASSEMBLY
			CHECKED	
			ENGRG APPVL	
		MATL:	MFG APPVL	
			APPROVED FOR U	SIZE D DRAWING NO 39200010
NEXT ASSY	USED ON	FINISH:	APPROVED FOR RLSE	SCALE: N/A ACAD FILE: 39200010 SHEET 1 OF 1
APPLICATION				

REVISIONS				
ZONE	LTR	DESCRIPTION	DATE	APPROVED
	–	INITIAL RELEASE	8/15/91	
	A	REPLACED U4 WITH CR1	11/27/91	



NOTES:

1. ALL RESISTORS ARE IN OHMS, ALL CAPACITORS ARE IN MICROFARADS.

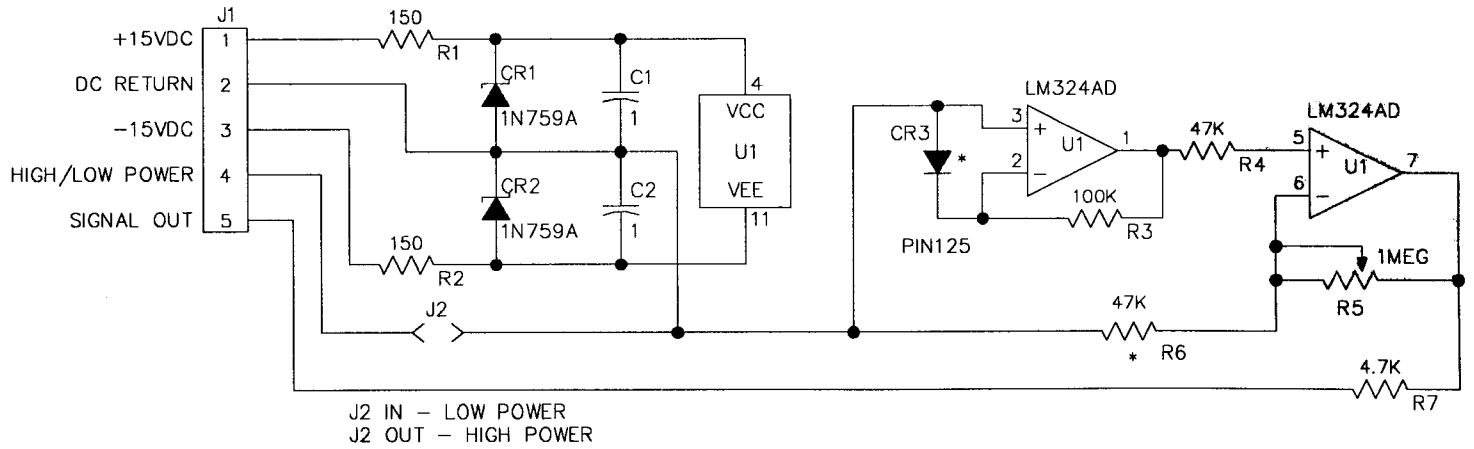
DWG NO 39200011

		UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN INCHES AND APPLY AFTER FINISHING TOLERANCES DECIMALS .XX ± .XXX± ANGULAR ±	CONTRACT NO	LASER IONICS, INC. 701 S. KIRKMAN ROAD, ORLANDO, FL. 32811-2090
			DRAWN E. THOMAS DATE 08-12-91	HEAD ROM ASSEMBLY SCHEMATIC DIAGRAM
		DO NOT SCALE DRAWING	CHECKED	
		MATL:	ENGRG APPVL	
			MFG APPVL	
02200011	851 PS	FINISH:	APPROVED FOR LI	SIZE C — DRAWING NO 39200011
NEXT ASSY	USED ON		APPROVED FOR RLSE	SCALE: NONE ACAD FILE: 39200011 SHEET 1 OF 1
APPLICATION				

REVISIONS				
ZONE	LTR	DESCRIPTION	DATE	APPROVED
	–	INITIAL RELEASE	6/11/91	
	A	CHG R7, ADD TABLE	9/17/91	

TABLE I – CONFIGURATION

DASH NO.	CR3	R6	APPLICATION
–001	PIN–125	47K	VISIBLE
–002	UV–215BQ	4.7K	UV



J2 IN – LOW POWER
J2 OUT – HIGH POWER

NOTES:

1. UNLESS OTHERWISE SPECIFIED, ALL RESISTORS ARE IN OHMS, ALL CAPACITORS ARE IN MICROFARADS.
2. COMPONENTS IDENTIFIED BY AN ASTERISK, (*), SHALL BE SELECTED IN ACCORDANCE WITH TABLE–I.

	1401–X
02200013	1400–X
NEXT ASSY	USED ON
APPLICATION	

UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN INCHES AND APPLY AFTER FINISHING
TOLERANCES
DECIMALS ANGULAR
.XX ± ±
.XXX ±
DO NOT SCALE THIS DRAWING
MATL
FINISH

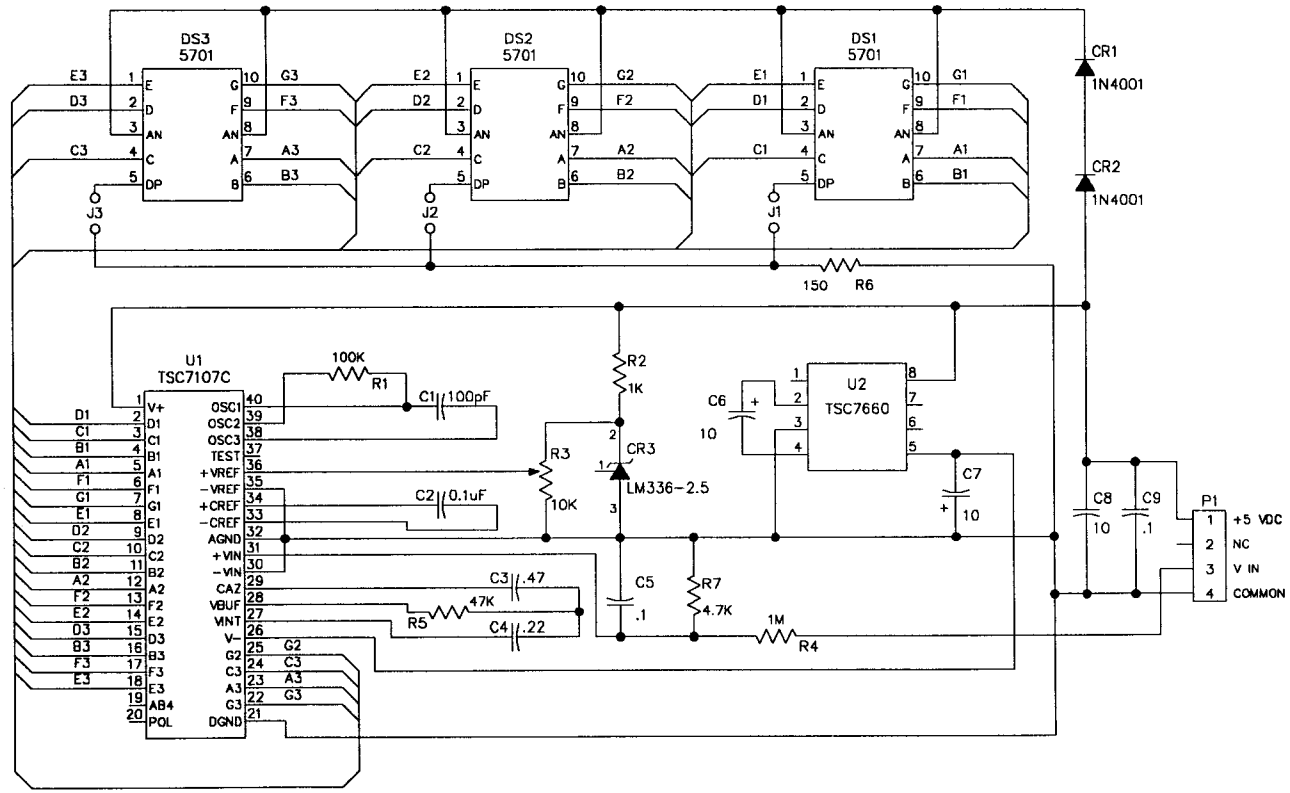
CONTRACT NO
DRAWN E. THOMAS DATE 06-11-91
CHECKED
ENGRG APPVL
MFG APPVL
APPROVED, LASER IONICS
APPROVED FOR RLSE

LASER IONICS, INC.
701 S. KIRKMAN ROAD, ORLANDO, FL. 32811–2090

AMPLIFIED PHOTODETECTOR ASSEMBLY

SIZE B | DRAWING NO 39200013
SCALE: N/A | ACAD FILE: 39200013 | SHEET 1 OF 1

REVISIONS				
ZONE	LTR	DESCRIPTION	DATE	APPROVED
	–	INITIAL RELEASE	10/7/91	
	A	ADDED R7	9/17/91	



NOTES:

1. UNLESS OTHERWISE SPECIFIED, ALL RESISTORS ARE IN OHMS, ALL CAPACITORS ARE IN MICROFARADS.

		UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN INCHES AND APPLY AFTER FINISHING TOLERANCES DECIMALS .XX ± .XXX± ANGULAR ±	CONTRACT NO	LASER IONICS, INC. 701 S. KIRKMAN ROAD, ORLANDO, FL. 32811-2090
			DRAWN E. THOMAS DATE 10/07/90	DIGITAL PANEL METER SCHEMATIC DIAGRAM
		DO NOT SCALE DRAWING	CHECKED	
		MATL:	ENGRG APPVL	
			MFG APPVL	
02150025	851 PS		APPROVED FOR LI	SIZE C DRAWING NO 39150025
NEXT ASSY	USED ON	FINISH:	APPROVED FOR RLSE	SCALE: NONE ACAD FILE: 39150025 SHEET 1 OF 1
APPLICATION				

DWG NO 39150025