Model 2020/2025

Ion Laser

User's Manual

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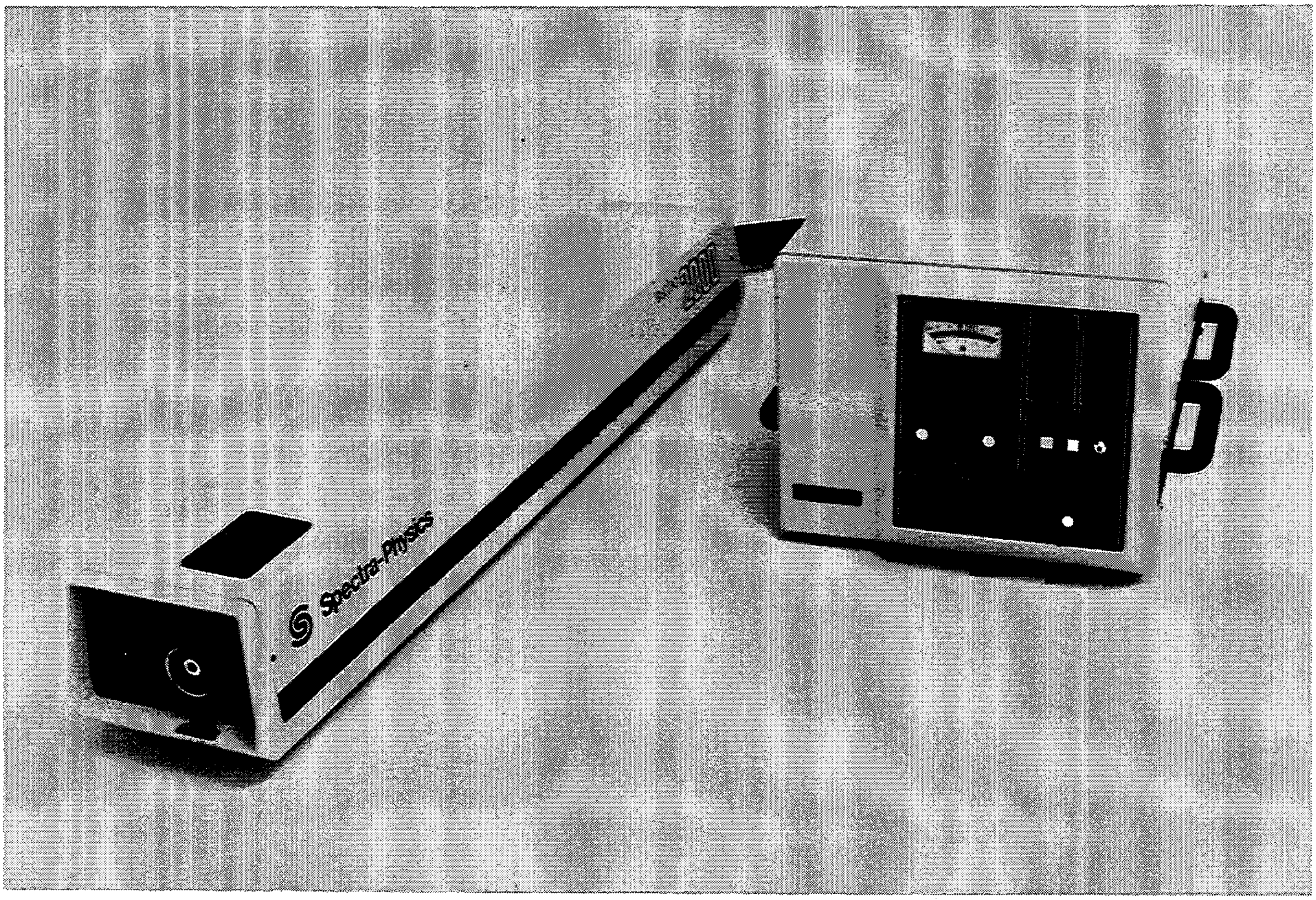
Part Number 0000-072A, Rev. B
April 1999



FRONTISPIECE: Spectra-Physics Series 2000 Ion Laser System

PREFACE

This manual contains information you will need for day-to-day operation and maintenance of your Series 2000 Ion Laser System. You will find instructions for installation, operation, routine maintenance, and such troubleshooting as can be done without removing the covers of the Model 2560 power supply. The manual also contains a section that describes external control of nearly all operations via optional RS232 or IEEE488 digital data links.

Thank you for buying Spectra-Physics instruments.

TABLE OF CONTENTS

TABLE OF CONTENTS (con't)

EXTERNAL CONTROL

MODEL 2270 REMOTE CONTROL

MAINTENANCE

SERVICE & REPAIR

TABLE OF CONTENTS (con't)

CUSTOMER SERVICE

LIST OF FIGURES

Figure #

LIST OF FIGURES (con't)

SI UNITS

The following System International (SI) units, abbreviations, and prefixes are used in Spectra-Physics manuals:

Quantity	Unit	Abbreviation	Prefixes		
mass	kilogram	kg	tera	(10^{12})	T
length	meter	m	giga	(10^{9})	G
time	second	s	mega	(10^{6})	M
frequency	hertz	Hz	kilo	(10^{3})	k
force	newton	N	deci	(10^{-1})	d
energy	joule	J	centi	(10^{-2})	c
power	watt	W	milli	(10^{-3})	m
electric current	ampere	A	micro	(10^{-6})	μ
electric charge	coulomb	C	nano	(10^{-9})	n
electric potential	volt	V	pico	(10^{-12})	p
resistance	ohm	Ω	femto	(10^{-15})	f
inductance	henry	H	atto	(10^{-18})	a
magnetic flux	weber	Wb			
magnetic flux density	tesla	T			
luminous intensity	candela	cd			
temperature	kelvin	K			

INTRODUCTION

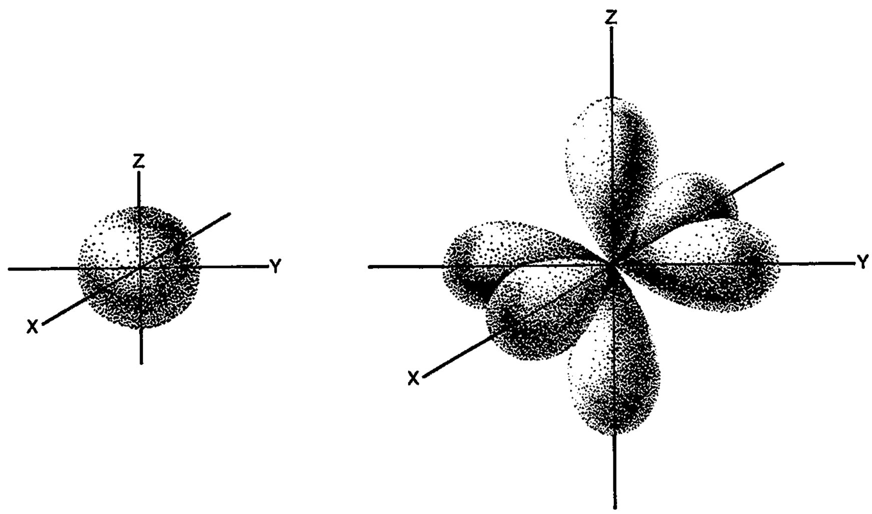


Figure 1.1: Electrons occupy distinct orbitals that are defined by the probability of finding an electron at a given position, the shape of the orbital being determined by the radial and angular dependence of the probability.

EMISSION AND ABSORPTION OF LIGHT*

Laser is an acronym derived from "light amplification by stimulated emission of radiation." Thermal radiators, such as the sun, scatter light in all directions, the individual photons having no definite relationship with one another. But because the laser is an oscillating amplifier of light, and because its output comprises photons that are identical in phase, direction, and amplitude, it is unique among light sources. Its output beam is singularly directional, intense, monochromatic, and coherent.

Radiant emission and absorption take place within the atomic or molecular structure of materials. The contemporary model of atomic structure describes an electrically neutral system composed of a nucleus with one or more electrons bound to it. Each electron occupies a distinct orbital that represents the probability of finding the electron at a given position relative to the nucleus. Each orbital has a characteristic shape that is defined by the radial and angular dependence of that probability, e.g., all "s" orbitals are spherically symmetrical, and all "p" orbitals surround the x, y, and z axes of the nucleus in a double-lobed configuration (see Figure 1.1). The energy of an electron is determined by the orbital that it occupies, and the over-all energy of an atom - its energy level - depends on the distribution of its electrons throughout the available orbitals. Each atom has an array of energy levels: the level with the lowest possible energy is called the ground state, and higher energy levels are excited states. If an atom is in its ground state, it will stay there until it is excited by external forces.

Movement from one energy level to another - a transition - happens when the atom either absorbs or emits energy. Upward transitions can be caused by collision with a free electron or an excited atom, and transitions in both directions occur as a result of interaction with a photon of light. Consider a transition from a lower level whose energy content is E_1 to a higher one with energy E_2. It will only occur if the energy of the incident photon matches the energy difference between levels, i.e.,

*"Light" will be used to describe the portion of the electromagnetic spectrum from far infrared to ultraviolet.

$$h\nu = E_2 - E_1 \quad [1]$$

where h is Planck's constant, and ν is the frequency of the photon.

Likewise, when an atom excited to E_2 decays to E_1, it loses energy equal to E_2-E_1. Because its tendency is toward the lower energy state, the atom may decay spontaneously, emitting a photon with energy $h\nu$ and frequency

$$\nu = (E_2 - E_1)/h. \quad [2]$$

Spontaneous decay can also occur without emission of a photon, the lost energy taking another form, e.g., transfer of kinetic energy by collision with another atom. An atom excited to E_2 can also be stimulated to decay to E_1 by interacting with a photon of frequency ν, shedding energy in the form of a pair of photons that are identical to the incident one in phase, frequency, and direction. By contrast, spontaneous emission produces photons that have no directional or phase relationship with one another.

A laser is designed to take advantage of absorption, and both spontaneous and stimulated emission phenomena, using them to create conditions favorable to light amplification. The following paragraphs describe these conditions.

POPULATION INVERSION

The absorption coefficient at a given frequency is the difference between the rates of emission and absorption at that frequency. It can be shown that the rate of excitation from E_1 to E_2 is proportional to both the number of atoms in the lower level (N_1) and the transition probability. Similarly, the rate of stimulated emission is proportional to the population of the upper level (N_2) and the transition probability. Moreover, the transition probability depends on the flux of the incident wave and a characteristic of the transition called its "cross section". It can also be shown that the transition cross section is the same regardless of direction. Therefore, the absorption coefficient depends only on the difference between the populations involved, N_1 and N_2, and the flux of the incident wave.

When a material is at thermal equilibrium, a Boltzmann distribution of its atoms over the array of available energy levels exists with nearly all atoms in the ground state. Since the rate of absorption of all frequencies exceeds that of emission, the absorption coefficient at any frequency is positive.

If enough light of frequency ν is supplied, the populations can be shifted until $N_2=N_1$. Under these conditions the rates of absorption and stimulated emission are equal, and the absorption coefficient at frequency ν is zero. If the transition scheme is limited to two energy levels, it is impossible to drive the populations involved beyond equality; that is, N_2 can never exceed N_1 because every upward transition is matched by one in the opposite direction.

However, if three or more energy levels are employed, and if their relationship satisfies certain requirements described below, additional excitation can create a population inversion, in which $N_2>N_1$.

A model four-level laser transition scheme is depicted in Figure 1.2(a). A photon of frequency ν_1 excites – or "pumps" – an atom from E_1 to E_4. If the E_4 to E_3 transition probability is greater than that of E_4 to E_1, and if E_4 is unstable, the atom will decay almost immediately to E_3. If atoms that occupy E_3 have a relatively long lifetime, the population will grow rapidly as excited atoms cascade from above. The E_3 atom will eventually decay to E_2, emitting a photon of frequency ν_2. Finally, if E_2 is unstable, its atoms will rapidly return to the ground state, E_1, keeping the population of E_2 small and reducing the rate of absorption of ν_2. In this way the population of E_3 is kept large and that of E_2 remains low, thus establishing a population inversion between E_3 and E_2. Under these conditions, the absorption coefficient at ν_2 becomes negative. Light is amplified as it passes through the material, which is now called an "active medium" – the greater the population inversion, the greater the gain.

A four-level scheme, like that described above, has a distinct advantage over three-level systems, in which E_1 is both the origin of the pumping transition and the terminus of the lasing transition. In the four-level arrangement, the first atom that is pumped contributes to the population inversion, while over half of the atoms must be pumped from E_1 before an inversion is established in the three-level system.

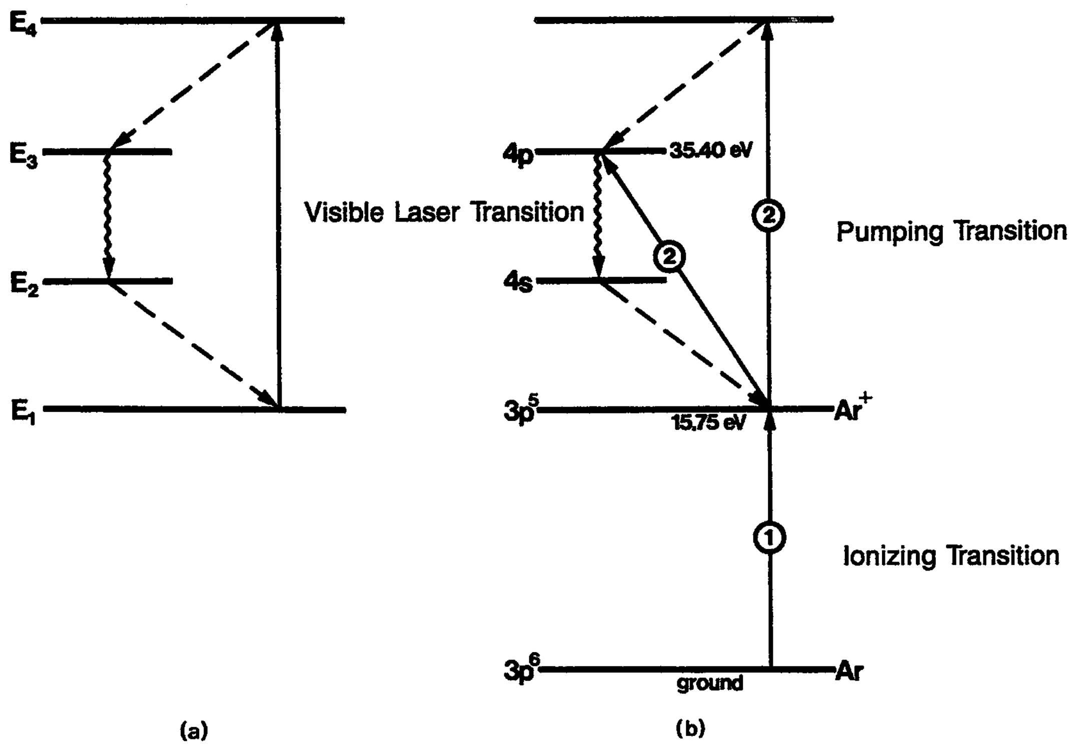


Figure 1.2: A typical four-level laser transition scheme (a) compared to that of visible argon (b). One collision ionizes neutral argon, and a second pumps the ion to an excited state.

In commercial laser designs the source of excitation energy is usually optical or electrical: arc lamps are often employed to pump solid-state lasers; the output of one laser can be used to pump another, e.g., a liquid dye laser is often pumped by an ion laser; and an electric discharge is generally used to excite gasseous media like argon or krypton.

ARGON AS AN EXCITATION MEDIUM

The properties of argon are probably the best understood of all the ionized gas laser media; its transition scheme is compared to the model in Figure 1.2(b), and its visible energy level diagram is depicted in Figure 1.3. The neutral atom is pumped to the 4p energy level - the origin of the lasing transition - by two collisions with electrons. The first ionizes the atom, and the second excites the ion from its ground state (E_1) either directly to the 4p energy level (E_3) or to E_4, from which it cascades almost immediately to 4p. The 4p ions will eventually decay to 4s (E_2), emitting a photon either spontaneously or when stimulated to do so by a photon of equivalent energy. The wavelength of the photon depends on the specific energy levels involved, but it will be between 400 and 600 nm. The ion decays spontaneously from 4s to the ionic ground state, emitting a photon in the vacuum ultraviolet - about 74 nm - as it vacates the lower level of the lasing transition.

The population in the ionic ground state at any given time is small. Recombination processes return ions to the neutral atom energy level scheme; therefore, there is no tendency toward a self-absorption "bottleneck", a population buildup in the lower laser levels.

The existence of only two lower states for a large number of visible laser transitions suggests that strong competition between lines with a common lower level may exist. Such competition would manifest itself as improved performance of a given line during single-line operation, compared to its strength when all lines are present. Although competition exists, its effect is minor, and single-line operation improves the power of principal lines by less than 10%. Even those upper state populations that are shared by more than one laser transition only exhibit minor competition effects. Therefore, the use of a prism or other dispersing element in continuous-wave argon ion

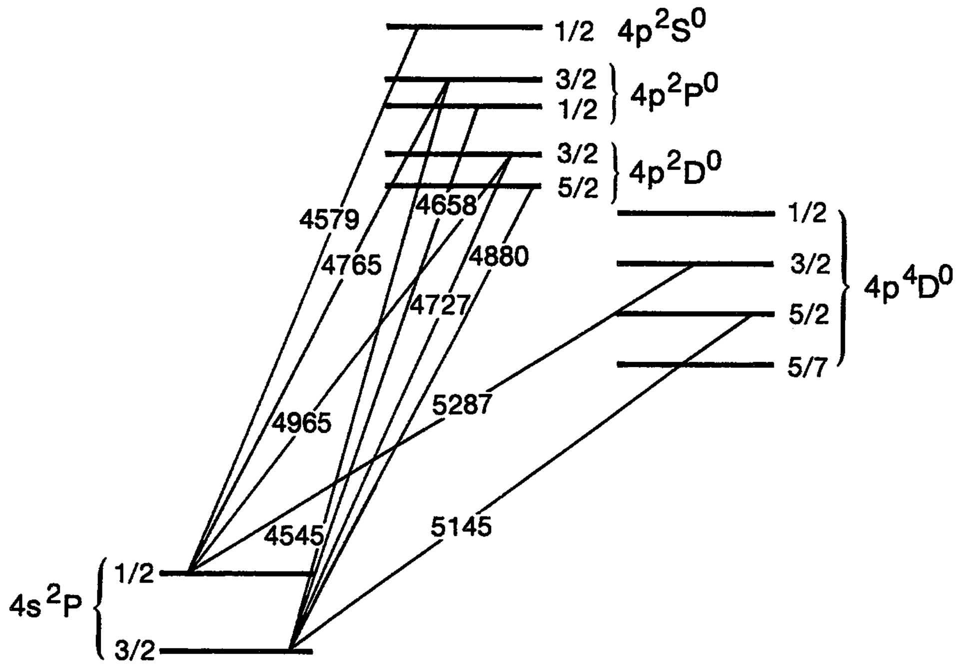


Figure 1.3: Energy levels of the 4p - 4s argon ion laser transitions

lasers is not necessarily advantageous, except in single-line applications.

Ion laser gain is directly affected by several factors including discharge current density, magnetic field, and gas pressure. Since two collisions with free electrons are required to pump an argon atom to the upper level of visible lasing transitions, the gain of the medium varies as the square of the current density. Below saturation, the multimode, all-lines output of an ion laser can be expressed as

$$P=kJ^2V \qquad [3]$$

where P is the output power, J is the current density (A/cm^2), V is the volume of the active medium, and k is a constant.

Visible output saturates at a current density of about 800 A/cm^2, while ultraviolet transitions require even higher current densities (see Figure 1.6). UV radiation is a product of transitions between excited states of doubly ionized argon (Ar^{++}), the ground state of which is about 43 eV above that of the neutral atom. By comparison, the ground state of singly ionized argon (Ar^+) is only about 16 eV above the neutral atom ground state. So two electron collisions, or a single collision with an extremely energetic electron, are required to move between the Ar^+ and Ar^{++} ground states. If the current density exceeds the saturation point of visible transitions, the additional energy drives argon ions to the doubly ionized state: UV output appears to rise exponentially with current density to a point beyond the design limit of available exciters.

A magnetic field that envelops the plasma discharge enhances the population inversion. It tends to force free electrons toward the center of the plasma tube bore, thereby increasing the probability of a pumping collision. Unfortunately, the magnetic field also causes Zeeman splitting of the laser lines, which elliptically polarizes the output, causing partial loss at the polarization-sensitive plasma tube windows.

Susceptibility to the Zeeman effect varies from line to line, and there is an optimum magnetic field strength for each. For example, the gain of most argon visible lines rises with magnetic field to a limit of about 1200 G, then it rolls over (see Figure 1.4). Similarly, the gain of argon

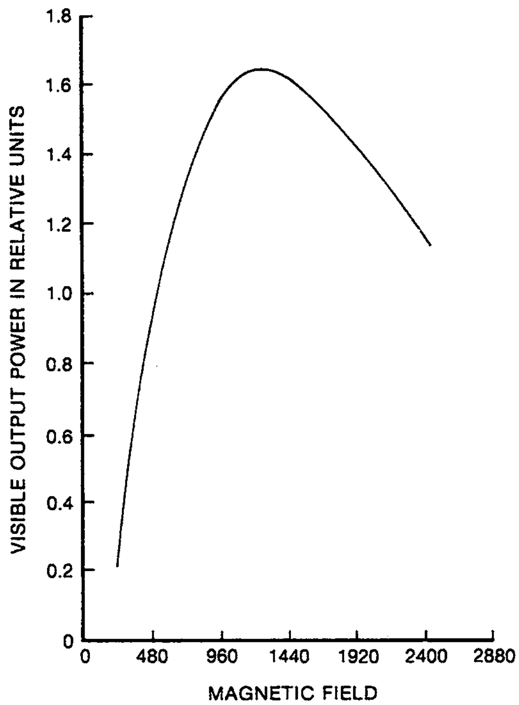


Figure 1.4: Ionized argon visible output power vs. magnetic field

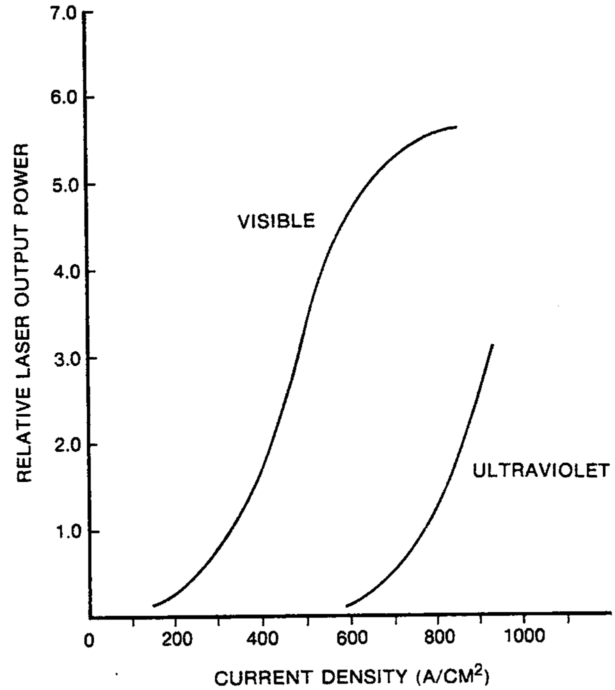


Figure 1.6: Relative output power behavior of singly and doubly ionized argon transitions

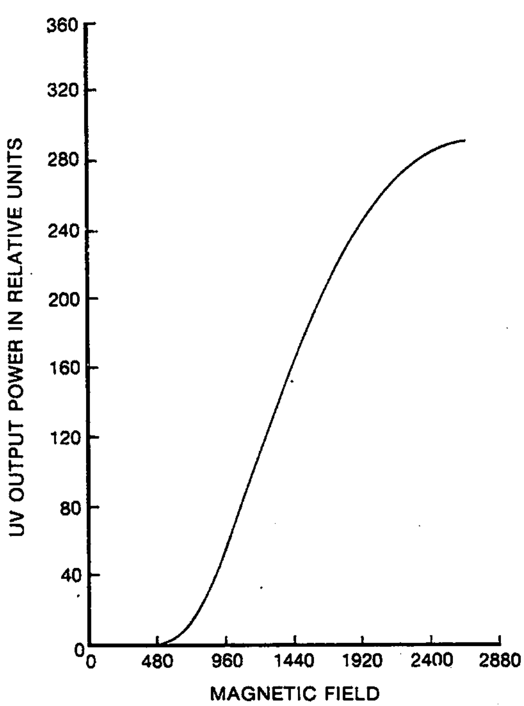


Figure 1.5: Argon ultraviolet output power vs. magnetic field

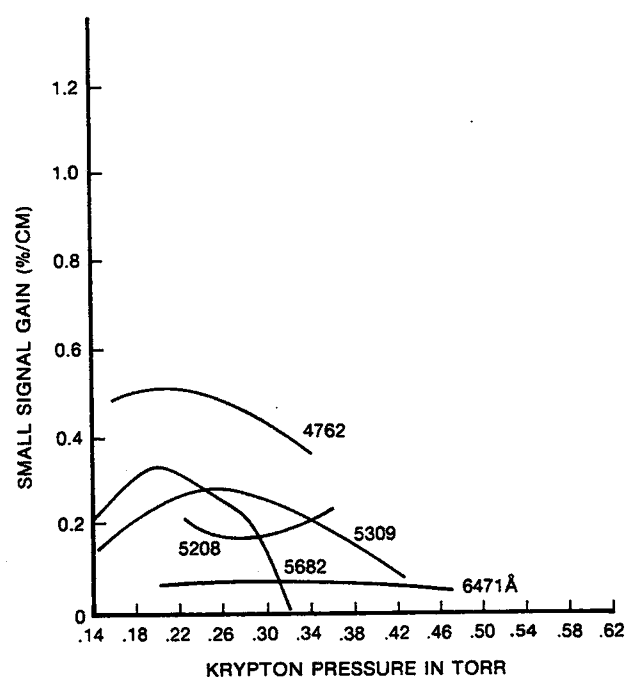


Figure 1.7: Pressure dependence of small signal gain for krypton at 50 A (800 A/cm^2)

ultraviolet lines continues to rise as the magnetic field exceeds the practical physical limit of laser solenoids, about 2000 G (see Figure 1.5). On the other hand, some krypton lines show a marked sensitivity to magnetic field, so it must be adjusted for optimum performance with each wavelength change.

Ion laser gain is also strongly dependent on gas pressure. For example, argon ultraviolet output is highest at low pressure. Reducing the number of argon atoms increases the time between collisions with free electrons, which increases the average electron energy. This creates conditions favorable to the high energy collisions required to excite argon ions to the Ar^{++} ground state. Other lines respond best at higher pressures.

Pressure dependence also requires uniformity of pressure distribution along the length of the discharge. Some krypton lines are especially sensitive to pressure distribution, and at a given discharge current they may exhibit gain at certain pressures and loss at others (see Figure 1.7). If the pressure distribution is uneven, regions of gain and loss may compete with one another causing noisy, unstable performance. The pressure-balanced design of the new generation of Spectra-Physics metal/ceramic plasma tubes brings unprecedented stability to both argon and krypton lasers.

THE RESONANT OPTICAL CAVITY

A resonant cavity, which is defined by two mirrors, provides feedback to the active medium. Photons that are emitted parallel to the cavity axis are reflected, returning to interact with other excited ions. Stimulated emission produces two photons of equal energy, phase and direction from each interaction. The two become four, four become eight, and the numbers continue to increase geometrically until an equilibrium between excitation and emission is reached.

Both mirrors are coated to reflect the wavelength, or wavelengths, of interest while transmitting all others. One of the mirrors - the output coupler - transmits a fraction of the energy that is stored within the cavity, and the escaping radiation becomes the output beam of the laser.

For broadband - or "all-lines" - operation the mirrors reflect a number of lines within a limited wavelength range (about 70 nm maximum). Several sets of broadband optics are available to cover different groups of laser lines.

Adding a prism to the cavity limits oscillation to a single line. The dispersion of the prism allows only one line to be perfectly aligned with the high reflector, so the tilt of the prism determines which line will oscillate.

The laser oscillates within a narrow range of frequencies around the transition frequency. The width of the frequency distribution - the "linewidth" - and its amplitude depend on the gain medium, its temperature, and the magnitude of the population inversion. Linewidth is determined by plotting the gain of each frequency and measuring the width of the curve where the gain has fallen to one-half maximum (full width at half maximum, see Figure 1.8).

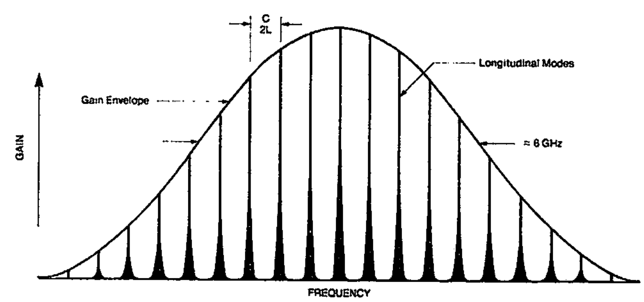


Figure 1.8: Frequency distribution of longitudinal modes for a single line

Line broadening is caused by the relative velocities of the excited ions as they radiate. If the ion is stationary at the time of stimulated emission, the product photons will possess the transition frequency. If the ion is moving toward the stimulating photon, the resultant frequency will be higher than that of the transition; likewise, if the ion is moving away, the frequency will be lower.

The output of the laser is discontinuous within the Doppler-broadened line. A standing wave propagates within the optical cavity and any frequency that satisfies the resonance condition

$$\nu_m = mc/2L \qquad [4]$$

will oscillate. ν_m is the frequency, c is the speed of light, L is the optical cavity length, and m is an integer. Thus, the output of a given line is a set of discrete frequencies - called "longitudinal modes" - spaced such that

$$\Delta v = c/2L \qquad [5]$$

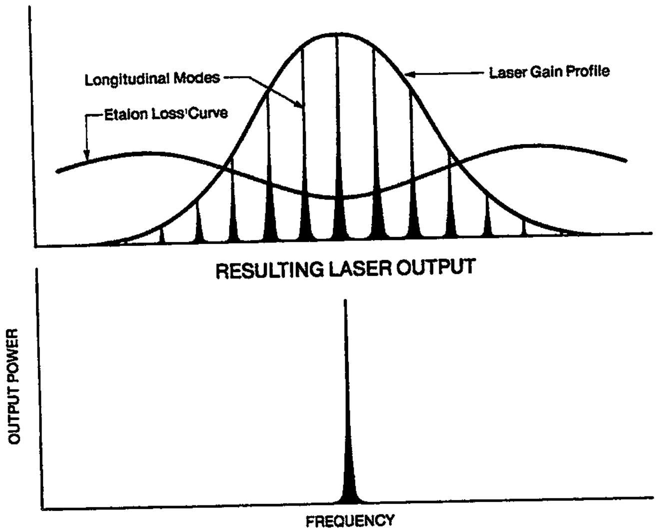


Figure 1.9: Etalon loss minimum tuned to laser gain maximum

An etalon, which is a frequency-selecting element, must be inserted in the cavity in order to isolate a single longitudinal mode. Spectra-Physics utilizes an optional Fabry-Perot interferometer that acts as a bandpass filter, introducing enough loss in all other modes to prevent them from reaching the lasing threshold (Figure 1.9). The coherence length - the distance over which the output beam maintains a fixed phase relationship - is inversely proportional to the linewidth:

$$l_c = c/\Delta v \qquad [6]$$

When the laser output is changed from single line to single frequency, the coherence length increases enormously. If the linewidth is reduced from 6 GHz (single-line) to about 10 MHz (single-frequency), the coherence length increases from 50 mm to 30 m.

RESONATOR STRUCTURAL CONSIDERATIONS

The stability of the oscillating frequency depends on the design of the resonator structure. Small changes in cavity length, which have several sources including temperature changes and mechanical shifts, will cause corresponding changes in the resonant frequency. Cavity length changes due to temperature can be expressed as

$$\Delta L = \alpha \Delta T\ L \qquad [7]$$

where L is the cavity length, α is the thermal expansion coefficient of the resonator structure and ΔT is temperature change. In order to eliminate frequency drift either α or ΔT must be zero.

The choice of materials affects the length stability of the structure. The ideal material has both a low thermal expansion coefficient and a high ability to distribute heat evenly, causing a constant ΔT along the length of the structure.

Graphite composite, such as that used in the Model 2020 resonator, has the lowest thermal expansion coefficient of any currently used structural material. Since its coefficient is also negative, the thermal compensation system of the resonator structure can be kept simple. The negative expansion of the graphite rods offsets the positive expansion of the metal parts, so the net change remains near zero over a wide range of temperatures.

Frequency stability also depends on the mechanical rigidity of the resonator structure. Modulation due to "jitter", the microphonic movement of cavity mirrors, can be caused by cooling water flow, external shock to the resonator structure, and acoustic noise. Isolation of the resonator from both the plasma tube, through which the cooling water flows, and the case that surrounds the laser, the source of other vibrations, helps reduce jitter.

The mechanical design of the structure also contributes to jitter-free operation. The most stable configuration is an arrangement of three resonator members in an equilateral triangle (Figure 1.10). As one of the angles increases, the resistance to flexure, in a plane represented by the longest side of the traingle, is reduced. The extreme case, in which all three members lie in the same plane, is the least rigid, its strength coming only from the members themselves. The Model 2020 resonator approaches the ideal equilateral triangle. The graphite rods are enveloped in steel tubes to strengthen the structure and for increased resistance to flexure.

CONCLUSION

Several factors influence ion laser output. The optical power can be calculated from

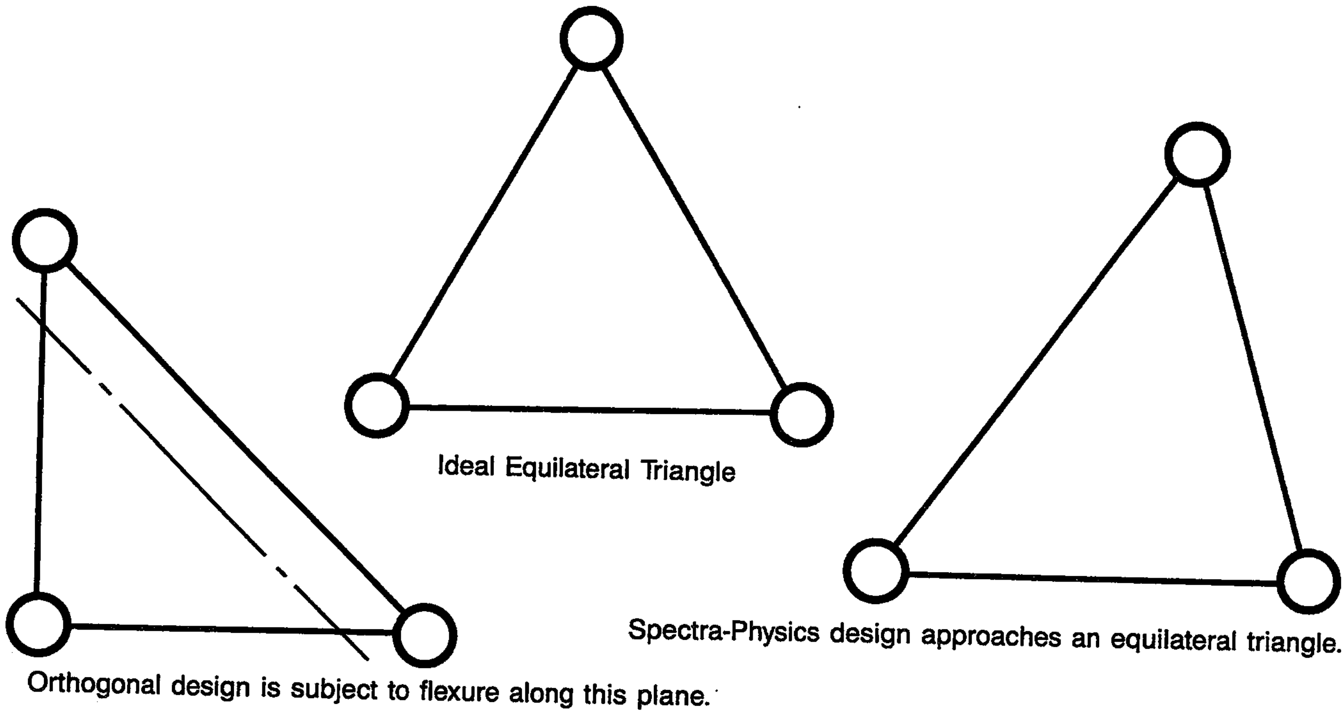


Figure 1.10: The relationship of resonator structural members affects the stability of laser output

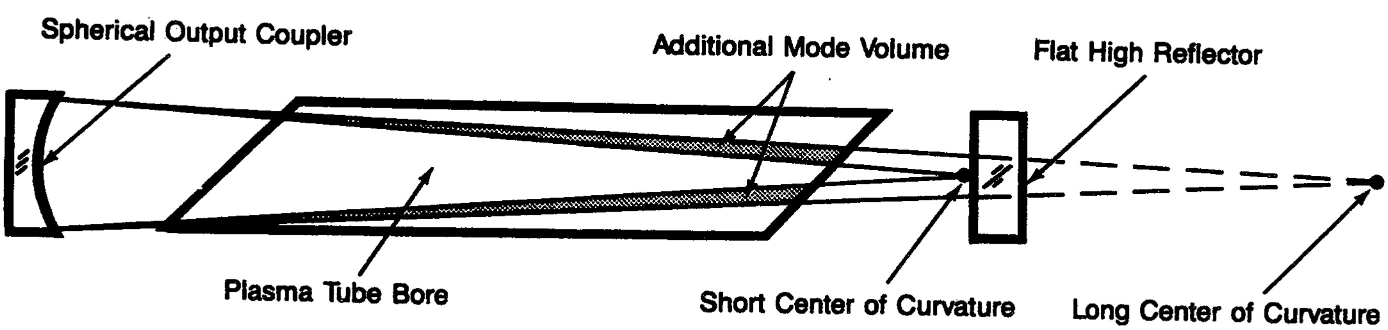


Figure 1.11: Lengthening the radius of curvature of the output coupler enhances output by increasing the mode volume of the cavity.

$$P_o = TAI_s \left(\frac{\alpha_o L}{T+\beta} - 1 \right) \quad [8]$$

where T is the output coupler transmission, A is the cross-sectional area of the beam, I_s is a saturation parameter, α_o is the small signal gain, L is the gain length, and β is the sum of all cavity losses.

The transmission of the output coupler should be the greatest of the cavity losses: it should be greater than the sum of all others. Ideally β, which is caused by unwanted absorption, reflection, diffraction, and transmission, should be zero. Cleanliness of plasma tube processing operations, which eliminates contaminants that can find their way to the inside surfaces of the windows, is essential to improved ion laser output. Cleanliness of other cavity elements, including both mirrors, is also important. A sealed cavity with a forced-air purge system contributes to overall performance. Regular attention to mirror and window cleaning can also reduce cavity losses.

The cross-sectional area, and therefore the volume of the gain region can be increased by enlarging the bore and using a long-radius output coupler (Figure 1.11). The use of long-radius optics requires an extremely rigid resonator structure. Increasing the mode volume of the cavity while maintaining a constant current density increases the output.

The Spectra-Physics Series 2000 ion lasers represent a leap in the evolution of laser technology. With its advanced plasma tube design, high-field magnet, thermally compensated graphite composite resonator, and fully digital high-current power supply, it is a system that delivers visible output to match the most exacting standards and UV performance that is unrivalled.

SPECIFICATIONS

PHYSICAL	Dimensions	Power Supply	81.6x54.3x37.2 cm
			32.1x21.4x14.6 in
		Laser Head	128.5x24.1x20.1 cm
			50.6x9.5x7.9 in
	Shipping Weight	Power Supply	
		Model 2020	83 kg, 183 lbs
		Model 2025	132 kg, 291 lbs
		Laser Head	
		Model 2020	59.4 kg, 131 lbs
		Model 2025	64 kg, 141 lbs
	Cavity Configuration		Long radius output, flat high reflector
	Cavity Length (without prism)		1.10 m
	Cavity Length (with prism)		1.17 m
ELECTRICAL SERVICE	Type		3-phase with earth ground
	Voltage Required		208 vac ±10%
	Current Required	Model 2020-03	44 A
		Model 2020-04, -05	48 A
		Model 2025-03	59 A
		Model 2025-04, -05	61 A
		Model 2020-11	48 A
		Model 2025-11	61 A
WATER SERVICE	Flow Rate	Minimum	9.5 l/min, 2.5 g/min
	Pressure	Minimum	1.1 kg/cm^2, 15 psi
		Maximum	5.3 kg/cm^2, 75 psi
PERFORMANCE	Noise[1,2]	Current mode	0.5% rms
		Power mode	0.2% rms
	Stability[3]	Current mode	±3%
		Power mode	±0.5%
	Beam Diameter[4]	514 nm	1.50 mm
	Beam Divergence[4]	514 nm	0.50 mrad
	Polarization		Vertical
	Mode Spacing		136.1 MHz

Specifications subject to change without notice

1. Performance at 514.5 nm for argon or 647.1 nm for krypton, 10 Hz - 2 MHz.
2. Using Model 2210 Linear Passbank; without Model 2210, typical noise in current or power mode is 3%.
3. In any 30 min period after 2-hr warmup
4. At $1/e^2$ points, data for 514.5 nm. Data for other wavelengths (assuming no change in optical configuration) is given by:

$$\frac{DIA_1}{DIA_2} = \left(\frac{\lambda_1}{\lambda_2}\right)^{1/2}$$

SPECIFICATIONS (con't)

Argon Ion Laser Power

Multi-line[1] (nm)	2020/2025 -03	2020/2025 -04	2020/2025 -05
457.9-514.5	3 W	4 W	5 W
351.1-363.8	0.050/0.200	0.075/0.300	0.100/0.400
Single-line[1] (nm)			
514.5	1.200	1.700	2.000
501.7	0.200	0.300	0.400
496.5	0.400	0.600	0.700
488.0	1.000	1.300	1.500
476.5	0.350	0.600	0.750
472.7	0.130	0.200	0.300
465.8	0.070	0.125	0.200
457.9	0.200	0.300	0.350
454.5	0.050	0.075	0.120

Krypton Ion Laser Power

Multi-line[1] (nm)	2020/2025 -11
647.1-676.4	0.750/0.600
406.7-415.4	- /0.150
337.4-356.4	- /0.150
Single-line[1] (nm)	
799.3	- /0.030
752.5	- /0.100
676.4	0.150/0.120
647.1	0.600/0.500
568.2	- /0.200
530.9	- /0.200
520.8	- /0.090
482.5	- /0.045
476.2	- /0.060
413.1	- /0.060

Specifications subject to change without notice.

1. Single-line powers for argon lasers are specified at 514.5 nm and 488.0 nm, and for krypton lasers at 647.1 nm only. Other powers indicated are nominal; firm specifications are available with special testing and are only available at the time of purchase. All output power specifications, except argon multiline visible, refer to TEM_{00} operation.

INSTALLATION

UNPACKING YOUR LASER

Inspect each component of the system carefully as you unpack it. If you notice any damage, such as dented or scratched covers, broken knobs or switches or a broken plasma tube end bell, notify the shipper and your Spectra-Physics sales representative immediately. If, upon installation, the laser fails to operate or meet performance specifications, Spectra-Physics will arrange for repair or replacement without waiting for your claim against the carrier to be settled.

Hold on to the shipping containers. If you file a damage claim, you may need it to demonstrate that the damage occurred as a result of shipping. If you need to return the laser for service, the specially designed crate assures adequate protection.

You will find the following items in the accessories kit in which this manual was packed:

- o a tool kit that contains all of the tools you will need to align and maintain your laser, including extra power supply fuses, a set of Allen wrenches for beam alignment, a hemostat and lens tissue for optics cleaning, the all-lines, high-reflector mirror, a pair of keys for the master switch, and a dispensing bottle;
- o two water hoses for the cooling system - you will need one hose for water service and one for the drain;
- o a filter for the water supply and two extra cartridges.

You will need to supply several items, including:

- o electronic grade, or better, acetone and methanol for optics cleaning;
- o several ball drivers for plasma tube alignment; the Allen wrench set supplied with the laser is adequate, but a set of ball drivers that includes one #28 (1/4"), three #24 (1/8") and four to six #23 (3/32") wrenches makes alignment a much simpler process.

ELECTRICAL CONNECTIONS

The power supply requires three-phase electrical service that is rated for 208 V ac (±10%) and 70 A.

The switch box should be less than 3.5 m (12 ft) from the power supply. **Connect the green lead of the electric cable to earth ground, not neutral.** Connect the remaining three leads to the legs of the three-phase service; the sequence will be checked during preoperation testing. If a quick-disconnect plug is used, it must be rated for at least 70 A.

WARNING

> Do not exceed 230 V ac! If the only available service exceeds 230 V ac, you must use a transformer to step down to 208 V ac. Contact your Spectra-Physics sales or service engineer for details.

Place both the laser head and power supply in their operating positions; the power supply must be less than 2.5 m (8 ft) from the laser head. Connect the laser head umbilical to the rear panel of the power supply. Connections for all electrical circuits and the line that carries cooling water to the laser head are contained within a single quick-release assembly (see Figure 3.1). Two long pins register the umbilical connectors with their power supply receptacles; align the umbilical with the power supply and push until all connections are snug. Tighten the locking knob finger-tight.

WATER CONNECTIONS

Cooling water may be supplied from an open-loop system consisting of a tap water source and direct connection of the outflow to a drain, provided the water flow rate is at least 9.5 l/min (2.5 US gal/min) at a differential pressure* between 1.1 and 5.3 kg/cm^2 (15 and 75 psig). The diameter of the incoming water service line should be at least 12.7 mm (0.5 in).

*defined as the difference between the exit back pressure and the input pressure

If the laser head is not mounted horizontally and the cathode end of the tube is higher than the anode end, you must purge the water cooling system with water flow of at least 19.0 l/min. (5.0 US gal/min.) for two minutes before turning on the laser. After two minutes, the flow can be reduced to the standard flow rate shown in Figure 3.2.

Install the filter in the supply line; the direction of flow is marked on the filter case.

Connect the cooling water supply line to the female fitting that is located below the umbilical connector. Connect the return line to the male fitting that emerges from the connector casing.

The cooling water in most locations is of adequate quality so that scale build-up on the plasma tube will not be a problem. However, if the cooling water has a concentration of dissolved solids greater than 150 ppm, we strongly recommend the use of a closed loop water conditioning system such as the Spectra-Physics Model 314. Failure to use a water conditioner can lead to reduced cooling efficiency and possible damage to the plasma tube.

The specifications for the Model 314 Water Conditioner are listed in Figure 3.3. These specifications exceed the thermal parameters of the Spectra-Physics Model 2020 Ion laser. If you plan to design your own closed-loop system, use the specifications and thermal parameters as a guide.

FIGURE 3.2: Model 2020 Ion Laser Thermal Parameters

Required Heat Dissipation:	18 kW*
Required Coolant Flow Rate:	9.5 l/min. 2.5 US gal/min.
Maximum Inlet Temperature:	35°C
Required Coolant Pressure:	1.1–5.3 kg/cm^2 15–75 psig

FIGURE 3.3: Model 314 Ion Laser Water Conditioning System Specifications

Allowed Heat Dissipation:	40 kW
Filtration:	25 µm
Deionization:	>0.175 MΩ-cm
Deoxygenation:	>1 ppm

*under worst case conditions, i.e., Model 2020-05 or 2025-05 with high-field magnet

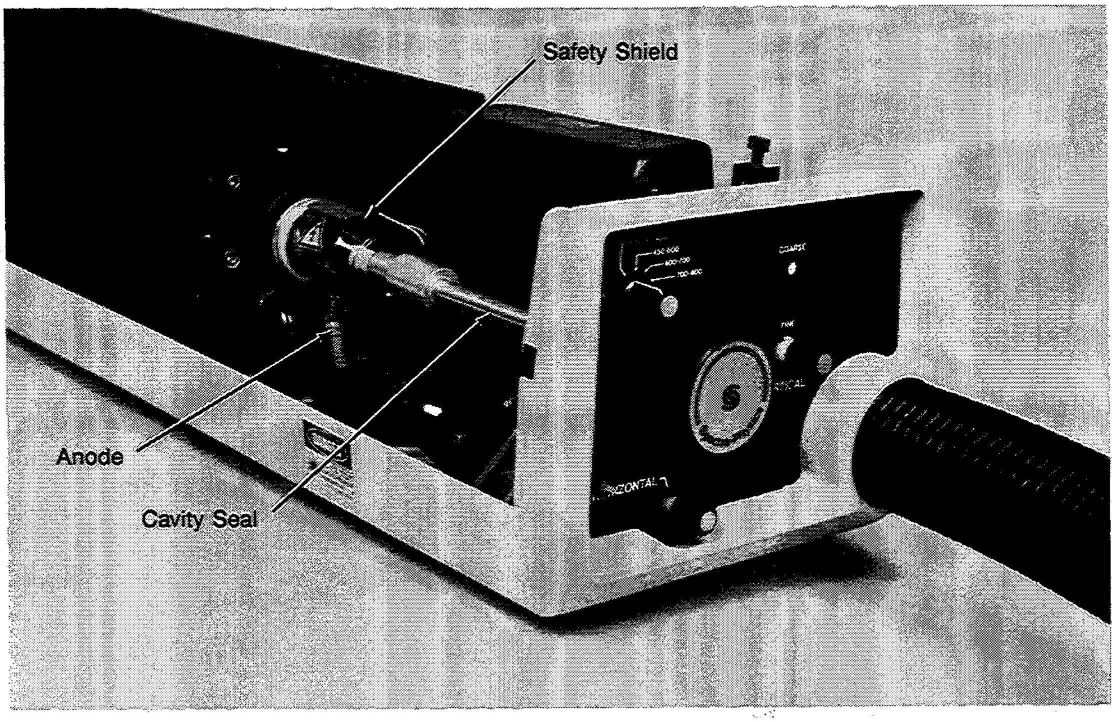


FIGURE 3.5: Laser Head Interior (Anode End)

UNPACKING THE LASER HEAD INTERIOR

Several precautions were taken when your laser was prepared for shipping. Remove the laser head cover and inspect the interior.

1 Inspect the cavity seal on each end of the plasma tube. If the seal was dislodged during shipping, the plasma tube window will have to be cleaned; see "Cleaning the Plasma Tube Windows" in MAINTENANCE for details.

2 Inspect the gas purge system feeder tubes. Be sure the Teflon™ gas purge tubing is securely attached to all fittings.

3 Inspect the shutter and aperture. Both should be fully open. The numbered positions on the aperture wheel indicate available apertures with "12" the largest. A "0" next to the shutter lever indicates that it is open.

4 Replace the laser head cover.

MODEL 2200A INTRACAVITY AIR PURIFIER

The Spectra-Physics Model 2200A intracavity air purifier must be used with the Model 2020/2025. The air purifier is a closed-loop system that supplies a constant flow of filtered air to the laser head intracavity spaces. This air flow removes dust particles, ozone, and contaminating vapors from the intracavity space, preventing loss of output power caused by contamination of optical surfaces. Using the Model 2200A eliminates the need for frequent optics cleaning to maintain long-term output power stability.

The unit operates on either 115 or 230 V ac; a slide switch on the rear panel sets the operating voltage. A 250 V, 1 A fast-blow fuse protects the circuit. The air flow rate is factory set between 0.2 and 0.5 l/min. (12.2 to 30.5 in^3/min) and is not adjustable.

Installation

The purge tubing connectors are located on the rear panel of the Model 2200A. The output fitting is black, and the input fitting is blue. Two color-coded lengths of Teflon™ tubing are supplied with your Model 2200A.

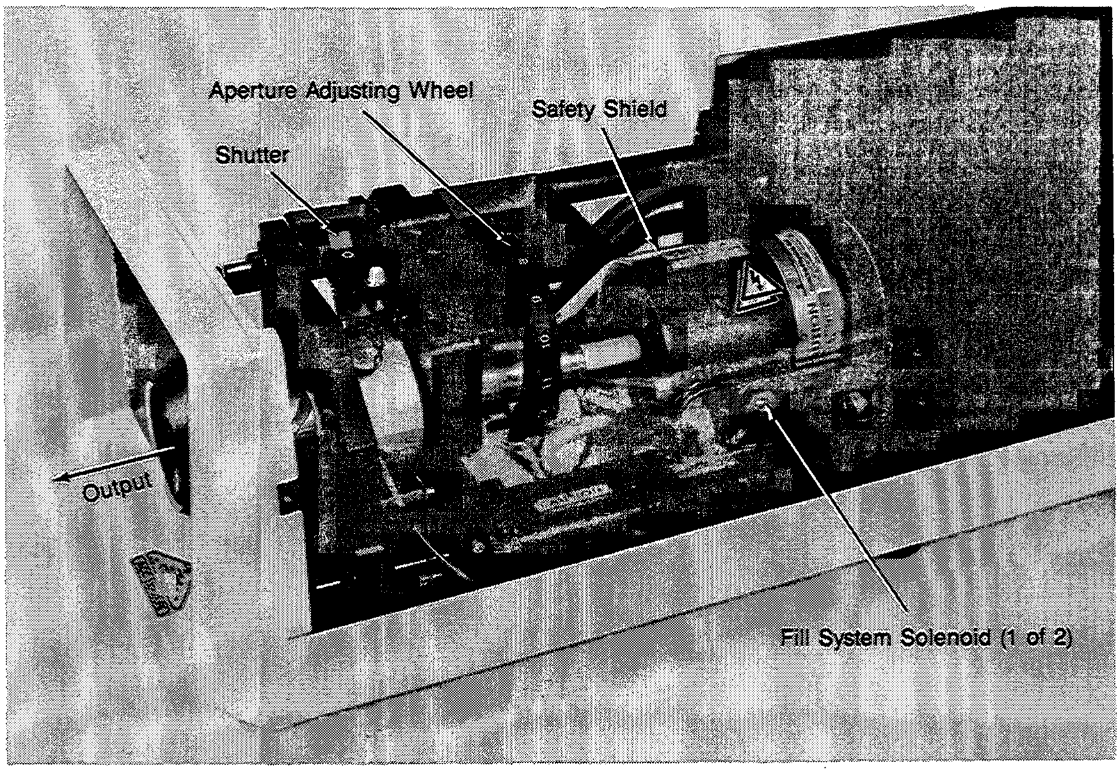


FIGURE 3.6: Laser Head Interior (Cathode End)

1 Connect the air lines to the Model 2200A by mating like-colored connectors and receptacles. This avoids crossing input and output lines.

2 Connect the air lines to the laser head, matching colors to prevent crossed lines. Verify that the output of the Model 2200A enters the input fitting (black) on the laser head.

3 Run the Model 2200A for a few hours to clear the lines of contamination; the laser can be off during this clean-up. Clean the plasma tube windows and cavity mirrors after this initial run.

Operation

There are no operator adjustments on the Model 2200A. The flow rate is factory set for use with Spectra-Physics ion lasers.

The air filter has a finite lifetime, typically more than 1500 hr of continuous operation. Air leaks, the relative humidity of the ambient air, and the frequency of mirror changes all influence this lifetime. Check the condition of the filter through the slots on the side of the Model 2200A. When the blue dessicant turns completely pink, replace the filter (S.P. part number 0431-4570). About one third of the dessicant will be consumed in the first few hours of operation as it removes water vapor from the activated charcoal. The remaining dessicant will then last 1500 hr or more.

The unit can be left on after turning off the laser, but this shortens the life of the air filter.

PREOPERATIVE TESTS

Perform the following tests before you attempt to start your laser for the first time. They are your final assurance that the system arrived in proper working condition. Refer to "Operation" for a complete description of the controls mentioned below.

Water Testing the Plasma Tube

1 Remove the laser head cover.

2 Slowly open the water supply valve until you hear the water begin to flow.

3 If leaks are present, shut water supply off, drain the cooling system and call your Spectra-Physics representative.

4 If no leaks are present, re-install laser head cover.

Control Operation Tests

1 Check the key switch to be sure that it operates smoothly.

2 Assure yourself that all control knobs turn smoothly; turn each to its minimum position (counterclockwise.)

3 With the MASTER key switch off and the water supply on, apply power to the Model 2560 and check the following:

- o all three LINE indicator lamps should glow;
- o the OFF indicator lamp should glow;
- o the CURrent MODE, CURrent/60 A, and LOCAL (optional) LED indicators should glow.
- o the power supply should "beep", indicating automatic reset

4 If the status fault display reads "01", shut the power off and reverse any two of the 3-phase leads.

5 Conduct the following control checks; if your system fails any test, call your Spectra-Physics service representative.

FIGURE 3.7: Power Supply Control Operation Tests

CONDITION	TEST	EXPECTED RESULT
Contactor OFF, INTERLOCK plug and REMOTE control jumper in socket, MASTER key switch off	Press the ON button.	The power supply should not switch on: error code 17
Contactor OFF, INTERLOCK plug and REMOTE control jumper in socket, MASTER key switch ON	Press the ON button.	Contactor should close, switching the power supply on; ON indicator should glow.
MASTER key switch ON, INTERLOCK plug and REMOTE control jumper in socket, contactor closed, ON button glows	Remove the INTERLOCK plug.	Contactor should open, switching the power supply off; OFF indicator should glow: error code 16.
MASTER key switch ON, INTERLOCK plug and REMOTE control jumper in socket, contactor open, OFF button glows	Turn off the water supply, then press the ON button.	The power supply should not switch on: error code 09, 10, and 12. When you restore the water supply and press the ON indicator, the power supply should switch on.

OPERATION

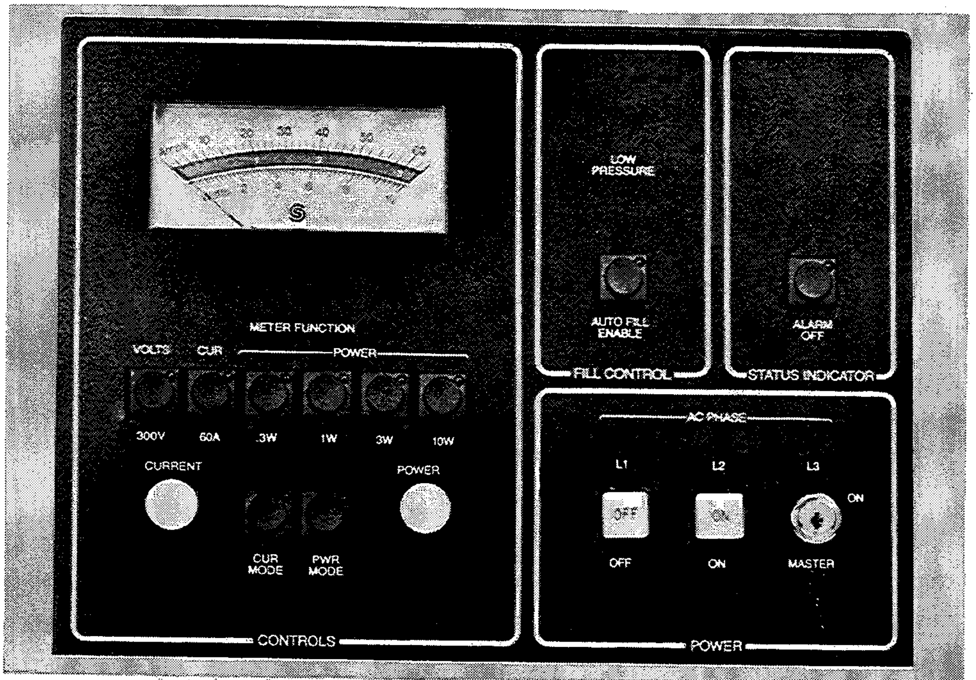


FIGURE 4.1: Model 2560 Power Supply Front Panel

POWER SUPPLY CONTROLS AND INDICATORS

The controls and indicators on the front panel of the power supply are divided into four functional groups: operating controls, fill controls, status indicators, and electrical power controls. A fifth group, the auxiliary controls, is available as an option. In the following descriptions capital letters identify the controls and indicators exactly as they are labeled and lowercase letters fill in the spaces for clarity, e.g., the AUTO FILL ENABLE button, the PoWeR MODE button, and the MAGnet CURrent button.

OPERATING CONTROLS

A light-emitting diode (LED) is incorporated in each selector button in this group. When a given function is active its LED will glow.

VOLTS/300 V button - displays the plasma tube voltage on the panel meter (displayed value is about 4 V higher than actual tube voltage because of a small voltage drop across the start circuit); full scale = 300 V.

CURrent/60 A button - displays the plasma tube current on the panel meter; full scale = 60 A.

POWER range buttons - displays the output power on the panel meter; each button limits the display to a specific range.

- 0.3 W - for output between zero and 0.3 W; read the 0-3 scale and divide the displayed value by ten.
- 1 W - for output between zero and 1 W; read the 0-10 scale and divide by ten.
- 3 W - for output between zero and 3 W; read the 0-3 scale.
- 10W - for output between zero and 10 W; read the 0-10 scale.

When the system is in the current control mode pressing one of the power range buttons will display output power within the selected range; its LED will glow, indicating the operating power range.

The power range LED's are always active when the system is in the power control mode. If the tube VOLTS, tube CURrent or optional MAGnet CURret display functions are on, a blinking power range LED will identify the operating power range. Pressing the blinking power range button will display the output power and cause its LED to hold steady.

CURrent MODE button - puts the laser in the current control mode, in which plasma tube current is held constant. The LED will blink if you ask for a current level that is beyond the operating limits of the power supply, typically either more than 55 A or less than 15 A.

CURRENT control knob - sets the plasma tube current when the system is in the current control mode; minimum is fully counterclockwise.

PoWeR MODE button - puts the laser in the power control mode, in which optical output is held constant (called the "Light Control" mode on earlier Spectra-Physics ion lasers); the LED glows when the system is in the power mode. The LED will blink if you ask for a power level that is unattainable.

POWER control knob - sets the output power when the system is in the power mode. Its maximum depends on the active power range, i.e., 0.3 W, 1 W, 3 W, or 10 W; its minimum is always zero.

NOTE

> If you change power ranges while the system is in the power mode, the position of the power control knob will determine the output power, e.g., to obtain 1 W of power using the 1 W power range, the power control knob must be at its maximum setting (fully clockwise). If you then press the 3 W power range button, the controller will raise the output power to 3 W, maximum for the 3 W scale.

Meter - display depends on the active meter function switch: plasma tube volts (includes nearly 4 V drop across the start circuit), tube current, output power, or magnet current.

FILL CONTROLS

LOW PRESSURE indicator - glows when the plasma tube pressure drops below a factory-set threshold. It glows continuously until the automatic fill system returns the pressure to normal. The indicator will blink in the unlikely event that the recharging reservoir is empty.

AUTO FILL ENABLE switch - toggles the automatic fill circuit, which maintains optimum plasma tube pressure, on and off. If the pressure drops while the circuit is active, the tube will be recharged automatically. The LED on the button glows when the circuit is on.

STATUS INDICATORS

Status Fault Display - a two-digit LED display that presents an error code. If the system is fault-free, the display is blank (see Figure 4.2).

ALARM OFF switch - has two functions: First, if a status fault causes the audio alarm to sound, pressing the button will silence it; the LED indicator on the button will flash as long as the alarm sounds. Subsequent presses will cause the status fault indicator to display relevant error codes, one at a time.

ELECTRICAL POWER CONTROLS

AC PHASE lamps - indicate the presence of three-phase power, one lamp for each phase. All lamps glow equally bright when acceptable electrical service is available.

All control circuits remain active as long as the main power is on; they can only be turned off by disconnecting the power supply from the ac power line.

MASTER key switch - prevents unauthorized operation of the laser. Turning the switch on enables the ON button, allowing laser operation; turning it off during operation shuts the laser off.

NOTE

> If the optional Spectra-Physics remote control unit is connected to the power supply, then both MASTER key switches, one on the power supply and one on the remote control, must be in the ON position before the system can be turned on.

Power ON button - starts the laser and serves as the emission indicator. If the cooling water supply and the MASTER key switch are on, pressing the ON button closes the power contactor, which applies filament current, and after a brief warm-up, sends a start pulse to the tube; it also turns on magnet power. The button glows white as long as the laser remains on.

FIGURE 4.2a: **Status Fault Display Error Messages - User-fixable Faults**

System Controller Firmware Version 3 (0431-8560)

1 = turn beeper on and latch error code in the status display if laser is on when error occurs.
2 = disable pilot relay (shut laser off).
3 = disable pilot relay (prevent laser turn on).

ERROR CODE	DESCRIPTION OF USER-FIXABLE FAULTS	SYSTEM RESPONSE
00	unassigned	
01	ac line phases reversed	1,2,3
02	ac line voltages out of range (208 V ±15%)	
03	ac line frequency out of range (46 to 64 Hz)	1,2,3
04	ac line symmetry (±4%)	1,2,3
05	passbank water temperature >40°C	1,2,3
06	passbank water temperature dropout	2
07	SCR air temperature dropout	2
08	head water temperature >80°C	1,2,3
09	head water flow rate <2 gpm	1,2,3
10	head temperature, flow, or cover interlock open	
11	head water temperature interlock open	
12	head water flow interlock open	
13	head cover interlock open	
14	umbilical connector interlock open	
15	power supply cover interlock open	
16	CDRH INTERLOCK open	
17	front panel key switch open	
18	front panel OFF switch stuck open	
19	remote panel key switch or off switch open, or jumper plug not installed	
20	remote key switch open	
21	remote OFF switch stuck open	
22	magnet current meter function disabled because magnet regulator not installed	
23	illegal configuration: high field magnet and no magnet regulator	1,2,3
24	RS232 frame error	
25	RS232 parity error	
26	IEEE I/O error	
27	unassigned	
•		
•		
49	unassigned	

FIGURE 4.2b: Status Fault Display Error Messages - Service-fixable Faults

System Controller Firmware Version 3 (0431-8560)

1 = turn beeper on and latch error code in the status display if the laser is on when error occurs.
2 = disable pilot relay (turn off laser).
3 = disable pilot relay (prevent laser turn on).

ERROR CODE	DESCRIPTION OF SERVICE-FIXABLE FAULTS	SYSTEM RESPONSE
50	unassigned	
51	+24 V dropout	
52	plasma overcurrent dropout	
53	+5 V reference out of specification	
54	magnet resistance > nominal + 25% (low field magnet resistance >50 Ω -or- high field magnet resistance >15.75 Ω)	1
55	magnet resistance < nominal - 25% (low field magnet resistance <30 Ω -or- high field magnet resistance <9.45 Ω)	1
56	magnet current sensor not OK	
57	plasma current sensor not OK	
58	plasma open circuit voltage sensor not OK	3
59	passbank voltage out of regulation	
60	tube won't start (start circuit fault or plasma SCR disabled)	1,2
61	firing controller sync pulse #1 missing	3
62	firing controller sync pulse #2 missing	3
63	firing controller sync pulse #3 missing	3
64	firing controller hardware error	
65	head controller does not respond	
66	firing controller does not respond	
67	remote panel does not respond	
68	remote panel I/O error	
69	low fill limit reached while auto fill enable off - system has switched auto fill enable on	1
70	fill reservoir empty - auto fill mode permanently disabled	1
71	tube pressure too low to operate	1,2,3
72	tube volts <100 V - tube pressure test disabled	
73	plasma current <16.5 A - tube pressure test disabled	
74	magnet current <3 A - tube pressure test disabled	
75	backup memory EEPROM write failure	
76	passbank water temperature sensor not OK	3
77	plasma regulator temperature sensor not OK	3
78	obsolete EPROMS on Smart Board - must be replaced with latest revision	
79	unassigned	
•		
•		
99	unassigned	

NOTE

When the system is under REMOTE control, the remote ON button will cause the power supply ON button to glow as well.

Power OFF switch - turns the laser off. Pressing the button opens the power contactor, turning the plasma, filament, and magnet currents off. It glows whenever the main power is on and the power contactor is open.

NOTE

The power supply control circuits remain active when the power contactor opens. If a malfunction occurs, such as loss of water flow, the contactor will open and the OFF indicator will glow. The front panel, which remains active, will display an appropriate error message.

REAR PANEL CONNECTIONS

REMOTE - connects the power supply to the Spectra-Physics remote control unit. A jumper plug, which hangs by a chain next to the jack, must be inserted if no remote control is used.

RS232 - connects the power supply to an RS232 digital device. The power supply supports full duplex operation, allowing simultaneous two-way data transmission. Turn to "External Control: RS232 Interface Operation" for details.

IEEE 488 - connects the power supply to a parallel IEEE 488 device. DIP switches on the IEEE 488 interface board control the address, which is factory set to 25. Turn to "External Control: IEEE Interface Operation" for details.

INTERLOCK - is the CDRH remote interlock. When the interlock circuit is open the laser is disabled. An extension cord and switch can be connected to the INTERLOCK jack to provide a safety switch, e.g., on the door of the laser operation area. A jumper plug, which hangs by a chain near the INTERLOCK jack, must be inserted if no safety switch is used.

MONITOR - is the analog monitor output. The voltage is variable between 0 and +5 V; the output impedance is typically 5 kΩ. The signal at the MONITOR output, which is determined by the METER FUNCTION switches on the front panel, can be used for strip chart recording. Interpret the signal according to the following table:

Function	0 to +5 V Represents
Magnet Current	0 to 31.6 A
Plasma Regulator Volts*	0 to 316 V
Plasma Current	0 to 63.2 A
Power (0.3 W scale)	0 to 0.316 W
Power (1 W scale)	0 to 1.0 W
Power (3 W scale)	0 to 3.16 W
Power (10 W scale)	0 to 10.0 W
Passbank Voltage (PBV)**	0 to 20 V
+5 V Reference**	actual
Error Analog Board Signal**	actual
Plasma Drive Signal**	actual

EXT. MOD. - allows amplitude modulation of either the plasma tube current, when the laser is in the constant current mode, or the optical output, when in the power mode. The input impedance is 10 kΩ. Any voltage supplied to the port causes a delta shift from its present operating state. A 5 V swing is allowed, but the input range may span -5 to +5 V depending on the position of the mode control pot (CURRENT or POWER). The following table illustrates the possibilities:

Output Modulation in the Constant Current Mode

CURRENT control position	Modulation Voltage	Effect
minimum (full ccw)	0 to +5	modulation from
midrange	-2.5 to +2.5	minimum to
maximum (full cw)	-5 to 0	maximum current

The relationship between the modulation voltage and output current is linear as long as the plasma tube is operated between the minimum and maximum current limits (17 A<I<55 A).

*Represents the tube voltage plus the nearly constant 4 V drop across the start circuit.
**Can only be selected via RS232 OR IEEE 488 device using the "METER=XXXX" command.

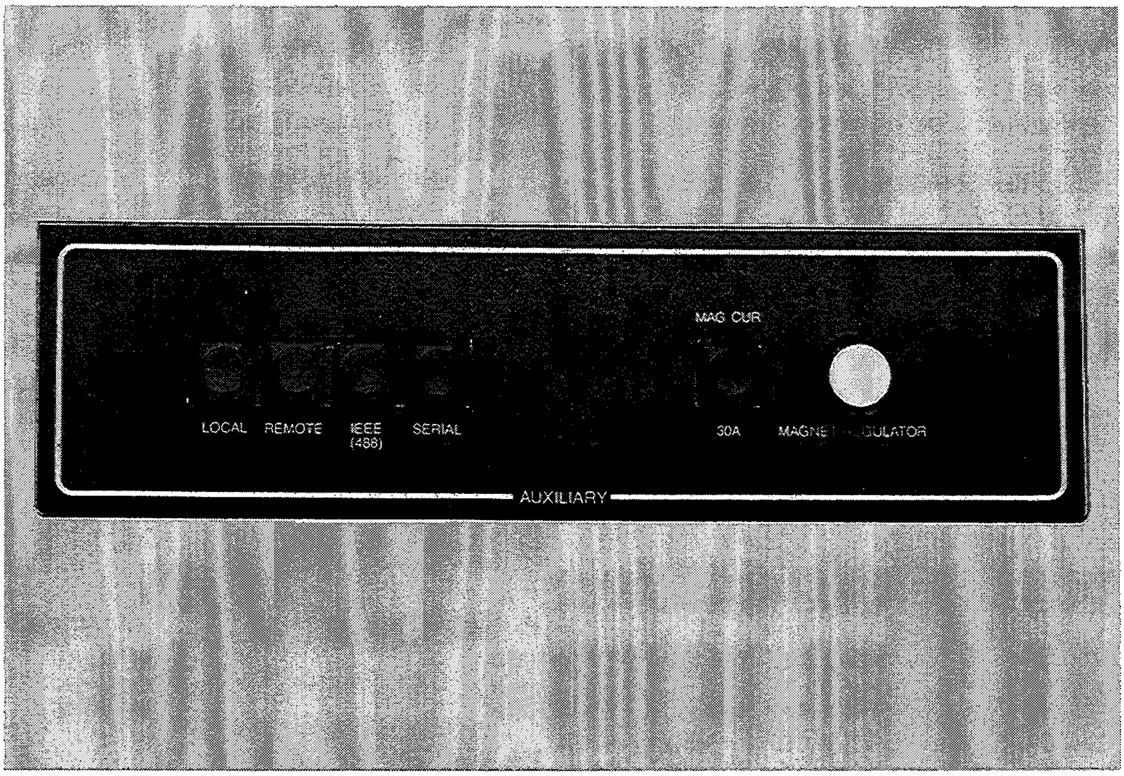


FIGURE 4.3: Model 2560 Auxiliary Control Panel (Optional)

Output Modulation in the Constant Power Mode

POWER control position	**Modulation** Voltage	Effect
minimum (full ccw)	0 to +5	modulation from
midrange	-2.5 to +2.5	minimum to
maximum (full cw)	-5 to 0	maximum power

The relationship between the modulation voltage and output power is linear as long as the plasma tube is operated between the minimum and maximum current limits.

The laser system has a small signal bandwidth* and a large signal bandwidth. The small signal bandwidth is approximately 5 kHz (measured to the 3 dB point) when using a linear passbank. A small signal is one in which the tube voltage is modulated less than ±5 V, which roughly corresponds to ±1 A change in tube current. At modulations larger than this the passband compliance range is exceeded and the voltage or current changes become slew-rate limited by the SCR switching regulator bandwidth. The large signal bandwidth can best be described as a slew-rate limit for a minimum-to-maximum current change. Typically slew rates are 200 ms for a full range change of 15-55 A.

AUXILIARY CONTROLS (Optional - see Figure 4.3)

LOCAL control button - transfers control from an external source (i.e. an RS232 or an IEEE488 device) to the power supply control panel. The controller automatically resets to local control upon initial turn on; the LED on the LOCAL button glows when the system is under local control.

REMOTE control button - is reserved for future design use.

NOTE

If a Model 2270 Remote Control unit is connected to the power supply, the LOCAL control state should be active, not the REMOTE control state.

*Only laser systems with the linear passbank have the 5 kHz small signal bandwidth.

IEEE 488 button - transfers control to an external controller that uses the industry standard IEEE 488 parallel data link protocol. The LED in the IEEE 488 button glows when the system is under IEEE 488 external control; other front panel LED's will follow external control commands.

NOTE

Both the Smart Board and an optional IEEE 488 interface card must be installed for IEEE 488 control. This card includes DIP switches that allow selection of the bus address for the power supply; it is factory set to address 25.

The IEEE 488 connector is on the rear panel of the power supply. Please turn to "External Control" for operating instructions.

SERIAL button - transfers control to an external controller that uses the industry standard RS232 serial data link protocol. The RS232 LED will glow when the power supply is under RS232 external control; other front panel LED's will follow external control commands.

NOTE

The optional Smart Board must be installed for RS232 operation. DIP switches determine the rate of data transfer. The following baud rates are available: 110, 150, 300, 600, 1200, 2400, 4800. The 4800 baud rate is the optimum data transfer rate and its use is recommended.

The RS232 connector is on the rear panel of the power supply. Please turn to "External Control" for operating instructions.

MAGnet CURrent button - causes the front panel meter to display the magnet current; its LED glows when the feature is active. Read the 0-3 scale and multiply by ten to get the current in amps. If the power supply does not have a magnet regulator, this button is disabled.

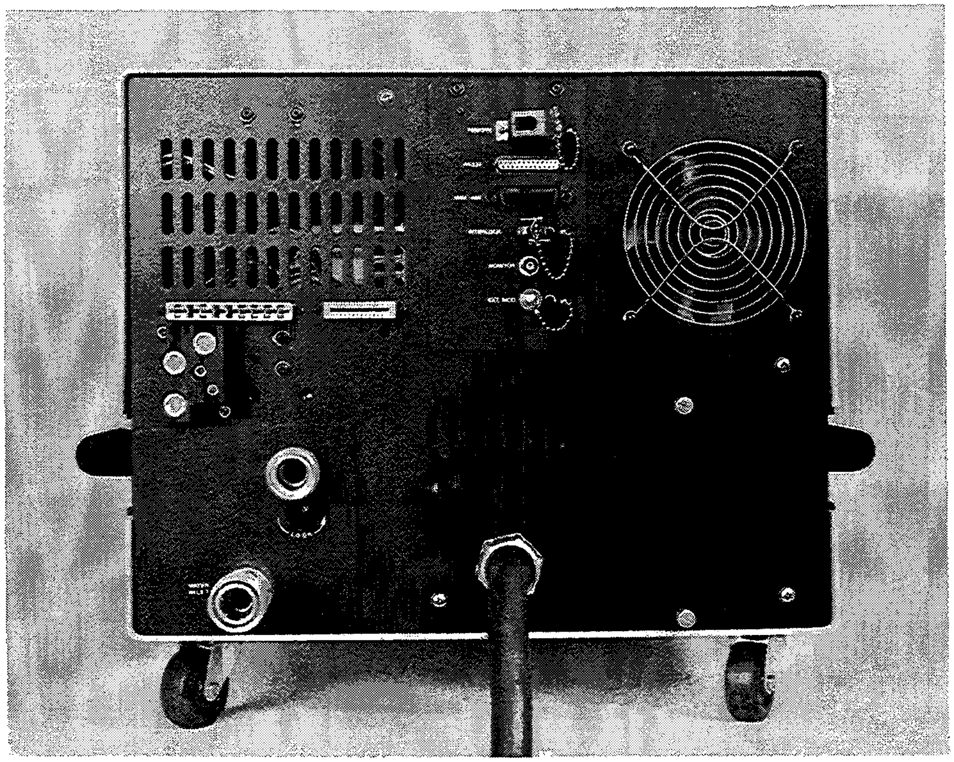


FIGURE 4.4: Model 2560 Power Supply Rear Panel

MAGNET REGULATOR knob - adjusts the current of the magnet regulator. If the power supply does not contain the magnet regulator, this potentiometer has no function.

LASER HEAD CONTROLS AND INDICATORS

Two control panels are available for the Model 2020 laser head. The standard control panel provides all of the adjustments necessary for both broadband and single-line operation. The optional high resolution panel simplifies tuning and adjustment by displaying the lasing wavelength and calibrating the optical output power sensor to it.

Standard control panel features:

Coarse vertical (wavelength) adjustment - changes the vertical alignment of the high reflector allowing rapid adjustment for optimum broadband performance. During single-line operation it provides a quick scan of individual laser lines. It is accessible through a hole in the control panel.

Coarse horizontal adjustment - changes the horizontal alignment of the high reflector allowing rapid adjustment for optimum performance. It is accessible through a hole in the control panel.

NOTE

Use the fine adjustments described below after peaking power and wavelength with the coarse mirror controls. Try to keep the fine controls near the middle of their ten-turn range (in the fifth revolution).

Fine VERTICAL ADJUSTment - moves the high reflector at 1/30th the rate of the coarse adjustment. Used for fine tuning both broadband and single-line performance.

Fine HORIZONTAL ADJUSTment - moves the high reflector at 1/30th the rate of the coarse adjustment. Used for fine tuning both broadband and single-line performance.

λ SELECTOR (nm) switch - calibrates the output power detector to the wavelength range selected. Insures an accurate output power display on the power supply panel meter.

FIGURE 4.5: High-resolution Laser Head Controls

Optional high-resolution features:

WAVELENGTH (nm) indicator - a three-digit LED display that shows the nearest lasing wavelength during single-line operation. During broadband operation it displays "ALL", and when the tube is being filled it displays "GAS".

PRISM position on the λ SELECTOR (nm) switch - used during single-line operation to calibrate the optical output detector to the operating wavelength. The controller reads the position of the wavelength selector and supplies the calibration factor required for an accurate optical power display.

λ COARSE TUNE adjusting knob - links the coarse adjustment to the WAVELENGTH indicator, identifying the nearest lasing line during single-line tuning.

CenTeR indicator - this LED glows when the λ FINE TUNE adjustment is at the center of its range (in its fifth revolution).

CALibration potentiometer - calibrates the wavelength indicator; accessible through a hole in the control panel.

STARTING THE LASER

CAUTION

The output beam of this laser is a safety and fire hazard. Avoid viewing the beam directly or blocking it with clothing or parts of the body.

1 Place a folded metal target (see LASER SAFETY) or an external power meter in the beam path and close the shutter.

2 Check the ac power line voltage; it should be between 188 and 228 V; extended operation near the limits of this range is not recommended.

3 Assure yourself that the green lead of the power cable is connected to **earth ground** .

4 Turn the cooling water supply on.

5 Move the CURRENT control fully counterclockwise, its minimum setting.

6 Turn the main power on; the power supply controller will "beep", indicating automatic reset, and all LED indicators will glow momentarily. Assure yourself that the OFF, CURrent MODE, CURrent 60 A, LOCAL (optional), and all three LINE indicators remain on; the STATUS ERROR indicator should be blank. The LINE indicators should be equally bright. If status error "01" appears, the power lines are out of phase; reverse any two leads at the switch box.

7 Wait 10 min; the oven-regulated current and power sensors must heat to about 55°C before they will supply dependable information, and the power supply has a built-in delay to allow proper warmup.

8 Turn the MASTER key switch ON.

9 Test the flow switch: turn the water supply OFF, wait 10 sec, and press the ON button; you should not be able to close the contactor under these conditions. If the ON button glows, indicating a closed contactor, immediately shut off the power and contact your Spectra-Physics service representative.

10 Restore the water supply, press the ON button, and if your laser is equipped with the optional magnet current regulator, set the current at about 10 A. The plasma tube will start automatically after about 10 sec.

11 Press the AUTO FILL ENABLE button (the auto fill system is disabled for the first 30 min).

12 Open the shutter; the laser beam will emerge from the output coupler.

13 Allow the laser to warm up in the current control mode for at least 10 min.

VERTICAL SEARCH ALIGNMENT PROCEDURE

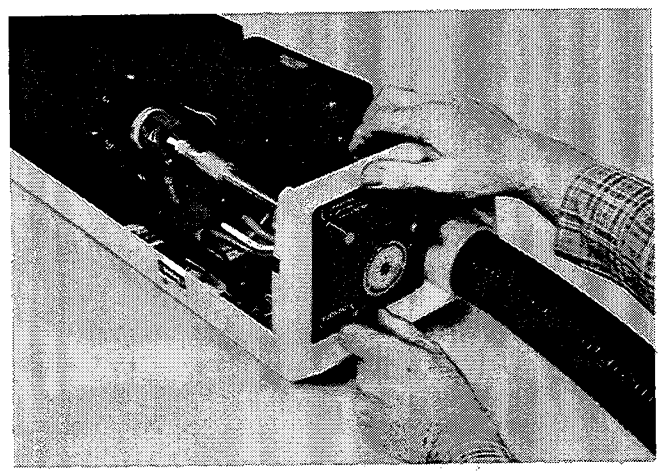


FIGURE 4.6: Vertical Search Technique

If your instrument fails to lase, the source of the problem is probably a severely misaligned high reflector. The following technique allows you to readily re-establish lasing.

Remove the top cover from the laser head and open the aperture fully ("12" on the scale).

Grasp the rear mirror mount near the coarse vertical adjustment screw and rock the mounting plate back and forth; simultaneously, turn the coarse horizontal adjustment screw to scan the high reflector horizontally. Keep rocking and scanning until you observe a bright flash of laser light. When the beam flashes, stop turning the horizontal control; then turn the vertical adjustment until you establish sustained lasing.

If you turn the horizontal adjustment so far that you are convinced that you will never achieve lasing, turn it in the other direction. Keep rocking the mirror mount as you turn the control.

ADJUSTMENT FOR PEAK OUTPUT POWER

Assuming the laser has been allowed to warm up properly, misalignment of the rear mirror mount is the most frequent cause of low output power. The beam must strike the mirror at right angles for optimum performance. If the mirror is misaligned on either the horizontal or vertical plane, or both, laser output will suffer.

Monitor the output power with an external power meter; the power supply must be in the current control mode.

The mirror mount is designed so that both planes can be independently adjusted. Insert a #23 (3/32") driver in each high reflector coarse adjustment; the optional high-resolution control panel provides a knob for coarse vertical adjustment.

Turn one control while observing the change in output power. If the power increases, continue to turn the control in the same direction. If the power declines, turn the control in the opposite direction.

Achieve peak power with one control before moving to the other one, then peak the other control in the same way. The adjustments may interact with each other so you will need to repeat the procedure, first with one control, then with the other, until the highest possible output power is achieved.

If the unit stops lasing while you are turning one of the controls, turn it in the opposite direction until lasing is re-established. Leave the other control alone until you get the unit lasing again.

Only adjust the high reflector to achieve peak power. The curved output coupler should remain stationary under normal operating conditions. If its alignment is disturbed, realignment may be time consuming and tedious. If, after adjusting the high reflector, the output performance remains below specification, clean the mirrors and plasma tube windows. If this fails to restore power, the output coupler or plasma tube, or both, may be misaligned; go to Maintenance for troubleshooting and alignment details.

WAVELENGTH SELECTION

For single-line operation the rear optics assembly contains a prism and a flat high reflector. The prism disperses the laser beam, bending individual lines according to their wavelength. A line will oscillate if its angle of refraction through the prism matches the vertical rotation angle of the prism. As you turn the vertical adjusting screw of the high reflector mount, labeled WAVELENGTH, the angle at which the beam strikes the prism will change, and with it the wavelength of the oscillating line.

The lines can be identified by their relative power, a comparison of which is found in the output power specifications, page 1-11. Positive identification of weaker lines requires a spectroscope.

The only resolvable lines that are difficult to distinguish are the two far red Krypton lines. 793.1 nm and 799.3 nm lie in a region where the dispersion of the prism is declining, and since the eye is relatively insensitive to these wavelengths, you will be unable to distinguish the lines by either the change in color or brightness that occurs when tuning from one to the other. To separate the lines, use a grating monochrometer or an external prism capable of separating the lines over a 2 m path.

If your laser is equipped with the optional high-resolution control panel, the coupled wavelength adjustors and display will simplify precise tuning.

If an external prism is unavailable, you can use a Spectra-Physics Model 404 power meter. Slowly and smoothly detune the wavelength from 799.3 nm toward the shorter wavelengths. The output will fall to 20-30% of the peak value, then it will rise slightly as the 793.1 nm line oscillates.

FINDING PEAK OUTPUT POWER WITH THE OPTIONAL MAGnet CURrent CONTROL

Two magnet options are available on the Model 2020. The basic system features a magnet that is wired in parallel with the plasma tube, and because of this arrangement, its current will vary with tube voltage. Under normal operating conditions magnet current will be about 5 A. The high-field system has a regulated high-field magnet that allows continuously variable current from 2 to 15 A.

The optical output at a given line is directly related to the strength of the magnetic field that envelops the plasma tube discharge. Visible argon lines perform best with a magnet current of about 8 A. Ultraviolet lines require higher field densities, which are obtainable with a magnet current of about 15 A, and some krypton lines yield optimum results when the current is less than 8 A.

Place the laser in the current control mode. After you tune to a given line and adjust the rear mirror for peak output power, try changing the magnet current. Use a power meter to observe the change in output power. Adjust the field for optimum performance.

If your working output power is less than the full capacity of the laser, adjust the magnet current for its optimum value before you make the final power setting using the CURRENT control.

USING THE SHUTTER

The Model 2020 laser is equipped with a shutter that blocks the intracavity beam. Switch the power supply to the current control mode before closing the shutter. If the power supply is left in the power mode when the shutter is closed, the power control circuit will increase plasma tube current to maximum. Prolonged operation at maximum current may reduce plasma tube life.

TRANSVERSE MODES

Variations in the electromagnetic field perpendicular to the direction of travel of the wave are called Transverse Electromagnetic, or TEM, modes. These variations determine, in part, the power distribution across the beam.

Most laser applications require a TEM_{00} beam, which appears as a round spot that is brighter in the center than it is on its edges (Figure 4.7). Other modes have different irradiance contours and are identified by the number of nulls in the irradiance distribution. The mode pattern for a given laser is a function of wavelength and can be affected by the size of the aperture, scratches on the mirrors, or dust on the optical surfaces.

The aperture control allows adjustment for true single-mode (TEM_{00}) output over a wide range of wavelengths. The aperture may also be used to reduce output power or, if TEM_{00} performance is not required, to increase it.

You may find it difficult to identify the mode of a beam by direct observation; however, lenses can be used to expand the beam, making observation of irradiance distribution easier.

CAUTION

> The Model 2020 is a Class IV laser the beam of which is, by definition, a safety hazard. Even reflected beams can be dangerous. Use a neutral density attenuator for mode observations and adjustments. Make sure the beam only strikes low-reflectance surfaces.

Place a positive lens (focal length about 1.5 cm) in the beam path and observe the beam, expanded to about 0.5 m, on a wall or screen. Multimode conditions appear as complex variations in the pattern. As the aperture closes, the multimode patterns will shrink in overall diameter, and the rapid intensity variations across the beam will disappear. TEM_{01} – the "donut" mode – usually appears; then, as the aperture tightens further, the TEM_{00} condition is established.

GAS FILL

When the plasma tube is new, gas fill may be required every few days of operation. After the first few hundred operating hours, fill will be required only every several hundred hours.

Since gas distribution and pressure change rapidly during the first few minutes of operation, the power supply will wait 30 min after the plasma tube has been started, before allowing a fill cycle.

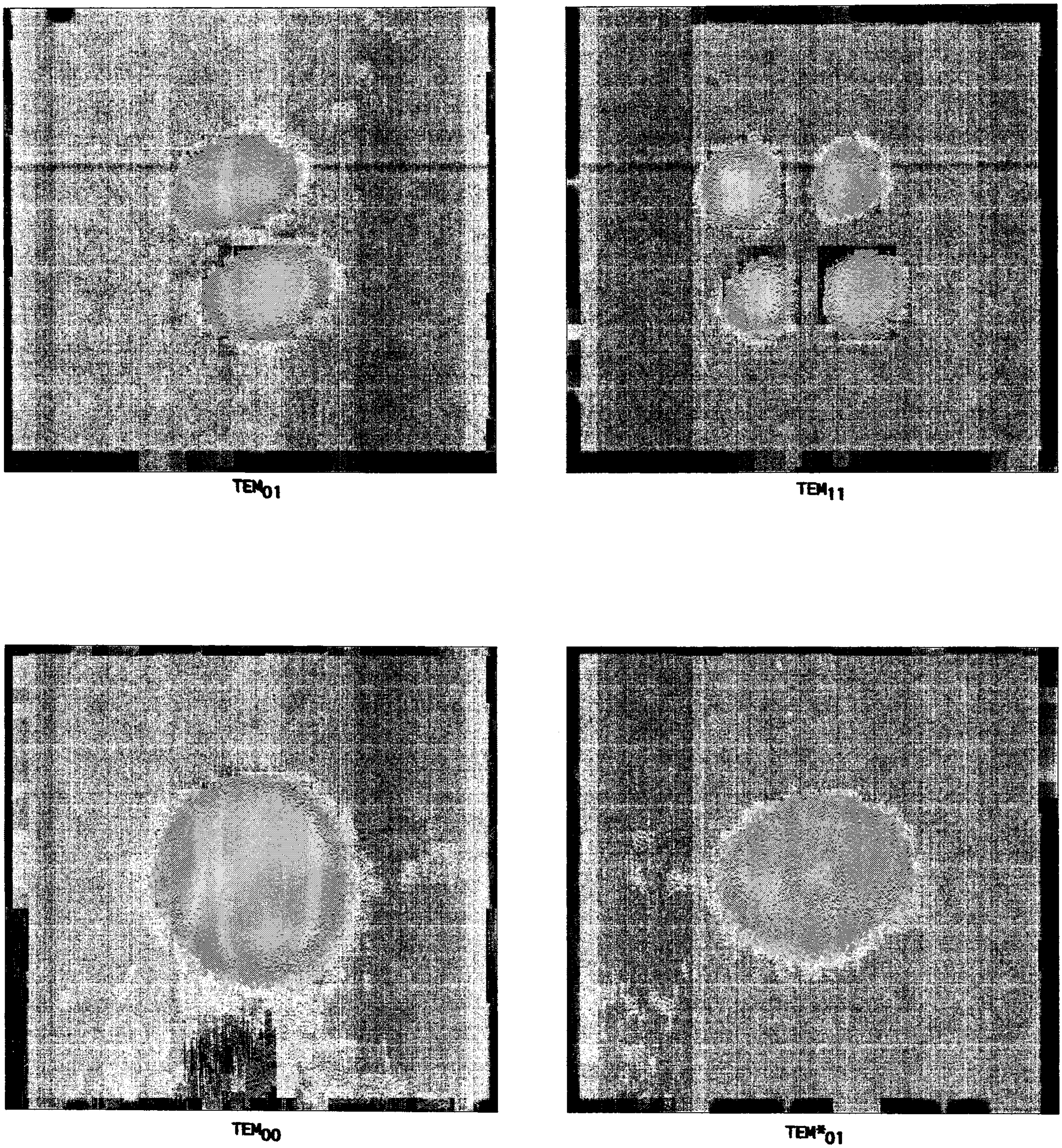


FIGURE 4.7: Transverse Modes

Gas Fill Algorithm

The algorithm maintains the plasma tube fill pressure at an optimal level. To protect the power supply, it also prevents turn on if the tube pressure is too low. Very-low-pressure tubes generate rf feedback to the power supply and can cause damage.

Since tube pressure cannot be measured directly, the controller measures three values - tube voltage, tube current, and magnet current. Then it compares the tube voltage to a lookup table held in memory. Four tables are available, each corresponding to one of the available tube types: visible argon, ultraviolet argon, visible krypton, and ultraviolet krypton. The controller determines fill requirements by comparing the actual tube voltage with the appropriate table.

If the tube voltage is less than the table value at the given tube and magnet currents, and assuming the system is properly warmed up, the controller executes one fill cycle, i.e., one actuation of each fill solenoid. Filling continues until the tube voltage equals or exceeds the table value. Each fill cycle takes about 64 sec.

The fill system is disabled if the AUTO FILL ENABLE switch on the front panel is off. However, if the switch is off and the pressure drops to the danger level (4% below the optimal fill level), the controller will automatically enable the auto fill system and begin filling the tube. The beeper will sound and the status error display will read "69".

Error 69 = "Low fill limit reached . . . switching to automatic fill."

If 50 fill cycles fail to raise the tube pressure above the table value, the controller assumes that the fill reservoir is empty; it will cause the LOW PRESSURE lamp to blink, sound the beeper, and display "70".

Error 70 = "Fill reservoir empty"

If 50 fill cycles fail to raise the tube pressure above the danger level, the controller will display "71" and shut the system down.

Error 71 = "Tube pressure too low to operate"

This condition can only be cleared by shutting off power at the switch box, thereby resetting the system.

When the AUTO FILL ENABLE switch is on (LED glows), filling commences automatically if the pressure drops below the table value.

The auto fill system is disabled if tube voltage, tube current, or magnet current are discovered to be abnormal:

Error 72 = "Tube volts <100 V"
Error 73 = "Tube current <16.5 A"
Error 74 = "Magnet current <3 A"

The filling system is disabled until 30 min after the ON switch is depressed to allow the gas pressure to stabilize. The filling system is also disabled for the following two reasons: when either the current or power mode LED on the front panel is flashing, indicating the system is out of regulation; or when error code 59 is displayed, indicating the passbank is out of regulation.

DIP switches on the Laser Head Controller board identify the tube and magnet. The DIP switch positions are sensed at initial turn on; therefore, changing switch positions after turn on has no effect. This eliminates the possibility of accidental overfill due to an unintentional change in the DIP switch settings. The DIP switch configuration is shown in Figure 8.6.

CHANGING OPTICS

CAUTION

The optics are fragile and can be damaged if dropped. Work over a clean, soft surface.

The Model 2020 comes equipped with a set of mirrors that were designed for optimum performance within the wavelength range specified at the time of purchase. Additional sets of optics can be obtained from Spectra-Physics.

The mirror mount features a bayonet receptacle for mirror holders, providing quick access and precise replacement for high performance without undue adjustment. The front reflector assembly holds the output coupler, a thin-film mirror that is coated to allow a few percent transmission of desired wavelengths. The prism and broadband high reflector assemblies hold flat mirrors coated for high reflectance of desired wavelengths.

Hold the output assembly vertical with the mirror on top. Use finger cots to protect the mirror during removal and replacement. A Spectra-Physics part number and an arrow appears on the edge of each mirror. Insert the mirror so that the arrow points into the laser cavity; Figure 4.9 identifies available optics.

Always align your laser for peak output power before removing any of its optics. Remove and replace them one at a time, and repeak the power upon replacement, adjusting only the mirror that was removed.

Your laser will usually operate at full power after changing optics. If a significant power loss occurs, try removing, cleaning, and replacing the mirror again.

The output and broadband mirror holders are designed to lock in precise alignment. If you notice that a mirror appears tilted in its holder, its alignment lock is disengaged. Try turning the mirror and its spring-loaded cup until the locking mechanism snaps back in place. You won't be able to turn the mirror and cup further, and the coated surface will be perpendicular to the long axis of the mirror holder. If the mirrors are clean and locked in alignment, but the output power remains low, go to Maintenance.

Under normal operating conditions the output coupler should not need realignment after a mirror change. Avoid tampering with output mirror controls unless you are certain that it is misaligned; realignment can be time consuming and tedious.

To reach the high reflector in the prism assembly, unscrew the knurled retaining ring and lift the assembly from its protective cup. A small screw holds the mirror-retaining spring in place; remove it and invert the assembly, dropping the mirror onto a soft surface. Reverse the sequence to replace the mirror.

SHUTDOWN PROCEDURE

1 Press the OFF button.

2 Turn the MASTER key switch OFF and remove the key. Don't leave the laser accessible to people who are untrained in laser safety or operation.

3 Turn the main electric power off.

4 Allow cooling water to run for a few more minutes to allow the tube to cool down. Then shut off water.

FIGURE 4.8: Series 2000 Optics Assemblies

FIGURE 4.9: Ion Laser Optics Options

Laser Model	Wavelength (nm)	Output Coupler	Broadband/ Prism HR
Series 2000 Argon	351.1 & 363.8	G3873-007	G3802-016
Model 2020-03,-04,-05	457.9 - 514.5	G3873-006*	G3802-009*
Model 2025-03,-04,-05	528.7	G3861-003	G3802-015
	488.0 & 514.5[4]	G3814-016	G3802-009*
	454.5	G3861-002	G3802-013
	454.5 - 514.5[1,2,3]	G3810-007	G3810-005
	454.5 - 514.5[2,3,5]	G3808-017	G3808-018
	1090[2,6]	G3812-006	G3812-005
Series 2000 Krypton	337.4 & 356.4	G3873-008	G3802-016
Model 2020-11	406.7 - 415.4	G3873-009	G3802-025
Model 2025-11	476.2 - 520.8	G3873-010	G3802-015
	530.9 - 568.2	G3873-011	G3802-015
	647.1 - 676.4	G3873-012*	G3873-013*
	752.5 - 799.3	G3812-014	G3812-013

	Output Mirror/ Beam Splitter Holder	Broadband Mirror Holder	Prism Assembly
Optics Holders	0428-5641	0428-5651	0428-6080
Optical Element	G0062-000		G0317-000

Etalons	Wavelength (nm)	Model 583 Temperature Stabilized	Model 589 Air Spaced
Argon Lasers	457.9	583-53	n/a
	488.0	583-13	589-13
	514.5	583-13	589-13
Krypton Lasers	413.1	583-53	
	647.1	583-23	

* Supplied with standard laser.

1 TEM^*_{01} multimode

2 Performance not guaranteed.

3 Mode size and divergence change

4 Recommended for two-color LDV applications. Suppresses 488.9 nm line. Improves conversion efficiency when etalon is detuned to balance simultaneous 488.0 nm and 514.5 nm single frequency operation.

5 Higher order multimode

6 Not optimized

EXTERNAL CONTROL

HARDWARE REQUIREMENTS

The Model 2560 is a programmable power supply that can be controlled either locally from buttons on its front panel, or remotely from an external control source. External control via the optional RS232 or IEEE data links requires the presence of other Series 2000 accessories. In order to use the RS232 interface, your laser must be equipped with the Auxiliary Front Panel and the Smart Board options. The computer or terminal you plan to use must have an RS232 interface and a standard RS232 interface cable.

If you wish to use IEEE 488 control, you must have the following options installed in the power supply: Auxiliary Front Panel, Smart Board, and an IEEE 488 Interface Card. Also required are an IEEE 488 bus controller, which is any computer having an IEEE 488 interface and bus control capability, and a standard IEEE 488 bus cable.

CONTROL SOURCE SELECTION

The control buttons on the Auxiliary Front Panel activate the four control sources for the power supply. Refer to "Operation: Auxiliary Controls" for a description of the function of each button. The control source can be changed manually by pressing one of the four buttons. When the active control source is either RS232 or IEEE, control can be passed from one active source to another by one of the following commands: LOCAL, REMOTE, IEEE, or RS232.

For example, if SERIAL is the active controller, and the operator enters the LOCAL command from a computer terminal that is connected to the power supply through the RS232 interface, the power supply responds to the command by activating LOCAL front panel control. At this point the power supply no longer responds to commands from the terminal until the operator once again selects the RS232 control source by pressing the SERIAL button on the auxiliary front panel.

IEEE INTERFACE OPERATION

IEEE 488 Universal Bus Commands

The power supply has implemented several of the universal bus commands that are defined by the IEEE 488 interface bus specification ANSI/IEEE Std 488-1978. The following table lists these commands and describes the power supply responses to them. Corresponding HP9836 and HPL GPIB control commands for each operation are also shown.

MESSAGE	GPIB MNEMONIC	POWER SUPPLY/IEEE INTERFACE OPERATION	HPL COMMAND	HP9836 BASIC COMMAND
REMOTE	REN	PUTS POWER SUPPLY INTO IEEE SYSTEM REMOTE CONTROL MODE	rem 725	REMOTE 725
LOCAL	GTL	PUTS POWER SUPPLY INTO FRONT PANEL LOCAL CONTROL MODE	lcl 725	LOCAL 725
LOCAL LOCKOUT	LLO	DEACTIVATES THE FRONT PANEL CONTROLS ON ALL EQUIPMENT ATTACHED TO THE IEEE BUS	llo 7	LOCAL LOCKOUT 7
	LCL	REACTIVATES THE FRONT PANEL CONTROLS ON ALL EQUIPMENT ATTACHED TO THE IEEE BUS	lcl 7	LOCAL 7
RESPONSE TO SERIAL POLL	SPE	SEND SERIAL POLL STATUS BYTE TO BUS CONTROLLER	rds (725)	SPE= SPOLL(725)

IEEE 488 Control Source Selection Using the REN Command

The remote enable (REN) command makes it possible for the IEEE 488 bus controller to select itself as the active system control source while one of the other sources is active. The bus controller should execute the following operations when it wishes to take control from another control source:

IEEE 488 Bus Controller Operation	Power Supply Response
Enable remote state for all devices on the bus by setting REN bus control line true.	
Address the power supply to listen.	Select IEEE 488 control source.
Run application program.	Execute commands recieved from the IEEE 488 bus controller.
Send go to local (GTL) bus message to the power supply.	Select front panel control source.

The power supply responds to the GTL bus message only when the bus controller has previously enabled the bus remote state and addressed the power supply to listen. Therefore, in this sequence of operations, step four would have no effect if steps one and two were not executed.

Normally, the bus controller should relinquish control of the power supply by sending the GTL bus message, as step four of the sequence demonstrates. However, if the bus controller has also previously activated the local lockout state in the power supply, then to cancel local lockout and restore front panel control, it must set the REN bus control line false. The local lockout state is discussed in detail in the next section.

Disabling the Auxiliary Front Panel with the LLO Command

The local lockout (LLO) bus message gives the IEEE 488 bus controller the capability of disabling all control of the power supply front panel and auxiliary front panel. This feature is useful in applications where it is important that the system control source for the power supply remain unchanged. To disable the front panel and auxiliary front panel control buttons, the bus controller must first enable the bus remote state by setting the REN bus control line true, then it must send the local lockout bus message. To cancel the local lockout state and restore front panel control in the power supply, the bus controller needs to disable the bus remote state by setting the REN control line false. Some computers with IEEE 488 I/O capabilities have defined special system commands that activate and clear the local lockout state. Refer to "IEEE 488 Interface Programming Examples" later in this chapter for two sample programs that demonstrate the use of these special IEEE 488 bus capabilities.

Serial Poll Status Byte

The power supply maintains a status byte that stores active system control source and system fault status information. The IEEE 488 bus controller can read this status byte by sending the serial poll enable (SPE) bus message to the power supply, to which the power supply responds by sending the status byte to the bus controller. Typically, the bus controller can perform a serial poll by executing a single program statement. A sample program that reads the serial poll status byte is shown later in this chapter in "IEEE 488 Interface Programming Examples." A definition of the status byte is shown in the table that follows.

SERIAL POLL STATUS BYTE

BIT	7-msb	6	5	4	3	2	1	0
	SYSTEM FAULT STATUS	0	LOCAL/ REMOTE	LOCAL LOCKOUT	RS232	REMOTE PANEL	FRONT PANEL	IEEE
			GPIB DEVICE STATE		ACTIVE SYSTEM CONTROLLER			

KEY:

Bits	3 to 0	= 0001	IEEE control
		= 0010	front panel control
		= 0100	remote panel control
		= 1000	RS232 control
	4	= 0	local lockout state disabled
		= 1	local lockout state enabled
	5	= 0	device local state enabled
		= 1	device remote state enabled
	6	= 0	unused
	7	= 0	no system faults
		= 1	one or more system fault conditions exist
	msb	= most significant bit	

IEEE 488 Bus Address Selection

Every device attached to the IEEE 488 interface must have a unique address that is different from all other addresses of devices on the bus. The DIP switch on the IEEE card selects the device address for the power supply. Addresses must be in the range of 0 to 31. The factory setting for the power supply bus address is 25. Refer to "Service and Repair: System DIP Switch Settings" for further information.

RS232 INTERFACE OPERATION

The serial interface of the power supply is an RS232C compatible interface. The RS232C interface standard specifies electrical and mechanical interface requirements, but it does not define the exact function of all the signals used by various manufacturers of serial I/O devices. In order for two devices to communicate with each other through an RS232C data link, the optional parameters of the two devices must be configured to match.

Hardware Configuration

The RS232C interface standard classifies serial I/O devices as either data terminal equipment (DTE) or data communications equipment (DCE). The standard identifies the interface connector pin numbers used for the various data and control lines in each type of equipment. Signal inputs and outputs are likely to be compatible when a DTE device is connected to a DCE device. If two DTE or two DCE devices are connected together, an interface cable adaptor that crosses the data and control signal pairs is usually all that is required to make the two devices compatible.

Problems usually arise when the configuration is unknown, or when the control signal and handshaking requirements of each device are unknown. Once these are determined, it is easy to match the two devices to each other with an interface cable that properly connects the data and control signals between them. In the power supply, hardware jumpers on the Smart Board provide a convenient way to configure the signal lines of the RS232 data link.

The power supply is configured as a DCE device at the factory. The following diagram shows the required interface signal connections between the power supply and a standard RS232 terminal. The data link signal names refer to the DTE.

```
 Terminal          RS232C Link          Power Supply
   (DTE)                                   (DCE)

TXD      (2) <--Transmitted Data-----> (2)     RXD
RXD      (3) <--Received Data--------> (3)     TXD
RTS      (4) <--Request to Send------> (4)     CTS
CTS      (5) <--Clear to Send--------> (5)     RTS
DSR      (6) <--Data Set Ready-------> (6)     DTR
DTR     (20) <--Data Terminal Ready--> (20)    DSR
         (7) <--Signal Ground--------> (7)
         (1) <--Safety Ground--------> (1)
```

FIGURE 5.1: RS232 Cable Wiring Diagram

Another important hardware configuration is the data transmission rate of the data link. Both devices must send and receive data at the same speed. The DIP switch setting on the Smart Board is used to select one of several possible bit transmission (baud) rates. The factory setting is 4800 baud, and this is the recommended setting for use with the 2560 power supply.

Character Format Settings

There are three character format settings that must be configured to match between the two communications devices: character length, parity, and stop bit. Most serial I/O devices allow the user to select these optional settings. In the power supply the character format settings are fixed to the following conditions:

Character length:	eight data bits
Parity:	disabled
Stop bits:	two

All character format settings must be made in the RS232 terminal or computer.

Data Transfer and Handshaking

The serial interface of the power supply operates in the full duplex mode. This means that data may be sent and received simultaneously. To synchronize data transmission with the RS232 controller, the power supply uses the Data Set Ready, Clear to Send, and Request to Send control signals in the manner described below. Control signal names refer to the DTE.

Data Set Ready - the power supply sets this line continuously.

Clear to Send - the power supply sets this line on when it is ready to receive messages from the RS232 controller. When the power supply is processing previously received messages, it sets this line off.

Request to Send - the power supply checks this line when it has data to send to the RS232 controller. The power supply sends the data only when the RS232 controller has set this line on.

Echo Mode

Echo mode is a special feature of the RS232 serial interface. The DIP switch on the Smart Board enables or disables the RS232 Echo Mode. When it is enabled, the power supply will "echo" back to the RS232 terminal all characters as they are received from the terminal. This feature is useful when the control source is a "dumb" RS232 terminal that requires characters to be echoed back to it in order to display the keyboard entries on the terminal screen. If the RS232 control source is a computer that is issuing commands to the power supply from a program, Echo Mode must be disabled. Refer to "Service and Repair: System DIP Switch Settings" for information on enabling and disabling Echo Mode.

COMMAND FORMAT FOR RS232 AND IEEE 488

When using the RS232 serial or IEEE488 parallel data links, you can send commands to the laser system or ask questions about it. Standard ASCII* characters are used to send commands and questions over the data link. The following pages describe the available commands and questions and explain their formats.

All question and command transmissions sent from an RS232 or IEEE control device to the power supply must be terminated with ASCII carriage return (OD hex) and line feed (OA hex) characters, which are identified in the text as <CR> and <LF>, respectively.

Examples:

?PWR<CR><LF> or MODE=PWR<CR><LF>

<CR><LF> = carriage return, line feed

All responses transmitted from the power supply to an RS232 or IEEE control device will be terminated with ASCII carriage return and line feed characters, e.g.,

question	response
?INLK<CR><LF>	05<CR><LF>

<CR><LF> = carriage return, line feed

Questions and commands must be formatted as specified. The power supply will ignore space characters and any input in which it detects an invalid format. However, for the "CUR", "MAGNET", and "PWR" commands, the power supply will accept data fields from one to four characters in length, with or without a decimal point, e.g.,

CUR=30.<CR><LF>
MAGNET=5<CR><LF>
PWR=.7<CR><LF>

When the Smart Board DIP switch is set to enable the echo mode (see Figure 8.8) each character received by the the power supply will be returned to the terminal for display. If the power supply detects an invalid question or command format, it will return a question mark (?) to the terminal, e.g.,

METER=POW<CR><LF> (invalid command from terminal)

?<CR><LF> (response to terminal)

Question and Command Format Definitions

Code	Definition
aaa	The ASCII representation of upper case alphabet characters A to Z
A-Z	The ASCII representation of upper case alphabet characters A to Z
n	The ASCII representation of decimal digits 0 to 9
0-9	The ASCII representation of decimal digits 0 to 9
h	The ASCII representation of hexadecimal digits 0 to F.
<CR>	The ASCII carriage return code (OD hex)
<CR><LF>	The ASCII carriage return and line feed codes (OD and OA hex)
$	The ASCII dollar sign code (24 hex)
.	The ASCII decimal point code (2E hex)

* American Standard Code for Information Interchange

OPERATOR INITIATED COMMANDS FOR IEEE488 OR RS232 CONTROL

Command	Data Field	Description	Example
ALARM		Turns the audible warning alarm off should it be on; it does not disable the alarm.	ALARM
BEEP		Turns the audible alarm on for 0.5 sec.	BEEP
CUR=	.nnn n.nn nn.n nnn.	Sets the plasma tube current in amperes. This command is executed immediately if the system is in the constant current mode; or it is deferred until the system mode is switched to the current mode.	CUR=22.5
CUR=	POT	Returns plasma tube current control to the front panel current potentiometer.	CUR=POT
DAC=	d	Selects computer control for seting the current and power setpoints of the laser, and disables the front panel pot control. The setpoint is specified by "d" which may be a decimal integer from 0 to 4095. When in current mode, the DAC=d command selects from 0 to 63.2 A of plasma current. In power mode it selects a corresponding output power setting dependant on the active power range as the following table indicates.	DAC=1948

Range	Power
.3 W	0 to .316 W
1 W	0 to 1.0 W
3 W	0 to 3.16 W
10 W	0 to 10.0 W

The DAC = d command clears any command entries that may have been made previously using the CUR=n or PWR=n commands.

Command	Data Field	Description	Example
FILL=		Turns the automatic gas fill mode on or off:	FILL=ON
	ON	Auto fill mode on	
	OFF	Auto fill mode off	
IEEE		Turns over system control to the IEEE488 bus control device.	IEEE

OPERATOR INITIATED COMMANDS FOR IEEE488 OR RS232 CONTROL

Command	Data Field	Description	Example
INC		Increments the front panel status display to show the next active status error number when multiple error conditions exist.	INC
LOCAL		Turns over system control to the front panel.	LOCAL
MAGNET=	.nnn n.nn nn.n nnn.	Sets the magnet current in amperes.	MAG=9.50
MAGNET=	POT	Returns magnet current control to the auxiliary panel MAG CUR potentiometer.	MAG=POT
METER=		Selects one of eight front panel meter functions:	METER=VLT
	CUR	Tube Current	
	DRV	Plasma Drive Signal (FS = 5 V)	
	EAB	EAB Signal (FS = 5 V)	
	MAG	Magnet Current (Ignored if there is no magnet regulator)	
	PBV	PBV Signal (FS = 20 V)	
	PWR	Output Power	
	REF	+5 V Reference Signal (FS = 5 V)	
	VLT	Tube Volts	
MODE=		Selects the system operating mode:	MODE=PWR
	CUR	Constant Current Mode	
	PWR	Constant Power (Light) Mode	
OFF		Turns the tube off immediately	OFF
OFF=	nnnn	Specifies the number of minutes (0000 to 9999) until the tube will automatically turn off; specifying OFF=0000 turns the tube off immediately.	OFF=0060
OFF=	$$$$	Disables the automatic tube turn off.	OFF=$$$$
PWR=	.nnn n.nn nn.n nnn.	Specifies the output power in watts. Also selects one of four power ranges. This command is executed immediately if the constant power mode is active, or it is deferred until the system mode is switched to the power mode.	PWR=2.00

OPERATOR INITIATED COMMANDS FOR IEEE488 OR RS232 CONTROL

Command	Data Field	Description	Example
PWR=	POT	Returns output power control to the front panel power potentiometer. Does not affect the power range or front panel meter function.	PWR=POT
RANGE=		Selects one of four power ranges:	RANGE=1
	1	0.3 W range	
	2	1 W range	
	3	3 W range	
	4	10 W range	
REMOTE		Turns over system control to the remote panel.	REMOTE
RS232		Turns over system control to the RS232 interface control device.	RS232
SAVE	IEEE LOCAL REMOTE RS232	Saves the present status of these system parameters in non-volatile memory for reactivation as initial startup conditions for future system operation. a. tube set current b. output set power c. magnet set current d. system controller (specified in command data field) e. meter function f. power range g. system operating mode (current or power) h. auto fill mode (on or off)	SAVE IEEE
TIME=	nnnn	Sets the 24-hour timer to the hour and minute specified (nnnn must be in the range 0000 to 2359). NOTE: The 24-hour timer is a software driven clock which is typically accurate to within 3 sec. in 24 hrs. The error may increase to as much as 3 min. per day if the computer interface is used constantly.	TIME=1330 (set time to 1:30 pm)

OPERATOR-INITIATED QUERIES FROM RS232 OR IEEE488 CONTROL

Query	Description	Response	Comment
?CUR	What is the measured tube current?	.nnn n.nn nn.n nnn.	amperes
?DIP1	What is the system controller board DIP switch status?	nnn	000 to 255
?DIP2	What is the IEEE board DIP switch status?	nnn	000 to 255
?DIP3	What is the smart board DIP switch status?	nnn	000 to 255
?DIP4	What is the laser head controller board DIP switch status?	nnn	000 to 255
?DIP5	What is the firing controller board DIP switch status?	nnn	000 to 255
?EMPTY	Is the fill reservoir empty?	Y or N	yes or no
?FILL	Is the auto fill mode on or off?	ON or OFF	on or off
?FLOW	What is the water flow rate?	n.n F.F	0.0 to 5.0 gal/min Flow>5 gal/min
?INLK	What is the interlock status?	nn	status code

nn = 00 all interlocks closed
- 01 front panel ON switch open
- 02 remote key switch, remote OFF switch or remote jumper plug open
- 03 remote panel key switch open
- 04 remote panel OFF switch open
- 05 front panel OFF switch open
- 06 front panel key switch open
- 07 CDRH INTERLOCK plug open
- 08 power supply cover switch open
- 09 umbilical interlock open
- 10 head temp, flow or cover interlock open
- 11 head water temp interlock open
- 12 head water flow interlock open
- 13 head water temp and flow interlocks open
- 14 head cover interlock open
- 15 interlock status unknown (dropout sensed or pilot relay disabled)

OPERATOR-INITIATED QUERIES FROM RS232 OR IEEE488 CONTROL

Query	Description	Response	Comment
?MCUR	What is the measured magnet current?	.nnn n.nn nn.n nnn.	amperes
		UNK	unknown - no magnet regulator
?METER	What is the front panel meter function? aaa = CUR tube current DRV plasma drive signal EAB EAB signal MAG magnet current PBV PBV signal PWR output power REF +5 V reference signal VLT tube volts	aaa	function code
?MODE	What is the tube operating mode?	CUR	current mode
		PWR	power mode
?MRES	What is the measured magnet resistance?	nnn	000 to 999 ohm
		UNK	unknown - no magnet regulator or magnet current less than 2 A
?MVOLT	What is the measured magnet voltage?	.nnn n.nn nn.n nnn.	volts
		UNK	unknown - no magnet regulator
?OFFTIME	How many minutes until automatic tube turn off?	nnnn	0000 to 9999 minutes
		$$$$	auto turn off is disabled
?ONCTL	What is the system controller status saved in non-volatile memory?	1	local
		2	remote
		3	RS232
		4	IEEE
?ONCUR	What is the tube current setting status saved in non-volatile memory?	.nnn n.nn nn.n nnn.	amperes

OPERATOR-INITIATED QUERIES FROM RS232 OR IEEE488 CONTROL

Query	Description	Response	Comment
?ONFILL	What is the auto fill mode on/off status saved in non-volatile memory?	ON	fill mode on
		OFF	fill mode off
?ONMAG	What is the magnet current setting status saved in non-volatile memory?	.nnn	amperes
		n.nn	
		nn.n	
		nnn.	
?ONMODE	What is the system operating mode status saved in non-volatile memory?	CUR	current mode
		PWR	power mode
?ONMTR	What is the front panel meter function status saved in non-volatile memory?	aaa	function code
	aaa = CUR tube current DRV plasma drive signal EAB EAB signal MAG magnet surrent PBV PBV signal PWR output power REF +5 V reference signal VLT tube volts		
?ONPWR	What is the output power setting status saved in non-volatile memory?	.nnn	watts
		n.nn	
		nn.n	
		nnn.	
?ONRNG	What is the power range setting saved in non-volatile memory?	1	0.3 W
		2	1 W
		3	3 W
		4	10 W
?PRES	Is the tube pressure low?	Y	yes
		N	no
?PWR	What is the measured output power?	.nnn	watts
		n.nn	
		nn.n	
		nnn.	
?RANGE	What is the power range?	1	0.3 W
		2	1 W
		3	3 W
		4	10 W

OPERATOR-INITIATED QUERIES FROM RS232 OR IEEE488 CONTROL

Query	Description	Response	Comment
?RES	What is the measured tube resistance?	nnn	000 to 999Ω
		UNK	unknown - tube is off
?SETCUR	What is the tube current setting?	.nnn n.nn nn.n nnn.	amperes
?SETDAC	What is the DAC setting?	d	0 to 4095
?SETMAG	What is the magnet current setting?	.nnn n.nn nn.n nnn.	amperes
?SETPWR	What is the output power setting?	.nnn n.nn nn.n nnn.	watts
?STATUS	What is the error code presently displayed on the front panel status indicator?	nn	01 to 99
		00	display blank
?TEMP1	What is the measured head water temperature?	nn	00 to 99°C
		EE	<00°C
		FF	>99°C
?TEMP2	What is the measured passbank water temperature?	nn	00 to 99°C
		EE	<00°C
		FF	>99°C
		UNK	unknown if no passbank
?TEMP3	What is the measured SCR module air temperature?	nn	00 to 99°C
		EE	<00°C
		FF	>99°C
?TIME	What is the time of day?	nnnn	0000 to 2359 nn hr nn min
?VOLT	What is the measured plasma regulator output voltage? Response is the tube voltage plus nearly 4 V constant start circuit voltage drop.	.nnn n.nn nn.n nnn.	volts

OPERATOR-INITIATED QUERIES FROM RS232 OR IEEE488 CONTROL

Query	Description	Response	Comment
?WAVE	What is the wavelength setting?	nnn	single-line
			400 to 800 nm
			broadband
		1	300-450 nm
		2	450-600 nm
		3	600-700 nm
		4	700-800 nm
@hhhh	What is the data contained in system controller CPU memory at hexadecimal address hhhh?	nnn	000 to 255

IEEE 488 INTERFACE PROGRAMMING EXAMPLES

NOTE

These programming examples are written for the HP9836 computer. The power supply has its IEEE Board DIP switch set to address 25.

Example 1

Use remote enable and go to local universal bus commands to take control from the active system control source, then pass control to the front panel:

```
10     REMOTE 725                  !Select IEEE 488 control source
•
•
90     LOCAL 725                   !Restore front panel control source
100    END
```

Example 2

Use local lockout universal bus command to disable front panel and auxiliary front panel keys, then cancel local lockout state:

```
10     REMOTE 725                  !Select IEEE 488 control source

20     LOCAL LOCKOUT 7             !Disable front panel keys
•
•
90     LOCAL 7                     !Restore front panel control
100    END
```

Example 3

Input the serial poll status byte from the power supply, then test the system fault status bit:

```
10     S = SPOLL(725)              !Input serial poll status byte

20     IF BIT(S,7) THEN
       GOSUB Fault                 !Call subroutine if bit 7 is set
```

DATA SOURCES FOR RS232 AND IEEE 488 OPERATION

Several devices within the laser system provide data to an RS232 or IEEE control device. The following table identifies the source of response data for each of the questions allowed by the current system.

Question	Program Status	12-bit ADC Measurement	8-bit ADC Measurement	LH 8-bit ADC Measurement	Non-volatile Memory
?CUR		X			
?DIP1	X				
?DIP2	X				
?DIP3	X				
?DIP4	X				
?DIP5	X				
?EMPTY	X				
?FILL	X				
?FLOW				X	
?INLK	X				
?MCUR		X			
?METER	X				
?MODE	X				
?MRES			X		
?MVOLT		X			
?OFFTIME	X				
?ONCTL					X
?ONCUR					X
?ONFILL					X
?ONMAG					X
?ONMODE					X
?ONMTR					X
?ONPWR					X
?ONRNG					X
?PRES	X				
?PWR		X			
?RANGE	X				
?RES			X		
?SETCUR	X				
?SETMAG	X				
?SETPWR	X				
?STATUS	X				
?TEMP1				X	
?TEMP2		X			
?TEMP3		X			
?TIME	X				
?VOLT		X			
?WAVE	X				
@	System controller ROM or RAM				

IEEE488 Data Link Test

```
10    !-----------------------------------------------------------------!
20    !     This program is used to test the IEEE 488 port of the Model !
30    ! 2560 ION Laser Power Supply.  The program allows the operator to ask !
40    ! a question or send a command to the Power Supply.  The program  !
50    ! requires a working Model 2560 with a Smart Board and a IEEE488 board. !
60    ! The IEEE address of the supply is assumed to be 25.  Also, the Power !
70    ! Supply's IEEE lamp on the Auxiliary Front Panel should be lit.  This !
71    ! indicates that the supply is ready to use the IEEE488 bus.      !
80    !     This program was written for the HP9836 desktop computer using !
90    ! BASIC language.                                                 !
92    !                                                                 !
93    ! DISK FILE NAME: IEEE488                LATEST REVISION: 30 Mar 84 !
94    ! WRITTEN BY: Alan W. Petersen           MODIFIED BY:             !
95    ! DATE: 30 Mar 84
100   !-----------------------------------------------------------------!
110                               ! Note to person who reads this program:
120                               ! The symbol "!" is used to separate the
130                               ! actual program statements from comments.
140                               ! Anything to right of the "!" is merely
150                               ! information to help you understand what
160                               ! the program statement means.
170                               !
10040    PRINT CHR$(12)           ! This command clears the CRT screen.
10041                             ! Now print a title block on the CRT.
10050    PRINT "    MODEL 2560 POWER SUPPLY IEEE488 DATA LINK TEST "
10060                             !
10111 Re_ask:                     !
10112    PRINT                    ! Print a blank line.
10113    PRINT
10119    INPUT "Enter question or command: ",C$
10120                             ! The INPUT statement waits for the
10121                             ! operator to type in a question or a
10122                             ! command. Typical questions are:
10123                             !      ?CUR, ?PWR, ?TIME, etc.
10124                             ! Typical commands are:
10125                             !   CUR=30.5, PWR=5.0, BEEP, etc.
10126                             !
10129                             ! Note: Only capital letters are recognized.
10131                             !
10142    IF C$[1,1]="?" THEN      ! If first letter is "?" then the operator
10143                             ! is asking a question. So ask the question
10144                             ! over the bus using the OUTPUT statement
10145                             ! and use the ENTER statement to receive
10146                             ! the answer.
10147                             !
10150       PRINT "Question:  ";C$
10152       OUTPUT 725;C$
10153       ENTER 725;Answer$
10162       PRINT "Answer  :  ";Answer$
10163                             !
10170    ELSE                     ! Otherwise, if the first letter is not a
10171                             ! "?" then the operator is giving a
10172                             ! command. No answer is expected so only
10173                             ! use the OUTPUT statement.
10180       PRINT "Command :  ";C$
10191       OUTPUT 725;C$
10200    END IF
10210    GOTO Re_ask              ! Go to statement line "Re_ask" to repeat.
30000 END
```

```
Question:  ?CUR
Answer  :  37.8

Question:  ?MODE
Answer  :  CUR

Question:  ?TIME
Answer  :  0006

Command :  METER=VLT

Command :  BEEP

Question:  ?STATUS
Answer  :  00

Question:  ?VOLT
Answer  :  228.
```

RS232 Serial Poll Test

```
10  !-----------------------------------------------------------------------!
20  !     This program is used to read and decode the Serial Poll command of !
30  !  the Model 2560 Ion Laser power supply.  It requires a working Model   !
40  !  2560 with a Smart Board and an IEEE488 board.  The IEEE address of the !
50  !  supply is assumed to be 25.  This program was written for the HP9836  !
60  !  desktop computer using BASIC language.                                !
70  !                                                                        !
80  !  DISK FILE NAME: Poll_Test                   LATEST REVISION: 30 Mar 84 !
90  !  WRTTTEN BY: Alan W. Petersen                BY: Alan W. Petersen       !
100 !  DATE: 30 Mar 84                                                       !
110 !-----------------------------------------------------------------------!
120                                 !
130                                 !
1000     PRINT CHR$(12)             ! This command clears the CRT screen.
1010     PRINT "      SERIAL POLL TEST FOR THE MODEL 2560 ION LASER POWER SUPPLY"
1020     PRINT
1030     PRINT                      !
1040     Spe=SPOLL(725)             ! This command sends the Serial Poll command
1050                                ! to the power supply.  The answer (a number
1060                                ! between 0 and 255) is returned and stored
1070                                ! into the variable "Spe".
1080                                !
1090      PRINT "Serial Poll Status Byte = ";Spe
1100      PRINT
1110      PRINT
1120                                ! Now it is time to decode the answer Spe
1130                                ! into its individual bits.
1150      IF Spe>127 THEN
1160          Bit_7=1
1170          ELSE
1180          Bit_7=0
1190          END IF
1191      Bits=128*Bit_7
1200      IF Spe-Bits>63 THEN       ! Spe-Bits=sum of bits 0...6
1210          Bit_6=1
1220          ELSE
1230          Bit_6=0
1240          END IF
1250      Bits=Bits+64*Bit_6
1260      IF Spe-Bits>31 THEN       ! Spe-Bits=sum of bits 0...5
1270          Bit_5=1
1280          ELSE
1290          Bit_5=0
1300          END IF
1310      Bits=Bits+32*Bit_5
1320      IF Spe-Bits>15 THEN       ! Spe-Bits=sum of bits 0...4
1330          Bit_4=1
1340          ELSE
1350          Bit_4=0
1360          END IF
1370      Bits=Spe-Bits-16*Bit_4
1380                                ! Now the variable "Bits" contains the
1390                                ! the value of the Status Byte bits
1400                                ! 0, 1, 2, and bit 3.
1401                                !
1402                                ! Now it is time to decode the individual
1403                                ! bits into their meanings.
1405      C$="BITS 0...3  ERROR"
1410      IF Bits=1 THEN C$="IEEE488"
1420      IF Bits=2 THEN C$="FRONT PANEL"
1430      IF Bits=4 THEN C$="REMOTE PANEL"
1440      IF Bits=8 THEN C$="RS232"
1450                                !
1460      Lockout$="DISABLED"
1470      IF Bit_4=1 THEN Lockout$="ENABLED"
1480                                !
1490      Local$="LOCAL"
1500      IF Bit_5=1 THEN Local$="REMOTE"
1510                                !
1520      Faults$="NONE"
1530      IF Bit_7=1 THEN Faults$="ONE OR MORE FAULTS"
1540                                !
1550                                ! Now it is time to print the true
1560                                ! meanings on the CRT display.
1561      PRINT
1562      PRINT
```

```
1563        PRINT "Status Byte = ";Spe;" means the following:"
1564        PRINT
1570        PRINT TAB(10);"Active Controller = ";C$
1580        PRINT
1590        PRINT TAB(10);"The Local Lockout is ";Lockout$;"."
1600        PRINT
1610        PRINT TAB(10);"The Power Supply's IEEE card is in the ";Local$;" state
."
1620        PRINT
1630        PRINT TAB(10);"Status Display Errors : ";Faults$
1640                                  !
1650    END                           !
```

```
Serial Poll Status Byte = 161

Status Byte = 161 means the following:

Active Controller:  IEEE488
Local Lockout    :  disabled
Device State     :  remote enabled
Status Faults    :  one or more faults
```

```
10    !-----------------------------------------------------------------!
20    !     This program is used to test the RS232  port of the Model 2560    !
30    ! ION Laser Power Supply.  The program allows the operator to ask     !
40    ! a question or send a command to the Power Supply.  The program      !
50    ! requires a working Model 2560 with a Smart Board.  The Power Supply's !
70    ! Serial RS232 lamp on the Auxiliary Front Panel should be lit.  This  !
71    ! indicates that the supply is ready to use the RS232 bus.            !
80    !     This program was written for the HP9836 desktop computer using   !
90    ! BASIC language. The program sets up the HP9836 to be communicate to !
91    ! the Power Supply with the following protocal:                       !
92    !      1.  Baud rate = 4800                                           !
93    !      2.  8 bits/character. (ie no parity bit)                       !
94    !      3.  2 stop bits/character                                      !
96    !                                                                     !
97    ! DISK FILE NAME: RS232                 LATEST REVISION: 30 Mar 84   !
98    ! WRITTEN BY: Alan W. Petersen          MODIFIED BY:                  !
99    ! DATE: 30 Mar 84
100   !-----------------------------------------------------------------!
110                                  ! Note to person who reads this program:
120                                  ! The symbol "!" is used to separate the
130                                  ! actual program statements from comments.
140                                  ! Anything to right of the "!" is merely
150                                  ! information to help you understand what
160                                  ! the program statement means.
170                                  !--------------------------------------
180                                  ! Now it is time to set up the HP9836
190                                  ! RS232 to be compatible with the Model
200                                  ! 2560's RS232 link.
210       Rs232=9                    ! Select code 9 to be known as "Rs232".
220       CONTROL Rs232,3:4800       ! Set baud rate = 4800 in register 3.
230       CONTROL Rs232,4:3+4        ! Parameters stored in control register 4:
240                                  !     3 = 8 bits character length.
250                                  !     4 = 2 stop bits/character.
260                                  !--------------------------------------
10040     PRINT CHR$(12)             ! This command clears the CRT screen.
10041                                !--------------------------------------
10043                                ! Now print a title block on the CRT.
10044                                !
10050     PRINT "    MODEL 2560 POWER SUPPLY RS232 DATA LINK TEST "
10060                                !--------------------------------------
10111 Re_ask:                        !
10112     PRINT                      ! Print a blank line.
10113     PRINT
10119     INPUT "Enter question or command: ",C$
10120                                ! The INPUT statement waits for the
10121                                ! operator to type in a question or a
10122                                ! command. Typical questions are:
10123                                !      ?CUR, ?PWR, ?TIME, etc.
10124                                ! Typical commands are:
10125                                !   CUR=30.5, PWR=5.0, BEEP, etc.
10126                                !
10129                                ! Note: Only capital letters are recognized.
10131                                !--------------------------------------
10141                                !
10143     IF C$[1,1]="?" THEN        ! If first letter is "?" then the operator
10144                                ! is asking a question. So ask the question
10145                                ! over the bus using the OUTPUT statement
10146                                ! and use the ENTER statement to receive
10147                                ! the answer.
10148                                !
10150        PRINT "Question:  ";C$
10152        OUTPUT Rs232;C$
10153        ENTER Rs232;Answer$
10162        PRINT "Answer   :  ";Answer$
10163                                !
10170     ELSE                       ! Otherwise, if the first letter is not a
10171                                ! "?" then the operator is giving a
10172                                ! command. No answer is expected so only
10173                                ! use the OUTPUT statement.
10180        PRINT "Command :  ";C$
10191        OUTPUT Rs232;C$
10200     END IF                     !--------------------------------------
10201                                !
10210     GOTO Re_ask                ! Go to statement line "Re_ask" to repeat.
10220                                !--------------------------------------
30000 END
```

```
Question:  ?CUR
Answer  :  28.6

Question:  ?MODE
Answer  :  CUR

Question:  ?TIME
Answer  :  0009

Command :  METER=VLT

Command :  BEEP

Question:  ?STATUS
Answer  :  00

Question:  ?VOLT
Answer  :  199.
```

EXTERNAL CONTROL USING A RADIO SHACK TRS-80 MODEL 100 MICROCOMPUTER

NOTE

> This program was written under a contract with one of our customers. It is presented here as a convenience for those interested in external control of the Model 2020. It is not an endorsement of the Model 100 or Radio Shack products.

Connect the computer and power supply using a "null modem" and RS232 cable assembly as described in the TRS-80 manual.

If you use the IPL command (e.g., IPL "2020.BA"), and if the program is running when you last turned off the computer, the program will run automatically each time you turn on the computer. If it fails to run, go to BASIC and type LOAD "2020.BA"; the computer will display OK. Then type RUN. If problems arise, refer to the Model 100 manual for details of IPL command usage.

Nineteen operations are available using function keys F1 through F8. Pressing NEXT displays the next set of functions.

Other commands recognized by the Model 2560 power supply can be sent by typing the command and pressing ENTER.

The preset operations are:

"PWR=" Type either the desired output power or press POT, then press ENTER. If you press POT, the POWER potentiometer on the control panel of the power supply will control output power. The laser must be in the power control mode before this command will be executed.

"CUR=" Type either the desired tube current or press POT, then press ENTER. The laser must be in the current control mode before this command will be executed.

"MAG=" Type either the desired magnet current or press POT, then press ENTER.

"METR" Redefines the function keys. You can cause the meter to display the following: tube current, magnet current, output power, tube voltage.

"MODE" Redefines the function keys. You can set the control mode to either current or power.

"POT" Can only be executed after the "PWR=", "CUR=", or "MAG=" commands. Sends control the laser to the relevant potentiometer on the control panel of the power supply.

"OFF" Immediately turns off the laser; ENTER need not be pressed.

"?PWR" Displays output power.

"?CUR" Displays plasma tube current.

"?VLT" Displays plasma tube voltage.

"?MCV" Displays magnet current.

"?MRE" Displays magnet resistance.

"?MTR" Displays meter setting.

"?MOD" Displays control mode setting.

"?WAV" Displays wavelength if using prism or displays number associated with power meter sensor.

"?FLW" Displays water flow rate in gpm.

"?FIL" Displays status of auto fill system.

"TIME" Displays time according to the computer clock, not that of the power supply.

PROGRAM LISTING

```
10   '
20   'THIS PROGRAM WAS WRITTEN TO CONTROL
     'THE 2560 POWER SUPPLY VIA THE RS232
30   'REMOTE CONTROL.
     'WRITTEN BY  :  NEAL R. STOKER
40   '               STAFF ENGINEER
     'DATE  :  12 DECEMBER 1984
50   '
60   'SET UP NECESSARY SCREEN PARAMETERS,
     'BAUD RATES AND FILES.
70   '
```

```
80   CLS
82   PRINT
84   PRINT "ENTER COMMAND"
90   SCREEN 0,1
100  MAXFILES=2
110  OPEN "COM:78N2D" FOR OUTPUT AS #1
120  OPEN "COM:78N2D" FOR INPUT AS #2
130  '
140  'SET FIRST FUNCTION KEYS
150  '
160  KEY1,"NEXT"+CHR$(13):KEY2,"PWR=":KEY
3,"CUR=":KEY4,"MAG="
170 KEY5,"METR"+CHR$(13):KEY6,"MODE"+CHR
$(13):KEY7,"POT"+CHR$(13):KEY8,"OFF"+CHR$(13)
180  '
190  'INPUT FIRST FUNCTION KEYS
200  '
210  INPUT A$
220  '
230  '  IF THEN ELSE FOR FIRST KEYS
240  '
250  IF A$="NEXT"  THEN 630
260  IF LEFT$(A$,3)="PWR"  THEN 600
270  IF LEFT$(A$,3)="CUR"  THEN 600
280  IF LEFT$(A$,3)="MAG"  THEN 530
290  IF A$="METR"  THEN 340
300  IF A$="MODE"  THEN 440
310  IF A$="POT"  THEN 190
320  GOTO 600
325  IF A$="OFF"  THEN 600
330  '
340  'METER KEYS
350  '
360  KEY1,"CUR"+CHR$(13):KEY2,"MAG"+CHR$(
13) :KEY3,"PWR"+CHR$(13):KEY4,"VLT"+CHR$(
13)
370  KEY5,"":KEY6,"":KEY7,"":KEY8,""
380  C$="METER="
390  INPUT "METER=";B$
400  IF B$="" THEN 390
410  A$=C$+B$
415  GOSUB 1250
420  GOTO 140
430  '
440  'MODE KEYS
450  '
460  KEY1,"CUR"+CHR$(13):KEY2,"PWR"+CHR$(
13) :KEY3,"":KEY4,"":KEY5,"":KEY6,"":KEY7,
 "" :KEY8,""
470  C$="MODE="
480  INPUT "MODE="  ; B$
490  IF B$="" THEN 480
500  A$=C$+B$
505  GOSUB 1250
510  GOTO 140
520  '
530  '  CHANGE MAGNET INPUT
540  '
550  B$=MID$(A$,5)
560  C$="MAGNET="
570  A$=C$+B$
580  GOTO 600
590  '
600  GOSUB 1250
610  GOTO 190
620  '
630  'SECOND FUNCTIOIN KEYS
640  '
650  KEY1,"NEXT"+CHR$(13):KEY2,"?PWR"+CHR
$(13):KEY3,"?CUR"+CHR$(13):KEY4,"?VLT"+CHR$(13)
660  KEY5,"?MCU"+CHR$(13):KEY6,"?MVL"+CHR
$(13):KEY7,"?MRE"+CHR$(13):KEY8,"OFF"+CH
R$(13)
670  '
680  '  INPUT SECOND FUNCTION KEYS
690  '
700  INPUT A$
710  '
720  'IF THEN ELSE FOR SECOND KEYS
730  '
740  IF A$="NEXT"  THEN 860
750  IF A$="?PWR"  THEN 830
760  IF A$="?CUR"  THEN 830
770  IF A$="?VLT"  THEN 1100
780  IF A$="?MCU"  THEN 1110
790  IF A$="?MVL"  THEN 1120
800  IF A$="?MRE"  THEN 1130
810  GOTO 830
820  '
830  GOSUB 1250
840  GOTO 680
850  '
860  '  SET UP THIRD KEYS
870  '
880  KEY1,"NEXT"+CHR$(13):KEY2,"?MTR"+CHR
$(13):KEY3,"?MOD"+CHR$(13):KEY4,"?WAV"+C
HR$(13)
890  KEY5,"?FLW"+CHR$(13):KEY6,"?FIL"+CHR
$(13):KEY7,"TIME"+CHR$(13):KEY8,"OFF"+CH
R$(13)
900  '
910  '  INPUT KEYS
920  '
930  INPUT A$
940  '
950  'IF THEN ELSE FOR THIRD KEYS
960  '
970  IF A$="NEXT"  THEN 140
```

```
980  IF A$="?MTR"  THEN 1140
990  IF A$="?MOD"  THEN 1150
1000  IF A$="?WAV"  THEN 1160
1010  IF A$="?FLW"  THEN 1170
1020  IF A$="?FIL"  THEN 1180
1030  IF A$="TIME"  THEN 1200
1040  IF A$="OFF"  THEN 1060
1050 '
1060 GOSUB 1250
1070 '
1080 '  REDEFINE KEYS
1090 '
1100 A$="?VOLT"  :  GOTO 830
1110 A$="?MCUR"  :  GOTO 830
1120 A$="?MVOLT"  :  GOTO 830
1130 A$="?MRES"  :  GOTO 830
1140 A$="?METER"  :  GOTO 1060
1150 A$="?MODE"  :  GOTO 1060
1160 A$="?WAVE"  :  GOTO 1060
1170 A$="?FLOW"  :  GOTO 1060
1180 A$="?FILL"  :  GOTO 1060
1190 '
1200 'TIME KEY
1210 '
1220 PRINT TIME$
1230 GOTO 930
1240 '
1250 '  SUBROUTINE
1260 '
1270 IF LEFT$(A$,1)="?"  THEN 1300
1280 PRINT #1,A$
1290 GOTO 1330
1300 PRINT #1,A$
1310 INPUT #2,B$
1320 PRINT "LASER RETURNED  :  ";B$
1330 RETURN
```

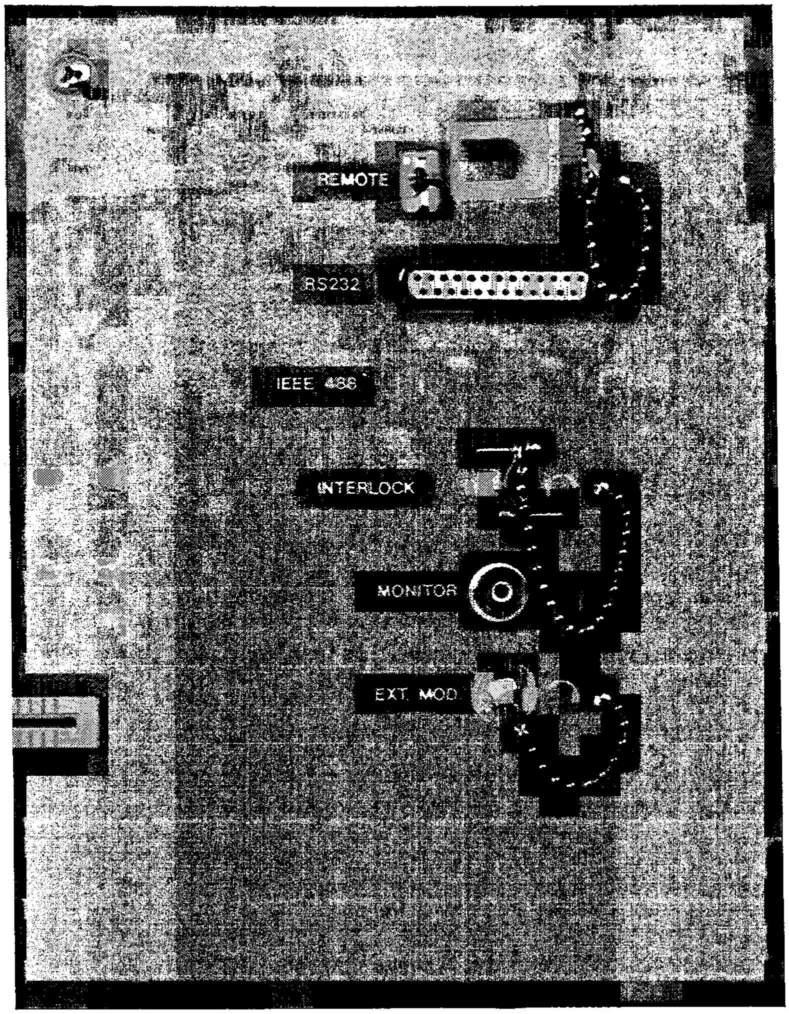


FIGURE 6.1: Model 2270 Connects to REMOTE, MONITOR, and EXT. MOD. Jacks

MODEL 2270 REMOTE CONTROL

SYSTEM DESCRIPTION

The Model 2270 is an optional remote control unit that is connected to the Model 2560 power supply with a flexible cable.

Features of the system are:

- o Key Switch
- o ON and OFF buttons
- o Adjustment of the current or power of the laser
- o Current or power reading from a meter

Installation

There is one (16') cable at the back of the Model 2270. This cable houses three smaller cables that go to the remote control plug, monitor jack and external modulation jack on the rear panel of the power supply. There is no power cord to the Model 2270.

Install the cables according to the following instructions. (Figure 6.1)

1 Remove the jumper plug from the power supply REMOTE jack and plug in the corresponding cable from the Model 2270.

2 Connect the plug marked MONITOR to the power supply MONITOR jack.

3 Remove the jumper plug from the power supply EXT. MOD. jack and connect the Model 2270 plug marked EXT. MOD.

4 A jumper PC board that supplies 5 V to the remote control is shipped with the Model 2270. The optional Smart Board also supplies 5 V to the remote control. If the laser has a Smart Board installed, the jumper board is not used. If the laser does not have a Smart Board, insert the jumper board in the connector labeled J4 in the card cage of the power supply. (Figure 6.2)

5 If the laser has the optional Auxiliary Control Panel, select the LOCAL mode, not the REMOTE mode.

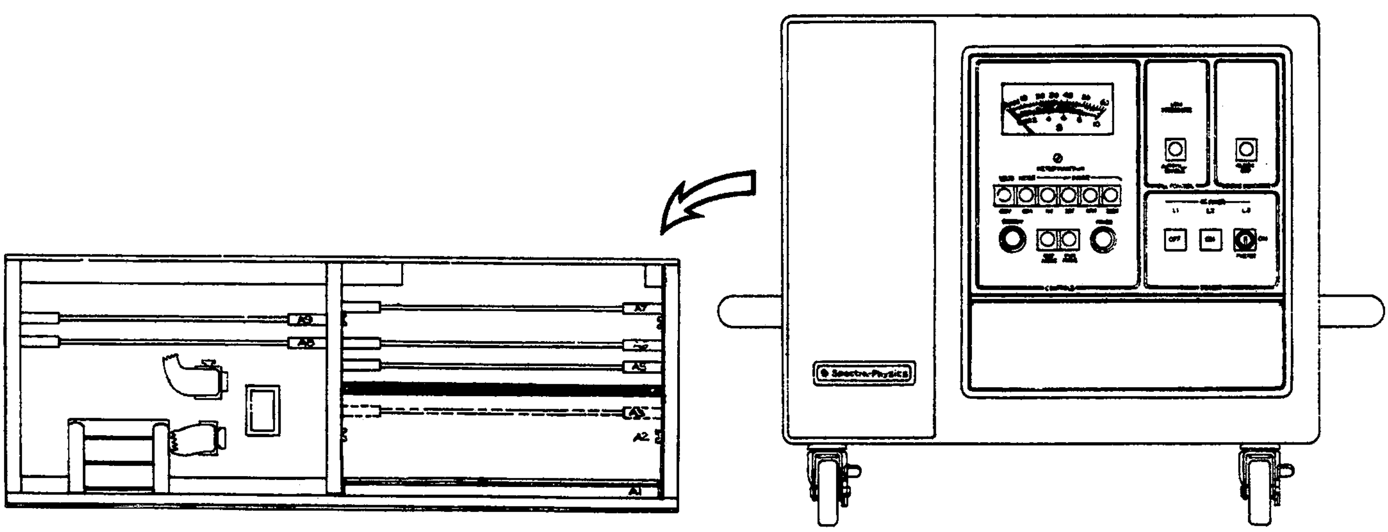


Figure 6.2: Installation of the Model 2270 Jumper Board

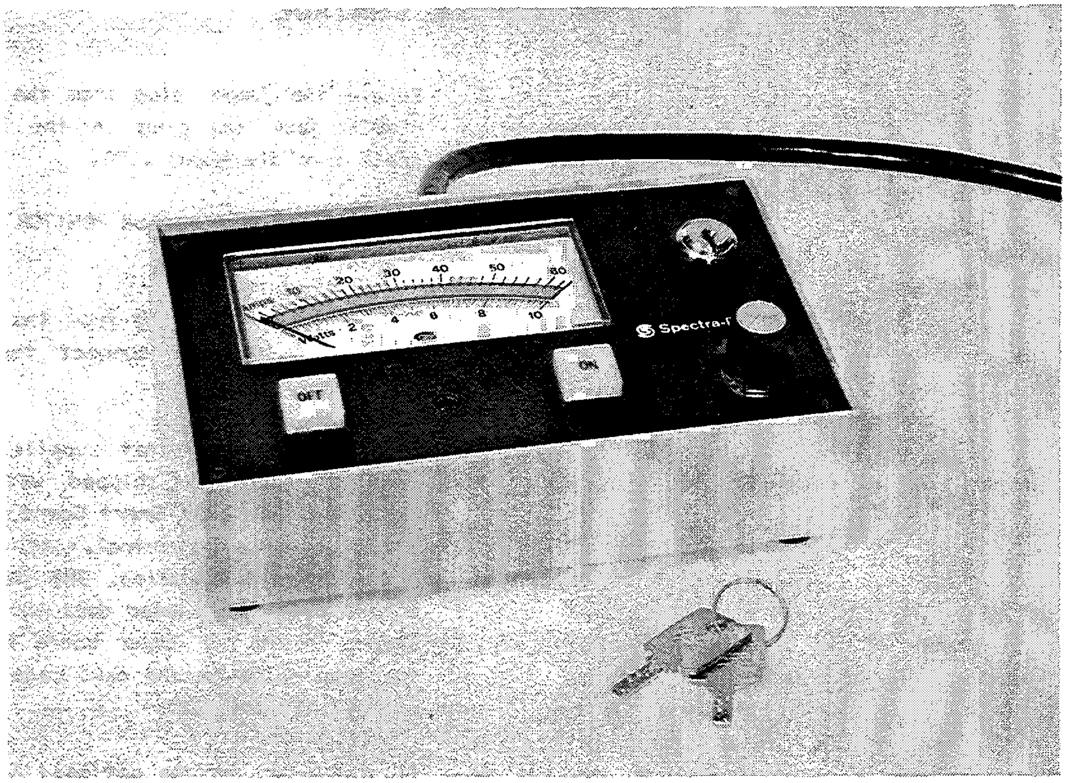


Figure 6.3: Model 2270 Control Panel

OPERATING CONTROLS

Meter - displays either tube current (in current mode), or output power (in power mode). The meter range is selected by the METER FUNCTION buttons on the power supply front panel.

Key Switch - when the power supply key switch is on, the key switch on the remote control is the master ON switch for the system. Turning it on enables the ON and OFF buttons on the remote control.

Power ON button - starts the laser and serves as the emmission indicator. The button glows white as long as the laser remains on.

Power OFF button - turns off the laser.

Control Knob - sets either the plasma tube current (in current mode) or the output power (in power mode). The active mode is selected on the power supply front panel.

ADDITIONAL FUNCTION DESCRIPTION

Current mode - the CURRENT control knob on the power supply establishes the minimum tube current level possible. The Model 2270 control knob will only allow an increase in the tube current level above that set by the power supply control knob. It is not possible to decrease the tube current level below that set by the power supply control knob. In order to have a complete current range adjustment at the Model 2270, the current level setting at the power supply must be turned to minimum.

Power mode - the POWER control knob on the power supply must also be set to minimum to allow the Model 2270 to have complete range of adjustment.

MAINTENANCE

NOTES ON THE CLEANING OF LASER OPTICS

Ion lasers are oscillators that operate with gain margins of a few percent. Losses due to unclean optics, which might be negligible in ordinary optical systems, can disable a laser. Dust on mirror surfaces can reduce output power or cause total failure. Cleanliness is essential, and the maintenance techniques used with laser optics must be applied with extreme care and attention to detail.

"Clean" is a relative description; nothing is ever perfectly clean, and no cleaning operation ever completely removes contaminants. Cleaning is a process of reducing objectionable materials to acceptable levels.

Since cleaning simply dilutes contamination to the limit set by solvent impurities, solvents must be as pure as possible. Use spectroscopic, electronic, or reagent grade solvents, and leave as little solvent on the surface as possible. As any solvent evaporates, it leaves impurities behind in proportion to its volume. Avoid rewiping a surface with the same swab; a used swab and solvent will redistribute contamination, it won't remove it.

Both methanol and acetone collect moisture during prolonged exposure to air. Avoid storage in bottles where a large volume of air is trapped above the solvent; instead, store solvents in squeeze bottles from which trapped air can be removed.

Laser optics are made by vacuum-depositing micro-thin layers of materials of varying indices of refraction on glass substrates. If the surface is scratched to a depth as shallow as 0.01 mm, the operating efficiency of the optical coating will be reduced significantly.

Stick to the following principles whenever you clean any optical surface.

- Remove and clean one optical element at a time. If all of the optics are removed and replaced as a group, all reference points will be lost, making realignment extremely difficult.
- Work in a clean environment, over an area covered by a soft cloth or pad.
- Wash your hands thoroughly with liquid detergent. Body oils and contaminants can render otherwise fastidious cleaning practices useless.
- Use dry nitrogen, canned air, or a rubber squeeze bulb to blow dust or lint from the surface before cleaning with solvent. Permanent damage may occur if dust scratches the glass or mirror coating.
- Use spectroscopic, electronic, or reagent grade solvents. Don't try to remove contamination with a cleaning solvent that may leave other impurities behind.
- Use photographic lens tissue to clean optics and plasma tube windows; use each piece only once. Dirty tissue merely redistributes contamination, it doesn't remove it.

CLEANING PRISMS AND MIRRORS

Equipment Required

- dry nitrogen, canned air, or rubber squeeze bulb
- photographic lens tissue
- spectroscopic grade acetone
- forceps
- hemostat

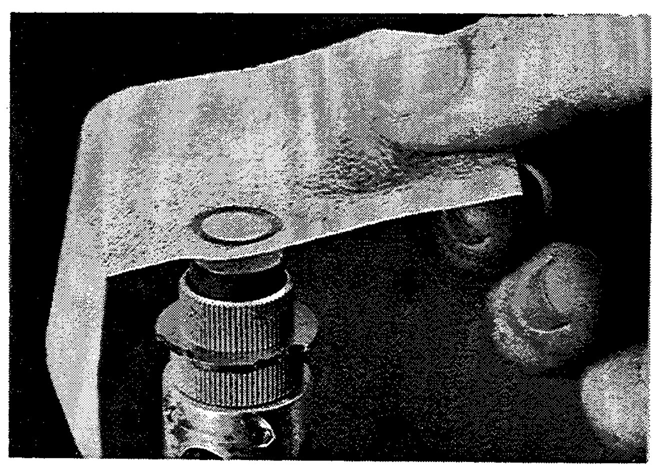


FIGURE 7.1: Cleaning the Mirror Surface

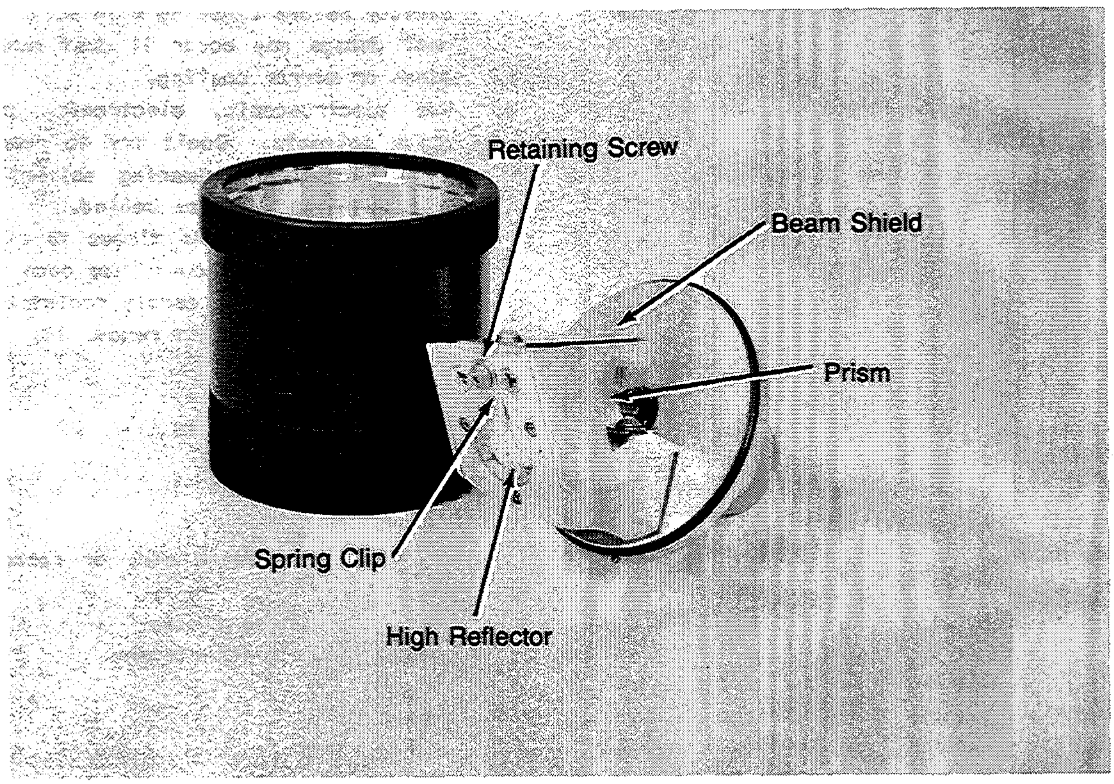


FIGURE 7.2: Series 2000 Single-line Prism Assembly

1 Remove the mirror assembly from its mounting plate.

The broadband high reflector can be cleaned without removing it from its holder. All other mirrors must be hand-held; use finger cots for protection.

2 Hold the mirror horizontal with its coated surface up and squeeze a drop or two of acetone onto it. Place a piece of lens tissue on the wetted surface and gently draw it across to remove dissolved contaminants.

3 If the mirror is an output coupler, invert it and repeat, cleaning the second surface.

4 Reinstall the mirror and adjust the mirror mount for peak output power.

Cleaning the Prism Assembly

1 Unscrew the retaining ring and lift the prism mount from its protective cup.

A small screw holds the mirror-retaining spring in place. Remove it and invert the assembly, dropping the mirror onto a soft surface.

Clean the mirror as described above.

2 Remove the prism shield but leave the prism alone; it can be cleaned in its mount.

3 Blow dust particles or lint away using nitrogen or air.

4 Fold a piece of lens tissue into a pad about 1 cm on a side and clamp it in a hemostat (Figure 7.3). Saturate the pad with acetone, shake off the excess, resaturate, and shake again.

5 Wipe one surface - bottom to top - in a single motion. Be careful that the tip of the hemostat does not scratch the surface. Repeat the operation with a clean tissue on the second prism surface.

A clean prism surface will scatter little or no light when the laser is operating.

6 Reinstall the prism assembly and adjust the vertical and horizontal mirror mount controls for peak output power.

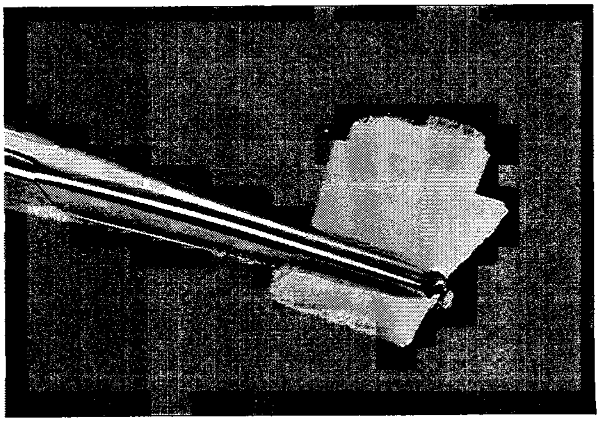


FIGURE 7.3: Lens Tissue Folded for Prism Cleaning

DANGER: LASER RADIATION

The following procedures require removal of the laser head cover and defeat of its safety interlock. Dangerous laser radiation is accessible when cavity seals are pulled back; therefore, permit only trained personnel to service and repair your laser system.

The Model 2020 resonator is designed so the center of the aperture and the centers of the front and rear mirror mounts lie on the same line, the resonator axis. In order for the laser to provide optimum performance, three conditions must be met:

- the line defined by the plasma tube bore must be centered on the resonator axis;
- the flat high reflector must be perpendicular to the resonator axis;
- the center of curvature of the output coupler must be on the resonator axis.

Your laser is factory aligned and, under normal operating conditions, should only require the preventive practices described in Maintenance to meet its performance specifications. If you discover a significant drop in power that can't be restored by mirror cleaning, the source of the problem is probably one of the following:

- unclean plasma tube windows,
- misaligned optics,
- misaligned plasma tube.

The procedures in this section allow you to solve these problems, thereby returning your laser to optimum performance. They are provided in the order in which you should perform them. The most probable cause of poor performance is contaminated optics; therefore, they should be cleaned before you try anything else. If the problem persists after cleaning the mirrors, clean the plasma tube windows. Then align the optics, if necessary. Finally, if all else fails, align the plasma tube.

These procedures are progressive in nature; if you achieve success at the end of one procedure, you don't need to go on to the next.

If the laser has been cleaned and aligned and you are sure that it is producing maximum power, but its performance remains below specification, call your Spectra-Physics service representative.

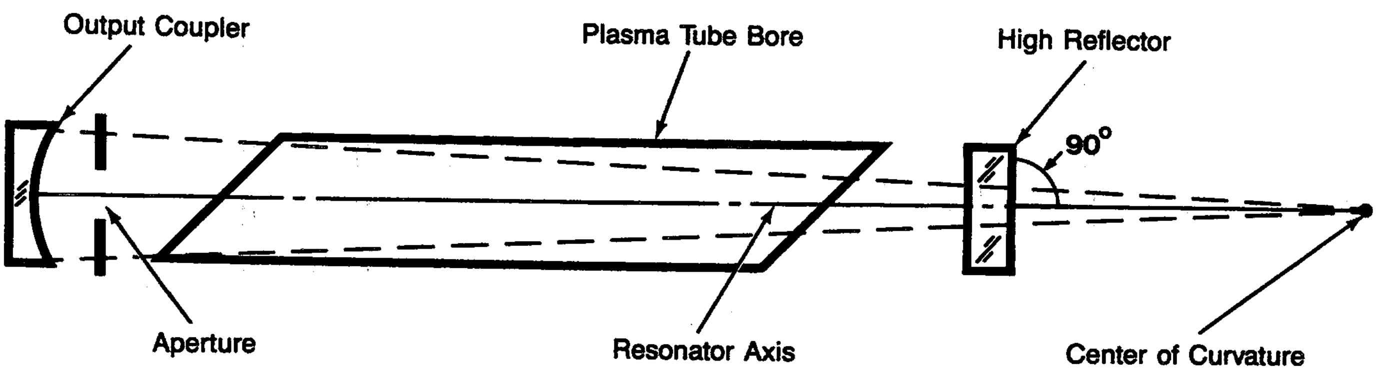


FIGURE 8.1: Schematic Representation of Ideal Resonator Alignment

CLEANING PLASMA TUBE WINDOWS

This is a progressive procedure designed to enable you to remove even the most stubborn contaminating films. If you achieve success before you complete all of the steps, those that remain are optional. Having begun a numbered step, be sure you follow it through to completion. Failure to do so may leave additional contamination on the window surface.

DANGER: LASER RADIATION

The following sequence requires removal of the laser head cover and defeat of its safety interlock. Dangerous laser radiation is accessible when cavity seals are pulled back; therefore, permit only trained personnel to clean plasma tube windows.

Equipment Required

- forced air supply or dry nitrogen
- photographic lens tissue
- cotton swabs
- hemostat
- deionized or distilled water
- hydrogen peroxide (H_2O_2), 5% solution
- prerinse solution, composed of:
  - 1 part nitric acid (HNO_3)
  - 19 parts deionized water
  - 17 parts methanol (CH_3OH)
- Calcium Carbonate ($CaCO_3$) - primary standard powder, 600+ mesh - per American Chemical Society specifications
  - Mallinckrodt 4071, 4072 or equivalent
- Micro Detergent™, manufactured by:
  International Products Corporation
  P.O. Box 118
  Trenton, New Jersey 08601
- three empty bottles to hold the cleaning solutions listed below

A kit comprising the above materials is available from Spectra-Physics (part number 0000-0013).

Cleaning Solutions Required

- spectroscopic grade acetone (CH_3COCH_3)
- spectroscopic grade methanol (CH_3OH)
- Oakite 33™, manufactured by:
  Oakite Products, Inc.
  50 Valley Road
  Berkeley Heights, New Jersey 07922

Procedure

1 Use compressed air or dry nitrogen to blow dust particles and lint away.

2 Fold a piece of lens tissue into a pad about 1 cm on a side and clamp it in a hemostat (Figure 7.3). Saturate the pad with methanol, shake off the excess, resaturate, and shake again.

Wipe the window with a single stroke from bottom to top. Most contamination can be removed with this step alone.

3 Fold another tissue and saturate it with acetone, as above. Wipe the window again.

Follow the acetone with a methanol wipe using a clean tissue pad.

4 Saturate a cotton swab with 5% hydrogen peroxide; use a circular motion to clean the entire window surface.

Follow the peroxide with a methanol wipe using a clean tissue pad.

5 Saturate a cotton swab with Oakite 33™; use a circular motion to clean the entire window surface.

Rinse using a fresh cotton swab and deionized water; repeat three times.

Follow the deionized water with a methanol wipe using a clean tissue pad.

6 Use a cotton swab to wet the entire window with prerinse solution. Dip the swab, wet with prerinse, lightly into calcium carbonate powder; the resulting paste should have the consistency of toothpaste. Scrub the window surface, using a circular motion, for about 30 sec.

Dip a dry cotton swab in the calcuim carbonate powder and scrub the window again. The additional powder will dry the paste remaining from the previous step.

Rinse with a cotton swab saturated with pre-rinse solution.

Saturate a cotton swab with Micro Detergent™ and clean the mirror surface using a circular motion.

Rinse the surface three times using cotton swabs saturated with deionized water.

Follow the deionized water with a methanol wipe using a clean tissue pad.

MIRROR ALIGNMENT

Patience and attention to detail are required to assure proper alignment. First, the laser must be tuned for apparent peak power. Then the beam must be "walked" along the parallel mirrors until you have satisfied yourself, by trial and error, that no additional power can be coaxed from the unit.

Adjusting the Mirrors for Apparent Peak Power

Insert a #23 (3/32") driver in the coarse horizontal and vertical mirror controls on the high reflector mount. (If your laser is equipped with the high-resolution control panel, it has a coarse vertical adjusting knob). Monitor the output power while you turn one control, moving it back and forth until the output is at its peak. Then adjust the other control. Repeat the adjustments, first turning one control, then the other, back and forth until the power reaches its peak. Repeat with the fine mirror adjustments. Make a note of the output power.

"Walking the Mirrors" to Assure Peak Power

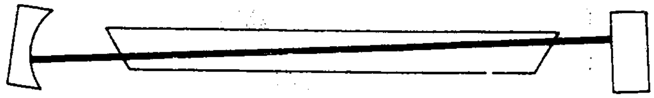


FIGURE 8.2: Misaligned Mirrors Allow Lasing at Reduced Power

Figure 8.2 illustrates an arrangement of cavity mirrors that will allow lasing, but with reduced output. A slight tilt of the high reflector compensates for a similar tilt of the output coupler. The resulting beam is skewed with respect to the resonator axis and the plasma tube bore. Under these conditions the laser can be "peaked", but the output will be less than optimum because part of the beam is obstructed by the bore walls.

Walking the mirrors is a trial and error procedure that assures optimum mirror alignment. The goal is to align the intracavity beam with the resonator axis by making small adjustments of the high reflector and matching them with adjustments of the output coupler. By observing the change in output power as you move the mirrors, you will find the optimal alignment positions.

Once the high reflector has been peaked, detune one of its coarse controls until the output is about half its peak value. Move to the other end of the laser and turn the corresponding output coupler control in the same direction.

Be careful! Use the same controls on both ends of the laser and turn them the same direction: If you turn the high reflector vertical control clockwise, turn the output coupler vertical control clockwise (keeping the same point of view). If you lose lasing, reverse the direction of mirror movement until lasing is restored.

Observe the change in output power as you turn the output coupler control; if the output peak exceeds the original value, walk the mirrors in the same direction again. Repeat until the power reaches its peak.

If the output fails to reach the original value, return both controls to their original positions.

Adjust the high reflector for peak power.

Walk the mirrors with the other pair of controls. If you first walked the vertical mirror controls, do the same with the horizontal controls or vice-versa.

Remember, always walk the mirrors in the direction of increased output power; if the power starts to decline, go the other way. And always find the peak power with one set of controls before moving to the other set; finish with the vertical controls before you move the horizontal controls and vice versa. Always readjust the high reflector for peak power before changing from one set of controls to the other.

Repeat the walking process several times, first with one set of controls, then with the other. Continue until the output power is as high as it can go.

PLASMA TUBE ALIGNMENT

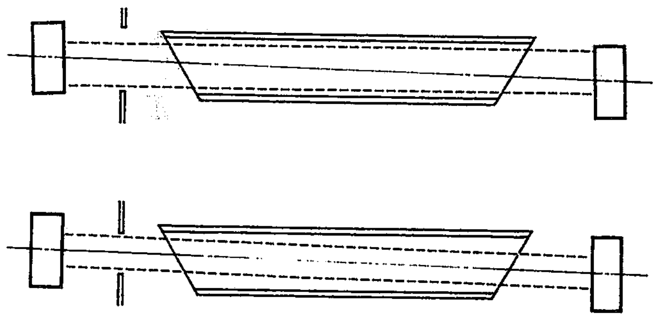


FIGURE 8.3: Misaligned Plasma Tube Allows Lasing at Reduced Power

Figure 8.3 illustrates two arrangements in which the plasma tube is misaligned with respect to the resonator axis. In the first, the tube is skewed and the mirrors have been aligned to compensate. In the second, the cavity mirrors are aligned for optimum output but the tube is skewed. Both problems cause a power loss, the first because the beam does not travel through the center of the aperture; closing it will cause a significant loss as the aperture wheel partially obstructs the beam. The second because the beam is partially obstructed by the bore walls.

The following procedures center the plasma tube bore on the resonator axis, thereby enabling the laser to produce maximum output power. Use an external power meter to monitor the alignment of the plasma tube.

DANGER: HIGH VOLTAGE AND CURRENT

The locking screws described below lie dangerously close to the anode and cathode terminals, and their voltage and current levels are lethal. Be sure to shut the system down before attempting to loosen the magnet mounting screws.

Remove the front and rear cavity seals. Tighten all eight adjustment screws (Figure 8.4) against the magnet carriage, then loosen the locking screws at each end of the carriage.

DANGER: LASER RADIATION

The following sequence requires removal of the laser head cover and defeat of its safety interlock. Dangerous laser radiation is accessible when cavity seals are pulled back; therefore, permit only trained personnel to align the plasma tube.

Start the laser. Then adjust the horizontal position of the cathode end, working one adjusting screw against the other, until you achieve maximum output power. Then move to the anode end and repeat, adjusting its horizontal position. Adjust the vertical position of the anode end for maximum power, then move to the cathode end and repeat.

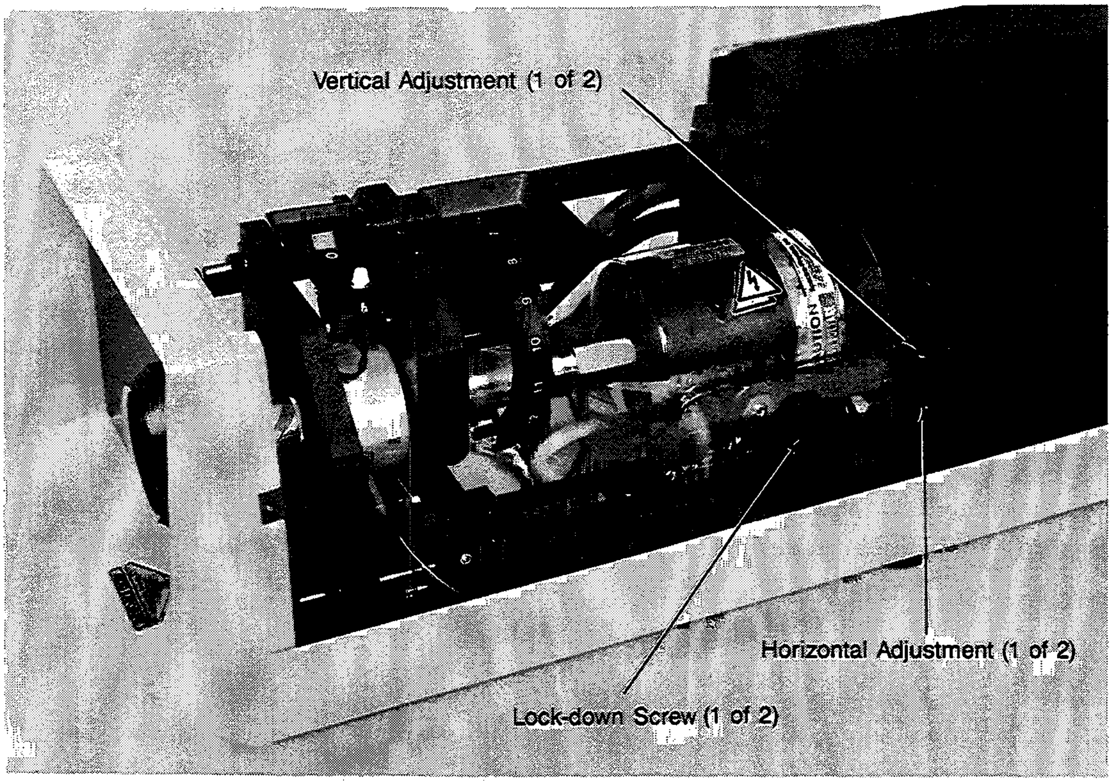
Repeat the adjustment sequence until no further increase in power occurs: the plasma tube alignment is "peaked".

Reduce the current to the lowest value that will still allow lasing and observe the position of the beam on the high reflector. If the beam is not centered, move it by walking the mirrors. Determine the axis, either horizontal or vertical, along which the beam must travel and adjust the appropriate controls. Monitor the output power as you walk the beam toward the center of the mirror. If the power drops significantly, adjust the tube position to repeak the output power.

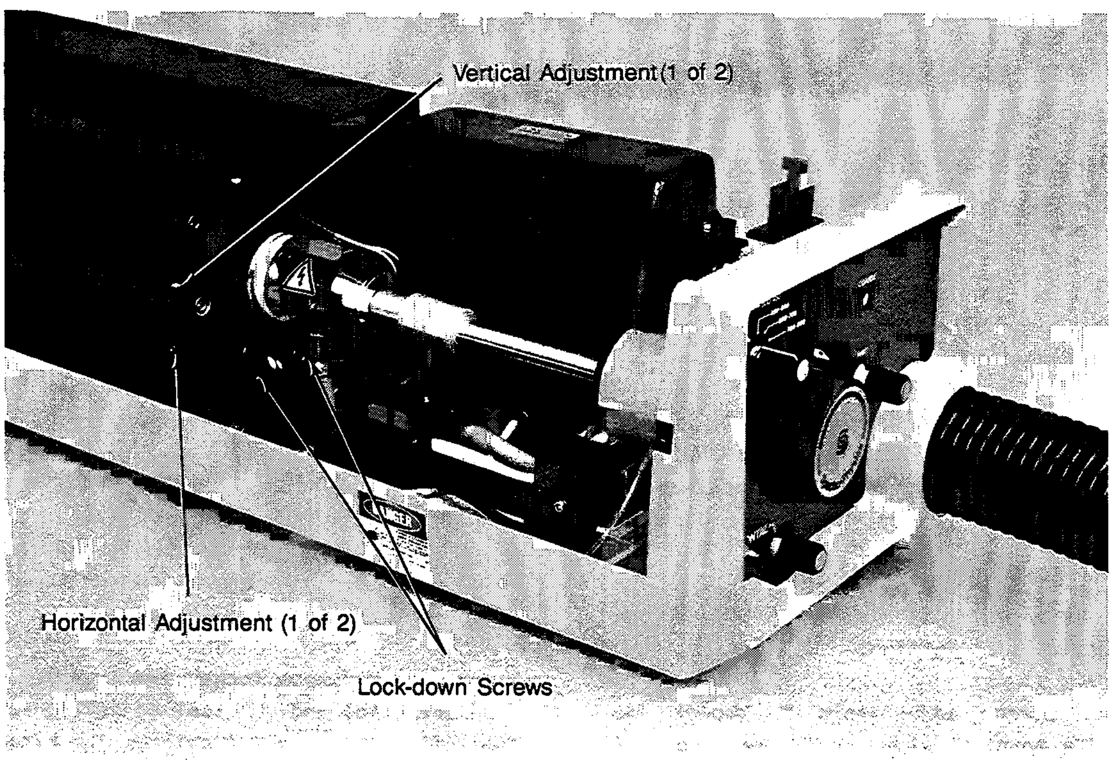
Tube and mirror adjustments interact with one another, so you will probably find it necessary to repeat the sequences several times, first walking the mirrors, then moving the tube, then walking the mirrors again, ... After several iterations you will reach a point where the last possible milliwatt has been coaxed from the laser.

Aligning on the Aperture

This sequence insures that the beam will travel directly through the center of the aperture, which is mounted between the plasma tube and the output coupler. It is different from the factory alignment procedure, which requires special fixtures



Cathode End



Anode End

FIGURE 8.4: Plasma Tube Alignment Adjustments

and tools that keep the beam in the center of the high reflector as well. Since it does not insure precise centering on the high reflector, the interchangeability of single-line prisms may suffer. You may also notice a slight overall power loss.

Clean the plasma tube windows; an acetone wipe followed by a methanol wipe should be sufficient (see "Cleaning Plasma Tube Windows" for details).

NOTE

> Because thermal effects in intracavity spaces affect the beam, this final cavity alignment sequence should be done with the cavity in its operating condition. That is, if you plan to run it open, align it open; if it will be sealed, align it that way. Before you install the cavity seals, however, check the position of the beam as it enters the high reflector mirror mount. It should be as close to the center of the opening as possible.
>
> If your laser will run with a cavity purge system, align with it running.

Adjust the high reflector to peak the output power; don't move anything else. Make a note of the maximum power.

Close the aperture until the power drops to less than half the peak value, then repeak the output power using only the high reflector adjustments.

Open the aperture to its maximum and make a note of the output power. If the beam is centered on the aperture, the new output value should be at least 97% of the old value; if it is, turn to "Magnet Lockdown".

If the new output value is less than 97% of the old value, continue as follows:

Use the rear mirror adjustments to repeak the output with the aperture wide open; make a note of the value.

Close the aperture until the power drops to less than half the peak value, then use the rear mirror adjustments to repeak the output.

Open the aperture wide and adjust the tube position for peak power; make a note of the output.

Close the aperture until the output drops 50% and repeak the high reflector. Open the aperture wide and check the output. If the second value is at least 97% of the first, turn to "Magnet Lockdown".If it is less than 97%, repeat the above alignment sequence.

Continue the check-and-align procedure until the beam is centered on the aperture, then proceed to "Magnet Lockdown".

MAGNET LOCKDOWN

Once the pasma tube and mirrors are aligned, the magnet/tube assembly can be locked into its final position. Check the power once more before beginning the locking sequence.

DANGER: HIGH VOLTAGE AND CURRENT

> The locking screws lie dangerously close to the anode and cathode terminals, whose voltage and current levels are lethal. Be sure to shut the system down before approaching these screws.

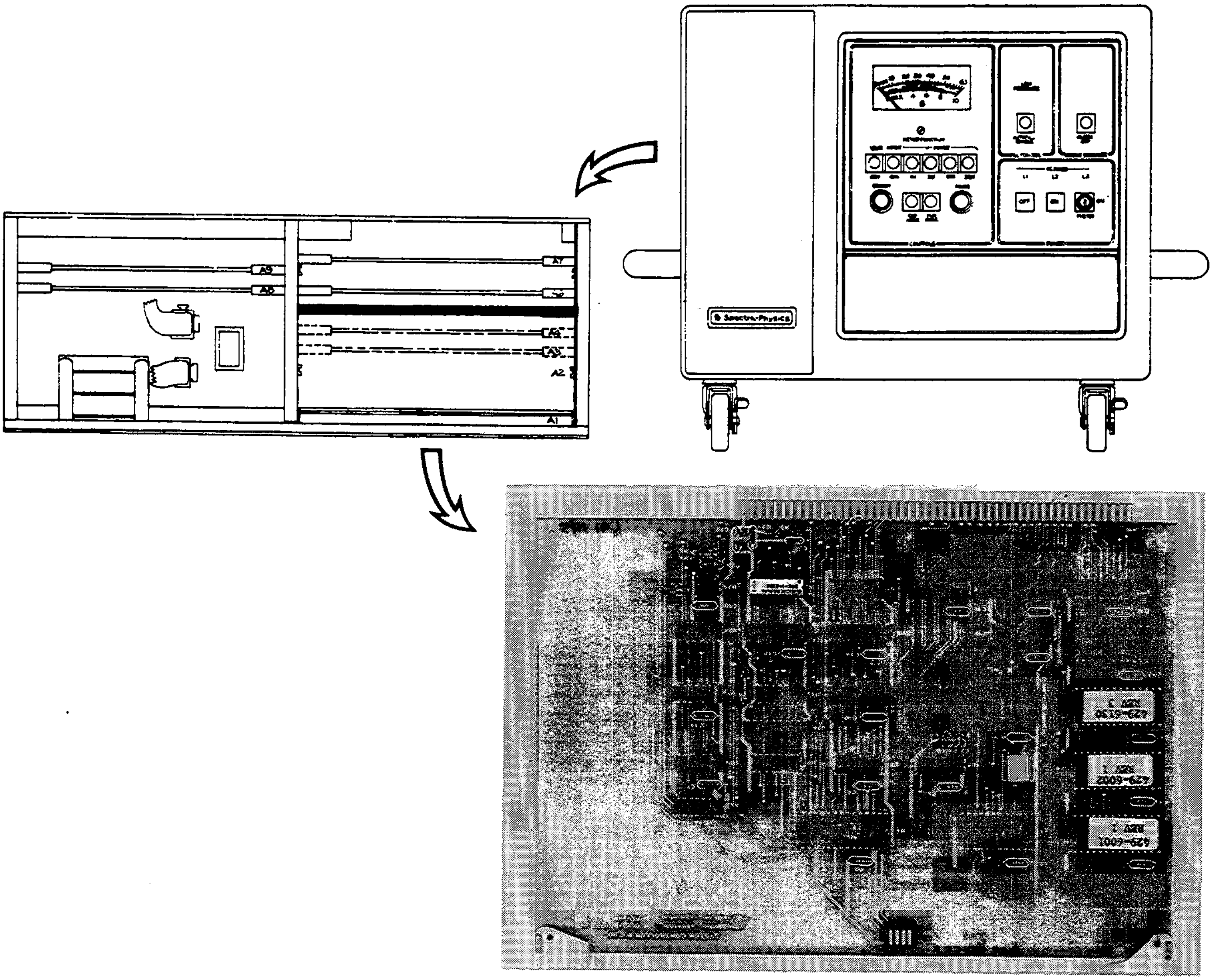
Tighten the four lockdown screws in a figure-eight pattern so that all screws apply equal pressure at all times.

Repeat the "Aligning on the Aperture" checking sequence. If the power readings deviate by more than 3%, loosen the magnet, repeak the plasma tube and repeat the lockdown sequence.

As soon as you have locked the magnet down, loosen its horizontal and vertical adjusting screws about two full turns. This completes the kinematic isolation of the plasma tube.

SYSTEM DIP SWITCH SETTINGS

System Controller Board DIP Switches - control the analog board loop gain: when n=0 the gain is maximum; for n=7 (factory setting) it is minimum; n = the sum of the binary digits, e.g., n=1+2+4+0=7.



ANALOG BOARD LOOP GAIN	
Switch #	4 3 2
Binary Weight	4 2 1
FACTORY SETTING = 7	
off = logic 1	
on = logic 0	

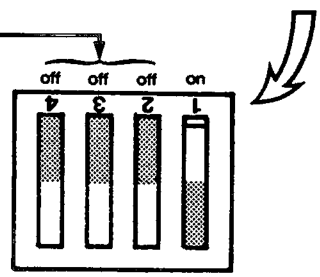
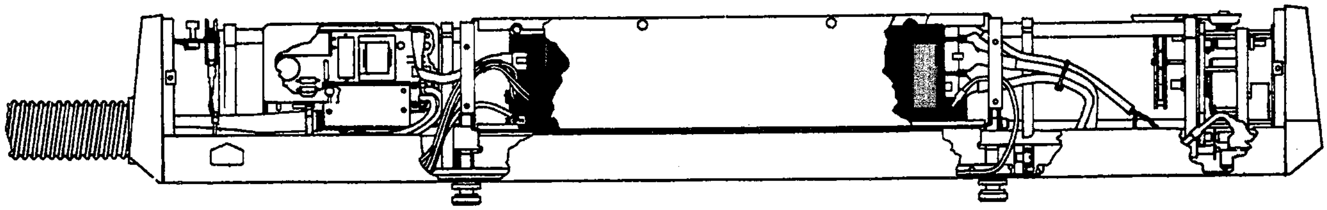
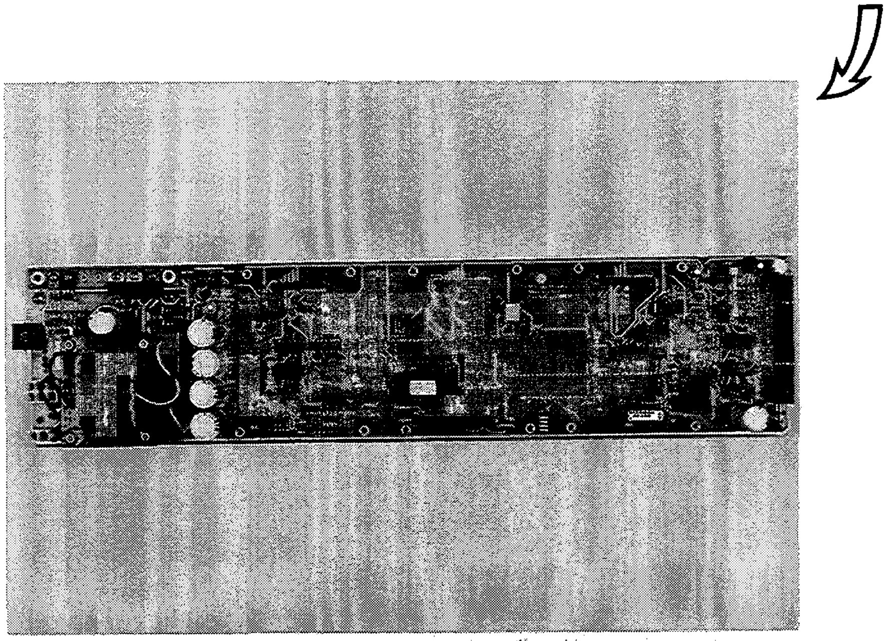
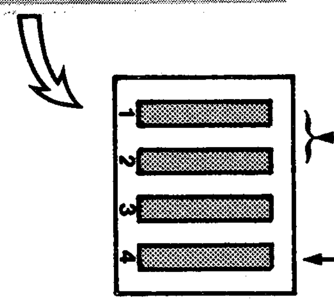


FIGURE 8.5: System Controller Board DIP Switch Configuration

Laser Head Controller DIP Switches - Identify the magnet and plasma tube type: set at the factory and should not require attention unless the plasma tube is changed.







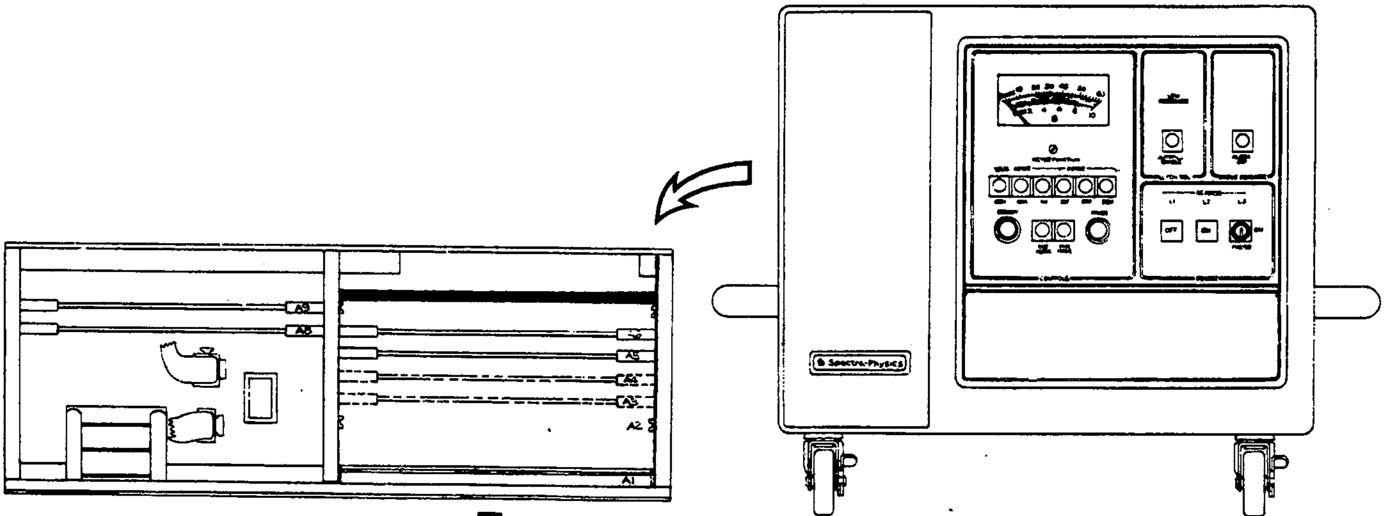
TUBE TYPE	
Switch # 2 1	Type
0 0	2020-03,04,05
0 1	2025-03,04,05
1 0	2020-11
1 1	2025-11

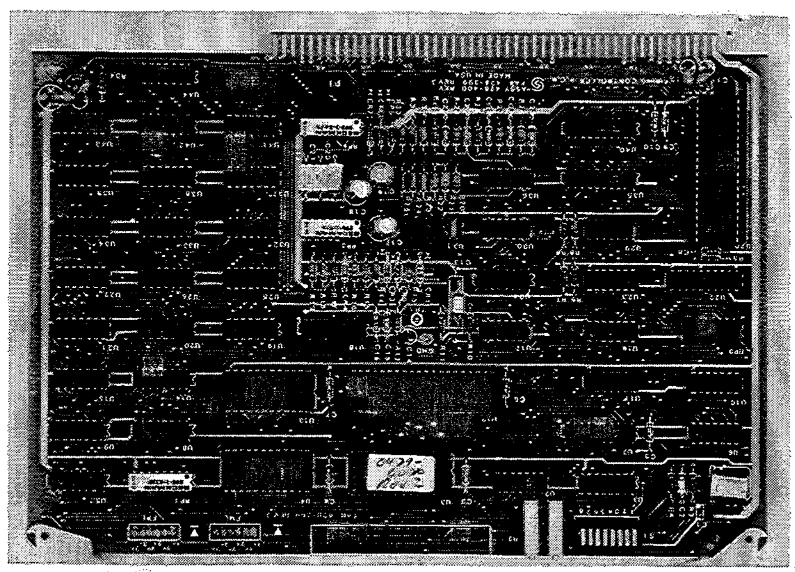
off = logic 1
on = logic 0

MAGNET TYPE
off (1) = high field magnet on (0) = standard magnet

FIGURE 8.6: Laser Head Controller Board DIP Switch Configuration

Firing Controller Board DIP Switches - adjusts the plasma tube gain to prevent oscillations when the system operates in the constant power mode. If the tube gain is high and the system is not equipped with a linear passbank, the tube may oscillate. To compensate, the gain can be reduced by a factor of 1, 2, 4, or 8; the factory setting is a 2x reduction.





PLASMA LOOP GAIN (w/o passbank)

Switch #	2	1	Gain
Binary Weight	2	1	Factor
	1	1	0.125
	1	0	0.250
	0	1	0.500
	0	0	1.000

FACTORY SETTING = 0.500
off = logic 1
on = logic 0

PASSBANK ENABLE

off (1) = disabled
on (0) = enabled

PLASMA SCR ENABLE

off (1) = disabled
on (0) = enabled

MAGNET SCR ENABLE

off (1) = disabled
on (0) = enabled

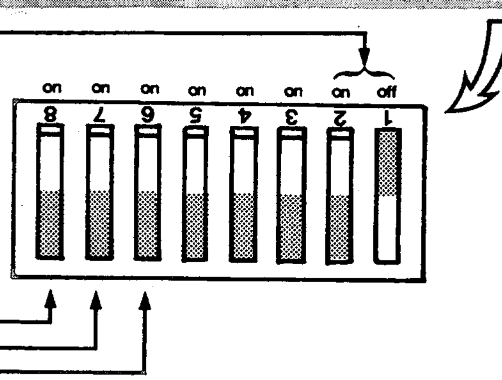
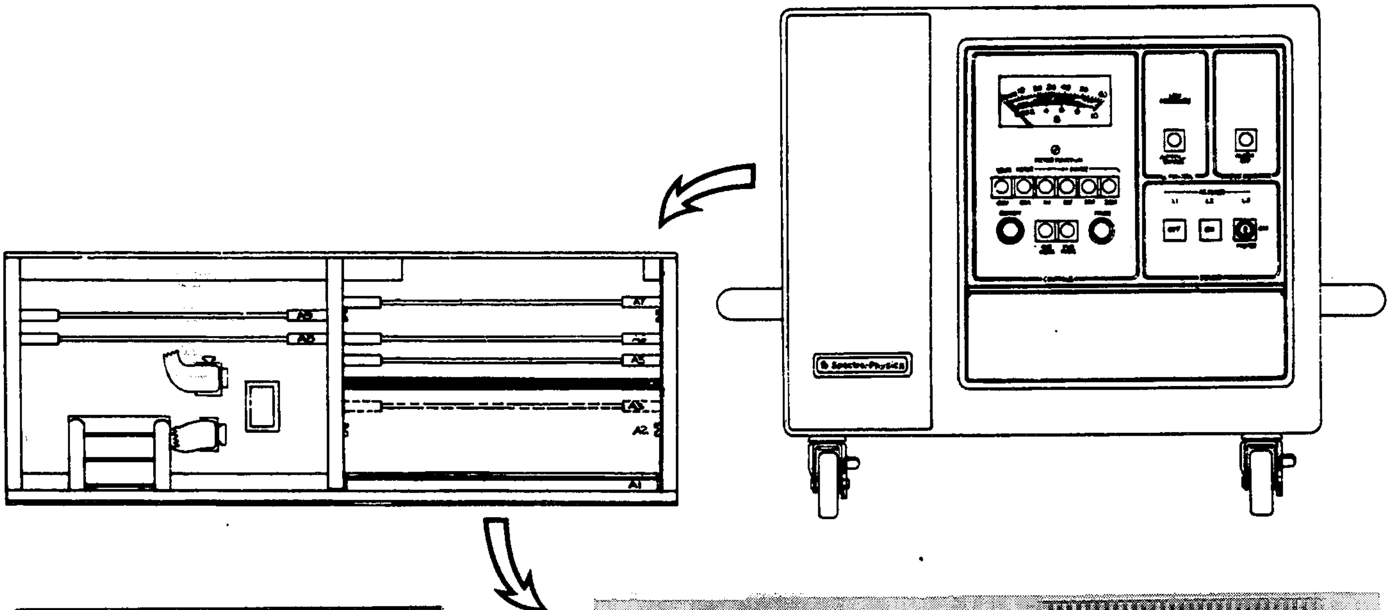


FIGURE 8.7: **Firing Controller Board DIP Switch Configuration**

Smart Board (optional) DIP Switches - determine the serial baud rate and enable the "echo" mode: the factory setting is n=6 (4800 baud), echo mode disabled; n = the sum of the binary digits, e.g., n=0+2+4+0=5.

Enabling the "echo" mode causes characters sent to the power supply to be echoed back to the device that sent them; thus a "dumb" terminal can display keyboard characters as they are typed. Also, if the power supply senses an invalid command, it will respond with a "?". In the echo disabled mode there is no "?".



RS232 BAUD RATE

Switch #	8	7	6	5	Baud Rate
Binary Weight	1	2	4	8	
	0	0	0	0	110
	1	0	0	0	150
	0	1	0	0	300
	1	1	0	0	600
	0	0	1	0	1200
	1	0	1	0	2400
	0	1	1	0	4800

FACTORY SETTING = 4800 baud
off = logic 1
on = logic 0

ECHO MODE

off (1) = disabled
on (0) = enabled

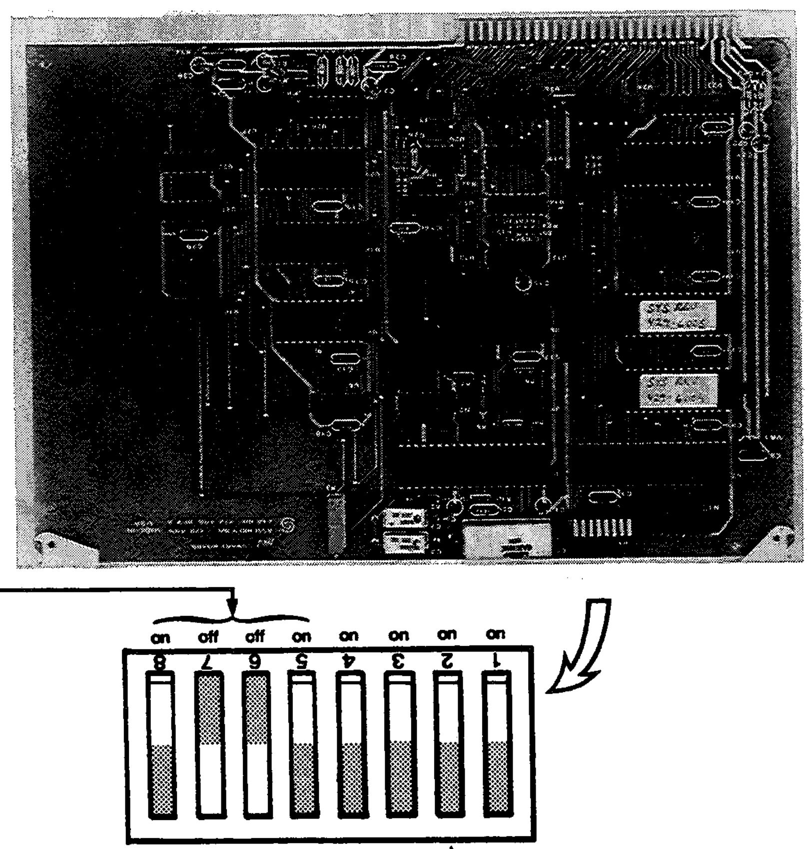


FIGURE 8.8: Smart Board DIP Switch Configuration

IEEE488 Interface (optional) DIP Switches - determine the address of the power supply: n = the sum of the binary digits, e.g., n=1+0+0+8+16+0+0+0=25 (factory setting)

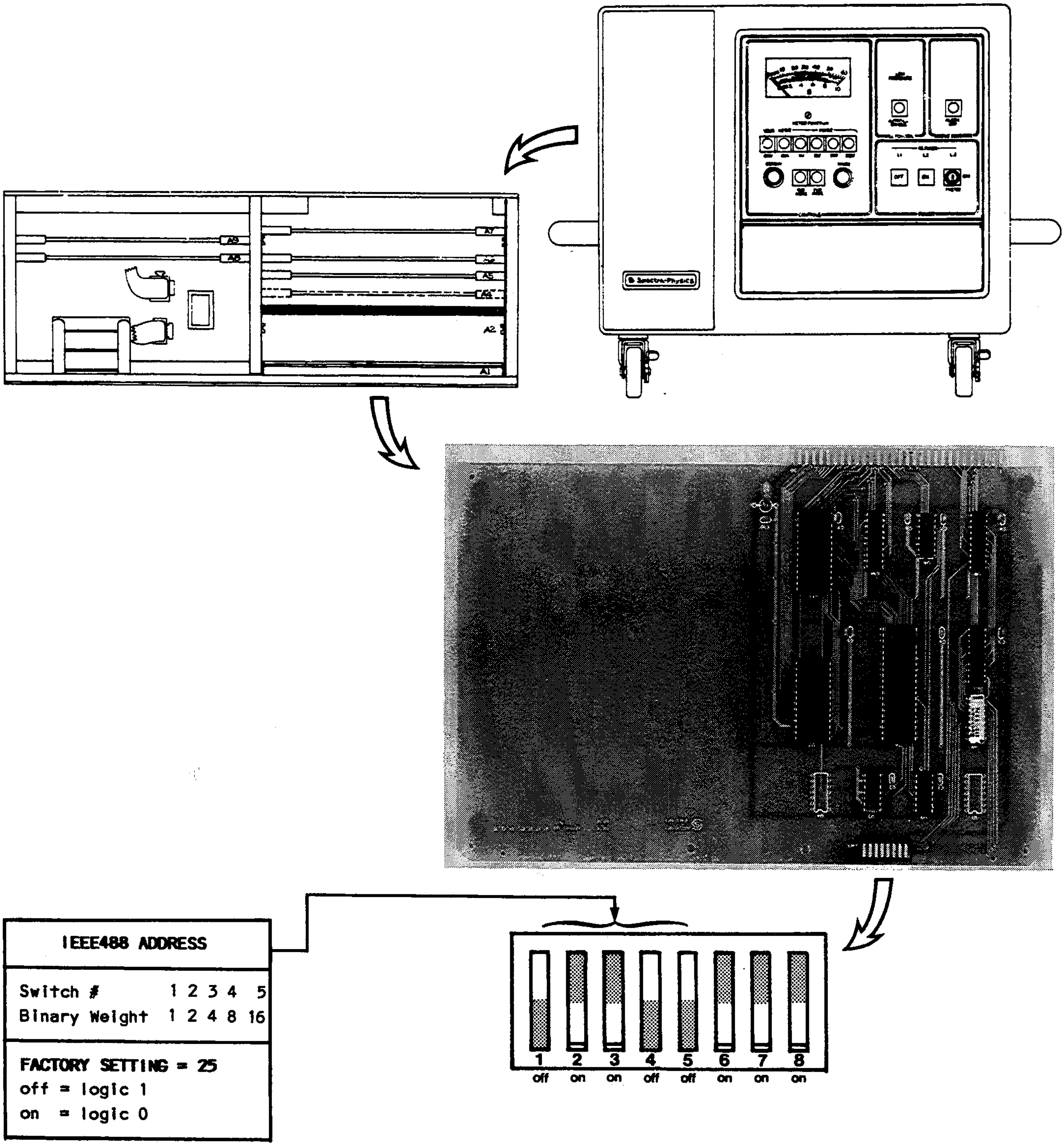


FIGURE 8.9: IEEE488 Interface Board DIP Switch Configuration

At Spectra-Physics, we take pride in the durability of our products. Considerable emphasis has been placed on controlled manufacturing methods and quality control throughout the manufacturing process. Never-the-less, even the finest precision instruments will need occasional service. We feel that our instruments have favorable service records compared to competitive products. We hope to demonstrate, in the long run, that we provide excellent service to our customers in two ways. First, by providing the best equipment for the money, and second, by offering service facilities that restore your instrument to working condition as soon as possible.

Spectra-Physics maintains major service centers in the United States, Europe, and Japan. Additionally, there are field service offices in major United States cities. When calling for service inside the United States, dial our toll-free number: **1 (800) 456-2552.** To phone for service in other countries, refer to the Service Centers listing located at the end of this section.

Order replacement parts directly from Spectra-Physics. For ordering or shipping instructions, or for assistance of any kind, contact your nearest sales office or service center. You will need your instrument model and serial numbers available when you call. Service data or shipping instructions will be promptly supplied.

To order optional items or other system components, or for general sales assistance, dial **1 (800) SPL-LASER** in the United States, or **1 (650) 961-2550** from anywhere else.

Warranty

This warranty supplements the warranty contained in the specific sales order. In the event of a conflict between documents, the terms and conditions of the sales order shall prevail.

The Model 2020/2025 Ion Lasers are protected by an 18-month/2000-hour warranty. All mechanical, electronic and optical parts and assemblies are unconditionally warranted to be free of defects in workmanship and material for the warranty period.

Liability under this warranty is limited to repairing, replacing, or giving credit for the purchase price of any equipment that proves defective during the warranty period, provided prior authorization for such return has been given by an authorized representative of Spectra-Physics. Warranty repairs or replacement equipment is warranted only for the remaining unexpired portion of the original warranty period applicable to the re paired or replaced equipment.

This warranty does not apply to any instrument or component not manufactured by Spectra-Physics. When products manufactured by others are included in Spectra-Physics equipment, the original manufacturer's warranty is extended to Spectra-Physics customers. When products manufactured by others are used in conjunction with Spectra-Physics equipment, this warranty is extended only to the equipment manufactured by Spectra-Physics.

Spectra-Physics will provide at its expense all parts and labor and one way return shipping of the defective part or instrument (if required).

This warranty does not apply to equipment or components that, upon inspection by Spectra-Physics, discloses to be defective or unworkable due to abuse, mishandling, misuse, alteration, negligence, improper installation, unauthorized modification, damage in transit, or other causes beyond the control of Spectra-Physics.

The above warranty is valid for units purchased and used in the United States only. Products with foreign destinations are subject to a warranty surcharge.

Warranty Return Procedure

Contact your nearest Spectra-Physics field sales office, service center, or local distributor for shipping instructions or an on-site service appointment. You are responsible for one-way shipment of the defective part or instrument to Spectra-Physics.

We encourage you to use the original Spectra-Physics packing boxes to secure instruments during shipment. If shipping boxes have been lost or destroyed, we recommend that you order new ones. Spectra-Physics will only return instruments in Spectra-Physics containers.

Benelux

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Japan (East)

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* *All European and Middle Eastern countries in this region not included elsewhere on this list.*

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Fax:	(650) 964-3584
e-mail:	service@splasers.com sales@splasers.com
Internet:	www.spectra-physics.com

* *And all countries not included elsewhere on this list.*

Spectra-Physics User's Manual Problems and Solutions

We have provided this form to encourage you to tell us about any difficulties you have experienced in using your Spectra-Physics instrument or its manual—problems that did not require a formal call or letter to our service department, but that you feel should be remedied. We are always interested in improving our products and manuals, and we appreciate all suggestions.

Thank you.

From:

Name ______________________________

Company or Institution ______________________________

Department ______________________________

Address ______________________________

____

Instrument Model Number ______________ Serial Number ______________

Problem: ______________________________

____

____

____

____

Suggested Solution(s): ______________________________

____

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Mail To:

Spectra-Physics, Inc.
ISL Quality Manager
1330 Terra Bella Avenue, M/S 15-50
Post Office Box 7013
Mountain View, CA 94039-7013
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E-mail: sales@splasers.com
www.spectra-physics.com

FAX to:

Attention: ISL Quality Manager
(650) 961-7101