Spectra-Physics

Model 168 and 168B OEM and Scientific Ion Lasers

Instruction Manual

LASER PRODUCTS DIVISION

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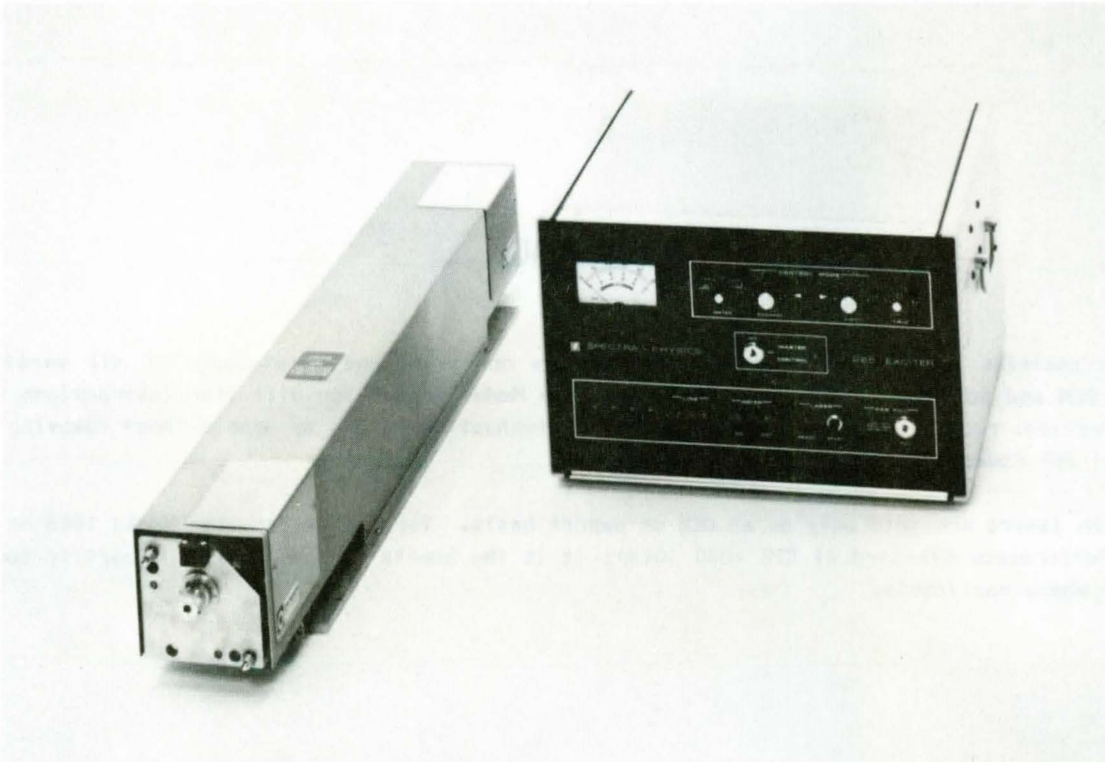
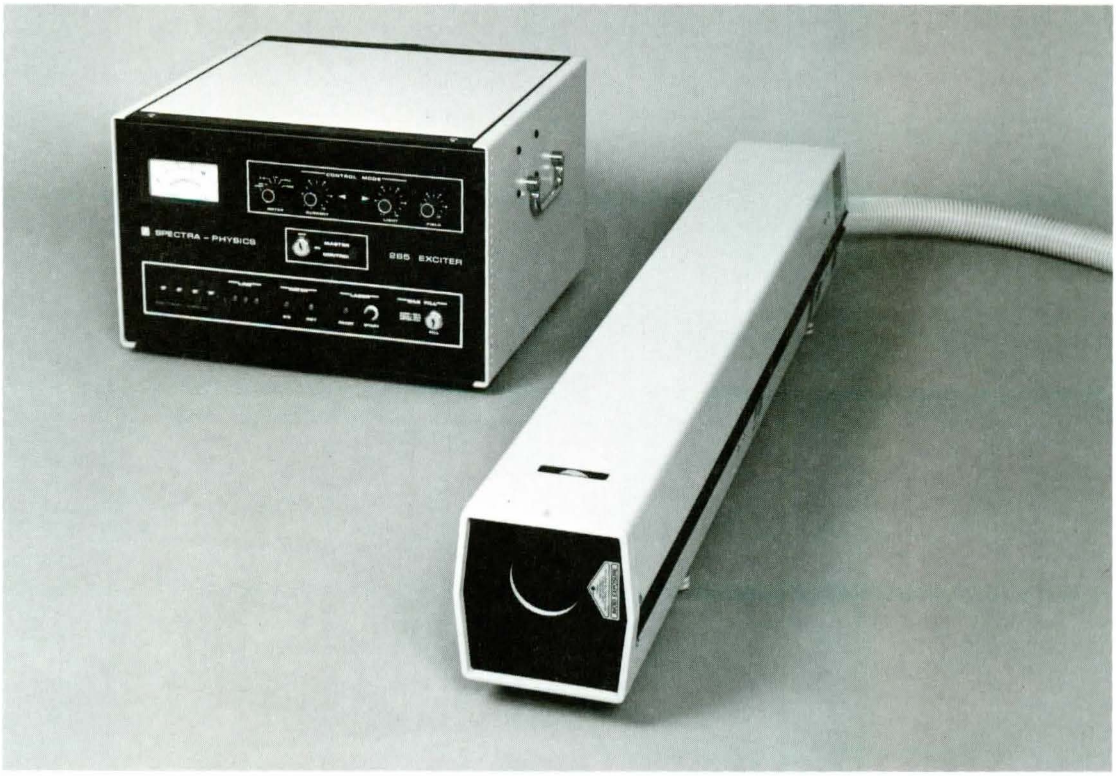


Model 168 OEM and Scientific Ion Laser with Model 265 Power Supply



Model 168B OEM and Scientific Ion Laser with Model 165 Power Supply

PREFACE

This manual contains information needed for day-to-day operation and maintenance of all versions of the **Model 168 OEM and Scientific Ion Laser,** including the **Model 168B.** You will find instructions for installation, operation, routine maintenance, and such troubleshooting as can be done without removing the covers of the Model 265 Power Supply.

Model 168 ion lasers are sold only on an OEM or export basis. Versions other than Model 168B do not comply with CDRH Performance Standard 21 CFR 1040 10(d); it is the user's responsibility to certify compliance of his product where applicable.

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SI UNITS

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

Quantity	Unit	Abbreviation
mass	kilogram	kg
length	meter	m
time	second	s
frequency	hertz	Hz
force	newton	N
energy	joule	J
power	watt	W
electric current	ampere	A
electric charge	coulomb	C
electric potential	volt	V
resistance	ohm	Ω
inductance	henry	H
magnetic flux	weber	Wb
magnetic flux density	tesla	T
luminous intensity	candela	cd
temperature	kelvin	K

Prefixes		
tera	(10^{12})	T
giga	(10^{9})	G
mega	(10^{6})	M
kilo	(10^{3})	k
deci	(10^{-1})	d
centi	(10^{-2})	c
milli	(10^{-3})	m
micro	(10^{-6})	μ
nano	(10^{-9})	n
pico	(10^{-12})	p
atto	(10^{-18})	a

INTRODUCTION

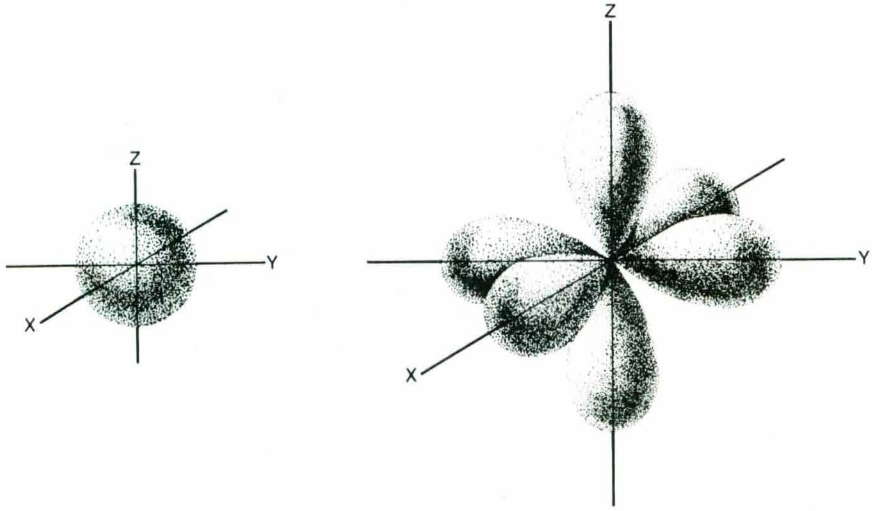

Figure 1.1: Electrons occupy distinct orbitals that are defined by the probability of finding an electron at a given position, the shape of the orbital being determined by the radial and angular dependence of the probability.

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 overall 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.

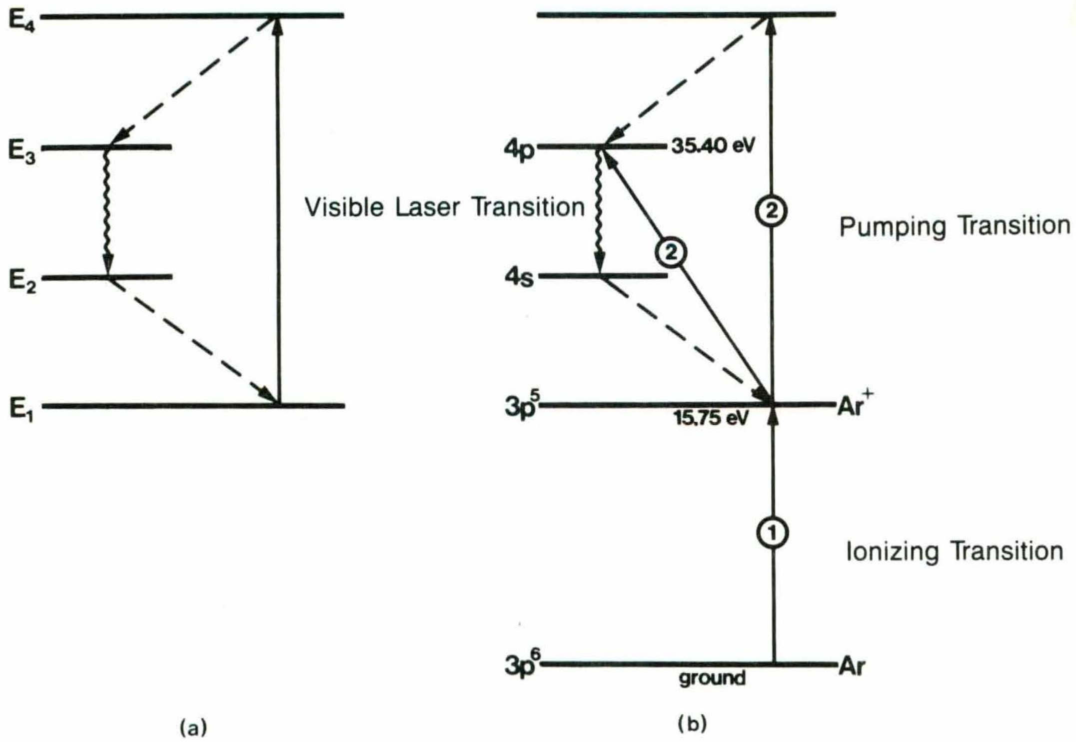

Figure 1.2: A typical four-level laser transition scheme (a) compared to that of visible argon (b). One collision ionizes neutral argon, and a second pumps the ion to an excited state.

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. 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 build-up) 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 (cw) argon

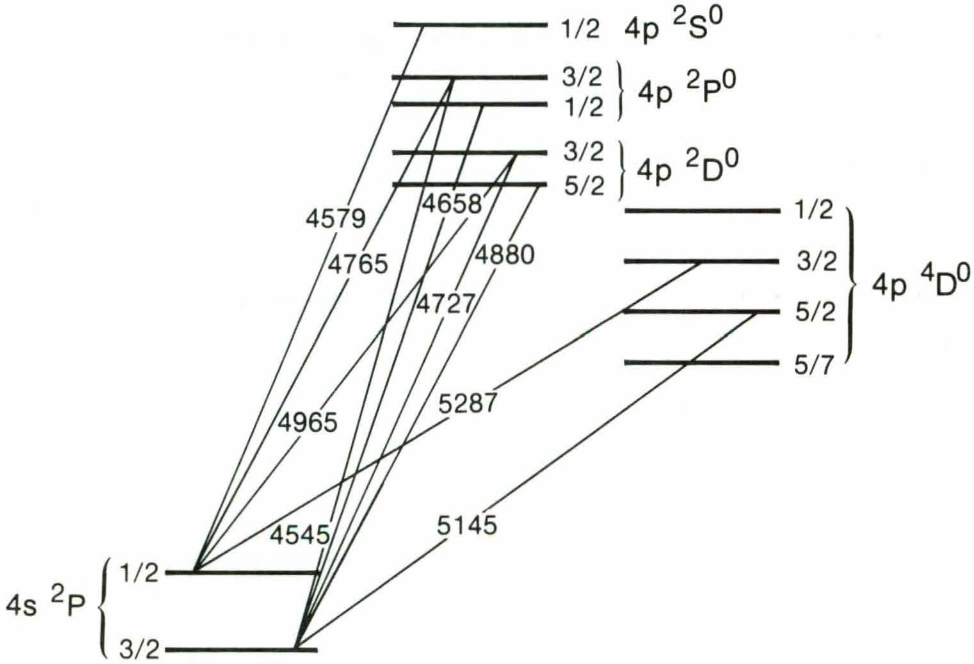

Figure 1.3: Energy levels of the 4p - 4s argon ion laser transitions

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

Most of the visible laser transitions in a continuous wave argon ion laser have approximately the same power-to-gain ratio as the 488 nm line, although they are weaker than that line and have less gain. The 514.5 nm line, however, is an exception. While its gain is only about 1/4 that of the 488 nm line, its output is approximately 25% greater, provided the gain is sufficient to overcome internal losses. The upper state of the 514.5 nm line is in a different family of levels than that of most of the other transitions and the difference in atomic constants changes the power-to-gain ratio.

The relationship of ion laser gain to input power is quite different from that of other lasers. The excitation process that produces the population inversion requires more than one collision to reach the upper state of the transition and the gain varies approximately as the square of the current density. The close relationship between current density and input power density suggests that high input power densities are desirable for maximum output power. The output power, in fact, varies approximately as the square of the input power over a large range of operating parameters.

A magnetic field, induced by a solenoid surrounding the plasma tube, tends to force electrons away from the tube walls. Since they are not lost, the electrons are subjected to the plasma discharge and the energy distribution of the free electron population rises. Since the upper energy levels can only be populated through collisions between ions and free electrons having at least the energy of the state being excited, the presence of the magnetic field enhances the population inversion.

The magnetic field also causes Zeeman splitting of the laser lines. These split lines have elliptical polarization. Since the plasma tube windows will only transmit vertically polarized lines, the energy of the split lines is lost.

Output power, increased by an enhanced population inversion and decreased by the Zeeman effect, depends directly on the strength of the magnetic field. There is an optimum field strength for each line.

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 broad-band (all-lines) operation the mirrors reflect a number of lines within a limited wavelength range (about 70 nm maximum). Several sets of broad-band 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.

PLASMA TUBE

The plasma tube is the most critical component of any ion laser. It must provide the optical gain necessary for lasing by sustaining a high-current-density arc discharge through its bore. The primary consideration in plasma tube design is the choice of bore material. The ideal material provides a combination of the following properties: high thermal conductivity, low porosity, high mechanical strength, electrical insulation, high dielectric strength, high purity, low vapor pressure.

Ion lasers are low-efficiency devices. For each watt of output, at least 1.5 kW of electrical power must be dissipated as heat in the plasma tube bore. Efficient heat transfer, from the inside of the bore to the cooling water, is essential; thus the need for high thermal conductivity.

Low porosity is important for three reasons. First, the bore must be vacuum-tight; porous materials can't sustain a vacuum. Second, porous materials provide traps for contaminants that will outgas during operation. Third, the more porous the material the greater the internal surface area of the bore and the greater the depletion rate of the fill gas.

The bore must be exceedingly strong to withstand mechanical and thermal shock. Moreover, the bore must maintain its integrity under bombardment by the discharge. It must not flake or powder, contaminating plasma tube windows from within.

To start and maintain an arc discharge, the electrical conductivity of the gas must be higher than the electrical conductivity of the surrounding walls. In order to start the discharge, a high voltage pulse must be applied across the gas. The dielectric strength of the bore material must be sufficient to allow it to withstand such a start pulse without breakdown.

To function properly in a high-vacuum evnironment, the bore material must have an extremely low vapor pressure and be free of extraneous materials with higher vapor pressures.

Of all the possible materials or combinations of materials that are presently available for plasma tube bore construction, beryllium oxide (BeO) has proven itself to be the material of choice for tubes of high reliability and long life.

- The thermal conductivity of BeO is 0.45 cal cm^{-1} sec^{-1} $°C^{-1}$, a value higher than that of most metals.
- Its modulus of rupture is greater than $2x1^3$ kg cm^{-2}, while its modulus of elasticity is greater than $3.5x10^6$ Ω-cm^{-2}.
- Its resistivity is 10^{16} Ω-cm^{-1}.
- Its dielectric strength is $1.8x10^6$ V cm^{-1}.
- Its vapor pressure is less than 10^{-11} mm Hg @ 120°C.
- The BeO used in Spectra-Physics plasma tube bores is guaranteed at least 99.5% pure.

THE MODEL 168 ION LASER SYSTEM

The Spectra-Physics Model 168 argon and krypton ion lasers provide optimum cw output power for a broad range of OEM applications. These include industrial spectroscopy, data recording and retrieval, biological cell sorting, retinal surgery, and endoscopic coagulation.

o Argon lasers are available in four basic versions, broad band or single line, TEM_{00} or multimode.

o Krypton lasers are available in four basic versions: standard or automatic pump, TEM_{00} or multimode. The krypton lasers provide broad band output in the red wavelengths and moderate power in the near infrared.

  The Krypton Automatic Pressure Control Pump Laser incorporates an automatic krypton pressure control pump and related electronics. In addition to the standard krypton wavelengths, this model performs well in the pressure-sensitive green-yellow region of the spectrum.

Refer to Output Power Specifications for a description of the available models and the version numbers.

The laser system is composed of the Model 168 Laser Head and the Model 265 Power Supply. The laser head contains the resonator with laser optics, plasma tube, and magnet. The power supply contains all of the electronic circuits necessary to create, sustain, and monitor the plasma tube discharge; to monitor and control the output power; and to supply and regulate the magnetic field.

THE LASER HEAD

Resonator

A massive extruded aluminum resonator provides support for the plasma tube, optics, and magnet. The excellent thermal conductivity of aluminum assures uniform distribution of heat throughout the structure, keeping thermal gradients to a minimum. As the temperature of the unit changes, its dimensions change uniformly, thereby maintaining alignment and beam-pointing stability. The aluminum mirror mounts are held against the resonator with stiff springs. The mass of the mounts and resonator, combined with the stiffness of the springs, reduce mechanical vibrations of the mirrors, thereby reducing frequency jitter.

A set of optics for either single-line or all-lines operation is supplied with each laser. The optics are held in threaded mounts that can be changed. The output mirror holder includes a beam splitter for the built-in power meter and light stabilizer. All-lines operation is obtained using a high reflector. An assembly containing a Brewster-angle prism and high reflector is employed for single-line operation.

Model 168B lasers employ a fixed aperture, located inside the cavity near the output coupler, to produce a TEM_{00} output beam.

Plasma Tube

All Model 168 Lasers use rugged BeO and glass plasma tubes built with hard-seal technology for long life and high reliability. The gas return path is a separate, large-bore tube that allows adequate gas conductance while preventing tube failure due to an arc discharge through the return line. The high thermal conductivity, strength, and mechanical stability of BeO make it an ideal material for plasma tube construction. Its resistance to erosion, caused by bombardment by the high energy plasma, assures long tube life. The bore segments are joined by a proprietary, non-metallic bonding process. The fused-silica windows are hard-sealed to the tube at Brewster's angle, thereby allowing a thorough, high-temperature bakeout of the entire tube during processing. The result is a contamination-free tube with a long life expectancy.

Model 168 argon and krypton lasers use the highest grade of optical fused quartz available. Fused quartz is the material of choice for visible operation because of its high purity, uniform optical and mechanical properties, and ability to be polished to a superb optical finish.

All argon models employ a gas fill reservoir connected to the plasma tube through a solenoid-actuated valve that is controlled by circuitry located within the power supply.

Most krypton laser lines are pressure sensitive. A combined pump and fill mechanism provides the ability to raise and lower gas pressure on laser models 168-01,-31,-41,-71 The pump can be operated automatically, or it can be operated manually for optimum performance at a selected pressure-sensitive krypton line.

THE MODEL 265 POWER SUPPLY

The fully regulated power supply controls the discharge current to provide consistent laser performance despite fluctuations in line voltage. A separate circuit provides current to the magnet. The magnetic field is continuously adjustable allowing maximum peformance at all laser lines.

A light stabilizer circuit uses feedback from a photo detector in the laser head to control output power by regulating plasma current. Current can also be controlled manually from the front panel of the power supply.

The photo detector signal can also be fed to the multi-purpose meter on the front panel. The meter can monitor output power, plasma current, gas pressure, or the condition of the plasma current regulator.

An audible alarm warns of low gas pressure. A key switch activates the gas fill circuit, adjusting the pressure to optimum performance levels. The circuit automatically prevents overfill. When the automatic pressure control system is used with a krypton laser, special electronics monitor plasma tube pressure and automatically control the pump/fill system for optimum performance.

Option 411-813 adds electronics to the Model 265 Power Supply that allows modulation and remote control of the laser. The laser output can be modulated at rates up to 10 Hz.

Option 411-814 adds a circuit to the Model 265 Power Supply that automatically starts the laser. The start sequence is initiated 30 sec after the circuit breaker on the front panel of the power supply is closed.

The following tables provide detailed specifications for all of the available Model 168 versions.

SPECIFICATIONS

PHYSICAL	Dimensions	Power Supply	42.5x27.7x41.9 cm
			16.7x10.9x16.5 in
		Laser	14.9x14.4x100.1 cm
			5.9x5.7x39.4 in
	Shipping Weight		105 kg, 232 lbs
	Cavity Length	w/o prism	0.9 m
		w/ prism	0.95 m
ELECTRICAL SERVICE	Type		3-phase w/ earth ground
	Voltage Required[1]		208±8% V
	Current Required		38 A
	Power Required		13.1 kW
WATER SERVICE	Flow Rate	Minimum	8.5 l/min, 2.2 g/min
	Pressure	Minimum	1.8 kg/cm^2, 25 psi
		Maximum	3.5 kg/cm^2, 50 psi
PERFORMANCE	Noise[2]	Light Control Mode	0.2% rms
		Current Control Mode	1%
	Stability	Light Control Mode (in any 30 min period, after 2 hr warmup)	±0.5%
		Current Control Mode (after 30 min warmup)	±3%
	Beam Diameter[3]		1.25 mm
	Beam Divergence[3]		0.69 mrad
	Polarization		Vertical
	Mode Spacing	w/o prism	167 MHz
		w/ prism	158 MHz

Specifications subject to change without notice.

[1] Versions 168-09 and -49 have a voltage regulation range of 208+8%-5% V (ac.)

[2] Performance at 514.5 nm (argon), at the specified power, 10 Hz-2 MHz. At 647.1 nm (krypton), at the specified power, 0.3% rms, 10 Hz-1 MHz. Contact Spectra-Physics for performance data at other wavelengths.

[3] For TEM_{00} versions: at $1/e^2$ points, data for 514.5 nm. Data for other wavelengths (assuming no change in optical configuration) is given by:

$$\frac{DIA(1)}{DIA(2)} = \left(\frac{\lambda_1}{\lambda_2}\right)^{\frac{1}{2}}$$

OUTPUT POWER SPECIFICATIONS

Argon Ion Laser Power (W)

Broad Band							
	TEM_{00}				Multimode		
OEM Scientific	-56 -16	-57 -17	-58 -18	-59 -19	-67 -27	-68 -28	-69 -29
457.9-514.5 nm	2W	3W	4W	5W	3W	4W	5W

Single-Line[1]							
	TEM_{00}				Multimode		
OEM Scientific	-46 -06	-47 -07	-48 -08	-49 -09	-77 -37	-78 -38	-79 -39
1090.0[2] nm	0.02	0.03	0.04	0.05	0.03	0.04	0.05
528.7[2]	0.15	0.25	0.30	0.34	0.25	0.30	0.34
514.5	0.80	1.20	1.70	2.00	1.20	1.70	2.00
501.7	0.10	0.20	0.30	0.40	0.20	0.30	0.40
496.5	0.28	0.40	0.60	0.70	0.40	0.60	0.70
488.0	0.70	1.00	1.30	1.50	1.00	1.30	1.50
476.5	0.25	0.35	0.60	0.75	0.35	0.60	0.75
472.7	0.05	0.13	0.25	0.30	0.13	0.25	0.30
465.8	0.05	0.07	0.13	0.20	0.07	0.13	0.20
457.9	0.11	0.20	0.30	0.35	0.20	0.30	0.35
454.5[2]	[3]	0.05	0.10	0.12	0.05	0.10	0.12

Krypton Ion Laser Power (W)

Broad Band				
	TEM_{00}		Multimode	
	Standard	Pump Version	Standard	Pump Version
OEM Scientific	-61 -21	-41 -01	-51 -11	-71 -31
752.5-799.3[2] nm	0.25	0.25	[3]	[3]
647.1-676.4	0.60	0.60	0.80	0.80

Specifications subject to change without notice.

[1] Single-line powers for argon lasers are specified at 514.5 nm and 488.0 nm only. Other powers indicated are nominal; firm specifications are available with special testing at extra charge.

[2] Special optics and testing required. There is an extra charge for the testing which is necessary to guarantee performance at these wavelenths. This is available at time of purchase or at a Spectra-Physics Service Center.

[3] Not specified.

LASER SAFETY

CAUTION

The Spectra-Physics Model 168 Laser is a Class IV-High Power Laser whose beam is, by definition, a safety and fire hazard. Take precautions to prevent accidental exposure to both direct and reflected beams. Diffuse as well as specular beam reflections can cause severe eye or skin damage.

PRECAUTIONS FOR THE SAFE OPERATION OF CLASS IV-HIGH POWER LASERS

- Do not attempt to view either a direct or reflected beam; even a diffuse beam reflection may be hazardous.
- Avoid blocking direct or reflected beams with any part of the body.
- Establish a controlled-access area for laser operation. Limit access to those persons who are trained in laser safety principles.
- Maintain a high ambient light level in the laser operation area so that the pupil of the eye remains constricted, reducing the possibility of damage.
- Post warning signs prominently near the laser operation area.

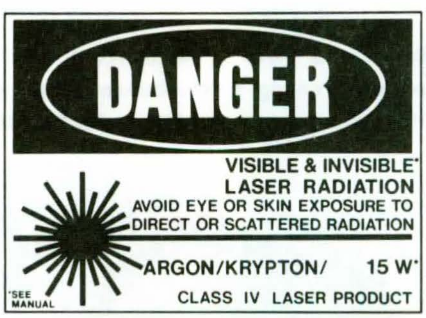

FIGURE 2.1: Standard Safety Warning Sign

- Provide enclosures for beam paths whenever possible.
- To avoid unnecessary radiation exposure, keep the laser cover in place during normal operation.
- Set up a metal beam target to capture the laser beam and prevent accidental exposure.

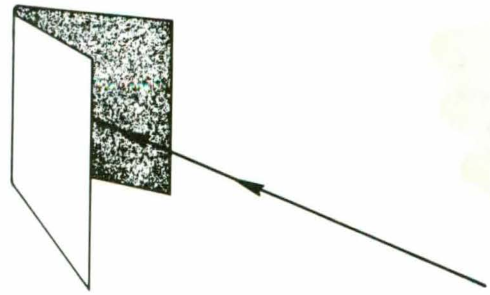

FIGURE 2.2: Folded Metal Beam Target

- Set up shields to prevent stray reflections from escaping the laser operating area.

WARNING: HIGH VOLTAGE AND CURRENT

Both the Model 168 and its power supply contain electrical circuits operating at dangerous voltage and current levels. Exercise extreme caution whenever the covers of the laser head or power supply are removed. Do not touch high voltage terminals or components.

CAUTION

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

Operating this laser without due regard for these precautions or in a manner that does not comply with recommended procedures may be dangerous. At all times during installation, maintenance or service of your laser, avoid unnecessary exposure to laser or collateral radiation that exceeds the accessible emission limits listed in Performance Standards for Laser Products, 21 CFR 1040 10(d).

Follow instructions contained in this manual for proper installation and operation of your laser. We recommend the use of protective eyewear whenever possible; selection depends on the energy and wavelength of the laser beam used as well as operating conditions.

Consult relevant OSHA, ACGIH or ANSI standards for further guidance.

SCHEDULE OF MAINTENANCE NECESSARY TO KEEP MODEL 168B LASERS IN COMPLIANCE WITH CDRH 21 CFR CHAPTER 1, SUBCHAPTER J, PARTS 1040.10 AND 1040.11

This laser product complies with Title 21 of the United States Code of Federal Regualtions, Chapter 1, Subchapter J, Parts 1040.10 and 1040.11, as applicable. To maintain compliance with these regulations, once a year or whenever the product has been subjected to adverse environmental conditions (e.g., fire, flood, mechanical shock, spilled solvent) check to see that all features of the product listed on the radiation control drawing (Figure 2.5) function properly. Also insure that all required labels are firmly attached.

1 Verify that removal of the remote control (interlock) plug (Figure 2.5 and 3.1) prevents operation of the laser.

2 Verify that the laser cannot be turned on without the key.

3 Verify that the emission indicator provides a visible signal when the instrument emits laser radiation that exceeds the accessible emission limits for Class I*. Also verify that the signal provides an advance warning sufficient to allow appropriate action to avoid radiation exposure.

4 Verify that the beam blocker actually blocks access to laser emission.

5 Verify that the safety interlock stops emission of laser or collateral** radiation upon removal or displacement of the interlocked part of the protective housing.

6 Verify that, when the safety interlock is defeated, the defeat plug is clearly visible and prevents installation of the cover.

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* 0.39 μW for cw operation where output is limited to the 400-1400 nm range.

** Any electronic product radiation, except laser radiation, emitted by a laser product as a result of or necessary for the operation of a laser incorporated into that product.

COVER INTERLOCKS

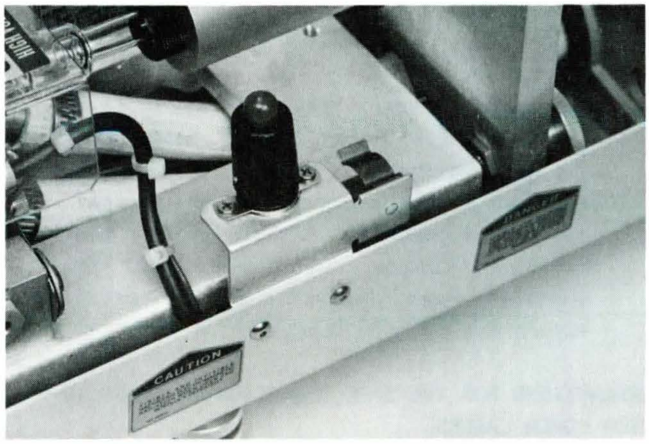


FIGURE 2.3: Cover Interlock Defeat Plug

An interlock that prevents accidental electric shock or exposure to collateral radiation is incorporated in the cover of the Model 168B. Removal of the cover opens a protective circuit, tripping the main circuit breaker. The laser will not operate until the cover is on or an interlock defeat plug has been installed. The cover cannot be installed until the defeat plug is removed. Shut down the laser before removing the plug.

Be careful to avoid high voltage terminals; familiarize yourself with their locations, which are identified by warning labels.

BEAM BLOCKER

Model 168B lasers have a mechanical shutter that can be operated using a thumbwheel that protrudes through the top cover near the emission indicator.

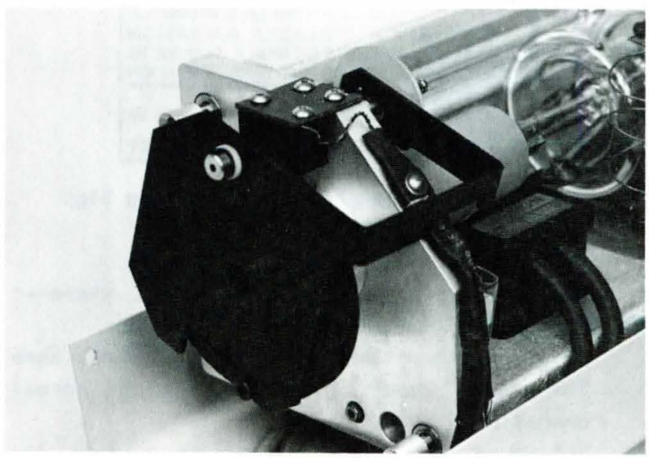


FIGURE 2.4: Model 168B Beam Blocker

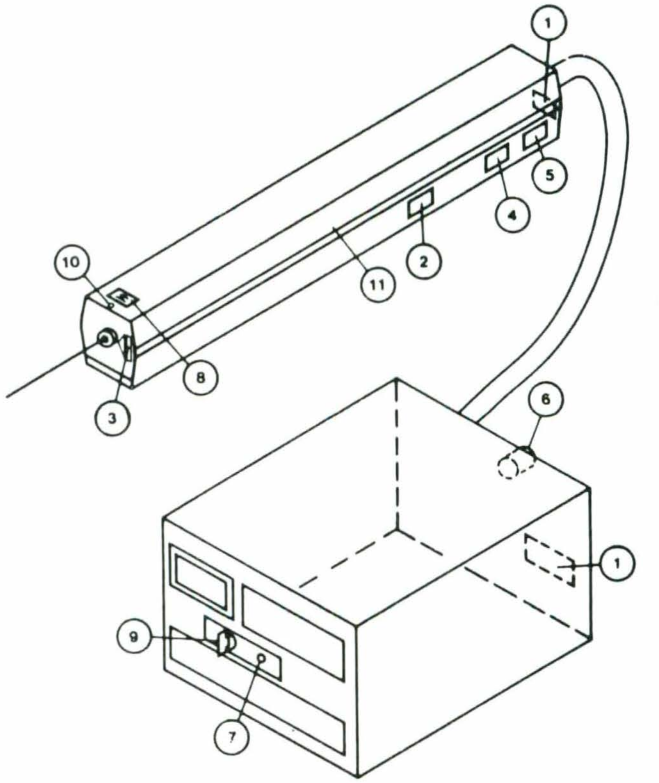


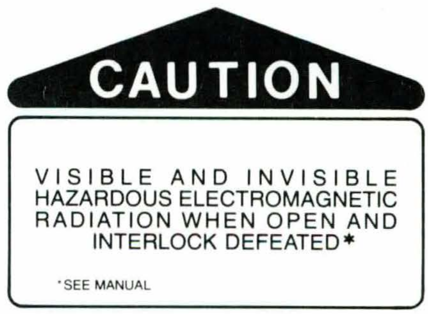
FIGURE 2.5: Model 168B Radiation Control Drawing

Laser Safety Feature	Location
Certification Label	1
Warning Logotype	2
Aperture Label	3
Cover Interlock Label	4
Electromagnetic Radiation Label	5
Remote Control (Interlock) Plug	6
Power Supply Emission Indicator	7
Beam Attenuator	8
MASTER Key Switch	9
Laser Head Emission Indicator	10
Cover Interlock	11

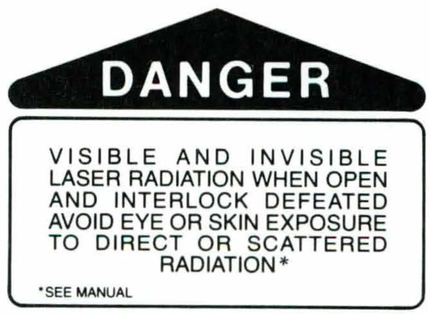
Certification Label

Warning Logotype

Aperture Label



Cover Interlock Label



Electromagnetic Radiation Label

FIGURE 2.6: Model 168B Warning Labels

INSTALLATION

UNPACKING YOUR LASER

Inspect each component of the system carefully as you unpack it. If you notice any damage, such as dents or scratches on the laser head or power supply cases, broken knobs or switches, or a broken plasma tube, 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.

Retain the shipping containers. If you file a damage claim, you may need them 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:

- A tool kit that contains all of the tools you will need to align and maintain your laser, including: fuses, extra hose washers, a set of Allen wrenches for beam alignment, a box wrench for unlocking the magnet for alignment, a mirror wrench for mirror removal, forceps and lens tissue for optics cleaning, a dispensing bottle for optics cleaning
- Two water hoses for system cooling water: you will need one hose for inlet water and one for outflow
- One water filter with three 25 μ m filter cartridges: one cartridge is packed in the filter housing
- A small cardboard box that contains the high-reflector mirror, a mirror wrench, and two sets of keys: a pair of master switch keys and a pair of gas fill switch keys

A large ball driver for plasma tube removal is packed separately.

In addition to these accessories, you will need to supply several items, including:

- electronic grade (or better) acetone for optics cleaning
- 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 three #25 and four #23 wrenches makes alignment a much simpler process)
- a third water hose for the over-pressure relief drain

ELECTRICAL CONNECTIONS

The power supply requires 208±8% V three-phase electrical service, rated at 50 A. The switch box should be less than 2.4 m (8 ft) from the power supply. **Connect the green lead to earth ground, not neutral.** Connect the remaining three leads to the legs of the three-phase service; sequence is not important. If a disconnect plug is used, it must be rated for at least 50 A.

WARNING

> Do not exceed 230 V! If only >230 V three-phase is available, you must use a transformer to step down to 208 V. Contact your Spectra-Physics field engineer for details.

Place both the laser head and power supply in their operating positions. The standard length of the umbilical between the laser and the power supply is 2.4 m. Connect the electrical umbilical to the receptacle on the rear panel of the power supply; insert the plug into the jack and press until the connection is snug. Tighten the retaining ring finger-tight.

WATER CONNECTIONS

Connect the laser head water hoses to the fittings located beneath the electrical umbilical. Cooling water may be supplied from an open-loop system consisting of filtered tap water source and direct connection of the outflow to a drain, provided the water flow rate is at least 8.5 l/min (2.2 US gal/min) at a differential pressure* between 2.11 and 3.52 kg/cm^2 (30 and 50 psig.) The incoming water service should be at least 3/4" diameter.

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

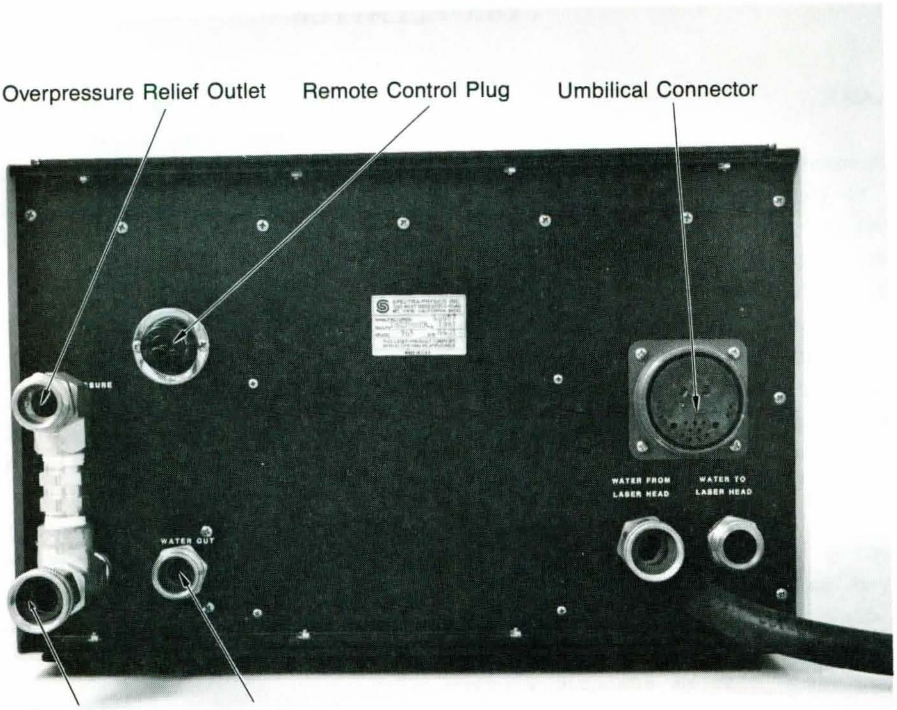


FIGURE 3.1: Model 265 Rear Panel

A 25 µm water filter is included with your laser system. It prevents blocked water passages by removing particles from the cooling water. Install it with a shutoff valve on the inlet side and a check valve on the outlet side. Provide enough room around the filter to allow easy access for service.

Connect the filtered cooling water to the female hose fitting on the rear panel of the power supply. Connect a drain hose to the male hose fitting.

An over-pressure relief valve protects the laser and power supply from damage due to high water pressure. It will open if cooling system pressure exceeds 3.5 kg/cm^2 (50 psig). Connect another drain hose to the over-pressure fitting. Both drain hoses may be merged with a "Y" connection before they reach the drain. However, if a "Y" is used, take care to avoid stepping on the outlet hoses, which can cause excessive back pressure.

A closed-loop cooling system, such as the Spectra-Physics Model 314 Water Conditioner may also be used. Its specifications, listed below, exceed the thermal parameters of all of the lasers in the Spectra-Physics 160 series. If you plan to design your own closed-loop system, use the specifications and thermal parameters as a guide.

FIGURE 3.2: Model 168/265 Ion Laser Thermal Parameters

Required Heat Dissipation	13.1 kW
Required Coolant Flow Rate	8.5 l/min 2.2 gal/min
Maximum Outlet Temperature	53°C (127°F)
Required Coolant Pressure*	30-50 psig

FIGURE 3.3: Model 314 Ion Laser Water Conditioning Specifications

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

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

FIGURE 3.4: Utility Requirements for Model 168 Ion Lasers Under Worst Case[1] Service Conditions

Laser Version	Maximum Outlet Temp[2] (°F)	Maximum Inlet Temp[3] (°F)	Temperature Change (°F)	Power Consumed (kW)	AC Current Required[4] (A)
-06,-16,-46,-56	127	95	32	10.4	28
-07,-17,-27,-37, -47,-57,-67,-77	127	91	36	11.6	31
-08,-18,-28,-38 -48,-58,-68,-78	127	88	39	12.6	34
-09,-19,-29,-39 -49,-59,-69,-79	127	85	42	13.5	37
-11,-21,-01,-31 -51,-61,-71,-41	127	88	39	12.6	34

1 224.6 V (ac) (maximum specified) and 2.2 g/min (minimum specified) cooling water flow

2 Preset at the factory - temperature at which the thermal interlock opens

3 Inlet water temperature must be below this value for safe operation

4 Current rating of the three-phase circuit that serves the laser should be at least 10 A higher than this value.

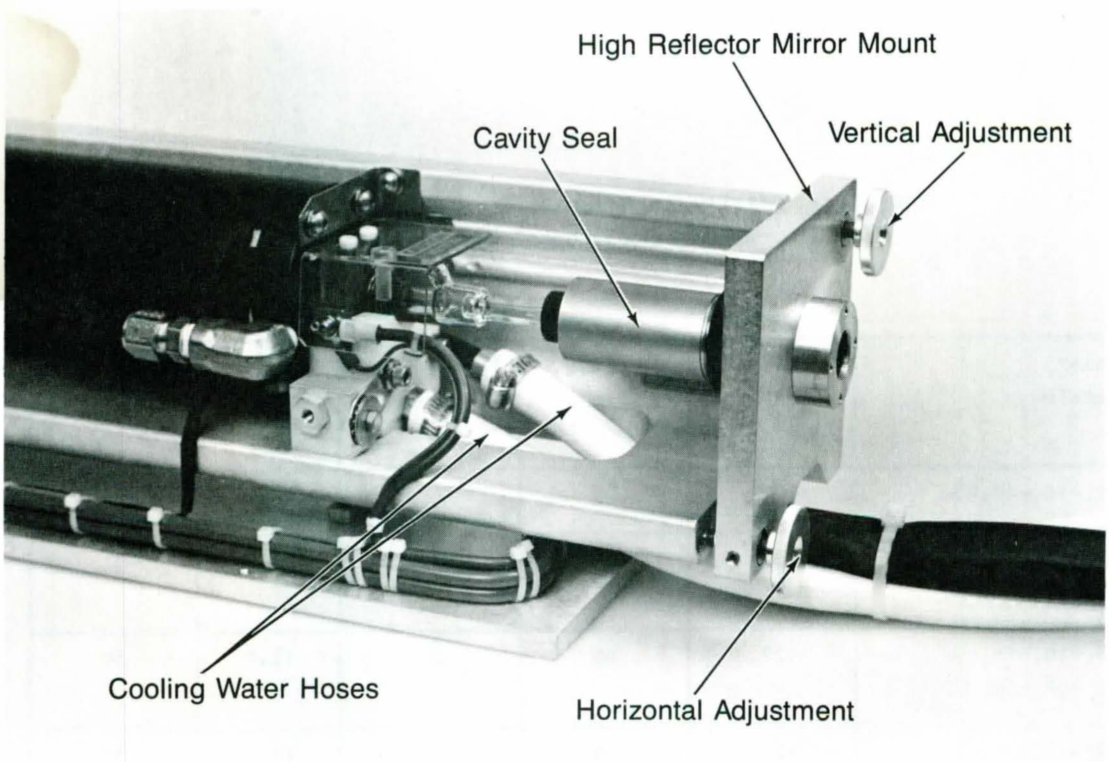


FIGURE 3.5: Laser Head Interior (Anode End)

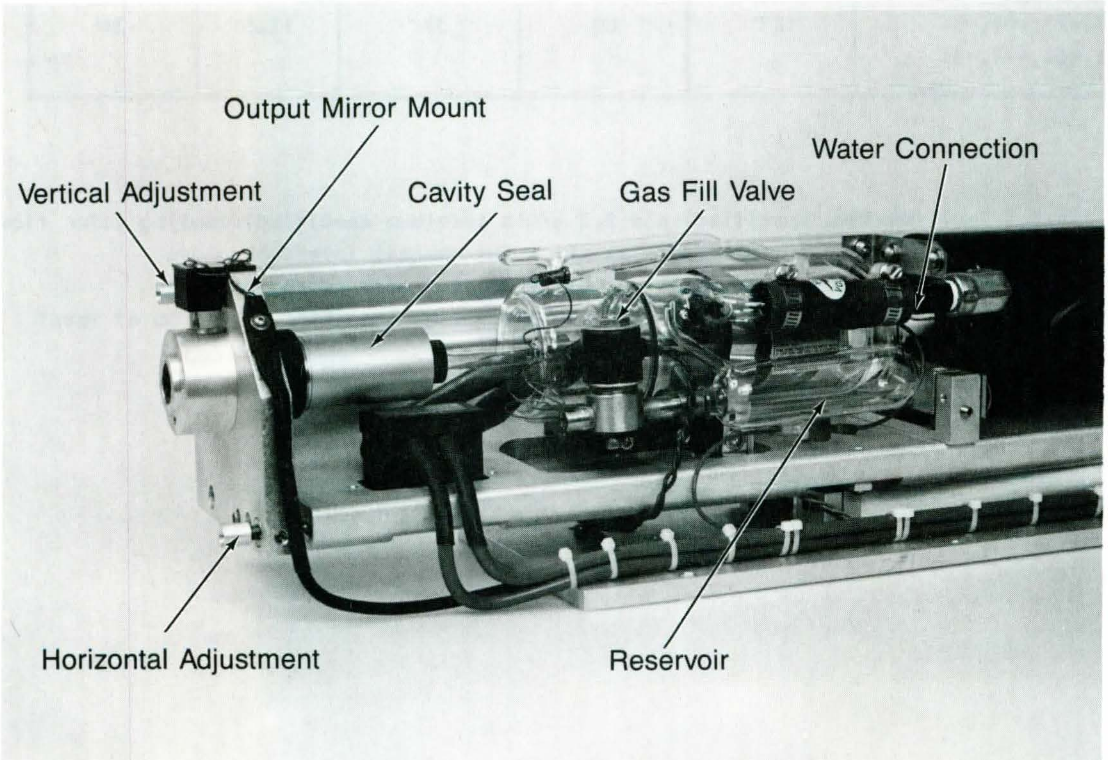


FIGURE 3.6: Laser Head Interior (Cathode End)

OPERATION

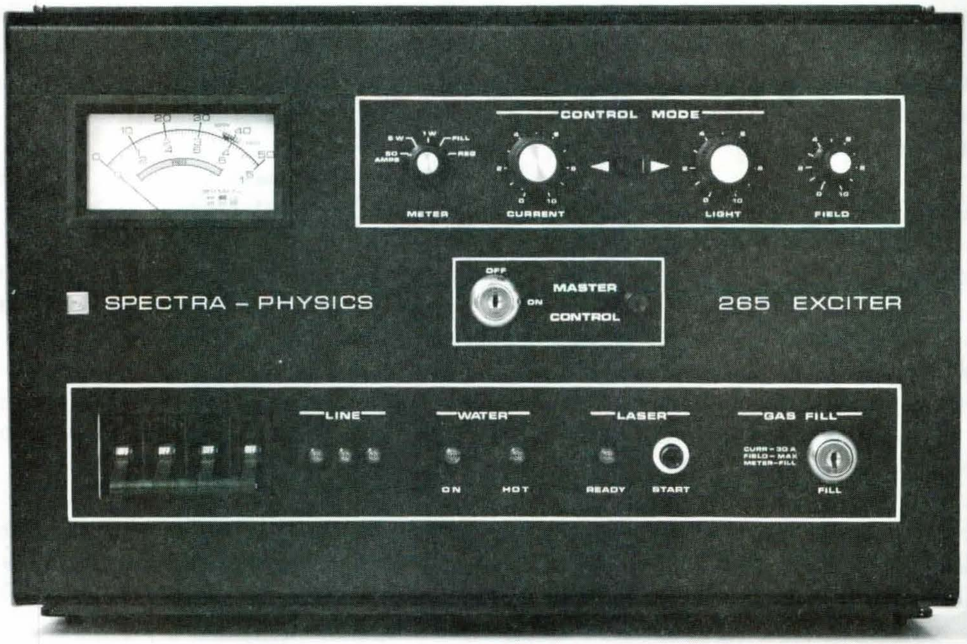


FIGURE 4.1: Model 265 Power Supply Front Panel

POWER SUPPLY CONTROLS

METER - the multi-function meter displays plasma tube current, laser output power, gas pressure as a function of tube voltage, and the operating condition of the tube current regulator.

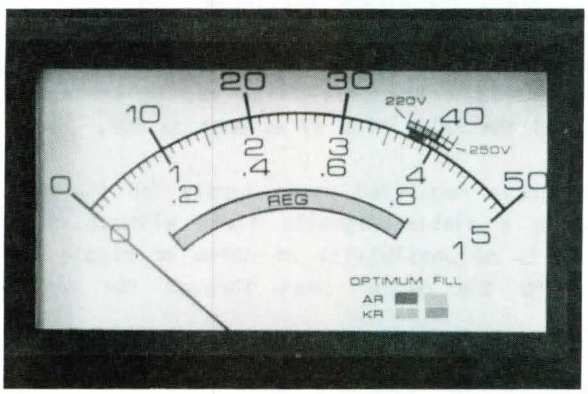


FIGURE 4.2: Front Panel Meter

CONTROL MODE

METER function selector - determines the value displayed on the panel meter.

50 AMPS - the meter displays plasma tube current from 0 to 50 A. Read values displayed on the 0-50 scale.

5 W - the meter displays output power from 0 to 5 W. Read values displayed on the 0-5 scale.

1 W - the meter displays output power from 0 to 1 W. Read values displayed on the 0-1 scale.

FILL - the meter displays plasma tube pressure as a function of tube voltage. Optimum pressure ranges for argon and krypton versions of the Model 168 are color coded on the meter face: Ar/blue is for visible argon operation; Kr/red is for krypton operation in the red (647.1-799.3 nm) range; Kr/green is for all other krypton lines. If the meter deflection, at maximum CURRENT, falls within the color bar corresponding to the operating wavelength of the laser, tube pressure is within its optimum range.

If the meter fails to reach the color bar, gas pressure is too low and the tube should be filled.

Multiply values displayed on the 0-50 scale by a factor of six to find the actual tube voltage. If the meter deflects beyond the color bar, the tube is overfilled. Refer to the "Gas Fill" instructions for details.

REG - the meter displays the voltage across the plasma tube current regulator by finding the difference between the supply line voltage and the plasma tube voltage. If the meter deflection is within the green REG bar, the regulator voltage is within its operating range. If the deflection fails to reach the REG bar, the current regulator voltage is too low. Low supply line voltage or high plasma tube voltage can both reduce regulator voltage. If the meter deflection exceeds the REG range, regulator voltage is too high. Either high supply line voltage or low tube voltage can be the cause. If either condition arises, check the tube voltage by switching the meter display to FILL.

Multiply the value displayed on the 0-1 scale by a factor of ten to find the actual regulator voltage.

CURRENT control knob - output power is stabilized by regulating the plasma tube current. Current is maintained at a selected value, independent of fluctuations in supply line voltage.

When the METER function selector is in the 50 AMPS

FIGURE 4.3: Maximum Plasma Current for Model 168 Versions

Argon Versions	
-06,-46...........28A	-16,-56,-97........30A
-27,-37,-67,-77...30A	-07,-17,-47,-57....32A
-28,-38,-68,-78...32A	-08,-18,-48,-58....35A
-29,-39,-69,-79...35A	-09,-19,-49,-59....38A
Krypton Versions	
-11,-21,-51,-61...........................30A	
-01,-31,-41,-71...........................35A	

position, plasma tube current can be selected by adjusting the CURRENT control until a predetermined value is displayed on the meter.

When the METER selector is in either the 1 W or 5 W position, laser output power can be adjusted to a predetermined value by turning the CURRENT control.

CONTROL MODE switch - selects either the CURRENT control or LIGHT control mode.

LIGHT control knob - output power is stabilized by sampling the output beam and compensating for fluctuations through feedback to the plasma tube current regulator. Minor resonator misalignments, voltage irregularities and other disturbances in the output beam can be compensated for in the LIGHT control mode.

When the METER selector is in either the 1 W or 5 W position, laser output can be adjusted to a predetermined value by turning the LIGHT control.

The usable output range is 100 mW to 2 W. To allow the stabilization circuit enough latitude to operate properly, plasma tube current must be set at least 2 A below its maximum rated value.

Light stabilization during multi-line operation is impossible since there is no way to assure the relative stability of all of the lines in the output beam.

FIELD control knob - adjusts the axial magnetic field along the plasma discharge from 500-1000 G. The output power of some krypton lines can be enhanced on the pump version by reducing the magnetic field. The 647.1 line can be enhanced by 30% and the 520.8 line by as much as 80%.

A separate regulated power supply for the magnet assures a stable magnetic field without ripple. There is no possibility of noise or ripple coupling to the output beam through the magnetic field.

MASTER CONTROL - the key switch activates the system and must be on before the circuit breakers can be closed. When it is on the lamp will glow.

Circuit Breaker - connects all power supply circuits to the 208 V ac supply line. It is interlocked with the water flow, cover, and temperature monitors to assure safe operation.

LINE indicator lamps - monitor the three phase line voltages with respect to one another. All three lamps glow when power is applied to the Model 265.

WATER indicator lamps - the WATER ON lamp glows when water pressure and flow are sufficient for safe operation. The WATER HOT indicator glows when the cooling system output is too hot for safe operation; it goes out as soon as a safe water temperature is reached. Such a change can occur quickly and the WATER indicator may only glow momentarily after the laser shuts down.

LASER indicator lamps - the READY lamp glows when the system is ready to start, about 15 sec after the MASTER CONTROL key switch is turned ON. Press the START button to send a high voltage pulse to start the plasma discharge.

GAS FILL control - the key switch activates the gas fill mechanism to increase plasma tube pressure. Refer to the "Gas Fill" instructions in the Operation section for details. Improper use of the Gas Fill system can cause permanent plasma tube damage. (If you have a krypton laser, refer to Krypton Laser Operation for additional instructions.)

LASER HEAD CONTROLS

Horizontal - moves the optical axis of the mirror horizontally.

Vertical - moves the optical axis of the mirror vertically.

ATTENUATOR - a mechanical shutter that blocks the beam as it emerges from the output coupler.

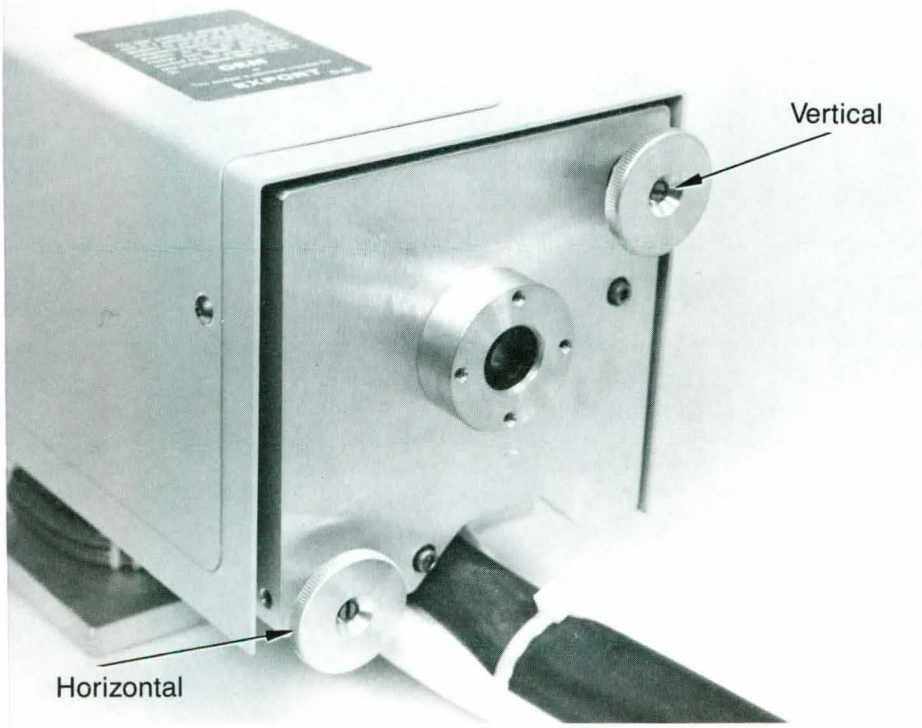


FIGURE 4.4: High Reflector Mirror Adjustments

TESTING

The following tests should be performed before you attempt to start your laser for the first time. They are your final assurance that the system arrived in proper working condition.

WATER TESTING THE PLASMA TUBE

Remove the laser head cover.

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

Check the following:

- o Water should enter the tube through the magnet water fitting.
- o Check for leaks at the anode block (see Figure 4.5), the hose clamps, and the connection at the rear of the power supply. Check for water drops beneath the power supply.

If water leaks appear at the fittings or hose clamps, tighten them to see if the leaks stop. If they persist, shut off the water supply, drain the tube and call your Spectra-Physics representative.

CONTROL OPERATION TESTS

Check the key switches to be sure that they operate smoothly.

Check to make sure the MASTER CONTROL key will not pull out when the switch is ON.

Check that each control knob turns smoothly; set each at its minimum value.

With the MASTER CONTROL switch OFF and the water supply on, apply power to the Model 265 and check the following:

- o All three LINE indicator lamps should glow.
- o The WATER ON indicator lamp should glow.
- o The WATER HOT indicator lamp should be dark.

Conduct the power supply tests in figure 4.6.

If your system fails any of the above tests, call your Spectra-Physics representative. If all tests were satisfactory, go on to "Starting the Argon Laser." (If you have a krypton laser, refer to Krypton Laser Operation for starting instructions.)

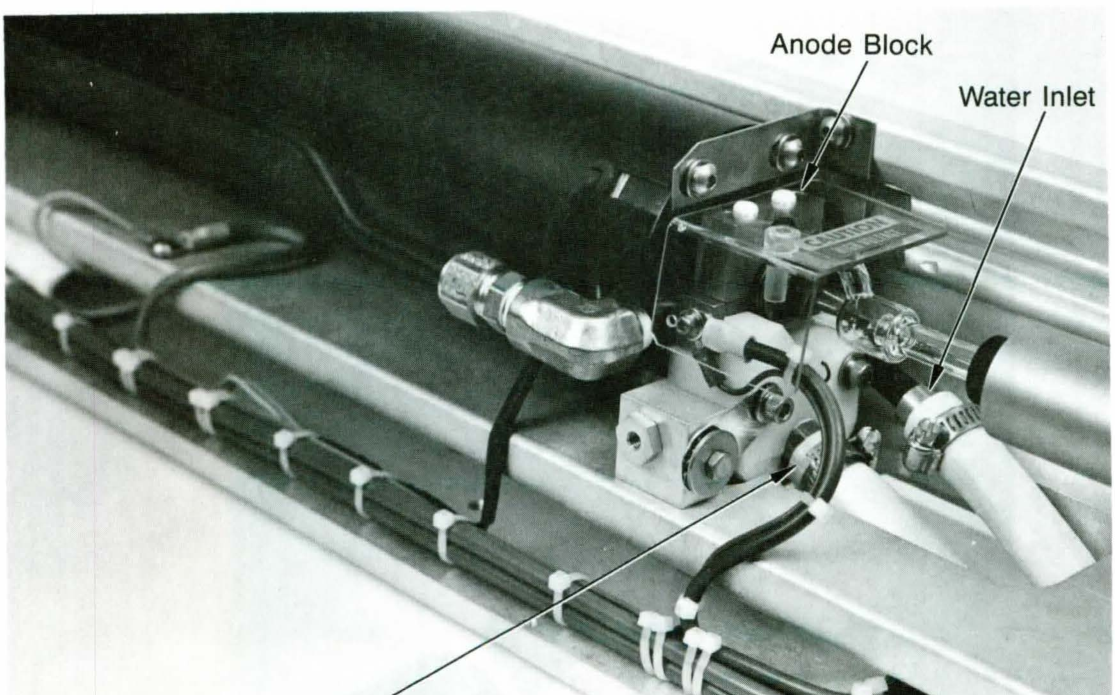


FIGURE 4.5: Anode End Water Connections

FIGURE 4.6(a): Power Supply Control Operation Tests for Model 168B Ion Lasers		
CONDITION	**TEST**	**EXPECTED RESULT**
Circuit breaker OFF, remote control plug in socket, MASTER switch OFF	Move circuit breaker to ON position	Circuit breaker should not remain ON
Circuit breaker OFF, remote control plug in socket, MASTER switch OFF	Move circuit breaker to ON position	Circuit breaker should engage and remain ON; MASTER indicator lamp should glow
MASTER switch ON, remote control plug in socket, circuit breaker ON	Remove remote control plug from rear of power supply	Circuit breaker should turn OFF
MASTER switch ON, remote control plug in socket, circuit breaker OFF	Turn OFF water supply	You should not be able to close the circuit breaker. When you restore the water supply, the WATER ON indicator should glow and the circuit breaker should remain ON.

FIGURE 4.6(b): Power Supply Control Operation Tests for Model 168 Ion Lasers		
CONDITION	**TEST**	**EXPECTED RESULT**
Circuit breaker OFF, MASTER key switch ON	Move circuit breaker to ON position	The circuit breaker should not remain ON.
Circuit breaker OFF, MASTER key switch ON	Move circuit breaker to ON position	The circuit breaker should engage and remain ON. The MASTER CONTROL indicator lamp should glow.
MASTER key switch ON, circuit breaker OFF	Turn off water supply	You should not be able to close the circuit breaker. When you restore the water supply, the WATER ON indicator should glow and the circuit breaker should remain ON.

STARTING THE ARGON LASER

CAUTION

The output beam of this laser is a safety and fire hazard. Avoid viewing the beam directly or blocking the beam with clothing or parts of the body. Place a power absorbing shield in the beam path (see Laser Safety).

1 Check the line voltage; it should be between 190 and 225 V; extended operation at the limits of this range is not recommended.

2 Check that the green power supply lead is connected to **earth ground** at the main switch box.

3 Turn the water supply on.

4 Check the water temperature; if it is <13°C (55°F), check the inside of the power supply for condensation. If condensation exists within the power supply, it will also exist within the laser head. Its presence can cause severe problems leading to failure and potential damage to the system. The cooling system must be warmed and the accumulated moisture removed before you can safely operate your laser. Try running prewarmed water through the system to promote evaporation. If you know that the water temperature will be below 13°C, start the laser as soon as cooling water circulation is established and stable, thereby avoiding moisture buildup.

5 Set the METER selector switch at 50 AMPS.

6 Set the CURRENT control at its midpoint.

7 Move the CONTROL MODE switch to the left to the CURRENT control position.

8 Set the FIELD control at maximum value.

9 Turn on the main power at the switch box. Check that all three LINE indicators and the WATER ON lamp are glowing; all other lamps should be dark.

10 Turn the MASTER CONTROL key to ON.

11 Test the flow switch by turning the water supply off; you should not be able to close the circuit breaker when the water supply is cut off.

12 Restore the water supply and switch the circuit breaker on. Wait 30 sec for the LASER READY lamp to glow.

13 Press the LASER START button; the READY lamp will go out and the laser beam will emerge from the output end.

When the laser is first turned on, plasma tube pressure may be low enough to activate the low pressure alarm. Ignore the buzzer until the laser has warmed up about 10 min. Turning the FIELD control to minimum may deactivate the alarm during warmup. If the alarm persists after warmup, refer to the GAS FILL section.

ADJUSTMENT FOR PEAK OUTPUT POWER

Misalignment of the high reflector mount is the most frequent cause of low output power, provided the laser has been allowed to warm up properly. The beam must strike the mirror at right angles for optimum performance. If the mirror is misaligned either horizontally or vertically, 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 the vertical and horizontal mirror angles can be readily adjusted. Turn one mirror adjustment 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.

Peak the output power with 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 restored. Don't turn the other control until you get the unit lasing again.

The curved output coupler should remain stationary under normal operating conditions. If its alignment is disturbed, realignment may be time consuming and tedious. **Use only the high reflector adjustments to achieve peak power.** If, after adjusting the mirror, the output performance remains below specification, refer to Maintenance.

WAVELENGTH SELECTION

For single-line operation the high reflector optics assembly contains a prism and a flat mirror. 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 mirror mount, the angle at which the beam strikes the prism will change and, with it, the wavelength of the line that will oscillate.

The lines can be identified by their relative power, a comparison of which is found in Specifications. Positive identification of weaker lines requires a spectroscope.

FINDING PEAK OUTPUT POWER WITH THE FIELD CONTROL

The laser output power at a given line is directly related to the strength of the magnetic field surrounding the plasma tube discharge. While most lines perform best at maximum field strength, some others can be enhanced by reducing the field with the power supply FIELD control.

After you tune the laser to a given line and adjust the high reflector for peak output power, try changing the FIELD setting while using the power meter to observe the change in output power. Adjust the field for maximum output power.

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

GAS FILL

(For krypton lasers refer to Krypton Laser Operation for instructions.)

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 after every several hundred hours.

Low pressure is indicated by the fill alarm buzzer in the power supply. Since gas distribution and pressure change during the first few minutes of operation, the buzzer should be ignored until after 10 min has passed. If it persists, increase the pressure in the following manner.

Turn the METER selector to FILL and set the CONTROL MODE switch to CURRENT. At full CURRENT and FIELD the meter should rise to the color bar that corresponds to the gas type (argon or krypton) and desired wavelength (see Power Supply Controls, METER selector for details). If it fails to reach the appropriate color bar, turn the GAS FILL key switch for a fraction of a second. Recheck the meter. Repeat the fill sequence until the buzzer stops and the meter rises to the correct color bar.

Avoid overfilling the tube. Excessive gas pressure causes the maximum possible current to decline thereby decreasing maximum output power. If the tube becomes overfilled, continued operation will eventually return the pressure to its optimum level. The amount of time required to reduce gas pressure depends on the age of the tube and the degree of overfilling.

CHANGING OPTICS

CAUTION

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

The Model 168 comes equipped with a set of mirrors designed to optimize performance at the wavelengths specified at the time of purchase. Other sets of optics can be obtained from Spectra-Physics for special applications. The mirror mount allows access to the mirrors for cleaning or replacement. The front mount holds the output coupler, a thin-film mirror coated to allow a few percent transmission of desired wavelengths. The broad-band high reflector mirror is coated for high reflectance of desired wavelengths. A Spectra-Physics part number and an arrow are printed on the edge of each mirror. Insert the mirror so that the arrow points into the laser cavity.

Always align your laser for peak output power before removing any of its optics. The intracavity spaces of the Model 168 are sealed at the factory to maintain cleanliness of the mirrors and windows. If you must clean the mirrors, remove, clean and replace them one at a time.

NOTE

> The intracavity spaces should not remain uncovered for more than a few minutes at a time.

Repeak the output power, adjusting only the mirror that was removed, after each optic is replaced. 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. If the problem persists, refer to Maintenance.

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

Hold the mirrors with their coated surface on top. To reach the high reflector unscrew the black nut with the mirror wrench. Push the mirror out with a cotton swab. Use finger cots to hold the mirror. Reverse the sequence to replace the mirror. Removing and replacing the high reflector may throw the mirror out of alignment.

SHUTDOWN PROCEDURE

(If you have a krypton laser, refer to Krypton Laser Operation for instructions.)

1 Shut off the circuit breaker.

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

3 Remove the key from the GAS FILL switch.

4 Wait at least 15 sec for the plasma tube to cool, then turn off the water supply.

FIGURE 4.7: MODEL 168 OPTICS OPTIONS

Argon Ion Laser

Laser Version	λ nm	Output Coupler	Broad Band High Reflector	Prism High Reflector	Remarks
-06,-07,-08,-09 -46,-47,-48,-49	457.9-514.5 528.7 1090	G3861-001 G3861-003 G3812-006	n/a n/a G3812-005	G3801-010 G3801-013 n/a	Prism TEM_{00} Prism TEM_{00} Prism TEM_{00}
-27,-28,-29, -67,-68,-69	457.9-514.5 457.9-514.5	G3808-017 G3808-017	G3808-018 G3808-018	n/a n/a	Broad Band Multimode Broad Band Multimode
-16,-17,-18,-19 -56,-57,-58,-59	457.9-514.5 457.9-514.5	G3861-001 G3861-001	G3802-009 G3802-009	n/a n/a	Broad Band TEM_{00} Broad Band TEM_{00}
-37,-38,-39 -77,-78,-79	457.9-514.5 457.9-514.5	G3808-017 G3808-017	n/a n/a	G0001-003 G0001-003	Prism Multimode Prism Multimode

Krypton Ion Laser

Laser Version	λ nm	Output Coupler	Broad Band High Reflector	Prism High Reflector	Remarks
-01,-21,-41,-61 -11,-31,-51,-71	647.1-676.4 647.1-676.4	G3812-012 G3808-001	G3812-011 G3808-004	n/a n/a	Broad Band TEM_{00} Broad Band Multimode

Optics Holders

Beam Splitter	421-624-2	Broad Band	421-626-2	Prism	423-600

MAINTENANCE

If you notice a significant drop in power, the source of the problem will probably be one of the following: dirty optics (output coupler, high reflector, or prism); dirty plasma tube windows; misaligned optics; or misaligned plasma tube. The procedures in this section allow you to solve these problems, thereby returning your laser to optimum output. They are provided in the order in which you should perform them.

- o Clean the optics.
- o Clean the plasma tube windows.
- o Align the optics.
- o Align the plasma tube.

The most probable cause of poor performance is dirty optics, therefore they should be cleaned before you try anything else. If, after cleaning the optics, the laser still performs below expectations, clean the plasma tube windows. Then, if necessary, align the optics. Finally, if all else fails, align the plasma tube. The procedures are progressive in nature; if you achieve success at to the next.

The Model 168 resonator is designed so that the plasma tube bore, the center of the aperture, and the centers of both mirrors lie on the same line: the resonator axis (See Figure 5.1.) In order for the laser to provide optimum performance, three conditions must be met:

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

Your laser is factory aligned and should perform to specifications without realignment.

If the laser has been cleaned and aligned, and you are sure that it is producing maximum power, but its performance remains below specification, either the plasma tube or a power supply circuit has failed. Call your Spectra-Physics Service representative in this case.

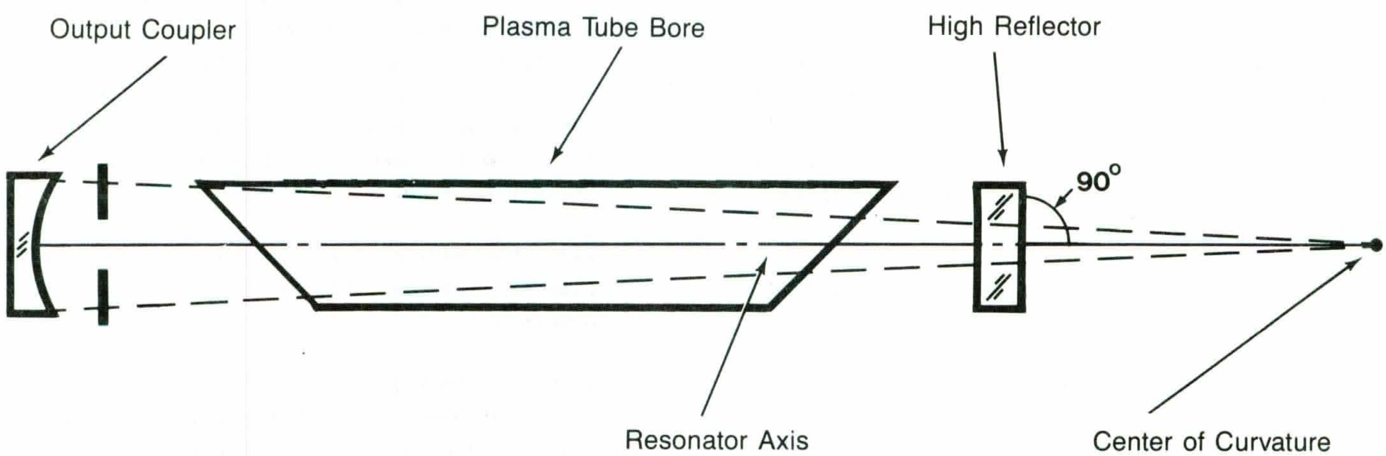


FIGURE 5.1: Schematic Representation of Ideal Resonator Alignment

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 microthin 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.

Follow these principles when you clean an optical surface:

- o Wash your hands thoroughly with liquid detergent. Body oils and contaminants can render otherwise fastidious cleaning practices useless.
- o Work in a clean environment, over an area covered by a soft cloth or pad.
- o 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.
- o Use dry nitrogen, canned air, or a rubber squeeze bulb to blow dust or lint from the surface before cleaning with solvent. Permanent damage can occur if dust scratches the glass or mirror coating.
- o Use spectroscopic, electronic, or reagent grade solvents. Don't try to remove contamination with a cleaning solvent that may leave other impurities behind.
- o Use photographic lens tissue to clean optics and plasma tube windows; use each piece only once.

CLEANING PRISMS AND MIRRORS

Equipment Required

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

Cleaning the Output Coupler

1 Get the cavity seal out of the way by unscrewing the smaller nut on the end of the cavity seal closer to the plasma tube. Push the nut and O ring towards the plasma tube. Unscrew the large nut on the front of the cavity seal. Carefully slide the seal toward the plasma tube.

2 With the mirror wrench, unscrew the black plastic nut on the front of the output coupler.

3 With a cotton swab, push the mirror out of the laser head. The beam splitter assembly and cylindrical mirror holder, with the mirror in it, will drop out.

4 The mirror can be safely held with fingers protected by finger cots. The high reflector mirror can usually be cleaned without

coupler, which has two surfaces to be cleaned, has to be removed.

FIGURE 5.2: Cleaning the Mirror Surface

5 Remove the mirror from the holder. Hold the mirror with its coated surface horizontal and squeeze out a drop or two of acetone to cover it. Place a piece of lens tissue on the wetted surface and gently draw it across to float away dissolved contaminants.

6 Invert the mirror and clean the second surface.

7 Replace the mirror in the mirror holder. The arrow on the edge of the mirror should point away from the cup. Note: the white Teflon™ O ring in the mirror holder may have come loose. If so, center it inside the holder and force it into the indentation which is there.

8 Slide the mirror and holder back into the opening in the mirror mount plate, mirror end first. Slide the beam splitter assembly back, lining up the dowel pin with the slot in the aperture.

9 Screw in the black plastic ring with the mirror wrench.

10 Slide the cavity seal and nut toward the output coupler. Screw first the small nut, then the large nut onto the cavity seal, finger-tight.

11 Follow a similar procedure for the high relector.

Cleaning the Prism

1 Unscrew the prism housing cap to gain access to the optical surfaces.

2 Do not remove the prism from its mount; it can be cleaned in its mount.

3 Blow away dust particles or lint 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 (see Figure 5.3). Saturate the pad with acetone, shake off the excess, resaturate, and shake again.

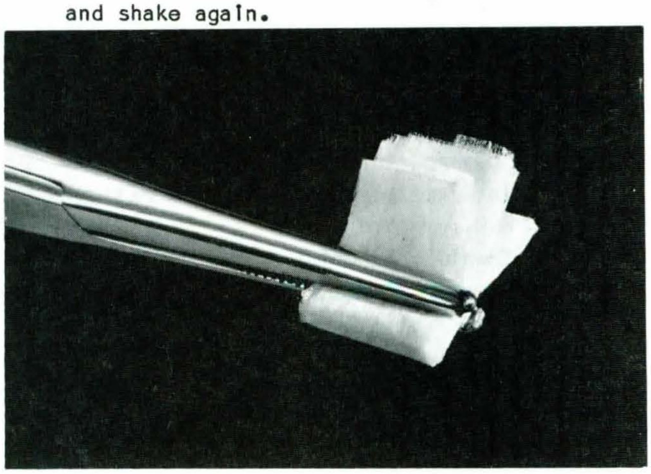


FIGURE 5.3: Lens Tissue Folded for Prism Cleaning

5 Wipe one surface of the prism, 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 other prism surface.

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

6 Replace the prism cap and adjust the mirror mount for maximum output power.

7 Reseal the intracavity spaces promptly.

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.

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, NJ 08601
- three empty bottles to hold the cleaning solutions listed below

A kit, composed of 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, NJ 07922

Procedure

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

2 Fold a lens tissue pad, clamp it in the hemostat, and saturate it with methanol. Shake off the excess, resaturate, and shake again. (See Figure 5.2)

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 another 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 H_2O_2 with another 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 cotton swab saturated with deionized water; repeat three times, using a fresh swab each time.

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

6 Use a cotton swab to wet the entire window with prerinse solution. Dip a cotton 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 seconds.

Dip a dry cotton swab in the calcium 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 prerinse 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 another methanol wipe, using a clean tissue pad.

7 Reseal the intracavity spaces promptly.

ALIGNING MIRRORS

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 determined, by trial and error, that no additional power can be coaxed from the unit.

Adjusting the Mirrors For Apparent Peak Power

While monitoring the output with an external power meter, turn one of the mirror adjustment controls back and forth until the output is at its peak, then turn the other. Repeat the adjustments, first turning one control, then the other, back and forth until no further power increases are attainable. Make a note of the output power.

"Walking the Mirrors" to Assure Peak Power

Figure 5.4 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.

FIGURE 5.4: Misaligned Mirrors Cause Lasing at Reduced Power

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 optimum alignment positions.

Once the high reflector has been peaked, detune one of its controls until the output is about 50% of 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, that is, if you turn the high reflector vertical control clockwise, turn the output coupler vertical control clockwise (keeping the same point of view as before). If you lose lasing, reverse the direction of mirror movement until lasing is restored.

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

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

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. Also, 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.

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.

ALIGNING THE PLASMA TUBE

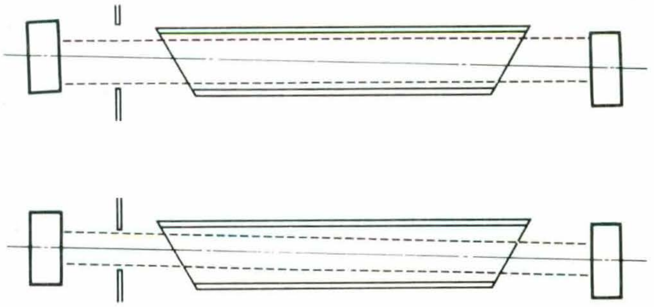


FIGURE 5.5: Misaligned Plasma Tube Causes Lasing at Reduced Power

Figure 5.5 illustrates two arrangements of the cavity elements 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 sub-optimum output.

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.

Remove the front and rear cavity seals and loosen the locking screws at both the anode and cathode ends of the magnet (see Figure 5.7).

Adjust the horizontal position of the cathode end by working one adjusting screw against the other; adjust until you achieve maximum output power. Move to the anode end and repeat the horizontal adjustment.

Adjust the vertical position of the anode end until you achieve maximum power. Move to the cathode end and repeat the vertical adjustment. 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, and so forth. After several repetitions you will reach a point where the last possible milliwatt has been coaxed from the laser.

PRISM ALIGNMENT

Figure 5.6 identifies the adjustment screws you will use in the alignment procedure. V is the prism mirror vertical adjustment screw. Two hex

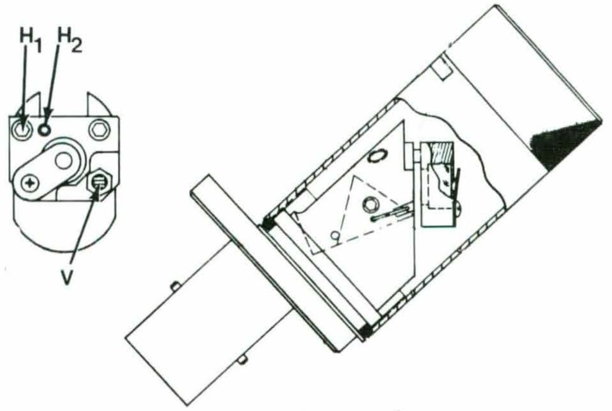


FIGURE 5.6: Prism Alignment Adjustment Screws

nuts, one on each side of the mirror mounting plate, determine the plate position. By loosening one nut and tightening the other, you can move the plate toward or away from the prism, thereby adjusting the vertical movement of the mirror. H_1 is the horizontal prism mirror adjustment and H_2 locks the horizontal position of the mirror.

Place a paper target around the anode end of the plasma tube and use the high reflector adjustments to peak the laser in broadband. Remove the broadband high reflector.

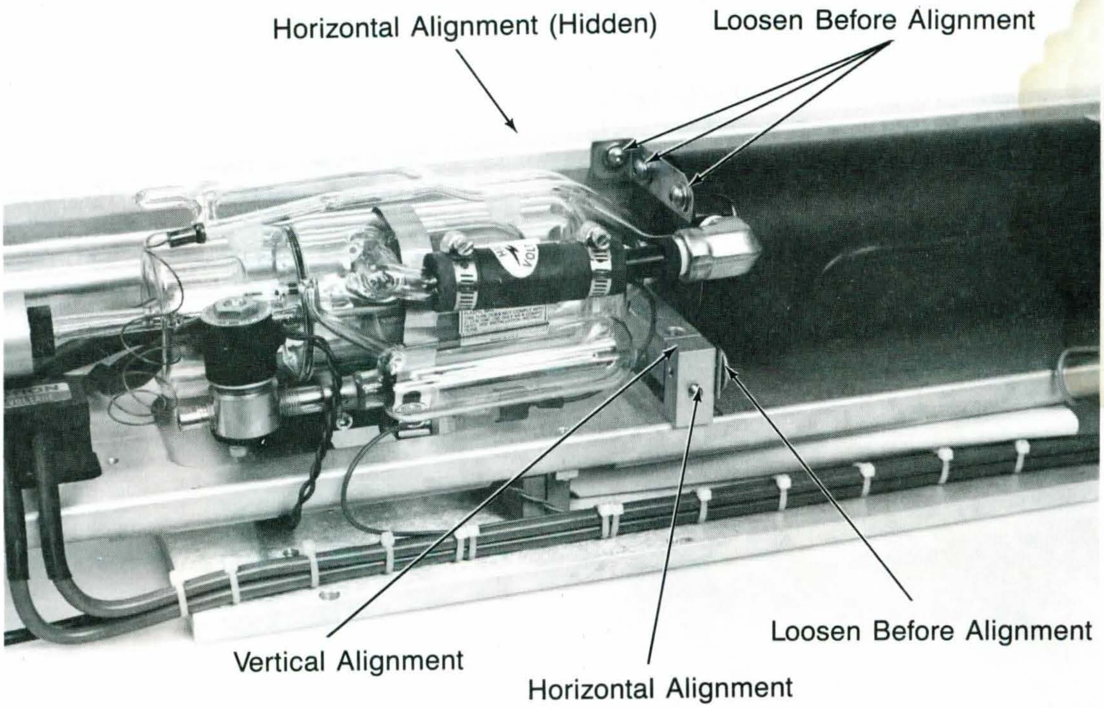
Remove the prism dust cap and loosen H_2 and the nuts around V. Grasp the sides of the prism assembly and insert it in the rear mirror mount.

Using H_1 and V, move the mirror until the reflected bore light strikes the paper target immediately below the center of the plasma tube.

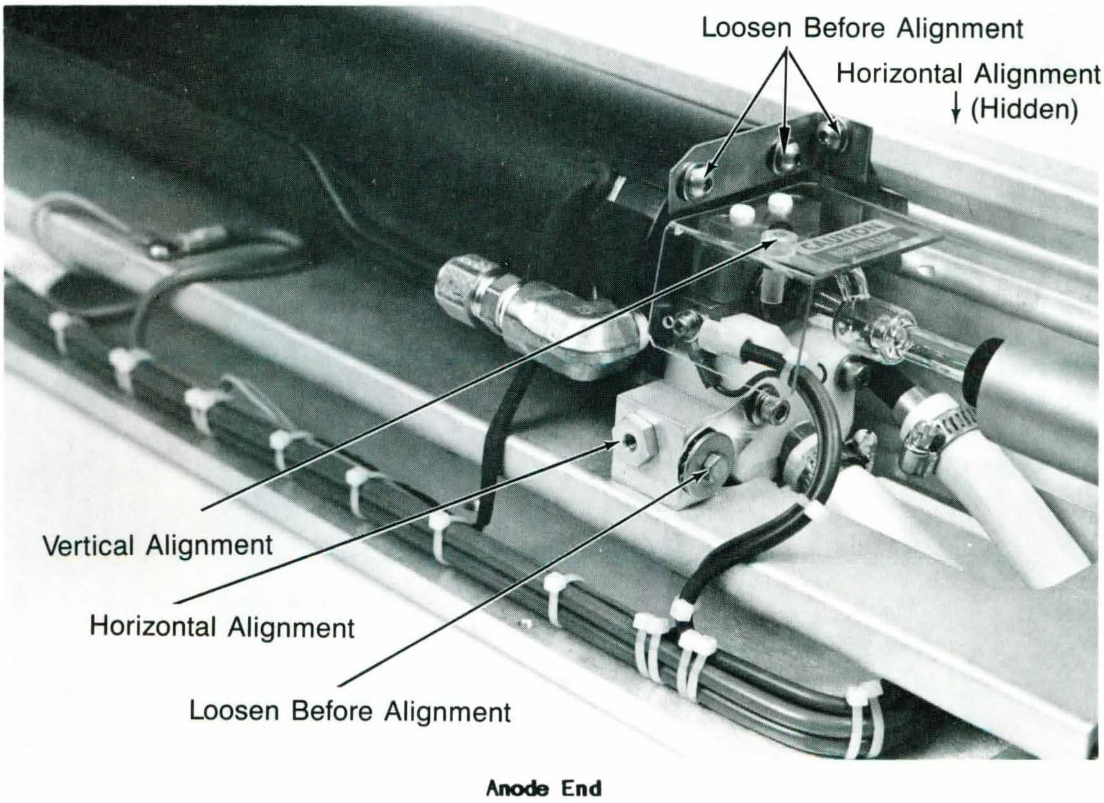
Rock the high reflector mirror mount back and forth by applying pressure near the end plate vertical adjustment. While you rock the end plate, turn H_1 to move the prism mirror horizontally. Continue the rocking and horizontal movement until you see a flash of laser light.

Use the nuts on V to adjust the prism mirror vertical position until the unit lases. Adjust H_1 for peak power, then tighten H_2. If the output power falls upon tightening H_2, work H_1 and H_2 against each other until the prism mirror plate is locked on its optimum horizontal position.

Remove the prism assembly and replace it with the broad-band mirror. Repeak the laser. As the assemblies are removed and inserted, the position of the mirror mount may be moved. In order to



Cathode End



Anode End

FIGURE 5.7: Plasma Tube Alignment Adjustments

keep it in its optimum lasing position, you must repeak the laser in broad band from time to time; use only the high reflector adjustments.

Reinstall the prism. If the unit fails to lase, repeat the prism mirror alignment sequence. If the unit lases, observe the color of the beam.

If the laser beam is green, lock the prism mirror in place. Remove the prism assembly and tighten V_1, then tighten V_2 and reinstall the prism assembly.

If the laser beam is blue-green or blue, the prism mirror plate needs to be moved away from the prism. Alternate tightening V_1 and loosening V_2 until the beam is green.

Horizontal and vertical adjustments may interact so you may have to repeat the prism mirror alignment sequence several times until full interchangability is achieved. Remember to repeak the laser in broad band periodically to maintain the reference point at which the prism will interchange. Restore the reference point after two or three prism mirror adjustments.

REPLACEMENT PARTS

1 5101-0300 Fuse 2A
2 5101-0310 Fuse 1/4A
3 5101-0090 Fuse 3A
4 5101-0240 Fuse 8A
5 5101-0280 Fuse 6A
6 5101-0270 Fuse 5A
7 5101-0070 Fuse 1/4A-5B
8 2604-0070 Water Filter Cartridges*

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*"Filterite" cartridges are manufactured by Silver Screen, part number 4-10. Contact your local "Filterite" distributor.

TROUBLESHOOTING

The following information will help you solve some common problems that arise with the Model 168/265. For information about factory repair of the laser or power supply, see Customer Service.

SAFE USE OF TEST EQUIPMENT

This instrument is connected directly to a high current power line and all control circuits are at or near line potential with respect to ground. **It is impossible to safely measure the voltages or waveforms within this instrument with test equipment that has a grounded case, or probe connections, or both.** An unintentional grounding of this equipment can cause powerful arcs and extensive damage to electronic components. Most circuits can be checked using a battery powered multimeter.

The safest troubleshooting method for the Model 168/265 is to check the equipment with an ohmmeter while the laser head and power supply are "cold" (power off). Measuring the resistance of semiconductor components will identify most common problems. It is possible to test the light stabilizer, the magnet regulator, and all threshold circuits without starting the plasma discharge current.

SYMPTOM: CIRCUIT BREAKER WON'T TURN ON

Probable Cause	Things to Check
Insufficient water flow	Inlet water may be too hot; the WATER HOT lamp on the front panel of the power supply only glows momentarily before the interlock trips; it will go out soon after the power supply shuts down.
Remote control plug absent or misaligned	Check the seating of both the cover interlock and remote control plug.
MASTER CONTROL key switch OFF	Turn MASTER CONTROL key ON.
Defective Circuit Breaker	Turn the main power off. Jiggle the Circuit Breaker: if it seems wobbly, the Circuit Breaker is defective. Contact your Spectra-Physics Service Center to have it replaced.

SYMPTOM: CIRCUIT BREAKER TRIPS OFF

Probable Cause	Things to Check
Inlet water temperature above 35°C (95°F)	Check the water service flow rate. The inline 25 μm filter may be dirty. A separate filter protects the flow switch; remove the bottom panel from the power supply to gain access. Check its condition and clean or replace it, if necessary.

SYMPTOM: PLASMA TUBE FAILS TO IGNITE

Probable Cause	Things to Check
Blown fuse	Check power supply fuses beneath top cover, behind front panel.

SYMPTOM: PLASMA TUBE FAILS TO IGNITE

Probable Cause	Things to Check
High plasma tube pressure	If possible, check past performance for indications of overfilling. Low tube current or high tube voltage are manifestations of high gas pressure. Tube replacement is the only sure cure.
Tube vacuum is lost; tube is "up to air"	If the getter, a silver material deposited near the cathode, has turned milky or has disappeared, or if a black, flaky deposit is found on the filament, the vacuum seal of the tube is most likely broken.

SYMPTOM: LOW OUTPUT POWER

Probable Cause	Things to Check
Dirty optics	Remove and inspect one mirror at a time. If either is unclean, refer to "Cleaning Prisms and Mirrors" in Maintenance. Repeak the mirror mount to maximum output power each time you replace a mirror. Inspect the plasma tube windows, if either is unclean, refer to "Cleaning the Plasma Tube Windows" in Maintenance.
Incorrect control settings	Double-check the CURRENT or LIGHT control setting. Check the FIELD control setting. If you are operating with single-line output assure yourself that the laser is tuned to the desired wavelength. Check the METER selector; are you reading the correct power scale?
Improper optics	Check the optics to see if they are coated for the wavelength to which the laser is tuned by comparing the part number on the mirror with the part number in the optics list. This is especially important with krypton lasers.
Misaligned Mirrors	Repeak and walk the mirrors as described in "Mirror Alignment" in Maintenance.
Misaligned Plasma Tube	Realign the plasma tube as described in "Plasma Tube Alignment" in Maintenance.
Defective Magnet	Switch the METER selector to the FILL position and turn the FIELD control back and forth. The tube voltage should swing three to four divisions on the meter scale.

SYMPTOM: CURRENT CANNOT BE RAISED TO MAXIMUM

Probable Cause	Things to Check
High gas pressure	Use the FILL meter, or an external voltmeter, to check tube voltage. **CAUTION** Avoid shorting the anode block to the magnet with the meter probe!. Do not connect an external meter until the tube is started. If the voltage is >250 V, the tube is probably overfilled. Be sure the CURRENT and FIELD controls are set to maximum value. Check the magnet condition.
Low line voltage	If the line voltage is too low, <190 V, the current will not reach 30 A.

SYMPTOM: NO CURRENT

Probable Cause	Things to Check
Short circuit, blown fuse	Check fuses beneath top cover, behind front panel.
Blown passbank	Check fuses on passback heat exchanger. If several are blown, then enough transistors are shorted to cause the passbank to shut off.

SYMPTOM: NO OUTPUT BEAM, PLASMA TUBE GLOWS INDICATING DISCHARGE

Probable Cause	Vertical Search Alignment Procedure
Severely misaligned rear end plate	Remove the top cover from the laser head and grasp the high reflector mirror mount near the vertical adjusting wheel and rock it back and forth. While rocking, turn the horizontal control to rotate the high reflector horizontally. Keep rocking and rotating until you observe a bright flash of laser light. When the beam flashes, stop turning the horizontal control. If you turn the horizontal control 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. Once the laser beam flashes, turn the vertical control until you establish sustained lasing.

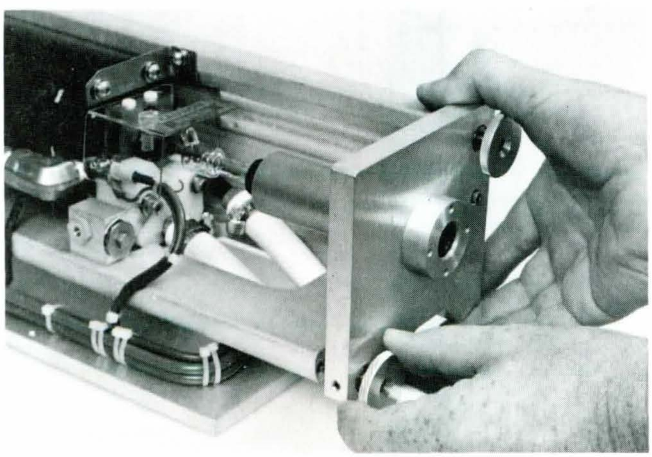
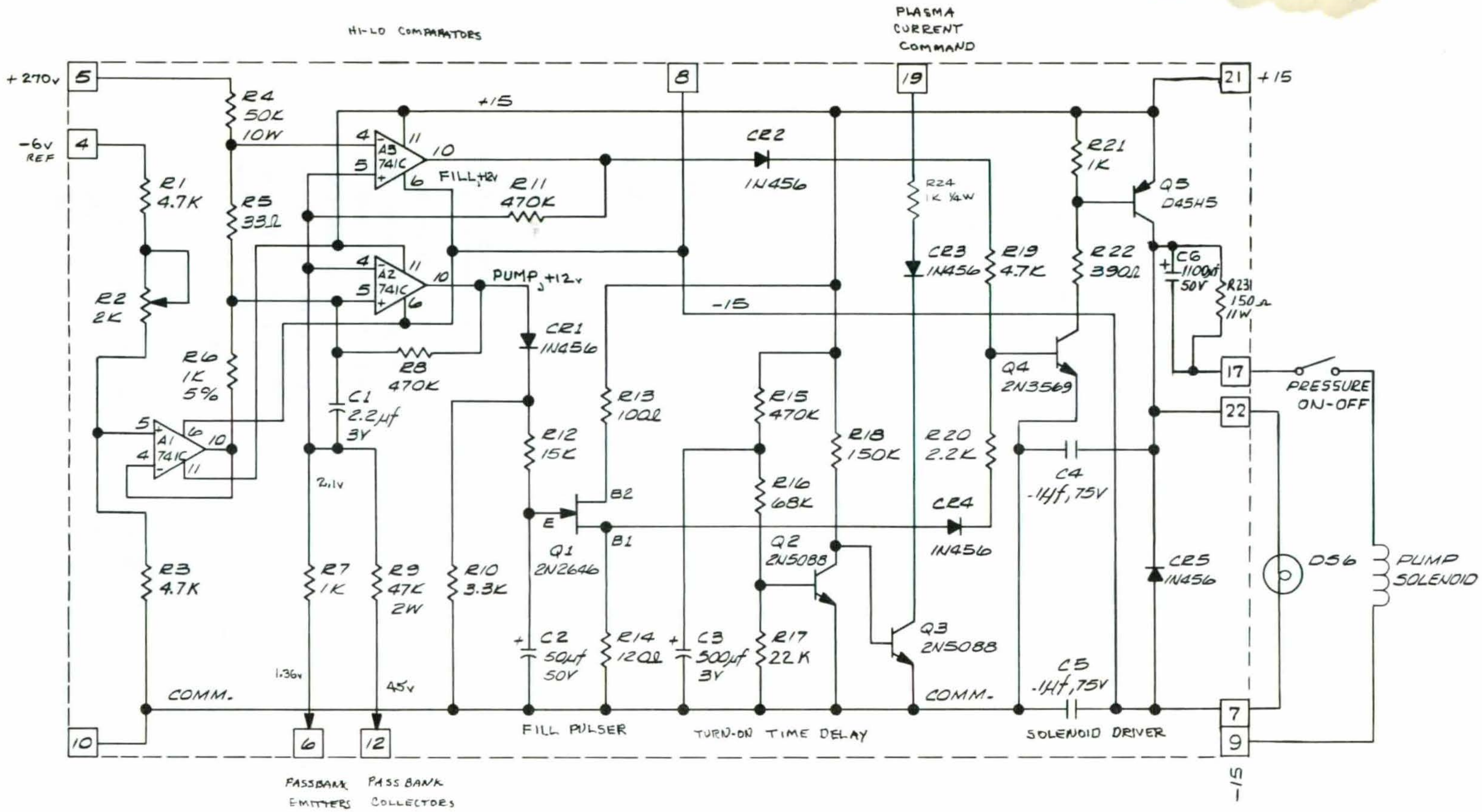


FIGURE 5.8: Vertical Search

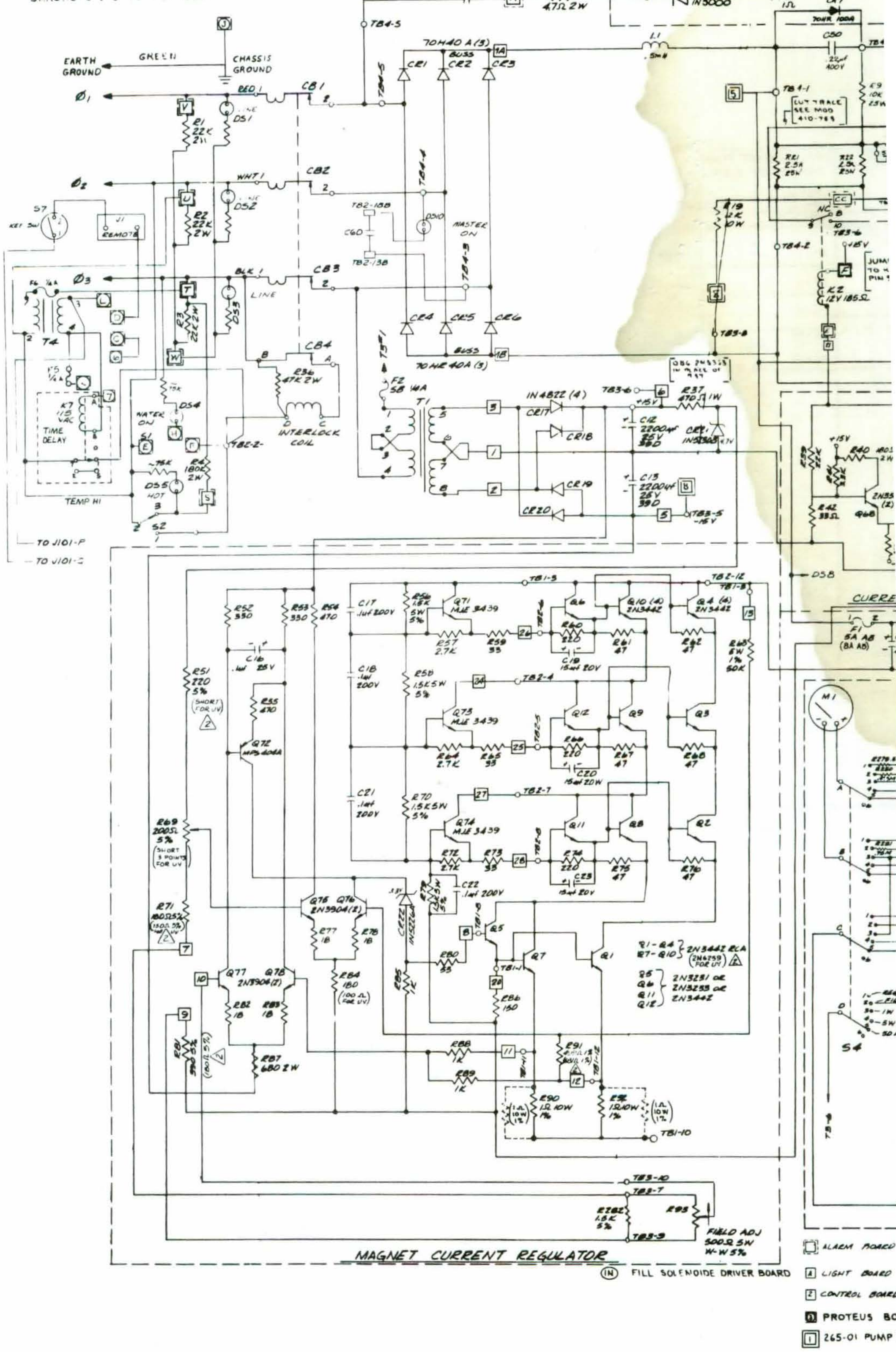


1. UNLESS OTHERWISE SPECIFIED, RESISTORS ARE 1/2WATT, 10%.

FIGURE 5.9: Schematic, Automatic Pressure Control Circuit - Model 168-01, -31 (C410-751, rev F)

NOTES:

1. R285 HIGHEST RESISTOR DESIG.
2. WHEN USED WITH 164-05, THE VALUE IN PARENTHESES SHOULD BE USED.
3. WHEN USED WITH 265-01 INSTRUCTIONS IN BRACKETS [ ] TO BE USED



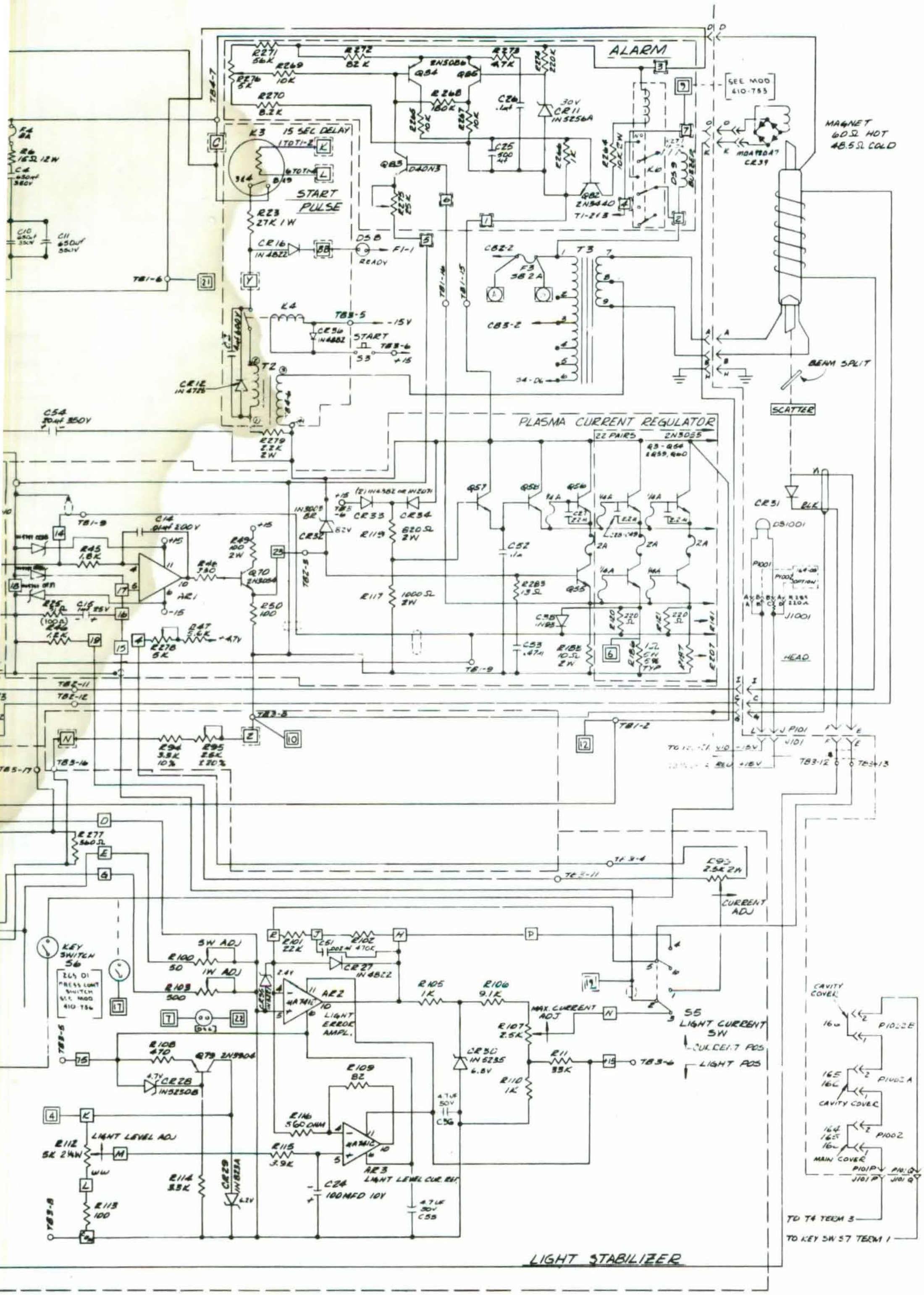
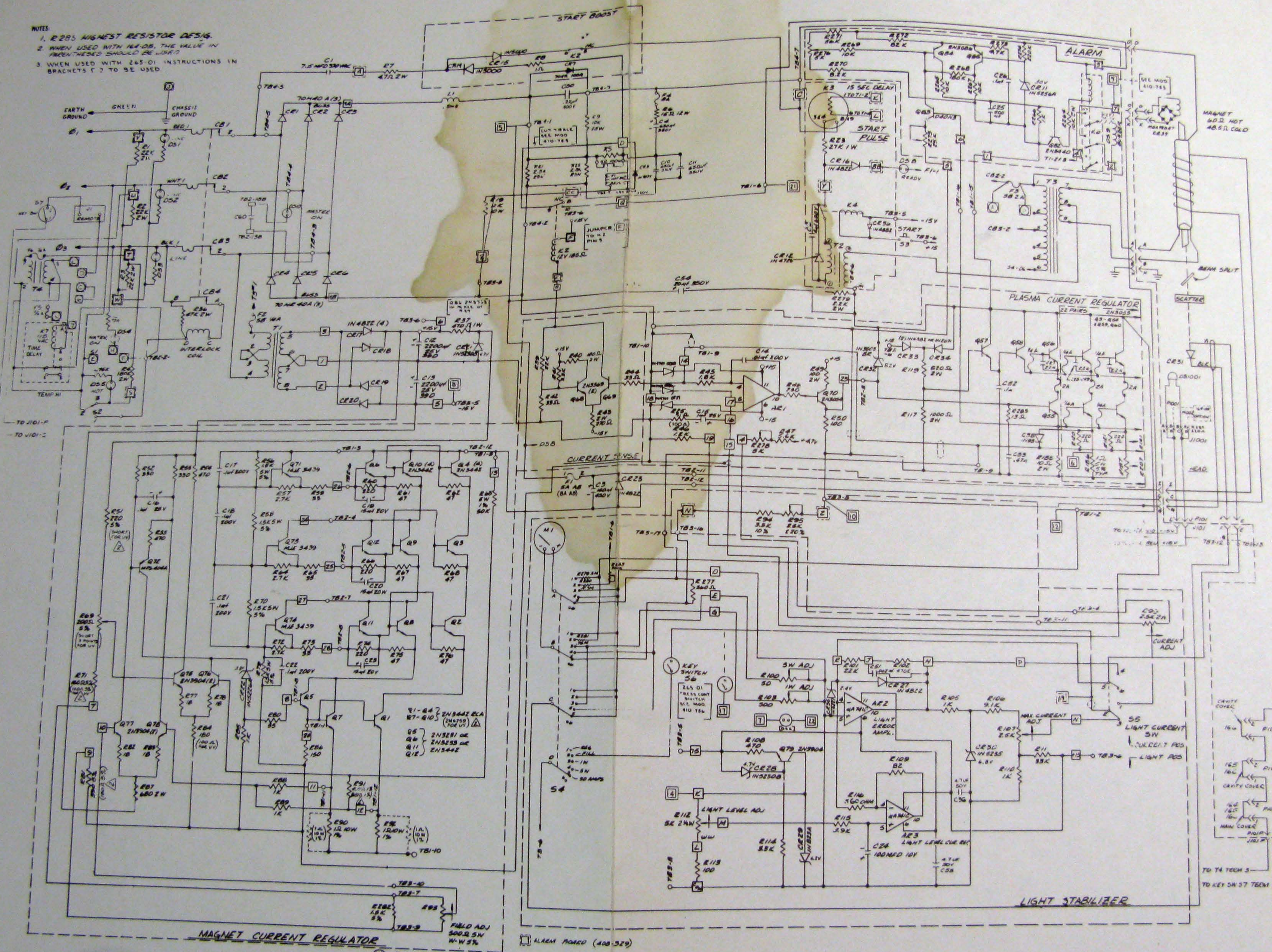


FIGURE 5.11: Model 265 Schematic (E407-904, rev AR)



(IN) FILL SOLENOIDE DRIVER BOARD

ALARM BOARD (400-329)

LIGHT BOARD (407-299)

CONTROL BOARD (406-741)

PROTEUS BOARD

265-01 PUMP BOARD

FIGURE 5.11: Model 265 Schematic (E407-904, rev AR)

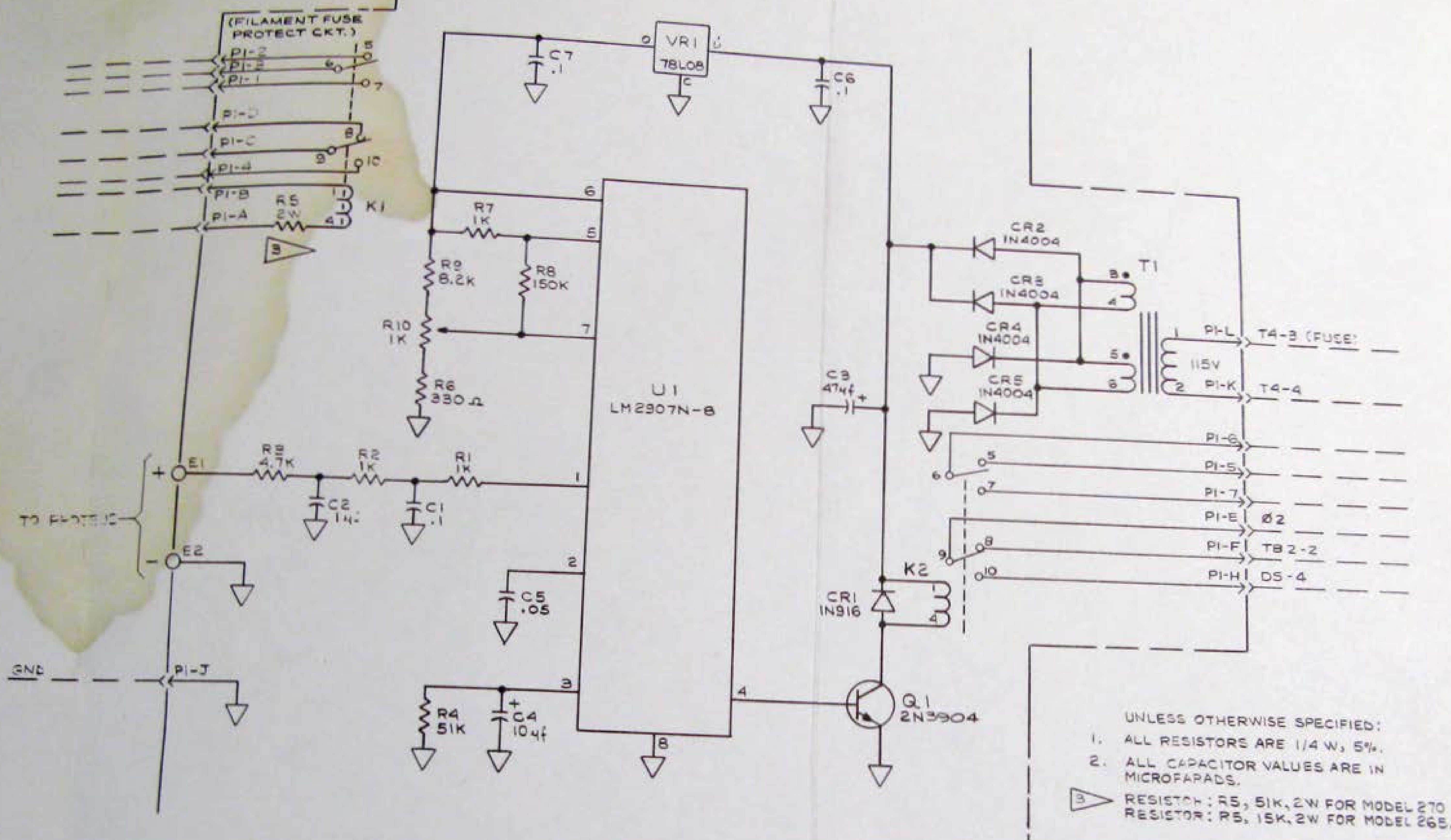


FIGURE 5.10: Schematic, Model 265 Proteus Flow Switch Circuit (C429-001, rev D)

KRYPTON LASER OPERATION

THE MODEL 168 KRYPTON
AUTOMATIC PRESSURE CONTROL PUMP LASER
(Versions 168-41,-71,-01,-31)

STARTUP PROCEDURE

CAUTION

The output beam of this laser is a safety and fire hazard. Avoid viewing the beam directly or intercepting the beam with clothing or parts of the body. Place a power absorbing shield in the beam path (see Laser Safety).

The output power and discharge characteristics of krypton ion lasers are not as stable as those of argon lasers. The effect of gas pressure changes during warmup is significant, especially if the laser is tuned to a wavelength other than 647.1 nm. To minimize pressure change effects and avoid plasma instability during warmup, use the following startup sequence.

1 Check the line voltage; it should be between 190 and 225 V ac.

2 Check that the safety green lead is connected to **earth** ground.

3 Turn on the water supply.

4 Check the water temperature; if it is <13°C (55°F), check the inside of the power supply for condensation. If condensation exists within the power supply, it will also exist within the laser head. Its presence can cause severe problems leading to failure and potential damage to the system. The cooling system must be warmed and the accumulated moisture removed before you can safely operate your laser. Try running prewarmed water through the system to promote evaporation.

   If you know that the water temperature will be below 13°C, start the laser as soon as cooling water circulation is established and stable, thereby avoiding moisture buildup.

5 Move the METER selector switch to 50 AMPS.

6 Turn the CURRENT control to its minimum value.

7 Move the CONTROL MODE switch to the left, or CURRENT control position.

8 Move the FIELD control to its minimum value.

9 Turn the FILL switch OFF.

10 Check that all three LINE indicators and the WATER ON lamp are glowing; all other lamps should be dark.

11 Turn the MASTER CONTROL key switch ON.

12 Test the flow switch by turning the water supply off; you should not be able to close the circuit breaker when the water supply is cut off.

13 Restore the water supply and turn the circuit breaker ON. Wait 30 sec for the READY lamp to glow.

14 Press the START button; the READY lamp will go out and the laser beam will emerge from the output end.

15 A built-in time delay will prevent operation at currents greater than 18 A for about 2 min. Wait 2 min.

16 Increase the FIELD by two marks on its scale.

   The optimum magnetic field depends on the wavelength of interest. If you intend to tune to yellow, green or blue, a setting between two and four on the scale produces optimum results. If you want a red line, the setting will be between six and eight, and if you expect to use all lines, the optimum setting will be between three and seven.

   If the FIELD setting is optimum for the wavelength of interest, turn on the PRESSURE control and go to step 18.

   If the field is less than optimum, check the GAS FILL indicator; it will indicate the need for pressure adjustment.

LAMP CONDITION	PRESSURE
OFF	OK
ON	LOW
FLASHING	HIGH

FIGURE 6.1: Gas Fill Indicator

If the light is off or flashing, repeat this step.

17 If the pressure control is off, turn it on. Wait until the fill circuit raises the gas pressure, turning the lamp off; go to step 16.

18 Increase the current by 5 A and check the fill lamp. If it is on, wait until the fill circuit raises the gas pressure, turning the lamp off.

19 The optimum current is the lowest value that will produce the desired output power. If the current is less than optimum or 25 A (the maximum current value suggested during the first 30 min of operation) go to step 18.

Krypton pump versions of the Model 168 should be operated in the CURRENT control mode for at least 10 min with a current limit of 25 A. Until the tube warms up enough to allow the gas to redistribute, higher currents will cause plasma oscillations which manifest themselves as a "chirping" sound. If allowed to continue for a prolonged period, the oscillations will cause power supply components to overheat. While in this condition the plasma tube voltage may reach 10 kV peaks. **Do not attempt to measure tube pressure if your krypton tube is chirping! Any attempt to do so will short circuit the meter and cause catastrophic power supply failure.**

SHUTDOWN PROCEDURE

1 Turn the FIELD control to its maximum value (fully clockwise.)

2 Move the CONTROL MODE switch to the CURRENT position and turn the CURRENT control to its maximum value (fully clockwise.)

3 If the FILL lamp glows, wait until it goes out. By filling the tube before shutdown, you assure adequate pressure the next time you turn the laser on.

4 Turn the FILL switch OFF.

5 Shut off the circuit breaker.

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

7 Wait at least 15 sec for the plasma tube to cool then turn the water supply off.

To eliminate the need for lengthy warmup periods, plan to operate your krypton laser for at least three hours each week.

THE STANDARD MODEL 168 (Non-Pumping) KRYPTON LASER

(Versions 168-61,-51,-21,-11)

STARTUP PROCEDURE

CAUTION

The output beam of this laser is a safety and fire hazard. Avoid viewing the beam directly or blocking the beam with clothing or parts of the body. Place a power absorbing shield in the beam path (see Laser Safety).

The output power and discharge characteristics of krypton ion lasers are not as stable as those of argon lasers. The effect of gas pressure changes during warmup is significant, especially if the laser is tuned to a wavelength other than 647.1 nm. To minimize pressure change effects and avoid plasma instability during warmup, use the following startup sequence.

Krypton non-pumping versions of the Model 168 should be operated in the CURRENT control mode for at least 30 min with a current limit of 25 A. Until the tube warms up enough to allow the gas to redistribute, higher currents will cause plasma oscillations which manifest themselves as a "chirping" sound. If allowed to continue for a prolonged period, the oscillations will cause power supply components to overheat. While in this condition the plasma tube voltage may reach 10 kV peaks. **Do not attempt to measure tube pressure if your krypton tube is chirping! Any attempt to do so will short circuit the meter and cause catastrophic power supply failure.**

1 Check the line voltage; it should be between 190 and 225 V (ac).

2 Check that the safety green lead is connected to earth ground, not neutral.

3 Turn the water supply on.

4 Check the water temperature; if it is <13°C (55°C), check the inside of the power supply for condensation. If condensation exists within the power supply, it will also exist within the laser head. Its presence can cause potential damage to the system. The cooling system must be warmed and the accumulated moisture removed before you can safely operate your laser. Try running prewarmed water through the system to promote evaporation.

If you know that the water temperature will be below 13°C, start the laser as soon as cooling water circulation is established and stable, thereby avoiding moisture buildup.

5 Move the METER selector switch to 50 AMP.

6 Turn the CURRENT control to its minimum value.

7 Move the CONTROL MODE switch to the left, or CURRENT control position.

8 Move the FIELD control to its minimum value.

9 Check that all three LINE indicators and the WATER ON lamp are glowing; all other lamps should be dark.

10 Turn the MASTER CONTROL key switch ON.

11 Test the flow switch by turning the water supply off; you should not be able to close the circuit breaker when the water supply is cut off.

12 Restore the water supply and turn the circuit breaker ON. Wait 30 sec for the READY lamp to glow.

13 Press the START button; the READY lamp will go out and the laser beam will emerge from the output end.

14 Allow the laser to warm up at least 30 min at minimum current. If the laser has been shut down for more than a week, allow it to warm up for at least 2 hr.

If the fill alarm buzzes during the warmup period, ignore it.

If, in addition to the fill alarm, plasma instabilities cause the laser to "chirp", contact your Spectra-Physics Service representative.

15 Turn the FIELD control slowly clockwise.

16 Turn the CURRENT control slowly clockwise.

17 If, after an adequate (see 14 above) warmup, the fill alarm sounds while you are increasing current or field, add one "buzz" of gas by turning the key switch momentarily, allowing just enough time for the fill system to actuate the solenoid. Listen for a buzz or click from the solenoid.

Wait at least 30 min for the pressure to stabilize before adding any more. If the alarm persists after 30 min add another buzz of gas.

If, in addition to the fill alarm, the laser starts to chirp, reduce the CURRENT until it stops and add one buzz of gas; wait at least 30 min for the pressure to stabilize before adding any more.

18 Continue to increase the CURRENT slowly, adding gas when prompted to do so by the fill alarm, until it is at maximum value. Wait at least 30 min between buzzes of gas.

19 Adjust the FIELD control for maximum output power.

20 Switch the METER selector to FILL and check that the meter rises to the color bar that

corresponds to the desired wavelength (see Power Supply Controls, Meter Selector for details.)

21 If the meter fails to reach the appropriate color bar, contact your Spectra-Physics Service representative.

Non-pumping krypton plasma tubes are susceptible to overfill, which severly limits their performance and can cause total tube failure. To prevent overfilling and prolong tube life, be sure to add gas one buzz at a time. Whenever the fill alarm sounds, add one buzz of gas, then wait at least 30 min to allow the gas pressure to stabilize.

The buzz is, at best, an imprecise unit of measure. Your first buzz may produce an increase of 5 V after stabilization; the next may only yield 2 V. Since the amount of change is unpredictable, a stepwise "buzz and wait" procedure is the best way to avoid overfilling.

SHUTDOWN PROCEDURES

1 Turn the FIELD control to its maximum value (fully clockwise).

2 Move the CONTROL MODE switch to the CURRENT position and turn the CURRENT control to its maximum value (fully clockwise).

3 If the FILL alarm buzzes, add gas slowly, one buzz at a time until it goes off. By filling the tube before shutdown, you assure adequate pressure the next time you turn the laser on. Remember to wait at least 30 min between buzzes to allow the gas pressure to stabilize. Switch the meter to FILL and monitor the change in tube volts as you increase the pressure. Bring the pressure up to its optimum operating level before shutting the laser off.

4 Shut off the circuit breaker.

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

6 Remove the key from the GAS FILL switch.

7 Wait at least 15 sec for the plasma tube to cool then turn the water supply off.

To eliminate the need for lengthy warmup periods, plan to operate your krypton laser for at least 3 hr each week.

CUSTOMER SERVICE

At Spectra-Physics, we take great pride in the durability of our products. Considerable emphasis has been placed on controlled manufacturing methods and quality control throughout the manufacturing process. Despite this fact, instruments do break down in operation. We feel that our instruments have favorable service records compared to competitive products and we hope to demonstrate, in the long run, that we provide above-average service to our customers—not only in providing the best equipment for the money, but, in addition, service facilities that get your instrument back into action 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. Call the nearest service center or field service office for assistance.

Replacement parts should be ordered directly from Spectra-Physics. For ordering or shipping instructions or for assistance of any kind, contact your nearest sales office or service center and give the instrument model and serial numbers. Service data or shipping instructions will be promptly supplied.

WARRANTY

Unless otherwise specified, all Spectra-Physics products are warranted to be free from defects in workmanship and materials for one year from the date of shipment. Spectra-Physics will repair or replace instruments which prove to be defective during the warranty period without charge. The obligation of Spectra-Physics is limited to such repair, and does not extend to consequential damages.

Simple maladjustments or unclean optics are frequent causes of poor instrument performance or failure and are excluded from warranty coverage. A service charge will be assessed if an instrument which, when shipped to Spectra-Physics for warranty repair, can be returned to operating condition by routine cleaning or adjustment.

Always drain cooling water from the plasma tube before shipping. Water expands when frozen and may shatter the tube; such damage is excluded from warranty coverage.

RETURN OF THE INSTRUMENT FOR REPAIR

Contact your nearest Spectra-Physics field sales office, service center, or local distributor for shipping instructions, and forward the instrument prepaid to the destination indicated. Special Spectra-Physics packing boxes designed to securely hold instruments during shipment should be used. If shipping boxes have been lost or destroyed, we recommend that you obtain a new one, for a nominal charge, from Spectra-Physics. Spectra-Physics will only return instruments in Spectra-Physics' containers.

(Turn the page for Service Center addresses.)

SERVICE CENTERS

WESTERN UNITED STATES

Spectra-Physics Inc	Tel:	(800) 227-8054
Laser Products Division	Telex:	348488
1250 W Middlefield Rd	TWX:	910-379-6941
PO Box 7013		
Mountain View, CA 94039-7013		

EASTERN UNITED STATES

Spectra-Physics Inc	Tel (NJ):	(201) 981-0390
366 S Randolphville Rd	(other):	(800) 631-5693
Piscataway, NJ 08854-4175	Telex:	710-997-9506

BENELUX COUNTRIES

Spectra-Physics BV	Tel:	(040)45 18 55
PO Box 2264	Telex:	51668
5600 CG Eindhoven		
The Netherlands		

CANADA, LATIN AMERICA, PACIFIC REGION

Spectra-Physics Int'l	Tel:	(415) 961-2550
1250 W Middlefield Rd	Telex:	348488
PO Box 7013	TWX:	910-379-6941
Mountain View, CA 94039-7013		

ENGLAND

Spectra-Physics Ltd	Tel:	(0727)30131
17 Brick Knoll Park	Telex:	23578
St Albans		
Hertfordshire, AL15UF		
England		

FRANCE

Spectra-Physics SA	Tel:	1.6907 99 56
Avenue de Scandinavie	Telex:	691183
ZA de Courtaboeuf		
BP 28		
91941 LES ULIS Cedex		
France		

JAPAN

Spectra-Physics KK	Tel:	(03)770-5411
15-8 Nanpeidai-cho	Telex:	2466976
Shibuya-ku		
Tokyo 150		
Japan		

SWITZERLAND

Spectra-Physics AG	Tel:	(061)54 11 54
Schweizergasse 39	Telex:	64335
4054 Basel		
Switzerland		

WEST GERMANY & EXPORT COUNTRIES*

Spectra-Physics GmbH	Tel:	(06151)708-0
Siemensstrasse 20	Telex:	419471
D-6100 Darmstadt-Kranichstein		
F. R. Germany		

FIELD SERVICE OFFICES

Albuquerque, NM	Tel: (800) 227-8054
Boston, MA	Tel: (800) 631-5693
Chicago, IL	Tel: (800) 631-5693
Dayton, OH	Tel: (800) 631-5693
Houston, TX	Tel: (800) 631-5693
Los Angeles, CA	Tel: (800) 227-8054
Washington, DC	Tel: (800) 631-5693

*CSSR, Denmark, Egypt, Finland, Greece, Ireland, Israel, Italy, Kuwait, Norway, Pakistan, Portugal, Saudi Arabia, Spain, South Africa, Sweden, Turkey, USSR, and Yugoslavia

SPECTRA-PHYSICS INSTRUCTION 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 instruction manual - problems or errors that did not require a call or formal 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 ______________________________

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Instrument Model Number __________ Serial Number __________

PROBLEM: ______________________________

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SUGGESTED SOLUTION(S): ______________________________

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MAIL TO:
Spectra-Physics, Inc.
LPD Technical Publications
P.O. Box 7013 MS 18-40
Mountain View, CA 94039-7013
U.S.A.

Spectra-Physics

ARGON ION LASER

START-UP CHECKLIST

ELECTRICAL SERVICE

- ☐ Line voltage OK [190<V<225 V (ac), 50A]
- ☐ Earth ground (green wire) connection at switchbox.

WATER SERVICE

- ☐ Water temperature OK (See FIGURE 3.3 for inlet specifications)
- ☐ Water pressure OK (30<P<50 psig)
- ☐ Water flow rate OK (R>2.2 gal/min)

FRONT PANEL CONTROLS

- ☐ METER selector - 50 AMPS
- ☐ CURRENT - midrange or lower
- ☐ CONTROL MODE - CURRENT
- ☐ FIELD control - maximum
- ☐ Main power (switch box) - ON
- ☐ LINE lamps - all 3 glowing
- ☐ MASTER CONTROL - ON
- ☐ Flow switch operation - OK
- ☐ Water supply - ON
- ☐ Circuit Breaker - ON
- ☐ READY lamp - ON
- ☐ START button - push (laser emission)

SHUTDOWN CHECKLIST

- ☐ Circuit Breaker - OFF
- ☐ MASTER CONTROL - OFF (key out)
- ☐ GAS FILL- key out
- ☐ Water supply - wait 15 sec, then OFF
- ☐ Main power - OFF

Spectra-Physics

AUTOMATIC PRESSURE CONTROL PUMP KRYPTON LASER

START-UP CHECKLIST

ELECTRICAL SERVICE

☐ Line voltage OK (190<V<225 VAC)

☐ **Earth** ground (green wire) connected at main switchbox.

WATER SERVICE

☐ Water temperature OK (T<27°C; if T<13°C, check power supply interior for condensation)

☐ Water pressure OK (30<P<50 psig)

☐ Water flow rate OK (R>2.2 gal/min)

FRONT PANEL CONTROLS

☐ METER selector - 50 AMPS

☐ CURRENT - minimum

☐ CONTROL MODE - CURRENT

☐ FIELD control - minimum

☐ FILL switch - OFF

☐ LINE lamps - all 3 glowing

☐ MASTER control - ON

☐ Flow Switch - OK

☐ Water Supply - ON

☐ Circuit Breaker - ON

☐ READY lamp - ON

☐ START button - Push (Laser Emission)

☐ Increase the field two marks; if the field is optimum, turn on the PRESSURE control and go to the next step.

If the FILL lamp is

OFF or FLASHING, repeat this step.

ON, turn the PRESSURE control ON and wait for the fill lamp to go out; repeat this step.

☐ Increase the current 5 A and check the fill lamp. If it is on, wait for it to extinguish.

If the CURRENT value is

<25 A and less than optimum, repeat this step.

25 A, allow the laser to warm up for at least 10 min before raising the CURRENT to its operating level.

SHUTDOWN CHECKLIST

☐ FIELD control - maximum value (fully clockwise).

☐ CONTROL MODE switch - CURRENT

☐ CURRENT control - maximum value (fully clockwise).

If the FILL lamp glows, wait until it goes out. By filling the tube before shutdown, you assure adequate pressure the next time you turn the laser on.

☐ FILL switch - OFF

☐ Circuit Breaker - OFF

☐ MASTER CONTROL key switch - OFF (key out)

☐ Water supply - wait 15 sec, then OFF

☐ Main power - OFF

NON-PUMPING KRYPTON LASER

START-UP CHECKLIST

ELECTRICAL SERVICE

☐ Line voltage OK (190<V<225 VAC)

☐ **Earth** ground (green wire) connected at main switchbox.

WATER SERVICE

☐ Water temperature OK (T<27°C; if T<13°C, check power supply interior for condensation)

☐ Water pressure OK (30<P<50 psig)

☐ Water flow rate OK (R>2.2 gal/min)

FRONT PANEL CONTROLS

☐ METER selector - 50 AMPS

☐ CURRENT - minimum

☐ CONTROL MODE - CURRENT

☐ FIELD control - minimum

☐ LINE lamps - all 3 glowing

☐ MASTER switch - ON

☐ Flow Switch - OK

☐ Water Supply - ON

☐ Circuit Breaker - ON

☐ READY lamp - ON

☐ START button - Push (Laser Emission)

☐ If the laser chirps call Spectra-Physics Service.

☐ Wait 30 min for warmup, 2 hr if the unit has been shut off for more than two weeks.

☐ Slowly increase the CURRENT and FIELD.

☐ If the fill alarm buzzes, add 1 buzz of gas by turning the key switch momentarily, allowing just enough time for the fill system to actuate the solenoid. Listen for a buzz or click from the solenoid. Wait 30 min.

☐ Repeat, increasing CURRENT and FIELD step-wise, adding gas one buzz at a time with a 30 min waiting period after each buzz, until maximum CURRENT and optimum FIELD values have been reached.

☐ Switch the METER selector to FILL and check the pressure.

SHUTDOWN CHECKLIST

☐ FIELD control - maximum value (fully clockwise).

☐ CONTROL MODE switch - CURRENT position

☐ CURRENT control - maximum value (fully clockwise).

☐ If the FILL alarm sounds, add gas slowly, one buzz at a time, until it stops. By filling the tube before shutdown, you assure adequate pressure the next time you turn the laser on. Remember to wait at least 30 min between buzzes to allow the gas pressure to stabilize. Switch the meter to FILL and monitor the change in tube volts as you increase the pressure.

☐ Circuit Breaker - OFF

☐ MASTER CONTROL key switch - OFF (key out)

☐ GAS FILL key out

☐ Water Supply - Wait 15 sec, then OFF

☐ Main Power - OFF