Important Notice

These mating units have been carefully tested and adjusted before shipment:

Laser	Exciter
Model______	Model______
Serial No.______	Serial No.______

Operation with units of different serial numbers can cause possible damage to the instrument, or performance may not meet specifications.

Interchanging one of these units with a unit having a serial number other than that listed above is not covered by warranty and may result in cost-of-repair charges.

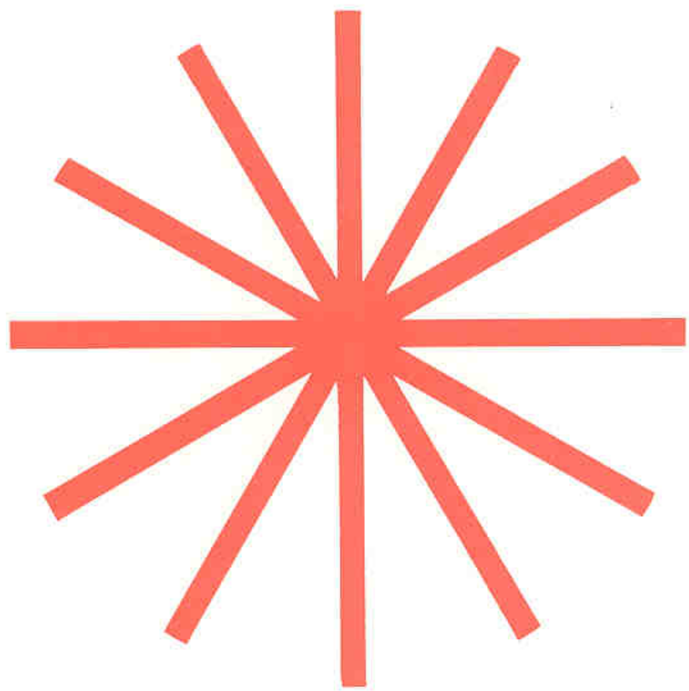
Model 120
Stabilite Gas Laser
with Model 256 Exciter

Instruction Manual

Issue C/120 2/19/70

Danger !

Laser Beam



Operation of lasers requires common sense. As with any other bright light, *do not* stare directly into beam.

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Model 120 Helium-Neon Laser

1.0 Introduction

The Spectra-Physics Model 120 Laser is a rugged, high-performance helium-neon laser designed for use in system applications. An outstanding feature of this unit is its high uniphase output power. Other features contributing to its high performance are:

(a) Excellent output stability resulting from kinematic resonator mounting.

(b) Magnetic suppression of competing infrared laser transitions.

(c) Two-point plasma-tube support for ease in servicing.

(d) Hermetically-sealed window-reflector space.

(e) Series pass-regulated dc exciter unit.

(f) Instant self-starting.

1.1 Model 120/256 Specifications

Output Power: 5.0 mw @ 632.8 nm
Transverse Mode: TEM_{00}

Warm-up Time: > 3 mw 2 minutes after turn-on
> 5 mw 30 minutes after turn-on
Operating Temperature: 10 to 40°C
Long-Term Power Drift: < 5%

Altitude: Sea level to 10,000 feet

Beam Amplitude Noise (1-100 KHz): < 3%
Beam Amplitude Ripple (120 Hz): < 0.5%
Beam Polarization: Linear to better than 1 part per thousand
Plane of Polarization: Vertical, adjustable ±20°
Beam Diameter: 0.65 mm at $1/e^2$ points.
Beam Divergence: 1.7 milliradians at $1/e^2$ points

Resonator Configuration: Long Radius
Axial Mode Spacing: 385 MHz

Plasma Excitation: Direct current self-starting
Cable Length (Exciter to Laser): 8 feet (Extension sections available)
Dimensions: Model 120 Laser Head: 3.26" w x 3.66" h x 18.48" l
Model 256 Exciter: 7.25" w x 3.72" h x 9.88" l
Weight: Laser - 7½ lbs.
Exciter - 7½ lbs.
Input Power: 115/230v, 50/60Hz, 50va

2.0 Theory of Operation

2.1 Basic He-Ne Process

The helium-neon gas laser operates with an electrical discharge in a plasma tube containing a mixture of helium and neon gases. The discharge energy, through an intermediate helium metastable state, raises electrons of the neon atoms to an excited energy state. When more atoms are present in the excited state than in some lower state, a condition known as "population inversion" is said to exist; optical radiation at the energy (wavelength) separation of these states can add to itself by stimulating emission from the excited neon atoms. In order to achieve continuous-wave laser oscillation, a reflector is placed at each end of the plasma tube to form a cavity resonator which stores most of the optical radiation (photons) by reflection back and forth along the axis of the tube. The probability is about .1 that a photon will stimulate the emission of another photon in one pass through the tube. This means that the photons must reflect through the cavity a number of times in order to be self-maintained. Therefore only a small transmission is permitted through one of the reflectors; this provides the spatially coherent and monochromatic output beam characteristic of the gas-laser operation.

When several different lower states are possible from the same excited state, the most likely transition to a lower state will occur first and thereby reduce the population of the excited state; this makes oscillation with other transitions extremely difficult or impossible if the population difference is eliminated between the upper state and one of the lower states. This phenomenon is known as "dominance".

In attempting to obtain a particular output wavelength from the helium-neon laser, the dominance of transitions from the $3s_2$ orbital state of the neon state of the neon atoms plays an important role. The most likely transition gives the 3.39μ infrared wavelength. To avoid oscillation at this wavelength, the supporting frame of the Model 120 laser contains a series of ceramic magnets adjacent to the plasma tube. These magnets serve to reduce the likelihood of a cascade of spontaneous 3.39μ transistions at the central wavelength by Zeeman broadening of the

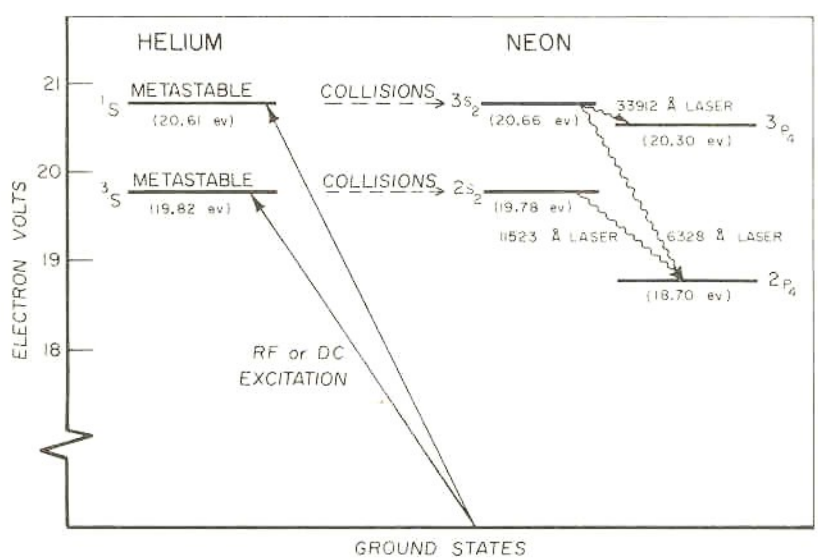


Figure 2-1 Helium-Neon Energy Level Diagram

Doppler linewidth. The Zeeman broadening has little effect on the visible lines which inherently have Doppler widths about six times greater than that of the 3.39μ line. Reducing the 3.39μ transitions increases the population inversion for the weaker visible lines.

2.2 Resonator Structure

The alignment of the reflectors at each end of the plasma tube must be accurately maintained for laser oscillation to take place. Permissible deflections are less than 0.005 degrees. There are two basic sources of resonator angular misalignment; distortions due to temperature gradients, bending of the structure by external mechanical forces.

The other possible disturbance to resonator alignment can come from the means of mounting. To completely position a structure, two equal and opposite forces must be applied in each of three orthogonal directions. If more forces are applied than needed, bending moments result. To permit operation with any external mounting forces, a set of low friction spherical bearings are used to connect the resonator structure to the external mounting feet. The external mounting can be stretched or warped slightly and the only effect is to cause a slight motion in the bearings. The friction components of the bearings are so small that negligible angular distortions occur in the resonator structure as the bearings are operated.

2.3 Beam Diameter and Divergence

The Model 120 laser uses high-gain tube geometry and long-mirror radii in order to obtain high uniphase power output. The tube bore is narrow and the optical mode is designed to almost fill the bore. As a result, small irregularities on the inside of the bore and the exit aperture diffract a small percentage of the light off the principal optic axis. The gain is high enough so that these small losses do not affect power output appreciably, but they do perturb the beam intensity distribution within the near field of the laser aperture.

Intensity perturbations of the order of 10 to 20% are common over those small portions of the exit beam where the diffracted light adds or subtracts with the main beam. (See Figure 2-2.) As distance from the laser is increased, the diffracted light spreads away from the main beam. Finally, in far field, the main beam follows a smooth distribution and the scattered light is irregularly scattered around it.

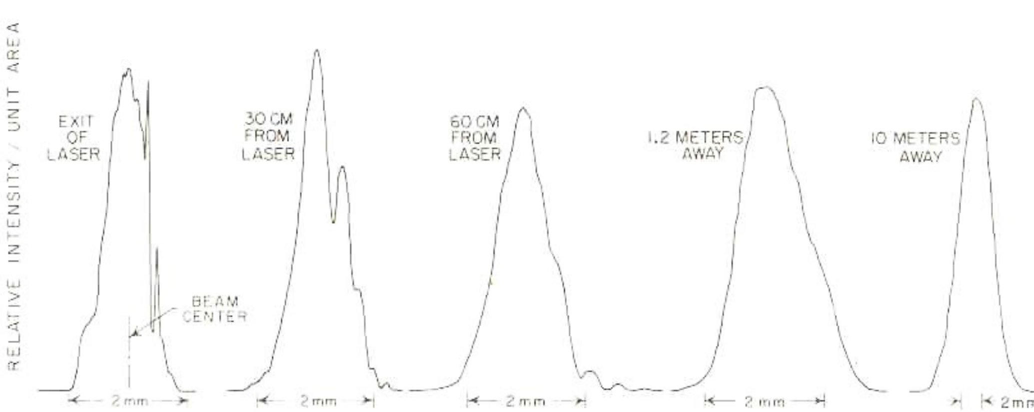


Figure 2-2 Power Density Perturbations at Indicated Distances from Laser Source

The equivalent of operating in the far-field of the laser can be obtained by any optical system which images the diffraction limit of the laser. Since the usual purpose for using laser light is to utilize its diffraction-limited characteristics, there is usually some point in the optical system where a limiting aperture may be inserted to exclude the light not within the diffraction limit. It is well to do this as late in the optical system as possible, since surface defects and unwanted reflections within the system will be eliminated from the output, along with the scattered light from the laser.

The irregular nature of the scattered light makes it difficult to accurately define and measure the beam diameter directly in the near field. The beam diameter given, is between the $1/e^2$ intensity points of the true uniphase part of the beam at the laser. This value is the appropriate one to use to predict the laser beam size after passing through an optical system operating near the diffraction limit.

2.4 Intermodulation of Optical Frequencies

Laser oscillators normally operate on several optical frequencies simultaneously unless special "single mode" techniques are used. The optical cavity of a one-meter laser is about 1,500,000 wavelengths and will resonate at each increment of one half wavelength. The resonant frequencies are spaced $\Delta f = 1c/2L$ (for L = 1 meter, f = 300 MHz). The temperature-broadened Ne resonance has a 1500 MHz half-width, so that a high gain one-meter laser might oscillate at five optical frequencies. The spacing between adjacent optical frequencies is not exactly Δf because the broad Ne resonance has a dispersion (phase) characteristic which adds or subtracts with the cavity dispersion (phase) to displace the oscillating frequency from the exact cavity resonance.

When the several optical frequencies are combined in a square-law detector such as a photo diode, the output contains all possible difference frequencies between the optical frequencies. See Figure 2-3.

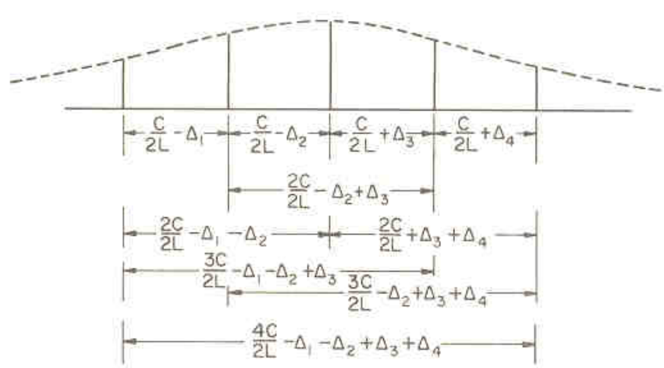


Figure 2-3 Difference Frequencies between Optical Frequencies

These frequencies are quite close to C/2L, 2C/2L, 3C/2L..., but they are perturbed by varying amounts, $\pm\Delta_1$, $\pm\Delta_2$..., depending on how far the particular cavity resonance is from the center of the Ne resonance. This perturbation changes rapidly with small changes in the cavity length.

In the output of a nonlinear detector, not only the principal difference frequencies are present, but also the difference between the principal frequencies ($\pm\Delta_1$, $\pm\Delta_2$, $\pm\Delta_3$...,) are present. These are intermodulation products, and their amplitudes are not as great as the principal difference frequencies, but they are readily detected; they generally are in the frequency range from about 1 KHz to about 100 KHz. Because several of these frequencies may be present simultaneously and are not usually harmonically related, they often have a noise-like appearance on a wide-band oscilloscope with a time-base presentation. This is a particularly true for long lasers with many optical frequencies oscillating. Also, the frequencies are rapidly varying with small cavity length changes which contribute to a noise-like appearance. When spectrum-analyzed, the individual frequencies can be resolved but they vary rapidly up and down the spectrum.

At certain critical cavity lengths, these mode intermodulation products disappear. Apparently when the cavity resonances are symmetrical around the Ne resonance, a kind of self phase locking occurs in the laser oscillator and the intermodulation terms go to zero frequency.

The intermodulation of the optical frequencies is a basic characteristic of nonlinear detectors and determines the minimum noise level for many light detection systems operating in the 1 KHz to 100 KHz frequency range. It is often possible to devise systems in which the data is carried outside of this frequency range; or, the intermodulation terms may be separately monitored and fed back to "demodulate" the light amplitude or the perturbed data.

3.0 Operating Instructions

The Model 120 Laser is a simple reliable unit which requires no special procedures to operate. To use the laser, connect the laser-head-exciter cable to the connector on the back of the Model 256 exciter, plug the Model 256 power cord into a 115 V, 50/60 Hz receptacle, and turn the switch on the Model 256 to "ON". The laser

Warning

Do not look directly into the laser beam. Direct viewing of laser light at close ranges may cause eye damage.

Note

To operate the laser from a 220-V line, the small switch on the back of the Model 256 exciter unit should be moved to "220".

3.1 Mounting Procedure

For many systems applications, it is necessary to mount the laser rigidly to a mounting plate. To mount the Model 120 laser in such systems, remove the four rubber feet from the bottom cover and attach the laser to the mounting plate using four screws and stand-off washers, as shown in Figure 3-1.

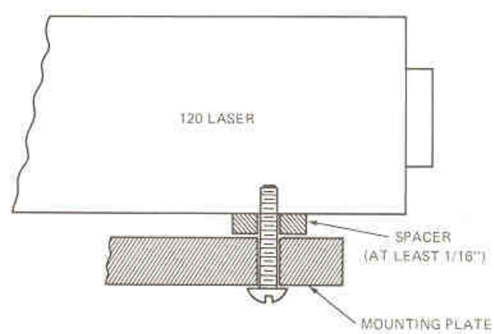


Figure 3-1 Mounting the 120 Laser

The stand-off washers should have a thickness of at least 1/16"; their use prevents the laser head from resting on a spherical-bearing nut which protrudes slightly from the bottom cover. Attach the laser to the mounting plate using four screws and stand-off washers, as shown in Figure 3-1.

The appropriate dimensions necessary to construct mounting plates can be determined by referring to the outline drawings, Figure 3-2. The Model 120 laser can be mounted in any orientation.

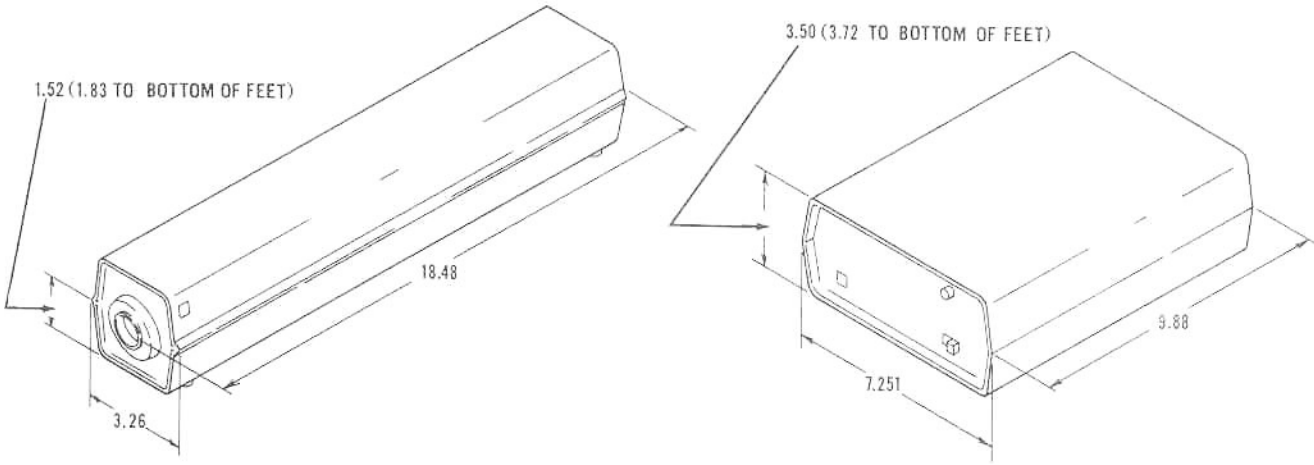


Figure 3-2 Model 120 and Model 256 Outline Drawing

4.0 Maintenance and Troubleshooting

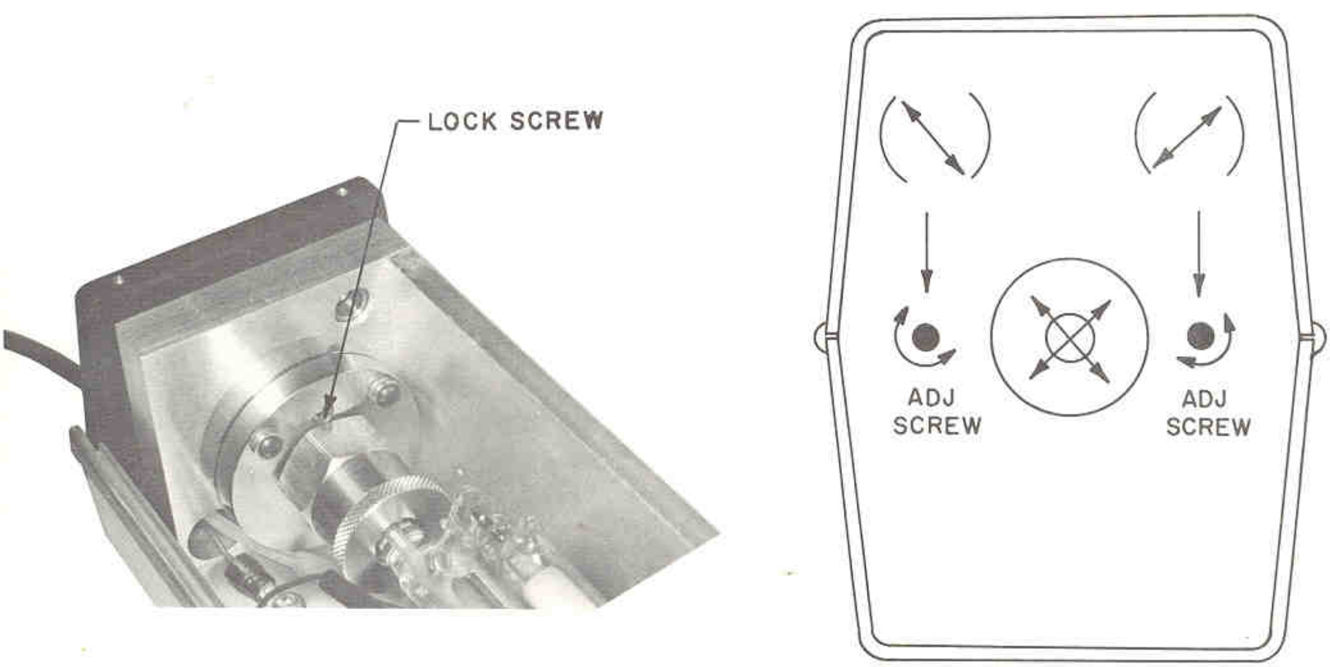
The Spectra-Physics Model 120 Laser is a simple reliable instrument which should require little maintenance. Do not adjust the instrument unless it is not performing according to its specifications.

4.1 Alignment

The Model 120 Laser employs fixed-mirror mounts and an adjustable plasma tube. This type of construction is extremely rugged, and ordinarily will require no adjustment. Occasionally, when the plasma tube or mirrors are changed, the tube-adjusting mechanism may require a touch-up to ensure that the laser is producing full power.

Under ordinary conditions, the adjustment mechanism on the Model 120 Laser will not get far enough out of position to cause the laser to stop working altogether. Therefore, if the laser is not working, do not touch the adjusting mechanisms until all other possible sources of trouble have been ruled out. In particular, the cleanliness of the optics should be checked before changing the adjustment on a non-working Model 120 Laser. It is usually possible to remove both the mirrors and the plasma tube without causing the laser to stop working when it is re-assembled.

The plasma-tube adjustment mechanism of the Model 120 Laser is shown in Figure 4-1. This mechanism is used to locate the axis of the plasma tube on the optical axis defined by the mirrors.



(a) (b)

Figure 4-1 Plasma-Tube Adjustment Mechanism

The adjusting screws for the plasma-tube adjusting mechanisms are located underneath the removable circular end bezels at each end of the laser (they have a normal right-hand thread). The two adjusting screws can then be turned by inserting a #6 Allen-head wrench in the two holes in the laser end plate.

A locking screw is located inside the laser (at each end) on the adjustment mechanism as shown in Figure 4-1a. This screw should be loosened before any gross adjustments are made to the laser adjustment mechanisms.

To adjust a Model 120 Laser for optimum power output, it is easiest to use a small power meter, such as a Spectra-Physics Model 401C which can be screwed into the end plates of the laser. With a power meter mounted on the laser, adjustments should be made at both ends of the laser with the screw adjustments shown in Figure 4-1b to optimize the output power. In general, it will be necessary to repeat a sequence of adjustments two or three times to obtain an optimum setting.

CAUTION

DO NOT MAKE ADJUSTMENTS ON THE PLASMA-TUBE ADJUSTING MECHANISMS WHICH ARE LARGE ENOUGH TO CAUSE THE LASER TO STOP LASING.

4.2 Care of Optical Surfaces

The Model 120 Laser employs hermetically-sealed optics. Under normal operating conditions, it is not necessary to clean the windows and mirrors. Over long periods of time, however, contaminating films sometimes build up on the window and mirror surfaces. When this happens, the laser will operate at reduced power, and the optical surfaces must be cleaned to restore normal operation.

It should be pointed out that "clean" is a relative term; nothing is ever perfectly clean and no cleaning operation completely removes all contaminants. Cleaning is a process of reducing the objectionable materials to an acceptable level. For this reason, re-wiping a surface with the same swab and solvent probably will do nothing except redistribute the contamination. The fact that cleaning is nothing but a dilution of the contamination down to the limit set by solvent impurities places stringent requirements on the quality of the cleaning solvent. Spectrographic grade solvents should be used, and only minimum amounts of these solvents should be left on the surface. As a solvent evaporates, it leaves impurities behind in proportion to the volume of solvent evaporating.

Equipment required:

(a) Lens tissue

(b) Spectrographic-grade acetone

(c) Pair of hemostats

(d) Double-surface masking tape

(e) Rod about 5mm (3/16-inch) diameter and approsimately 15 cm (6 inches)

The steps in cleaning a laser optical surface are as follows:

(a) Using dry nitrogen, blow away any dust or lint on the optical surface. This step is extremely important as any dust or line left on the optical nitrogen is not available, a rubber bulb can be used to generate a low surface can result in a scratch that will damage it permanently. If dry air pressure for the same purpose.

(b) Wash your hands thoroughly with a liquid detergent. This step is important for the reason that body oil and contaminants on the fingers can be transferred to the optical surface during the cleaning process and result in re-contamination.

(c) Draw some acetone into an eyedropper and squeeze out one drop (or two if necessary) to cover the mirror surface. Then take a piece of lens tissue, place it on the wetted surface, and gently draw it across the mirror to remove the contaminants that have dissolved or floated to the cleaning solvent surface. Use a lens tissue only once.

4.3 Window Cleaning and Plasma Tube Removal

To clean the Brewster windows on a Model 120 plasma tube, the plasma tube must be removed from the laser head. It is necessary to disconnect the electrical leads from the plasma tube.

CAUTION

DANGEROUS VOLTAGES EXIST WITHIN THE LASER HEAD. TURN OFF THE POWER SUPPLY BEFORE PROCEEDING.

To remove the plasma tube from a Model 120 Laser, use the following procedure:

(a) Remove the four screws with a 1/16-inch Allen wrench from the top cover of the laser and remove the top cover.

(b) Loosen the two knurled nuts which hold the plasma tube to the hex nuts.

(c) Remove the two Allen-head screws which lock the cathode clamp to the plasma-tube rotation-adjustment bracket.

(d) Unscrew the 7/8-inch hex nut which holds the plasma tube to the wedge-adjusting system, on the power-cable end of the laser. The plasma tube can now be slid back until free of the front mount (at the output end) and lifted free of the laser. BE CAREFUL TO AVOID SCRATCHING THE FRONT BREWSTER WINDOW WHEN REMOVING THE TUBE. EXERCISE THE SAME PRECAUTION PUTTING THE LASER TUBE IN PLACE.

(e) Without removing the hex nut from the plasma tube, the windows can now be easily cleaned.

(f) If the plasma tube is to be replaced, remove the hex nut and knurled-screw assembly from one end of the plasma tube; also remove the cathode-clamp bracket from the other end (remove one Allen-head screw). Then assemble these parts on the new plasma tube.

4.4 Mirror Cleaning

To clean the mirrors on a Model 120 laser, they must be removed from the laser. To remove the mirrors, first unscrew the circular bezel from each end of the laser. Then unscrew the mirror retaining nuts using the wrench supplied with the laser. The "O" rings which hold the mirrors and the mirrors themselves may then be removed by using a piece of masking tape on the end of a small stick, as shown in Figure 4-2.

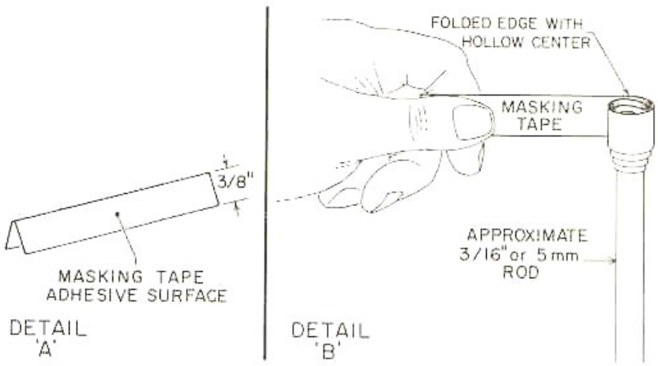


Figure 4-2 Preparation of Adhesive Mirror-Removal Tool

Clean the mirrors one at a time by the procedure described in Section 4-2. The laser should lase after it is re-assembled. If it does not, check to make sure that the mirrors are properly seated in their cells.

4.5 Model 256 Exciter Unit

The Model 256 Exciter provides current to maintain the electrical discharge in the plasma tube of the Model 120 laser. It should not require maintenance. The circuit diagram of the unit is at the rear of the manual.

The circuit of the Model 256 Exciter consists of a voltage step-up transformer T101 followed by a voltage doubler (CR105, CR106, C106, and C105). A stage of lightly-coupled multiplication (CR104 & C102) provides the necessary 8 KV open-circuit voltage to start the plasma tube. When the plasma tube fires, therefore drawing current, CR104 & C102 no longer provide voltage multiplication and the voltage output drops to approximately 4.5 KV.

Series-connected transistors Q101 through Q105 provides a series-pass regulating element with a 500-volt compliance range. Operation of the regulator is as follows. Reference voltage is fixed by CR113 and current supplied by R102 through R104 is applied to the base of Q105. Q105 draws a constant current to keep the voltage across the sense resistors R112, R113 at a fixed value. Variable R113 provides the current level.

Q106 and associated circuitry limit the voltage across the series-pass element to 500 volts. As the voltage across the regulator approaches 1500 volts, the voltage across R110 approaches the 24-volt zener voltage of CR112. It conducts, turning Q106 on, shunting current around the sense resistors preventing further rise of the voltage across the regulator.

R101 limits the current surge from C105 and C106 in case of accidental short circuit of the output to a safe value for the regulator.

4.6 Troubleshooting

The Spectra-Physics Model 120 laser is a simple reliable unit that will ordinarily give many years of trouble-free operation. Occasionally, however, trouble may develop which prevents the laser from performing according to its normal specifications.

If, when the laser is turned on, it does not lase, check to see if the plasma tube is lighted. If the plasma tube is lighted, remove the top cover and check the color of the light coming from the sides of the plasma tube. If it is a salmon pink color, the plasma tube is probably not the trouble. If it is a blue color, the plasma tube may need replacement.

If the plasma tube appears satisfactory, clean the optics, as described in the preceeding sections. If cleaning does not restore normal operation, call your nearest Spectra-Physics Field Engineering Office for assistance.

DO NOT ADJUST THE WEDGE ADJUSTMENT SYSTEM OF A NON-WORKING LASER!

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 through accident or long time use. 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.

For assistance of any kind, contact your nearest Spectra-Physics Field Sales office or Service Center for instructions. Give full details of the difficulty and include the instrument model and serial numbers. Service data or shipping instructions will be promptly supplied. There will be no charge for repair of instruments under warranty, except transportation charges. Estimates of charges for non-warranty or other service work will be supplied, if requested, before work begins.

Complete service facilities are located at the factory in Mountain View and in Avenel, New Jersey (New York City area). These Spectra-Physics service centers supplement service operations of the Spectra-Physics sales representatives. Customers with facilities generally east of the Mississippi are serviced from the Avenel office and customers west of the Mississippi are serviced from the Mountain View office.

<u>Ask for the Service Manager.</u>

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Spectra-Physics GMBH 12 Alsfelderstrasse 61 Darmstadt, Germany	Phone: 06150-75081 TWX: 841-419471

WARRANTY

All Spectra-Physics products are warranted against defects in materials and workmanship for one year from the date of shipment. The obligation of Spectra-Physics is limited to repairing or replacing instruments which prove to be defective during the warranty period. The obligation of Spectra-Physics does not extend to consequential damages. Limited warranty may apply to plasma tubes which are not operated by the appropriate Spectra-Physics exciter.

A replacement plasma tube will be supplied at no cost during the warranty period in exchange for a defective tube which is not physically damaged. The obligation of Spectra-Physics does not extend to the replacement of a plasma tube which has been physically damaged.

CLEANING AND ADJUSTMENT

Frequent causes of failure are simple maladjustments of the reflectors or contaminated optics. The warranty does not cover the return, cleaning, or adjustment of the instrument, if these are the cause of failure. A charge will be made in the event that a returned unit requires cleaning and adjustment only.

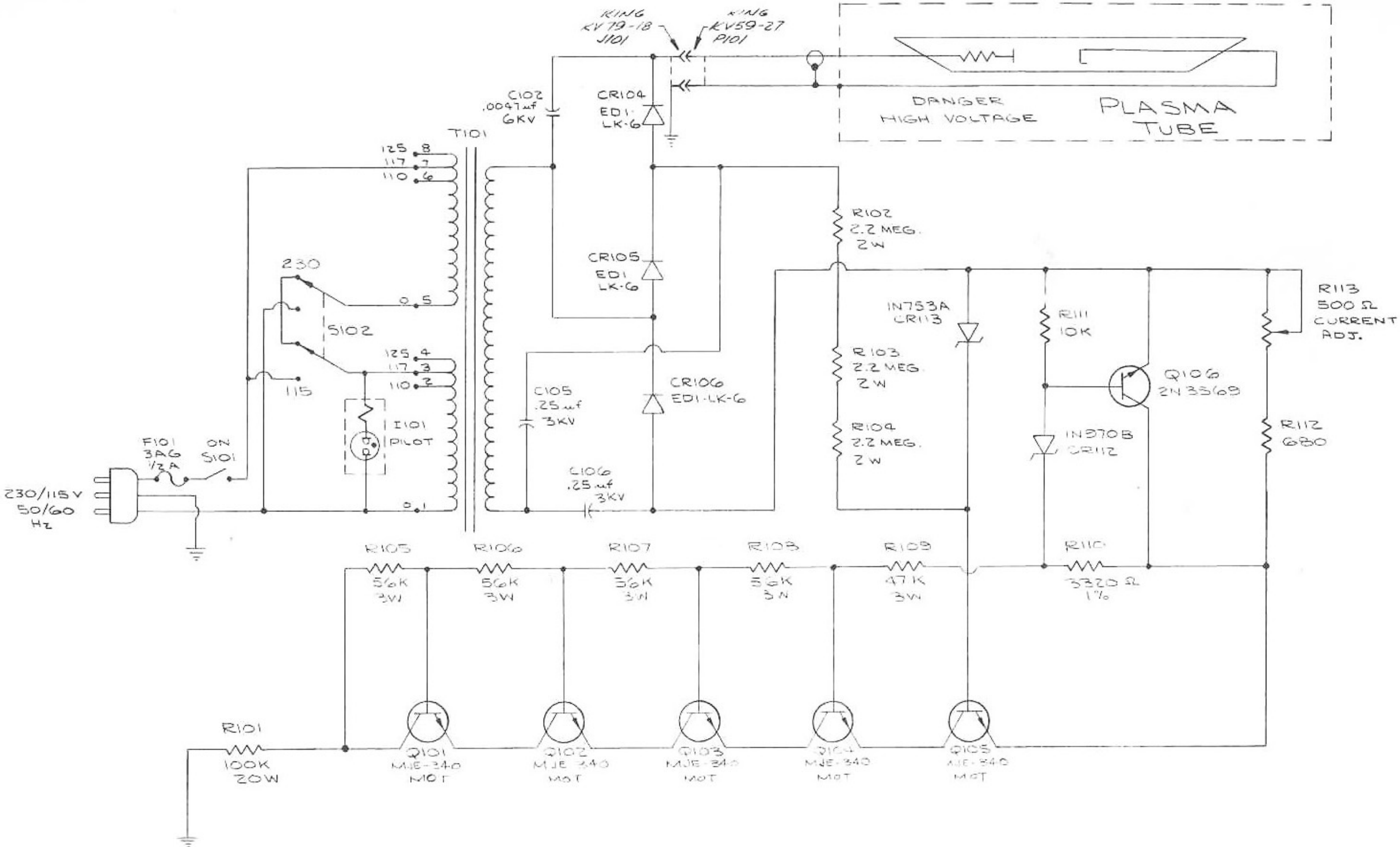
ASSISTANCE

For assistance of any kind, contact your nearest Spectra-Physics Field Sales Office or Service Center for instructions. Give full details of the difficulty and include the instrument model and serial numbers. Service data or shipping instructions will be promptly sent to you. There will be no charge for repair of instruments under warranty, except transportation charges. Estimates of charges for non-warranty or other service work will be supplied, if requested, before work begins.

RETURN OF THE INSTRUMENT FOR REPAIR

Contact your nearest Spectra-Physics Field Sales Office or Service Center for shipping instructions. On receipt of shipping instructions, forward the instrument prepaid to the destination indicated.

Spectra-Physics has designed a special package to securely hold the laser during shipment. This container should be used. If the shipping box has been lost or destroyed, we recommend that another one be obtained from Spectra-Physics.



Model 256 Exciter Schematic Diagram