Plotkin 982-5503

Spectra-Physics

Model 130 Gas Laser

Operation and Maintenance Manual

MODEL 130 GAS-PHASE LASER

OPERATION AND MAINTENANCE MANUAL

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1.0 INTRODUCTION

The helium-neon gas-phase laser provides continuous emission at various wavelengths in the visible and infrared regions of the spectrum. The population inversion between the atomic states of the neon is obtained by d-c plasma excitation of sufficient level to sustain continuous laser oscillation. An optical high Q cavity resonator is formed by a pair of high reflectivity dielectric multilayer reflectors (mirrors) mounted outside the plasma tube. To obtain minimum transmission loss, the plasma tube is terminated by Brewster's angle windows resulting in the output being plane polarized. Readily interchangeable resonator reflectors allow the operator to select the resonator configuration and the operating wavelength.

1.1 DESCRIPTION OF EQUIPMENT

> WARNING
>
> The power supply furnishes high voltage at potentially lethal current. The jacks in the potted power supply, the high voltage leads from the plasma tube to the jacks and the potted ends of the plasma tube should always be treated with extreme caution.

The Model 130 Gas Laser (Figure 1-1) consists of a single package containing plasma tube, reflectors, reflector supporting and adjusting mechanisms, and a d-c power supply which supplies the energy necessary to create and sustain the glow discharge in the plasma tube.

The heart of the Model 130 Gas Laser is a 27.5 centimeter long, 2.5 millimeter I.D. plasma tube with two appendages for the d-c electrodes. The plasma tube is terminated at each end with an optical quality, Schlieren-free, fused silica Brewster's angle window. The ends of the electrode appendages are enclosed in a permanent insulating material and have high voltage leads terminated with plugs for safe connection to the power supply. The plasma tube is supported within the high Q optical cavity resonator which is formed by two highly reflecting dielectric-coated reflectors. These reflectors are suitably supported normal to the axis of the plasma tube by means of precise mechanical adjusting assemblies located at each end of the instrument.

The reflector angle adjustments, located at each end, consist of a dual set screw arrangement located about the periphery of the beam aperture. The dual set screws provide two axes of rotation, 45° to the left and right of vertical. For each axis of rotation there are two pairs of set screws, an outside pair for imparting inward motion and an inside pair for imparting outward motion. The cavity length adjustment, located on

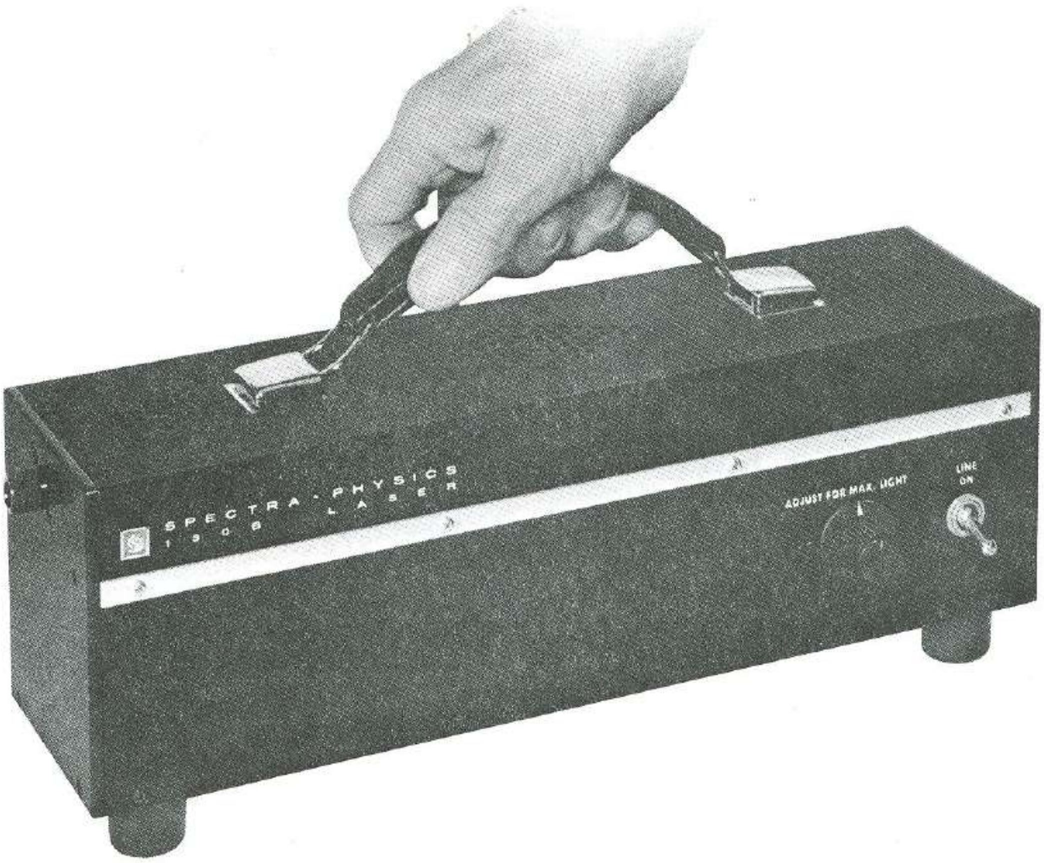

Figure 1 - 1 Model 130 Gas-Phase Laser

the left end in Figure 1-1, consists of a reflector mounting tube which slides in an adjustable friction collet. The precision machined top, side plates, end plates and bottom of the Model 130 provide a rigid mounting frame for the reflector adjusting mechanisms.

The self-contained Model 130 power supply is a resistor-stabilized solid-state, rectified d-c supply with a silicon-controlled rectifier circuit providing smooth intensity control of glow discharge in the plasma tube. All the power supply, except the SCR circuit and the power transformer, are potted in an insulating material in order to prevent accidental contact with the high voltage supply. Front panel controls are an ON-OFF switch and an INTENSITY control.

When furnished with the standard hemispherical resonator configuration the spherical (30 cm radius) reflector has a curved back surface for collimating the beam (screw-in lens may be supplied instead of the curved-back reflector).

1.2 MODEL 130B SPECIFICATIONS

Wavelength	Standard: 6328Å (visible red) Optional: 11,523Å or 33,912Å
Output Power*	Hemispherical Resonator: 0.75 milliwatt CW (minimum) from spherical end. All power in a uniphase wavefront for insertion into the diffraction limit of an optical system.
Optics	The plasma tube windows and resonator reflectors are of optical quality, Schlieren-free, fused silica. The reflectors are multi-layer dielectric coated for greater than 99% reflectivity at desired wavelength, and are anti-reflection coated on back surface.
Resonator Configurations*	Standard: Hemispherical resonator with 1 spherical reflector (30 cm radius) and 1 planar reflector. Optional: Confocal resonator with 2 spherical reflectors (30 cm radius). A readily interchangeable third reflector (available at additional cost) permits both hemispherical and confocal operation. Nominal length of resonator is 30 cm.
Resonator Adjustments	Non-interacting adjustments of separation between reflectors and rotation of each reflector about two independent axes.

Beam Polarization	Output beam is plane-polarized by virtue of passage through Brewster's angle windows on plasma tube.
Beam Diameter	Approximately 1.4mm at the exit aperture.
Beam Divergence	Output beam of hemispherical resonator is collimated at the spherical reflector exit aperture to less than 0.7 milliradians (145 seconds of arc). Output beam of confocal resonator can be collimated to less than 5.5 milliradians (19 minutes of arc).
Discharge Exciter	Self-contained, d-c power supply; 50/60/400 cps, 90va (approx.) input. Specify 115 or 230 volts.
Mounting	Unit is supplied with rubber feet for table-top use. Integral adapter permits optional mounting on standard optical bench fixture.
Dimensions	13½" long x 4½" high x 3½" wide.
Weight, Net	11 lbs. (including power supply).

*NOTE

Thermal drift of uniphase laser resonators can cause variations in the output light intensity as a result of the c/2L, resonator modes (where L is the resonator length) being thermally tuned through Doppler-broadened neon spectral line. In general, these amplitude variations become more pronounced as the number of oscillating modes in the resonator decreases. At 6328Å, these medium-term (seconds to minutes) variations result in amplitude fluctuations of typically 2→5% when using short resonators ($L \cong$ 30 cm) at maximum output intensity. As a percentage of the total, these fluctuations increase as the output intensity is reduced. Also since the Doppler linewidth narrows inversely with wavelength, these variations are proportionately greater when operating a laser at the 11,523Å and 33,912Å wavelengths. Where amplitude stability is important and multiphase wavefronts can be tolerated, it is recommended that the confocal resonator be used, particularly when operating at the infra-red wavelengths.

1.3 ACCESSORIES & OPTIONS

See Data Sheets at rear of Manual

2.0 THEORY OF OPERATION

2.1 GENERAL

In the Model 130, laser oscillation is obtained through stimulated emission (maser action) of optical radiation arising from an inverted population of energy levels of a neon atomic system located inside a high Q optical resonator. The optical resonator consists of two highly reflective multi-layer dielectric reflectors spaced 30 centimeters apart. A plasma tube is located between the reflectors and contains a mixture of helium and neon gases at a pressure of about 1.5 torr. A gas discharge is maintained inside the plasma tube by d-c excitation.

The following simplified energy level diagram, Figure 2-1, illustrates the step-by-step atomic processes involved in producing coherent oscillation in a cw helium-neon gas laser. (In this instance we will follow the process which produces the visible output at 6328Å.)

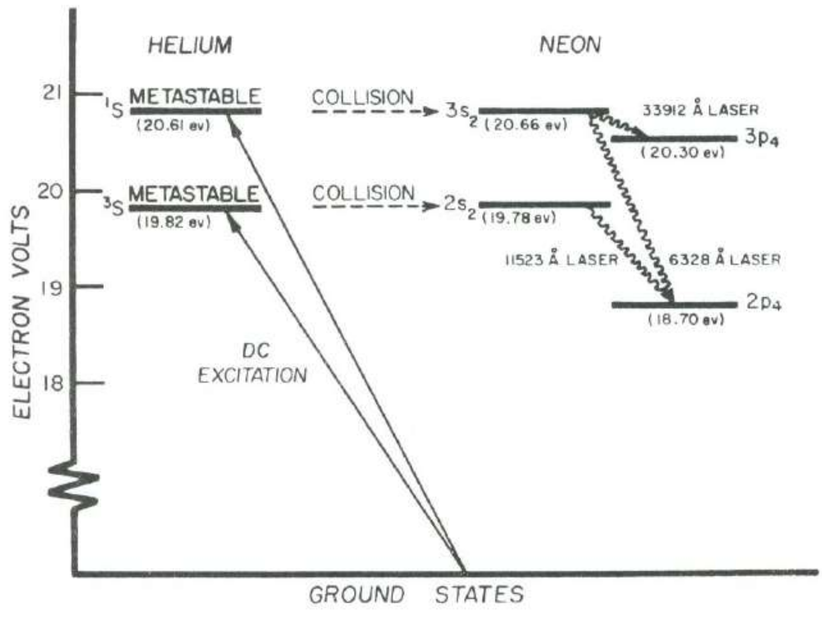

Figure 2 - 1 Helium-Neon Energy Level Diagram

Helium atoms are raised to the metastable excited state 20.61 electron volts above the ground state by means of the d-c excitation. Nearly coincident in energy is the $3s_2$ state of neon, 20.66 electron volts above the neon ground state. Energy exchange collisions occur between the excited helium atoms and the ground state neon atoms through which the neon atoms are raised to the excited $3s_2$ state and the helium atoms returned to the ground state with the small difference in energy taken up by thermal motion. This action leads to a preferential population of the neon $3s_2$ level relative to the $2p_4$ level and the atomic system, then, assumes the characteristics of negative resistance or gain at the transition wavelength of 6328Å. A neon atom undergoing the transition from the $3s_2$ level to the $2p_4$ level will emit a photon having an energy of 6328Å. This photon can be pictured as an electromagnetic wave traveling down the axis of the optical resonator and being reflected back from the resonator reflector surfaces. If the gain in energy per round trip through the resonator is greater than the loss in energy in reflecting from the surfaces, the wave will be reinforced and oscillation will occur. Gain is achieved by virtue of the process of stimulated emission whereby one photon can induce other excited neon atoms in its path to radiate, in phase, photons of the same wavelength. The output from the laser consists of the small amount of coherent energy transmitted through the 99% reflective resonator reflector surfaces.

After having been stimulated to emit the 6328Å energy, the neon atoms undergo normal relaxation from the $2p_4$ level to the neon ground state where they are again excited through collisions with the continuously DC excited helium atoms, thereby making this cycle and the resultant coherent output a stable and continuous one.

A more rigorous discussion of cw gas laser theory is to be found in the references given in Section 2.2.5

2.2 RESONATORS

The resonator configuration is determined by the shape of the reflectors that are placed at the end of the resonator. The two different resonator configurations in which the Model 130 can be operated are the confocal and hemispherical.

2.2.1 CONFOCAL RESONATOR

The confocal resonator is obtained in the Model 130 by employing two reflectors whose radii of curvature are 30 centimeters. Since the radius of curvature is approximately equal to the separation of the reflectors, the focal length of each reflector is one-half this distance. Proper operation is obtained when the center of curvature of each mirror lies on the tube axis. Under these conditions, the focii of the two reflectors are substantially coincident, hence the term "confocal."

The confocal resonator is commonly used where phase coherence across the entire wavefront is not of great importance. When this condition can be tolerated, the confocal resonator provides a large amount of output power combined with simplicity of operation. The angular adjustment of the reflectors is not at all critical, since large variations in angle can be tolerated within which at least parts of each reflector will satisfy the conditions given above for resonance. Likewise, the adjustment in spacing is not critical and may be varied by large factors. In fact, the condition in which the mirrors are exactly confocal corresponds to a condition of instability in that very slight variations in mirror curvature (either real or apparent, due to refractive effects) can cause large diffraction losses. These can result in poor threshold and low output power. Stable configurations, leading to good threshold and high output power, are obtained by pushing the mirrors together or pulling them apart so that the separation differs by a few millimeters from exact confocal. Maximum power output is obtained by pushing the mirrors together so as to be as close together as possible.

The confocal resonator has been discussed in detail by Boyd and Gordon, Reference (5), and by Boyd and Kogelnik, Reference (6). According to the idealized calculations carried out in these papers, the single resonator mode of a confocal resonator consists of a "spot" whose approximate diameter is $\sqrt{b\lambda/\pi}$ where b is the spacing between reflectors and λ the wavelength. For a resonator 30 centimeters long, this spot size is approximately 0.25 millimeters. Each of these spots may contain one or more angular modes, for which the relative amplitude of the electric field may be described by $\cos M\phi + \sin N\phi$, where ϕ is an angle around the axis of the resonator standing wave and M and N are integers. When operating at full power, the output of the confocal resonator consists of a large number of such spots. In general, the phases between them are uncorrelated, although the region over which phase is constant is approximately the diameter of one spot--much larger than is the case with an incoherent light source. The divergence of the beam, consisting of the collection of spots, is as if the origin is a point at the surface of the opposite reflector whose area is approximately the diameter of one spot. Thus, the confocal external laser beam can be focused down to a small spot, although not as small as is possible with the hemispherical resonator.

The confocal resonator is recommended for the 1.15μ and 3.39μ wavelengths for reasons stated in the note in paragraph 1.2, SPECIFICATIONS.

2.2.2 HEMISPHERICAL RESONATOR

The hemispherical resonator is capable of providing a single coherent uniphase wavefront and is, therefore, the preferred resonator configuration for most applications. The power of the hemispherical resonator is approximately one-half that of the confocal resonator. This resonator consists of one plane (flat) reflector and one spherical reflector (30 cm radius) with its center of curvature located approximately at the plane reflector.

Under these conditions, the plane reflector forms the hemispherical plane to the complete sphere defined by the surface of the spherical reflector, and a spherical resonator is formed by the spherical reflector and its mirror image on the plane reflector. The distance from the center of curvature point on the plane reflector to all points on the spherical reflector is the same and the mode of this resonator consists of spherical wavefronts centered about the center of curvature of the spherical mirror. The radiation pattern on the spherical reflector is a uniphase wavefront with a Gaussian-like decrease of intensity toward the edge of the pattern from diffraction effects. The radiation pattern on the plane reflector is a plane wave with a spot size given by the diffraction limit from the opposite reflector. For the 2.5 mm plasma tube bore diameter and 30 cm resonator spacing, this spot is approximately 0.1 millimeter in diameter.

The output of the hemispherical resonator is a continuation of this wavefront at either end of the resonator. Since it is a spatially coherent wavefront, however, a much smaller spot size than that observed at the plane reflector may be obtained by the use of sharply converging, diffraction-limited optics. By using the spherical mirror with the curved back surface the emerging beam is collimated to diffraction-limited divergence.

The adjustment in angle of the reflectors in the hemispherical resonator is not critical inasmuch as it is required that only a part of the spherical reflector satisfy the condition of seeing an image of itself upon reflection by the plane reflector. Maximum power, of course, is obtained when the reflectors are precisely adjusted in angle.

Adjustment in length is not overly critical for this resonator, although deviations from the uniphase wavefront of the lowest order TEM_{oo} mode (Figure 2-2A) may be observed if the reflectors are moved too close together by more than several millimeters. Under these conditions, a reduced mode diameter favors oscillation in one of the higher order modes (B, C, D) of Figure 2-2. (Using the convention of Reference (10), TEM^*_{01} is used to designate the mode formed by two degenerate TEM_{01} modes combining in phase and space quadrature.) If the reflectors are pulled too far apart, an abrupt falling off in power occurs.

The hemispherical configuration is relatively simple to use. However, care should be taken to insure that reflectors and Brewster windows are clean, particularly at the plane reflector end. Small spots of dirt or dust in strategic places may reduce power or cause the wavefront to split into a higher order mode.

2.3 LONGITUDINAL MODES

The output of the Model 130 Laser is highly monochromatic in that the emission can take place only within the Doppler width of the spectral line--approximately 1500 megacycles in width at 6328Å. Within this width, however, a number of longitudinal modes can exist, corresponding to the various precise wavelengths at which an integral number of standing waves can exist between the boundaries defined by the end reflectors. The exact

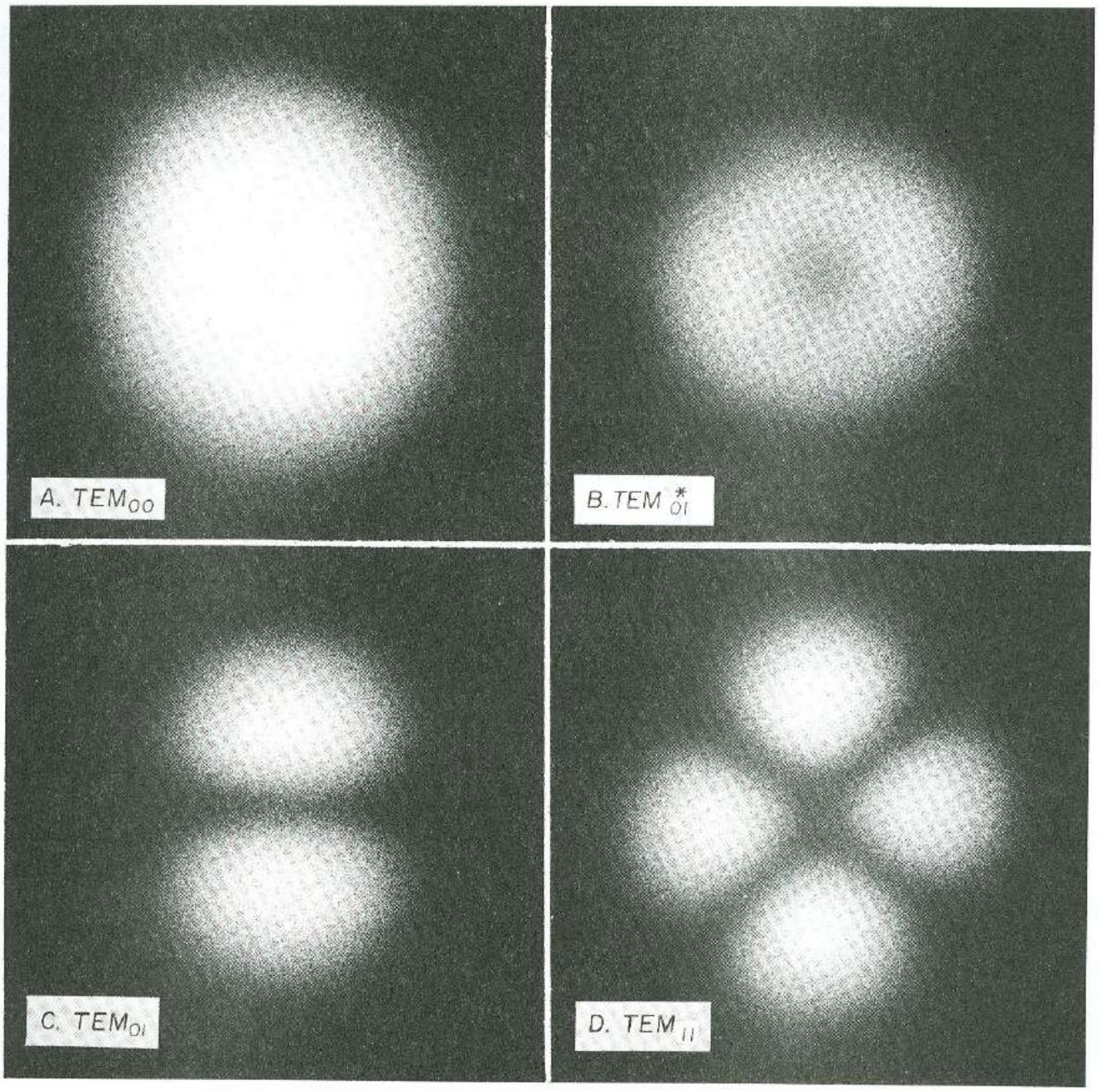

Figure 2 - 2: Beam Spots for Typical Modes Of Hemispherical Resonator

positions of these resonant wavelengths depend sensitively on the distance between reflectors; however, in all cases, the difference between these wavelengths is approximately constant. This difference can be expressed in terms of frequency, and is given by c/2b, where c is the velocity of light within the laser and b is the separation between reflectors. For the Model 130 Laser, this separation expressed in frequency is approximately 500 megacycles. It represents the frequency separation for all modes of the same angular order (M + N = constant). However, the boundary conditions are differenct for M + N = an odd number than for M + N = an even number, so that if both even and odd modes are present within the resonator, then a frequency difference of half the above number, or 250 megacycles, occurs.

The above analysis is approximately true for the hemispherical resonator when the laser is operated at relatively low gain. At higher gain, other factors involving the quantum nature of the resonance in the gas tends to pull the various frequency modes slightly, and by different amounts, so that a wide variety of difference frequencies occur. For more details, refer to W. R. Bennett, Jr., Reference (8). In addition, in the confocal resonator, additional beats occur if the mirrors are separated by a distance not exactly identical to their radius of curvature. These are discussed in the paper by Boyd and Gordon, Reference (5).

2.4 TECHNICAL REFERENCES

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(10) W. W. Rigrod, "Isolation of Axi-symmetrical Optical Resonator Modes," Appl. Phys. Lett., Vol. 2, pp. 51-53; February, 1963.

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(12) A. L. Bloom, W. E. Bell, and R. C. Rempel, "Laser Operation at 3.39μ in a Helium-Neon Mixture," Appl. Opt., Vol. 2, pp. 317-318; Mar., 1963.

(13) W. W. Rigrod and A. J. Rustako, Jr., "Diffraction Studies with Plane-Parallel Maser Interferometer," Vol. 34, pp. 967-968; April, 1963.

(14) C. C. Cutler, "Coherent Light," International Science and Technology, pp. 54-63; September, 1963.

3.0 OPERATING INSTRUCTIONS

> **CAUTION**
>
> Always be sure to ground the third wire in the power cord. If an internal short should develop in the Model 130, a potentially lethal voltage could appear on the case or other parts of the unit.

3.1 TURN-ON PROCEDURE

(1) The Model 130 Laser is delivered wired for 115v or 230v operation at the customer's option. If wired for 115v operation, a power plug will be attached to the power cord; if wired for 230v operation, the power plug is omitted. To switch from 115v to 230v operation or vice-versa, see the schematic at the rear of the manual for input transformer details and modify input transformer wiring accordingly.

If the intended power source is 230 volts, make certain that the Model 130 is wired for 230 volt input or serious damage will result.

(2) Plug the power cord connector into a 50 or 60 cps line. If a ground connection is not provided in the receptacle, connect the ground prong on the plug to a good ground.

(3) Turn the ADJUST FOR MAX LIGHT control to MAX. (Note: This control adjusts the level of d-c current to the plasma tube.)

(4) Place the ON-OFF toggle switch to the ON position.

(5) A reddish glow should be seen through the vent holes in the top of the unit indicating that the plasma tube has fired. The intensity control should smoothly adjust output intensity and the plasma tube may quench before the MIN position is reached.

(6) If the unit is in proper adjustment, an output pattern may be observed out the ends of the Model 130 when the plasma tube is ignited. If no output is observed investigate the following:

a) Improper angular or length adjustment of reflectors. See 4.3

b) Contamination of optical surfaces. See 4.1

c) Improper alignment of plasma tube. See 4.2.2.

WARNING

> There are no known instances of eye damage resulting from c-w helium-neon gas-laser beams. This does not mean that precautions can be disregarded when viewing the beam, and in particular, the laser beam should never be viewed directly but should always be observed on some diffuse surface.

3.2 REFLECTOR REPLACEMENT

The Model 130 is normally shipped with a hemispherical resonator configuration. Since in this configuration alignment of the reflectors is more critical than in the confocal configuration, no reflector adjustments should be required when changing to confocal operation. For reflector adjustments, see Section 4.3 Reflector replacement may be simply achieved by the following procedure (refer to Figure 3-1):

(1) Insert a paper clip or similar tool in the slots provided in the reflector holder retaining ring and remove the ring by turning in the CCW direction.

(2) Remove the reflector spacer. Figure 3-1 shows the long spacer from the length adjustment end (left end in Figure 1-1) of the Model 130. The spacer at the right end is considerably smaller.

(3) Remove the reflector by gripping the back surface of the reflector with a narrow strip of masking tape or a small roll of double backed tape wrapped around the end of an Allen-head wrench or similar probe, being extremely careful not to touch or damage in any way the front or rear surfaces.

(4) Insert the replacement reflector with the reflecting surface facing the plasma tube.

(5) Insert the O-ring spacer and retaining ring. Tighten the retaining ring to a snug tightness. Do not over-tighten.

(6) Always keep the unused reflector in a protective lens tissue For care and cleaning of the reflector optical surfaces, see Section 4.1.

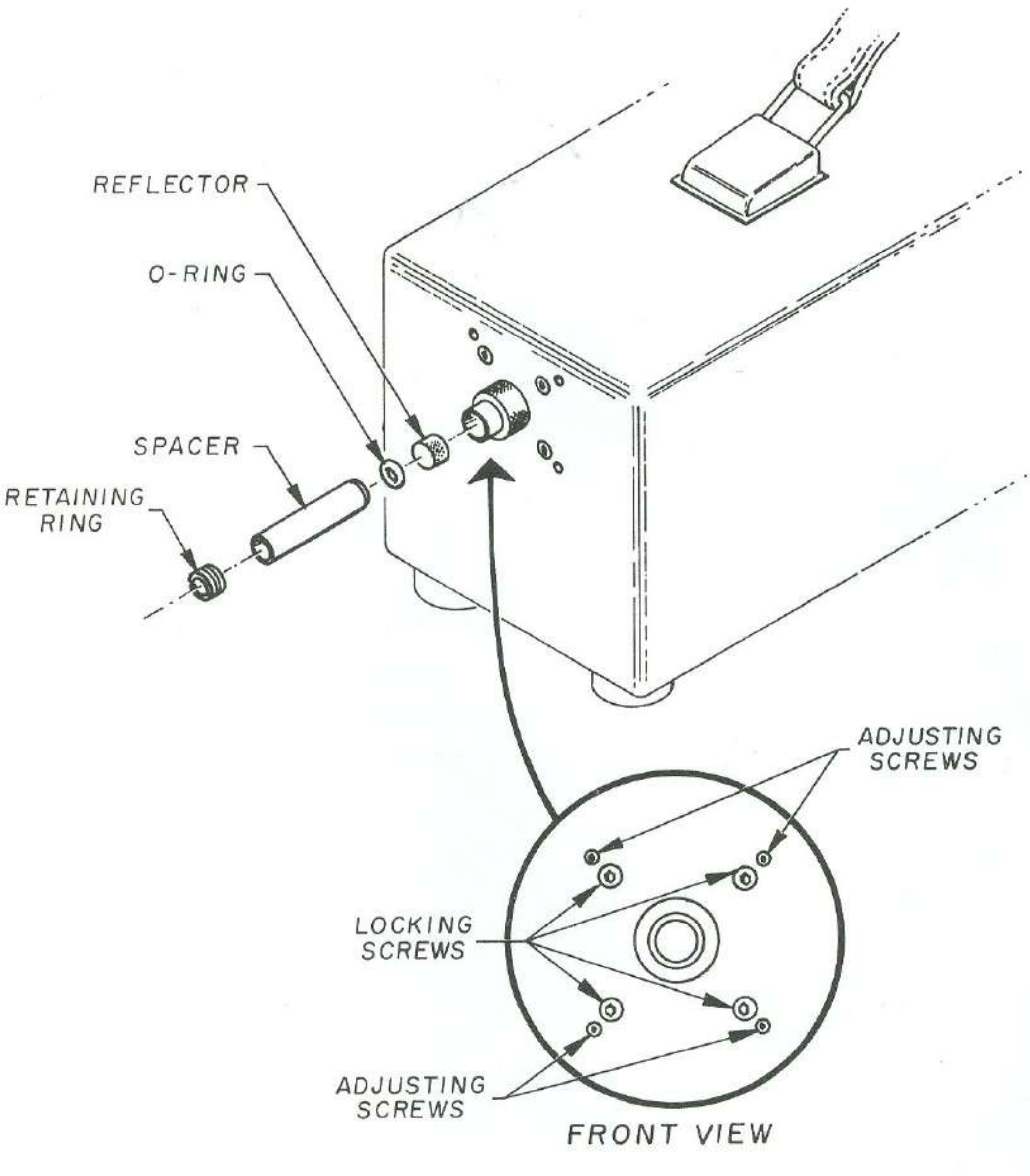


Figure 3 - 1 Length Adjustment End View of Model 130

4.0 MAINTENANCE AND TROUBLESHOOTING

4.1 CARE OF OPTICAL SURFACES

In general, reflectors and Brewster windows should be cleaned and handled as little as possible. When cleaning is required, high purity acetone (such as Matheson, Coleman & Bell, number CQ 2953, Chromatoquality Reagent) should be used as the cleaning solvent. Impure grades of acetone may leave a film of nonvolatile residue which will lessen the optical efficiency of the reflector. High quality, low fat lens tissue should be used as acetone will leach fatty materials from the paper and deposit them on the reflector. Kodak Lens Cleaning Paper in 3" x 5" sheets is both satisfactory and conveniently available.

CLEANING INSTRUCTIONS

(1) Gently remove any coarse dust particles with a clean camels hair lens brush prior to wiping the reflector. Abrasive dust particles may scratch the coating even under the very light contact pressures of wiping.

(2) Remove two sheets of 3 x 5 Kodak Lens Cleaning Paper from the packet. Holding the sheets together, loosely fold and refold them to form a strip 3" long by approximately 5/8" wide (the width of the reflector). Double the strip so the two ends may be grasped between the thumb and forefinger.

(3) Apply two or three drops of acetone to the folded end of the pad of tissue and shake off the excess liquid. (Do not allow acetone to contact the fingers as body oils will be dissolved and be deposited on the optics.)

(4) Allow the moistened lens tissue to lightly contact the coated surface of the reflector or the surface of the Brewster window near one edge. Draw the tissue across the optical surface applying no pressure but allowing the tissue to contact the optical surface by its own weight.

(5) Examine the optical surface for surface films and deposits. Discard the used tissue and repeat the entire process if there is evidence of surface contamination.

(6) Repeat the process for the opposite face of the reflector.

> NOTE
>
> USE ONLY THE MINIMUM AMOUNT OF ACETONE REQUIRED TO MOISTEN THE TISSUE. NEVER FLOW ACETONE DIRECTLY ONTO THE COATED SURFACE. If acetone is allowed to

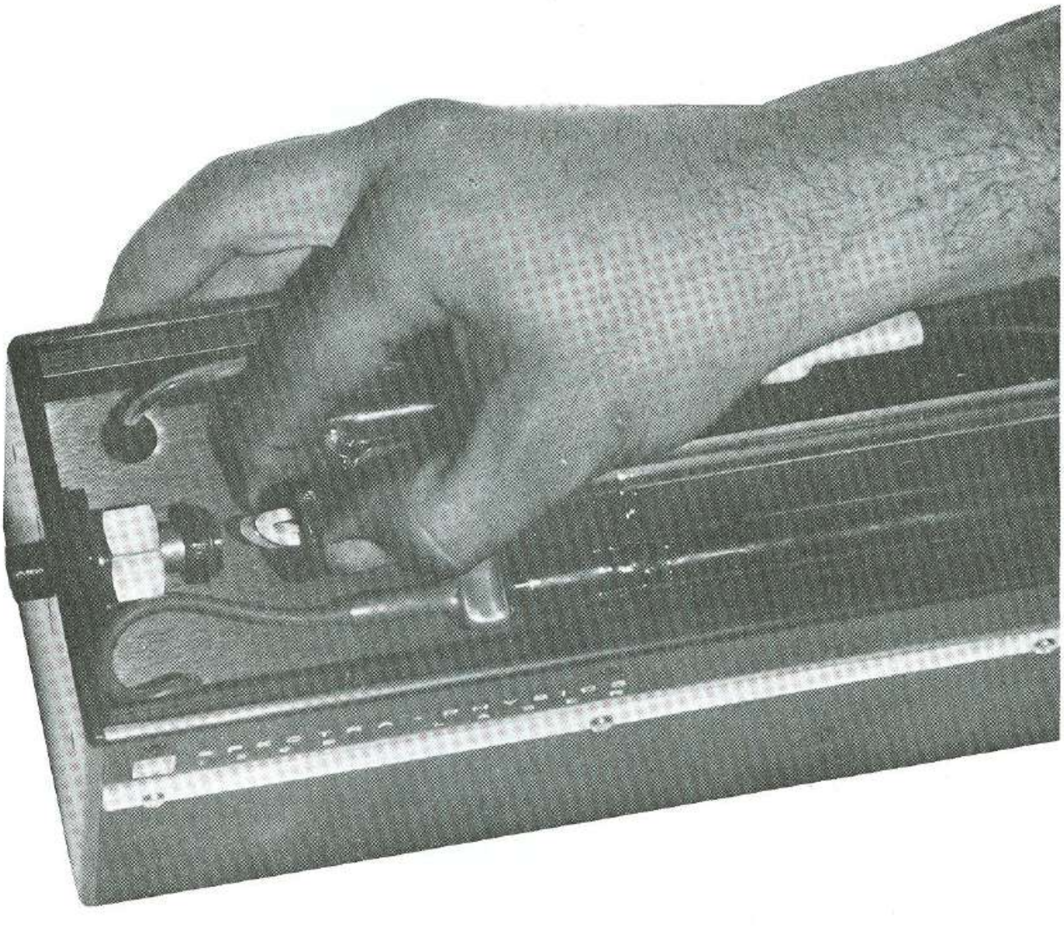


Figure 4 - 1 Dust Cover Removal

> stand in bulk on the surface of the reflector catastrophic disruption of the coating may result.

Reflectors should never be stored in areas of high humidity where water may condense on the coated surfaces. Storage under these conditions may result in slow degradation of the coating.

In normal use, dust may be removed with a lens cleaning brush. Use particular care in handling to prevent fingerprints from appearing on the optical surfaces.

Although every attempt is made to provide reflectors of uniformly high quality, slight inhomogeneities in reflection surfaces inevitably occur. In addition, some mirrors appear to have a preferred polarization and an optimum orientation relative to the Brewster's angle windows. Therefore, laser operation may vary with the rotation of the mirrors.

4.2 CARE OF THE PLASMA TUBE

The plasma tube should be treated with extreme care, especially if it should require replacement or realignment. The plasma tube has been properly aligned at the factory prior to shipment so that the axis of the tube corresponds to the center of the mirror reflecting surfaces. Proper alignment is necessary in order that reflections from the surfaces of the inside wall of the plasma tube be minimized.

4.2.1 REMOVAL OF THE PLASMA TUBE

The plasma tube may be removed by removing the top section of the plasma tube supports (See Figure 4-2). Unplug the two power-supply leads, and remove the locking springs which hold the dust covers to the reflector mounts before removal. Be careful not to damage the Brewster angle windows or scratch the reflectors when removing the tube. Upon removal note the possibly differing sizes and locations of the half O-rings inside both the top and bottom halves of the plasma tube supports. When replacing the same tube, be sure the original size half O-rings are used in the original positions inside both halves of the plasma tube supports. Different size half O-rings may have been necessary to obtain proper tube alignment between the reflectors. If realignment is required or a replacement tube is being installed, see the following alignment procedure.

4.2.2 ALIGNMENT OF THE PLASMA TUBE

The axis of the plasma tube may be aligned as follows:

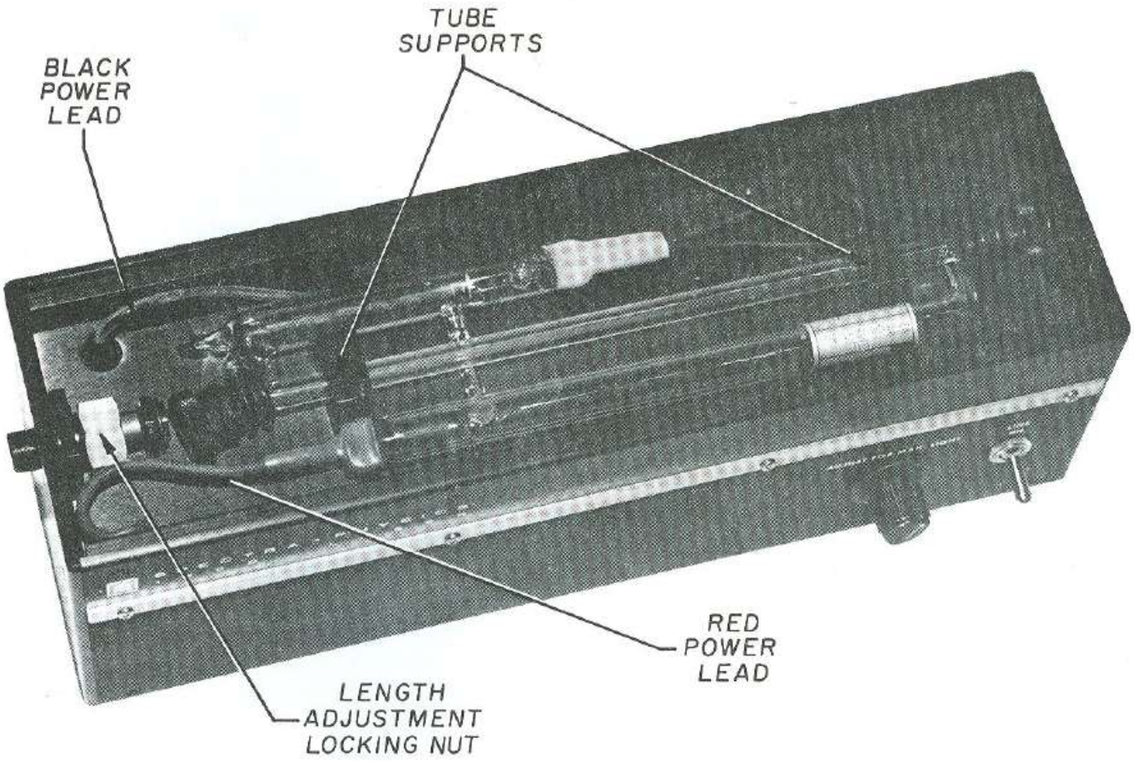


Figure 4 - 2 Model 130 with Top Cover Removed

(1) Strike a low intensity discharge in the plasma tube or place a light bulb at the opposite end of the tube.

(2) Sight each end of the plasma tube through the adjacent reflector. The i.d. of the tube should be centered in the reflector at each end.

(3) If the tube is not centered, remove the top halves of the tube supports (Figure 4-2) and change the sizes of the half O-rings in the tube supports to bring the centers to the desired position. Tighten down the tube supports (do not exert excessive force on the tube) and recheck for centering.

4.2.3 PLASMA DISCHARGE

The plasma glow discharge is normally reddish-orange and should fill the plasma tube and electrode appendages with approximately uniform intensity and color. It is possible that after extended periods of idleness the plasma discharge may exhibit a slight blue tinge. This color will normally disappear after a reasonable period of operation. If the blue persists after several hours of continuous use, it is likely that the tube should be returned to the factory for refilling.

4.3 ALIGNMENT OF REFLECTORS

Angular adjustment of the reflectors about axes plus and minus 45° from the vertical is made by means of the dual set screws seen in Figure 3-1. Angular adjustment should be performed about one axis at a time with set screws tight for the other axis of rotation. For adjustment loosen the locking screws (inside larger screws) about one-quarter turn, and then the two adjusting screws (outer smaller screws) are systematically moved to obtain the desired rotation. For example, to rotate the mirror about the 45°-225° axis in such a fashion that the 135° sector is moved inward towards the cavity, the adjusting screw at 315° is loosened and the adjusting screw at 135° is tightened. After both adjusting screws are tightened to the desired positioning, the locking screws are retightened. While all these adjustments are being made, the four set screws for the other axis of rotation remain tight.

Two alignment procedures are suggested below. The first procedure is:

a-1 Place a spherical reflector in each reflector mount.

a-2 Loosen the adjusting screws (Figure 3-1) at each end and tighten the locking screws until both reflector mounts are flush against the end plates of the unit.

a-3 Turn the unit on and an output beam should be observed. If not, loosen the length adjustment locking nut (Figure 4-2) and slide the length adjustment in and out until an output is observed.

a-4 Walk the reflector mounting plates in slightly (far enough to be able to adjust about each rotational axis) by carefully loosening the locking screws and tightening the adjusting screws without losing the output beam.

a-5 With the unit now operating in the confocal configuration, adjust the reflector mount at each end until the laser beam spot appears to be centered on the opposite reflector.

a-6 Replace the spherical reflector at the right end (Figure 1-1) with a flat reflector, and operate in the hemispherical resonator configuration. An adjustment of the length may be necessary to operate or to obtain the TEM_{00} mode. Readjust the reflector mount holding the remaining spherical reflector (at the left or length adjustment end) until the small beam spot on the flat reflector is precisely centered (a machinist's scale held across the reflector aperture will help).

a-7 Reverse the reflectors and adjust the mirror mount now holding the spherical reflector (at the right end) until the spot on the flat reflector is precisely centered.

a-8 For final adjustment, fine-adjust the reflector mounts for maximum power.

> NOTE
>
> The reflector mounts on the Model 130 are mounted on the end plates of the unit. Therefore, the end plates, side plates and top and bottom plates are carefully machined and assembled to provide a rigid mounting for the optical cavity. If the unit is disassembled, therefore, it may be necessary to realign the reflectors for optimum output upon reassembly.

The second alignment procedure is:

b-1 Place a spherical reflector in each mirror mount.

b-2 Illuminate the plasma tube with a light bulb placed at the opposite end of the tube.

b-3 Sight directly down the axis of the tube while holding a flashlight on one rotational axis (for 45°-225° axis, hold flashlight at 45°) and approximately in the plane of the reflector. Shine the flashlight into your eye.

b-4 Observe the image of the pupil of the eye, appearing on the opposite end of the reflector. If difficulty is encountered in observing this reflection, remove the flashlight beam from the eye and observe the simultaneous loss of the image.

b-5 Adjust the locking and adjusting screws at the 135^{o} and 315^{o} positions and note that the image of the pupil of the eye moves parallel to the 135^{o}-315^{o} axis although it may not fall on this axis. Adjust until the image falls on the 45^{o}- 225^{o} axis.

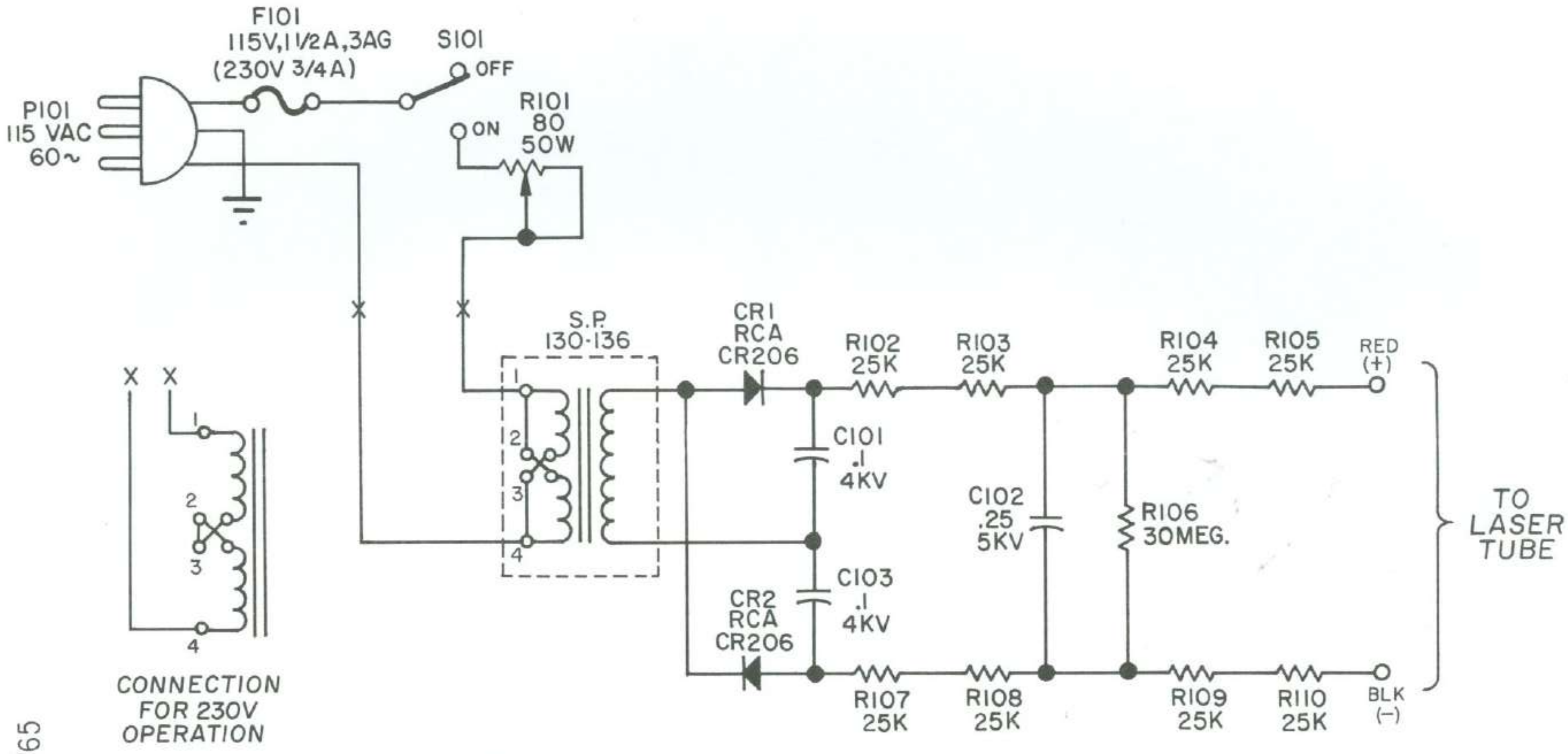
b-6 Repeat steps 3, 4, 5 holding the flashlight on the 135^{o}-315^{o} axis and adjusting until the image falls on the 135^{o}- 315^{o} axis.

b-7 Repeat for the other reflector. The unit should now operate in the confocal configuration and steps a-5 through a-8 should be followed.

4.4 POWER SUPPLY

> **CAUTION**
>
> The Model 130 power supply contains very dangerous voltage levels. If a power supply malfunction is suspected, it is recommended that the unit be returned to the factory for repairs.

The Model 130 power supply consists of a potentiometer-controlled AC supply and a full-wave rectifier circuit with r-c filtering. The output terminals provide approximately 5000 volts unloaded and 1500 volts at 6 to 11 ma when loaded. Transformer T102 furnishes 2.5 volts at approximately 5 amps for the plasma-tube filament.



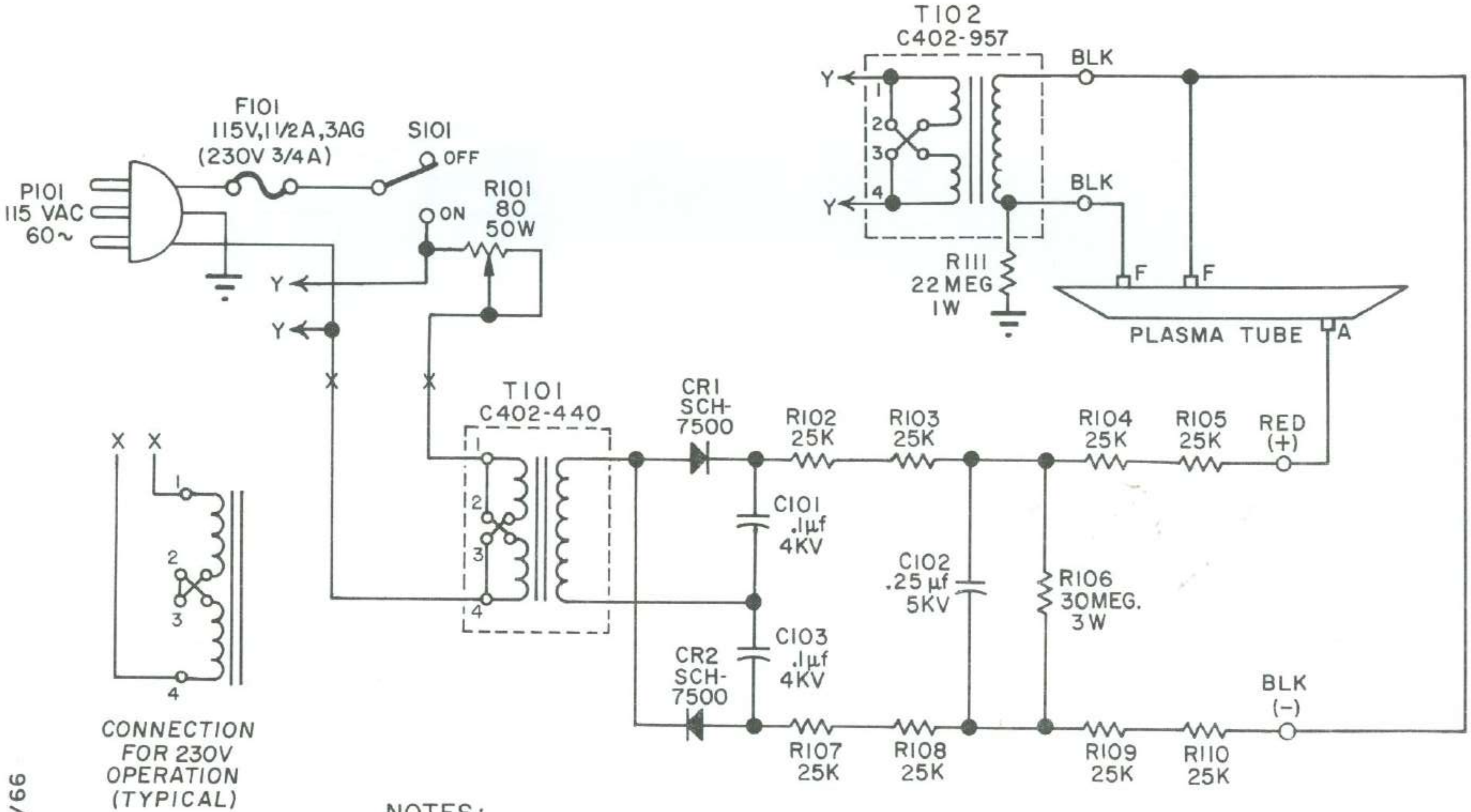
11/25/65

NOTES:

1. ALL RESISTOR VALUES ARE IN OHMS UNLESS OTHERWISE SPECIFIED.
2. ALL CAPACITOR VALUES ARE IN MICROFARADS UNLESS OTHERWISE SPECIFIED.

SERIAL No. 469 & ABOVE

Model 130B Power Supply Schematic (B402-784B)



NOTES:

1. ALL RESISTORS 10W UNLESS OTHERWISE SPECIFIED.

6/6/66

SERIAL No. 720 & ABOVE

Model 130 Hot Cathode Power Supply Schematic (B402-784D)

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 excited 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 that 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.

CLAIM FOR DAMAGE IN SHIPMENT

Your instrument should be inspected and tested as soon as it is received. The instrument is packaged for safe delivery. If the instrument is damaged in any way, file a claim with the carrier or, if insured separately, with the insurance company.

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. You should use the original shipping carton. If the original carton is not available, wrap the instrument in heavy paper or a plastic bag and surround it with four to six inches of shock-absorbing material to cushion it firmly. Be certain the container is sturdy and full of packing material to prevent movement of the instrument in the container.

GENERAL

Your nearest Spectra-Physics Representative, Field Office or Service Center is ready to assist you in any situation. Refer to the list on the following pages.

SPECTRA-PHYSICS SALES ENGINEERING REPRESENTATIVES

Maine, New Hampshire, Vermont, Massachusetts, Rhode Island, Connecticut

APPLIED MEASUREMENTS, Inc.

*Acton, Massachusetts
(617) MI6-7250

Hamden, Connecticut
(203) 248-5048

New York State, Northern New Jersey

SBM ASSOCIATES, Inc.

*Rochester, New York
(716) BR1-7430

Union, New Jersey
(201) 687-8737

Syracuse, New York
(315) 454-9377

Plainview, New York
(516) 433-1421

*Thornwood, New York
(914) 769-1811

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(201) 542-1441

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(303) 934-5505

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(505) 265-7766

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(214) AD1-2573

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(713) M06-4188

Canada

ALLAN CRAWFORD ASSOCIATES, Ltd.

*Downsview, Ontario
(416) 636-4910

Ottawa, Ontario
(613) PA5-1288

Montreal, Quebec
(514) RE9-6776

SPECTRA-PHYSICS FIELD ENGINEERING OFFICES
(for areas not covered above)

Spectra-Physics Inc. (home office)
1255 Terra Bella Avenue
*Mountain View, California
(415) 961-2550
TWX 415 969-9135

Spectra-Physics, Inc.
So. Calif. District
Office
Los Angeles, Calif.
(213) 462-7639

Spectra-Physics, S.A.
Chemin de Somais 14
*Pully, Switzerland
Telephone: 28.35.35
Telex: specphysa lsn 24838

* Spectra-Physics Authorized Service Center

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