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ARGON/KRYPTON ION LASER SYSTEM

OPERATIONS MANUAL

MODEL 52

Argon/Krypton Ion Laser System

OPERATION MANUAL

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1.0 SPECIFICATIONS

1.1 Laser Medium -- Ionized Argon or Krypton

1.2 Output Power (All Lines)-- Argon - 2-Watts
Krypton - 0.3-Watts

1.3 Output Power Vs. Wavelength

Argon			Krypton		
Wavelength	Simultaneously	Singly, w/prism	Wavelength	Simultaneously	Singly, w/prism
514.5 nm	700 mw	700 mw	676.4 nm	--	5 mw
501.7 nm	150 mw	150 mw	647.1 nm	150 mw	150 mw
496.5 nm	150 mw	150 mw	568.2 nm	60 mw	60 mw
488.0 nm	700 mw	700 mw	530.8 nm	--	60 mw
476.5 nm	250 mw	250 mw	520.8 nm	60 mw	60 mw
472.7 nm	--	30 mw	482.5 nm	--	20 mw
465.8 nm	--	30 mw	476.2 nm	30 mw	30 mw
457.9 nm	50 mw	50 mw	468.0 nm	--	5 mw
			461.9 nm	--	5 mw

Total Power (All Lines): 2 Watts (TEM_{00}) Total Power (All Lines): 300 mw (TEM_{00})

1.4 Beam Diameter -- 1.4 mm at $1/e^2$ points.

1.5 Beam Divergence -- 0.8 milliradians.

1.6 Excitation -- Regulated DC.

1.7 Cooling System -- Flow-through water; 2 gpm @ 30 psi.

1.8 Power Requirement -- 3-phase, 3-wire, 200-240 volts, 35 amperes.

1.9 Laser Head Dimensions -- 8"W x 8"H x 50"L with 8' umbilical cable.

1.10 Laser Head Weight -- 60 lbs.

1.11 Power Supply Dimensions -- 19"W x 9"H x 18"D

1.12 Power Supply Weight -- 90 lbs.

1.13 Warranty -- One Year.

2.0 SAFETY PRECAUTIONS

2.1 Laser Operation

The Model 52 is capable of producing severe eye damage if improperly handled. No person other than a thoroughly trained operator should be allowed to use the laser or direct or manipulate the output beam.

The laser should be installed in a work area which has been designed to protect personnel from inadvertent exposure to the beam. The primary consideration should be protection of the eye from a direct or reflected laser beam. It is also advisable not to look directly at scattered laser light from a light colored object as the light spot is very intense. If possible, keep experimental setups at a low height to prevent inadvertent encounter with an eye-level beam.

Reflecting or refracting objects should not be moved into the beam without careful consideration of the new beam path. Although eye damage is probably the greatest hazard involved with the Model 52 ion laser, it should be noted that the power level is sufficient to kindle many materials such as paper, cloth, wood and paints.

Flesh burns, while usually minor, are easily produced. Users should know that the focused beam is being investigated as a surgical scalpel.

Post warning signs.

Protect against unauthorized access.

Safety glasses which reject many laser wavelengths are available. However, users should ascertain that the glasses have been specifically designed for the particular wavelengths emitted by Argon or Krypton Ion Lasers.

2.2 Electrical System

The Model 52 Ion Laser is operated by DC power rectified directly from a 208 volt, 3-phase, power line. The voltages are sufficient to give a dangerous shock and relatively high currents are involved. Every portion of the electrical system, including the printed circuit card, should be assumed to be at power line potential.

If the laser head is open while in operation, contact with the gas ballast tank and fill system should be avoided as it is possible for the gas in the tube connecting this system to the laser to become ionized bringing the metal assembly to cathode potential.

Power should be disconnected before opening the power supply and the large electrolytic filter capacitor should be shorted before undertaking any work inside the supply.

Use extreme care if testing inside the power supply or laser head is required while the system is operating. Ground leads from grounded external test equipment may be connected only to the chassis of the power supply or laser.

3.0 UNPACKING AND ASSEMBLY

3.1 Unpacking

The equipment is shipped in two separate containers. Check that all items are present according to the shipping list. While unpacking, check that everything was received in good condition. Remove laser head cover to inspect laser tube for visible shipping damage. Any damage should be reported at once to the shipping carrier and to COHERENT RADIATION LABORATORIES.

3.2 Assembly

3.2.1 Laser Head

The laser head is normally shipped in operating condition, and, if a wavelength selecting prism assembly has been ordered, it will normally be shipped separately. It should not be installed until the laser has been operated and aligned using the mirror which is shipped in place.

3.2.2 Interconnections

The cables and water lines from the laser head should be connected to the power supply. The inlet and outlet water connections from the laser must not be interchanged as the laser is protected from over-heating by means of a thermistor in the laser head which responds to outlet water temperature. A relief valve is fitted on the return line from the laser.

3.2.3 Electrical Power

Electrical power should be connected to the power supply by means of a suitable cable connected to the terminal block inside the the supply. Four wires are required; three for 3-phase power and the fourth for chassis ground. Phase sequence is unimportant. For safety reasons, the power supply chassis should be connected to ground using a wire at least as large as the power supply wires.

3.2.4 Water Supply

The water supply and drain should be connected to the fittings on the rear of the power supply by means of ordinary garden hose. Pressure differential required is approximately 30 psi. A water filter is supplied with the equipment and should be installed at the supply valve. The water flow rate required varies with the water supply temperature according to the following table:

Inlet Water Temperature	Minimum Flow Rate
°C	GPM
20	1.6
25	1.75
30	2.0
35	2.4
40	3.0

If the water flow is inadequate, the power supply breaker will trip off after several minutes of operation.

4.0 OPERATION

4.1 Transformer Taps

Before initial operation of the equipment, taps on transformers T101 in the power supply and T203 in the laser head must be connected according to the line voltage to be used and the filament voltage specified for the laser tube (see final test results).

4.1.1 Power Auto-Transformer Taps

Before initial operation, measure the line voltage to be used and connect the power auto-transformer T101 according to the following table.

Line Voltage	Connect Input Wires (Labeled 1) to Terminals	Connect Output Wires (Labeled 2) to Terminals
Below 192	1, 2, 3	10, 11, 12
192-200	"	7, 8, 9
200-208	"	4, 5, 6
208-215	"	1, 2, 3
215-224	4, 5, 6	"
224-234	7, 8, 9	"
234-242	10,11,12	"

Because of power line voltage drop under load and variations in laser tube voltage drop, it may be necessary to change the connections of these taps after the laser has been tested. See Paragraph 4.4.1 for the procedure to be followed.

4.1.2 Filament Transformer

Taps on the filament transformer are normally selected at the factory and the filament voltage (see final test results for correct value) will be within tolerance after the correct taps are selected on the power auto-transformer, T101. The filament voltage can be checked by removing the top cover from the laser head and measuring the voltage across the filament transformer secondary terminals. The filament voltage is changed if necessary by moving the snap on connectors on the filament transformer primary. Terminals 1 and 5 are used for lowest filament voltage and terminals 1 and 2 for the highest filament voltage.

4.2 Cooling

Water must be flowing in the cooling system before turning on AC power at the power supply. If a valve is used on the drain line, it must be opened before the supply line valve or the safety relief valve provided on one of the laser fittings will open, spraying water around the room. Always open drain and supply valves before applying power to the unit and close supply and drain valves at least 10 minutes after shutting off power. The 10-minute cool-down period is required to remove heat stored in the segments of the laser tube.

4.3 Starting

Turn on AC power at the power supply. The power light and delay light will come one. After approximately 15 seconds, the delay light will go off. Turn the output current control knob on the power supply front panel to about mid-range and press the start button momentarily. The laser current meter should jump up, indicating current to the tube. This current should be controllable by means of the front panel control up to 30 amperes and down to 15 amperes or less. If laser does not start, see section 8.1.

4.4 Adjustments

4.4.1 Transformer Taps

Observe the pass transistor voltmeter while adjusting the front panel laser current control. The pass transistor voltmeter should stay within the marked operating range of 10 to 40 volts over the current range of 15 to 30 amperes. If the current cannot be brought up to 30 amperes or the voltmeter drops below 10 volts at this setting, the power auto-transformer should be set for the next lower line voltage connection as indicated in the table given in Paragraph 4.1.1. If the current cannot be adjusted below 15 amperes or the pass transistor voltmeter goes above 40 volts at 15 amperes, or if the laser current meter goes to full scale and the circuit breaker trips off when the laser is started, adjust the auto-transformer to the next higher line voltage setting as called out in the table.

4.4.2 Laser Mirrors

The laser mirrors should be adjusted for maximum light output. Normal variations caused by shock in transportation or temperature change can be compensated by adjustment of the mirror at the rear end of the laser without the necessity of moving the output mirror. The adjustment can best be done using a laser power meter such as the COHERENT RADIATION LABORATORIES' Model 201 or 212. The vertical and horizontal adjusting knobs should be turned for maximum output. If power is still low, clean inside surfaces of both mirrors (see maintenance test procedure addenda) and outside surface of output mirror as well as Brewster windows. Only as a last resort should the output mirror be adjusted, in which case a walking procedure must be used. This consists in making a small change in the setting of either vertical or horizontal adjustment of the output mirror and then readjusting the corresponding adjusting knob on the rear mirror for maximum output. If this maximum is larger than the maximum obtained before adjusting the front mirror, make another rear mirror adjustment in the same direction. If it is smaller, adjust in the opposite direction. This procedure should be followed first for the vertical axis and then the horizontal axis. The output mirror is carefully adjusted at the factory by this procedure and can be expected to remain in proper adjustment for the life of the equipment under normal conditions. Unless there is reason to believe that adjustment of the output mirror has been disturbed, it is best left alone.

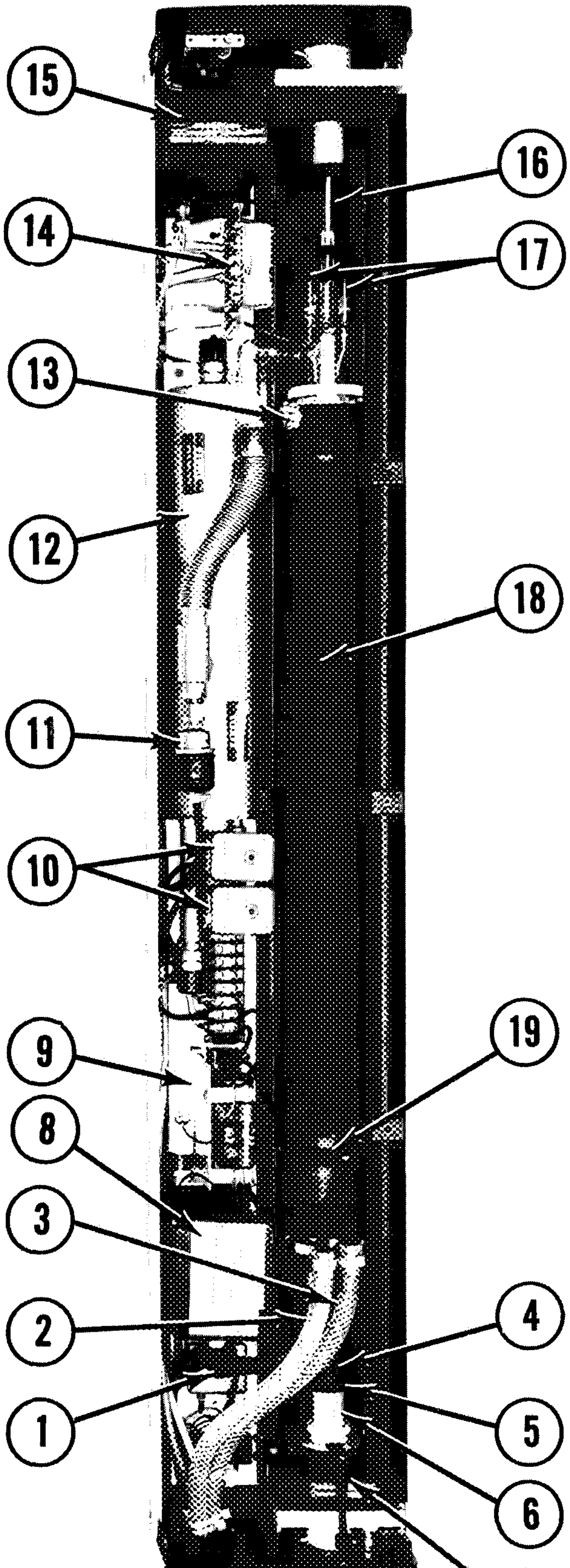
5.0 GAS SUPPLY SYSTEM

A gas supply system is provided in the laser head to make up for the the loss of gas into the walls of the laser tube during normal operation. The laser will require a gas fill about every 10 hours when new and the interval between fills can be expected to lengthen as the tube ages. A thermocouple gauge is provided in the laser head to actuate the laser pressure meter on the power supply. The correct operating pressure is stated on the test sheet delivered with the laser. When the pressure drops below the stated value, the refilling system should be activated. A pressure difference from the final test value of less than 10 microns for argon or 5 microns for krypton will not noticeably affect the laser performance. Pressure should be read after warm-up at 30 amperes laser current. Turn the locking key clockwise and press and release first the ready button and then the fill button. An increase in the pressure as indicated by the front panel gauge should be observed. If the laser pressure is allowed to drop beyond these limits, a decrease in the output of the laser can be expected. The key switch is provided to aid in preventing careless or unauthorized use of the fill system. If the fill system is actuated repeatedly, it is possible to bring the tube pressure up to an excessive value (greater than 350 millitorr) preventing starting of the discharge. The tube must then be reprocessed with suitable vacuum apparatus, preferably at the COHERENT RADIATION LABORATORIES factory. This will not normally be considered a warranty repair.

6.0 GENERAL DESCRIPTION

6.1 Laser -- Theory of Operation (See Fig. 6.1)

The Model 52 Ion Laser consists principally of a high-current gas arc-discharge tube, excited with direct current, placed in an optical cavity.



1. Anode Lead Connection
2. Outlet Water Hose
3. Inlet Water Hose
4. Brewster Window Dust Shield
5. Dust Shield Retaining Nut
6. Etalon Dust Shield
7. Etalon Mount
8. Starter Transformer (T202)
9. Starter Circuit Support
10. Gas Fill Solenoids (V201-V202)
11. Thermocouple (TC) Gauge
12. Ballast Tank
13. Thermistor
14. P.C. Board
15. Filament Transformer (T203)
16. Brewster Window Dust Shield
17. Cathode Pin Leads
18. Solenoid Heat Sink
19. Solenoid Retaining Clamps

Fig. 6.1
Laser Head - Internal View

A high percentage of the gas atoms are in the ionized state. As in all gas lasers, population inversion amongst pairs of energy levels occur and, in the case of Kr^+ and Ar^+, exhibit gain at frequencies in the visible part of the electro-magnetic spectrum. The optical cavity provides the feedback and output coupling for self-sustained oscillation and useful output.

The arc-discharge is restricted to a small diameter by a graphite bore structure with the bore holes maintained in optical alighment. The discharge is terminated at a concentric cathode and anode allowing the optical beam to pass through to the Brewster windows. A gas bypass is provided to minimize the unwanted effects of gas pumping. The voltage drop in the bore region is 6 V/cm, at 30 A current, resulting in 7.5 kw being dissipated in the bore. A major consideration of tube construction is that of providing for the dissipation of this large power in a precisely aligned and relatively small structure. In the Model 52, the graphite disk temperature rises to 1000°C (at 30 A), due to the discharge. At 1000°C, the disks radiate the energy (11 watts/cm^2) through a quartz wall to a water flow jacket about the tube. This water-cooling serves to remove virtually all the tube power from the optical cavity. Additional stainless steel parts of the laser tube, shown in Fig. 6.1, perform important functions in the performance of the tube. These are a ballast volume and gas refill system. The gas ballast is a stainless steel tank, connected to the quartz laser tube jacket via a stainless steel bellows and a glass-to-metal seal. The function of the ballast is threefold:

(1) It supplies a large volume of gas which lessens the effect of gas clean-up, (2) It maintains the gas pressure at the proper value at the cathode despite anode pumping (no gas bypass can be totally effective), and (3) It provides an expansion chamber for the gas driven from the bore when the bore reaches 1000°C during operation.

A solenoid electromagnet encloses the tube bore and provides an axial magnetic field of 850 Gauss for Ar^+ and 400 Gauss for Kr^+. The function of the field is to increase the power output by increasing the ion density (the active laser medium is the ionized gas) without lowering the electron energy enough to degrade the laser excitation. The magnetic field also decreases the formative time lag in arc initiation through this same mechanism.

From an electrical point of view, the operation of a Kr^+ tube and and Ar^+ tube is virtually identical (with the major exception, the difference in axial magnetic field). The tubes are interchangeable in the laser head and use the same control console. However, the optical output characteristics are quite different. The Model 52A (Ar^+) emits a minimum of 2-watts in the blue-green region of the visible spectrum (457.9, 465.8, 472.7, 476.5, 488.0, 496.5, 501.7 and 514.5 nm) with principal laser emission at 488.0 and 514.5 nm. The Model 52K (Kr^+) emits a minimum of 300 mw spread principally in four lines from the blue to the red at 476.2, 520.8, 568.2 and 647.1 nm. With the reflectors provided, the laser emission is white in appearance with these four lines in simultaneous oscillation.

The power and control circuitry requirements for the dc excited ion laser tube are provided by the power supply. These involve filtered dc for the discharge tube and the electromagnet, as well as a controller for a thermocouple gauge tube.

The optical cavity is composed of a flat and a 5m sphere 1.18m apart. The flat is interchangeable with a wavelength selective prism (COHERENT RADIATION Model 431) for single line operation. A broad band (440 to 660 nm) high reflectivity coating is applied to the flat. The 5m sphere is the coupling reflector. It has a broad band transmitting coating for Kr^+ operation and a normal multilayer dielectric coating for Ar^+. The reflectors are held in adjustable mounts. These have an angular resolution of 0.1 milliradians. When the prism wavelength selector is employed, single line oscillation is obtained and set on a particular line through use of a calibrated drum dial. The drum drives the prism through a lead screw. A heat shield between the laser tube and resonator structure minimizes thermal distortion of the resonator. Dust shields enclose the Brewster angle windows and reflectors.

The output characteristics of the laser are controlled by the cavity configuration, power input, discharge conditions, and atomic properties of Ar^+ and Kr^+. The cavity configuration limits operation to a single transverse mode with a beam diameter of less than 1.4 mm at the $1/e^2$ points and a beam divergence of less than 0.8 milliradians (for TEM_{00}). The axial mode spacing is 115 MHz. However, the Doppler broadened line width is of the order of a few GHz. Therefore, many axial modes may oscillate simultaneously (depending upon current level or gain in excess of losses). This limits fringe visibility (coherence length) to less than 10 cm under normal operation. A COHERENT RADIATION LABORATORIES Intra-Cavity Etalon (Model 421) provided as an accessory to the Model 52 can increase fringe visibility to 10m.

6.2 Gas Supply System (See Fig. 6.2)

The gas supply system consists of a reservoir filled with argon or krypton, as appropriate, to a pressure of approximately 1 atmosphere and 2 solenoid valves in series connecting this reservoir to the laser. The small volume between the valves is filled by opening the first valve, V201, when the ready button on the power supply is depressed. This valve is then closed and the gas trapped in the small volume released into the laser when valve V202 is opened by pressing the fill button. The buttons are electrically interlocked so that it is impossible to open both valves at the same time. The volume between valves and the make-up reservoir pressure are chosen to give an appropriate increase in laser pressure when the two valves are cycled as described above.

6.3 Cooling System (See Fig. 6.3)

Filtered water is used in a flow-through system to cool the power supply and laser head. Tap water or re-circulating cooling water is brought into the power supply where it flows through a large heat sink. The pass transistors and rectifiers are mounted on the heat sink. Heat dissipated by the transformer, filter choke and other

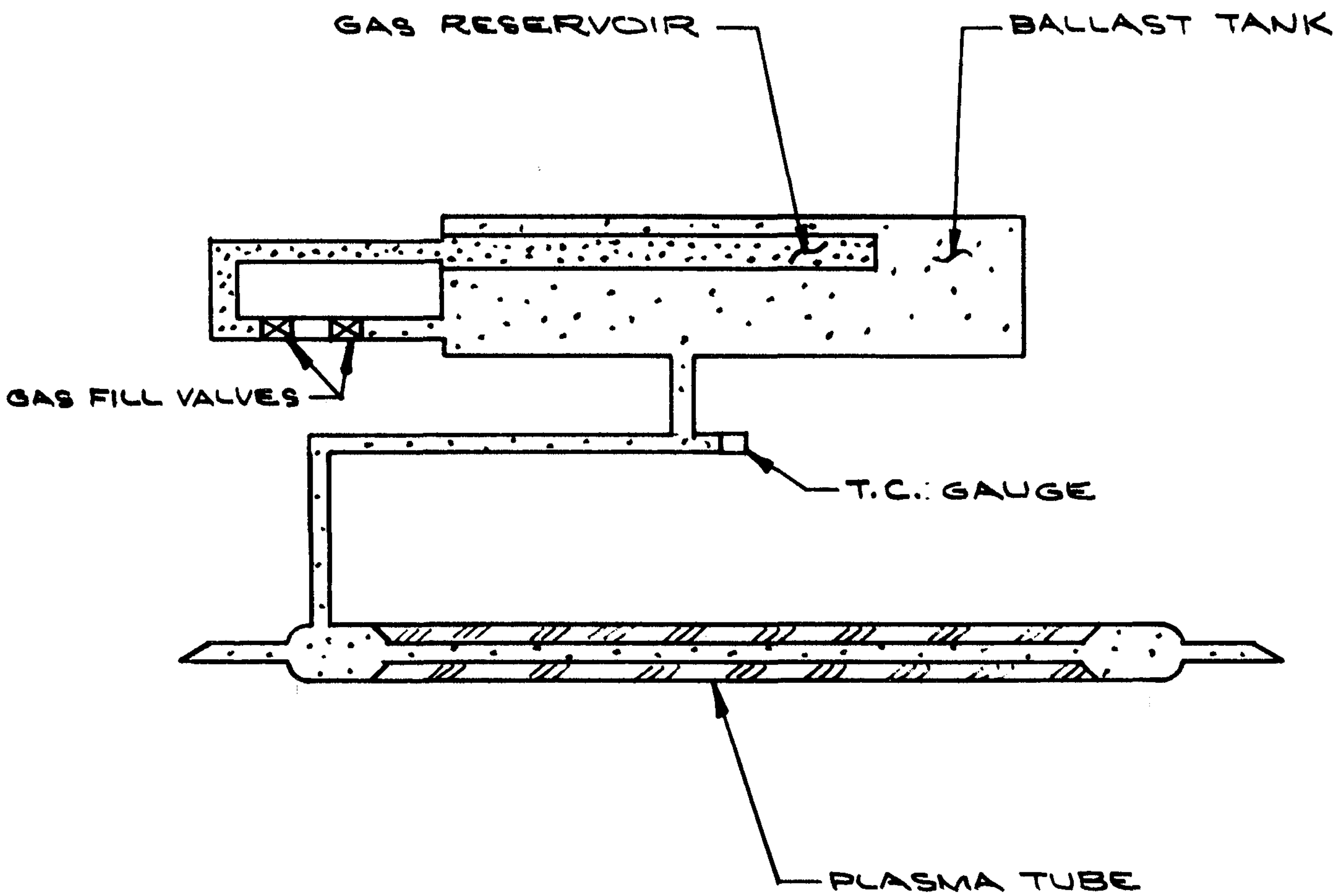


FIG. 6.2

GAS SUPPLY SYSTEM SCHEM.

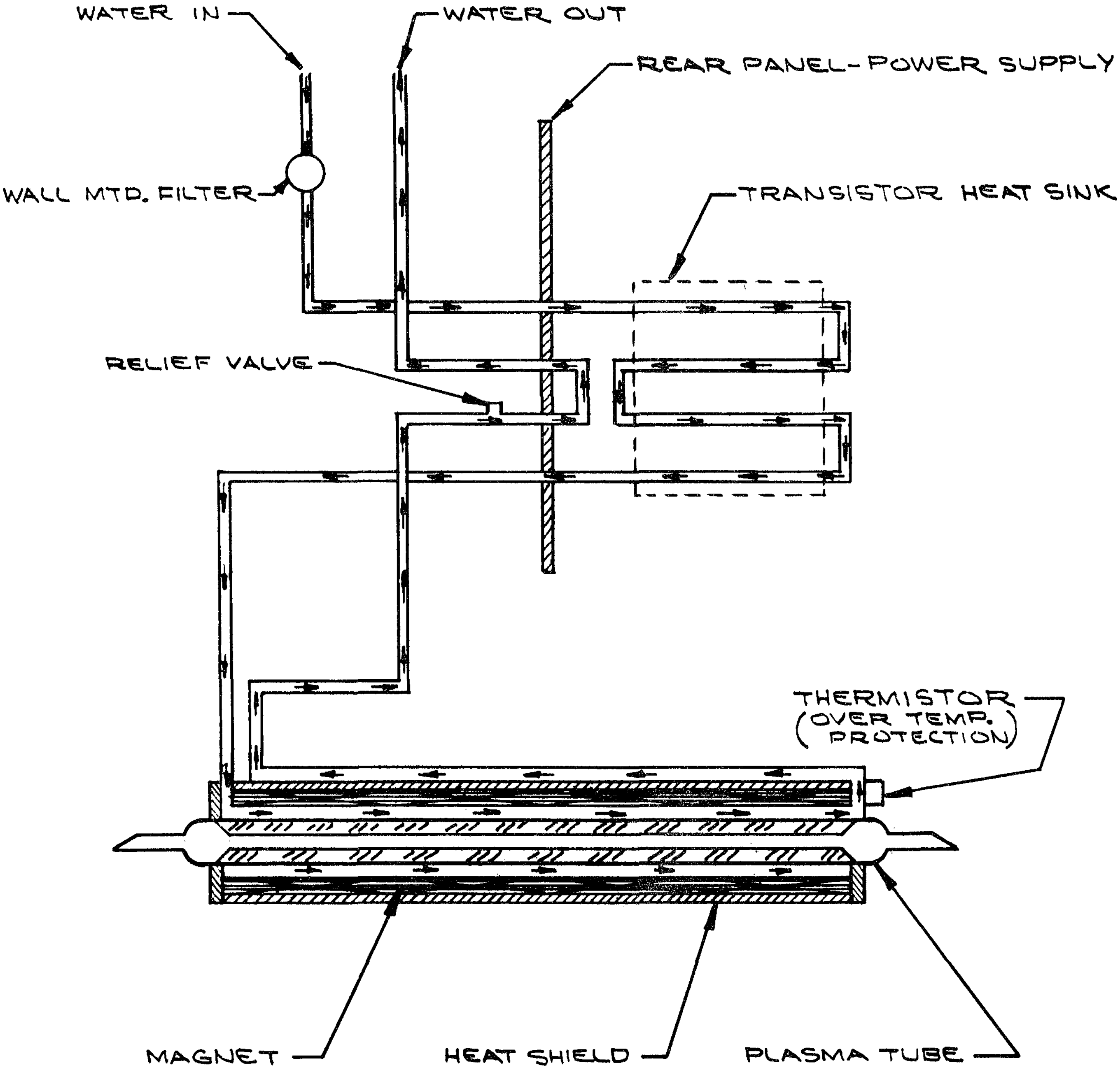


FIG. 6.3

WATER FLOW SCHEM.

power supply components, is transferred primarily to the heat sink by convection within the power supply cabinet. Water leaving the heat sink is conducted to the laser head where it flows through a channel between the laser tube and solenoid. A water-cooled heat shield is provided outside the solenoid for the purpose of preventing distortion of the laser resonator structure because of heat radiation from the magnet. A thermistor is mounted at the outlet end of the cooling jacket for the purpose of sensing the water temperature. If the water flow rate is inadequate, this temperature will rise and the thermistor will actuate circuitry which turns off the main power breaker in the power supply. Sufficient power is dissipated in the thermistor to cause it to heat to the trip point if it is not immersed in water. This protects the laser from damage if it should be operated with no water in the cooling system.

6.4 Power Supply (See Figures 6.4.1, 6.4.2, 6.4.3)

The power supply provides dc power to the laser tube and magnet by means of rectification directly from a 3-phase, 208 V, power line. A buck/boost auto-transformer is provided which allows operation over the line voltage range of 200 to 240 volts by changing connections. The auto-transformer is capable of adding or subtracting voltages up to 15 volts in five volt steps to the line to neutral voltage. The main power switch is a circuit breaker which must be manually closed but automatically opens in the event of excessive current, excessive temperature in the cooling system or opening of the cover which actuates the cover interlock switch. Fast acting fuses are provided to protect the rectifiers in the event of short-circuit.

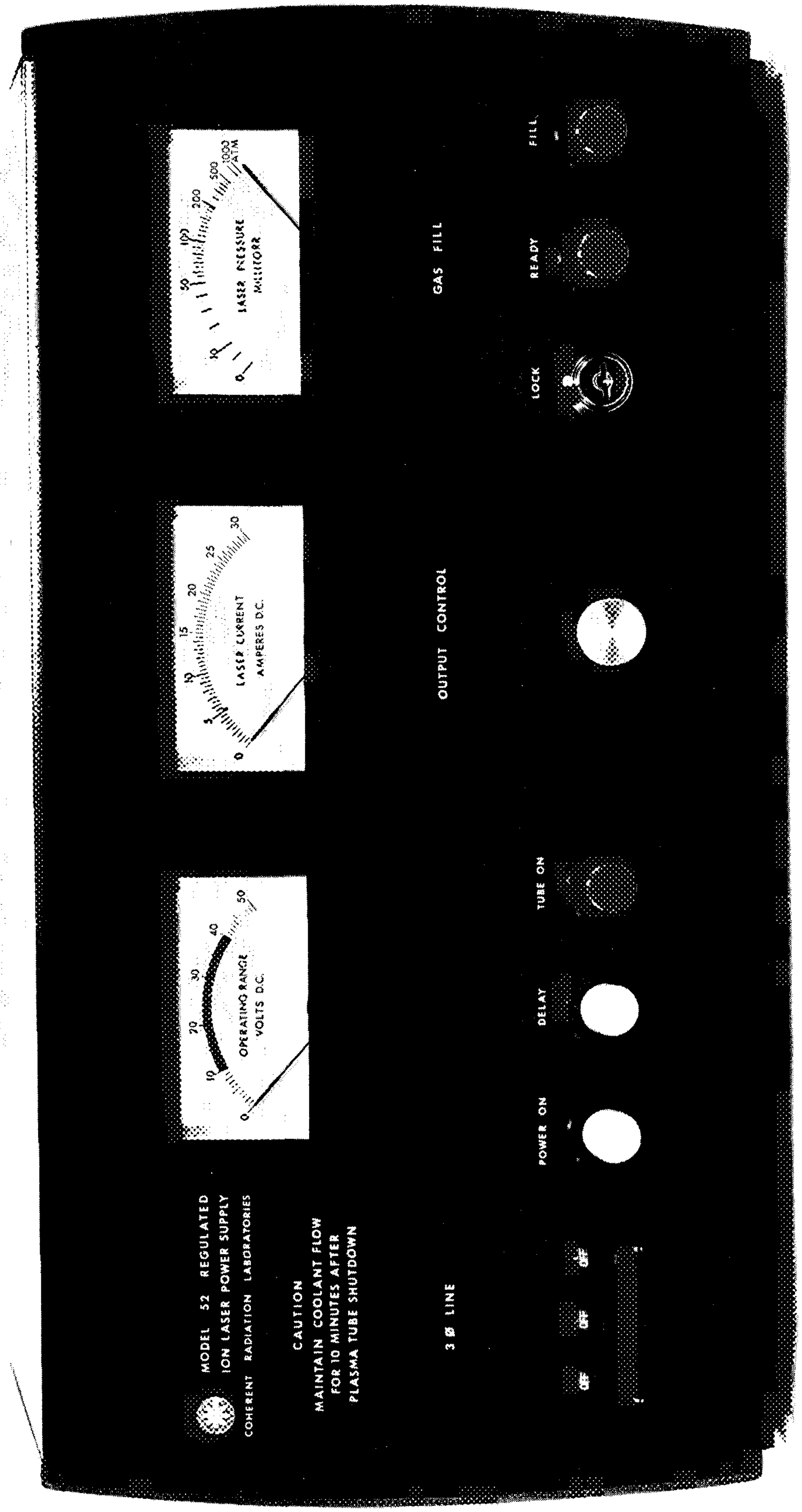


FIGURE 6.4.1

POWER SUPPLY, FRONT PANEL

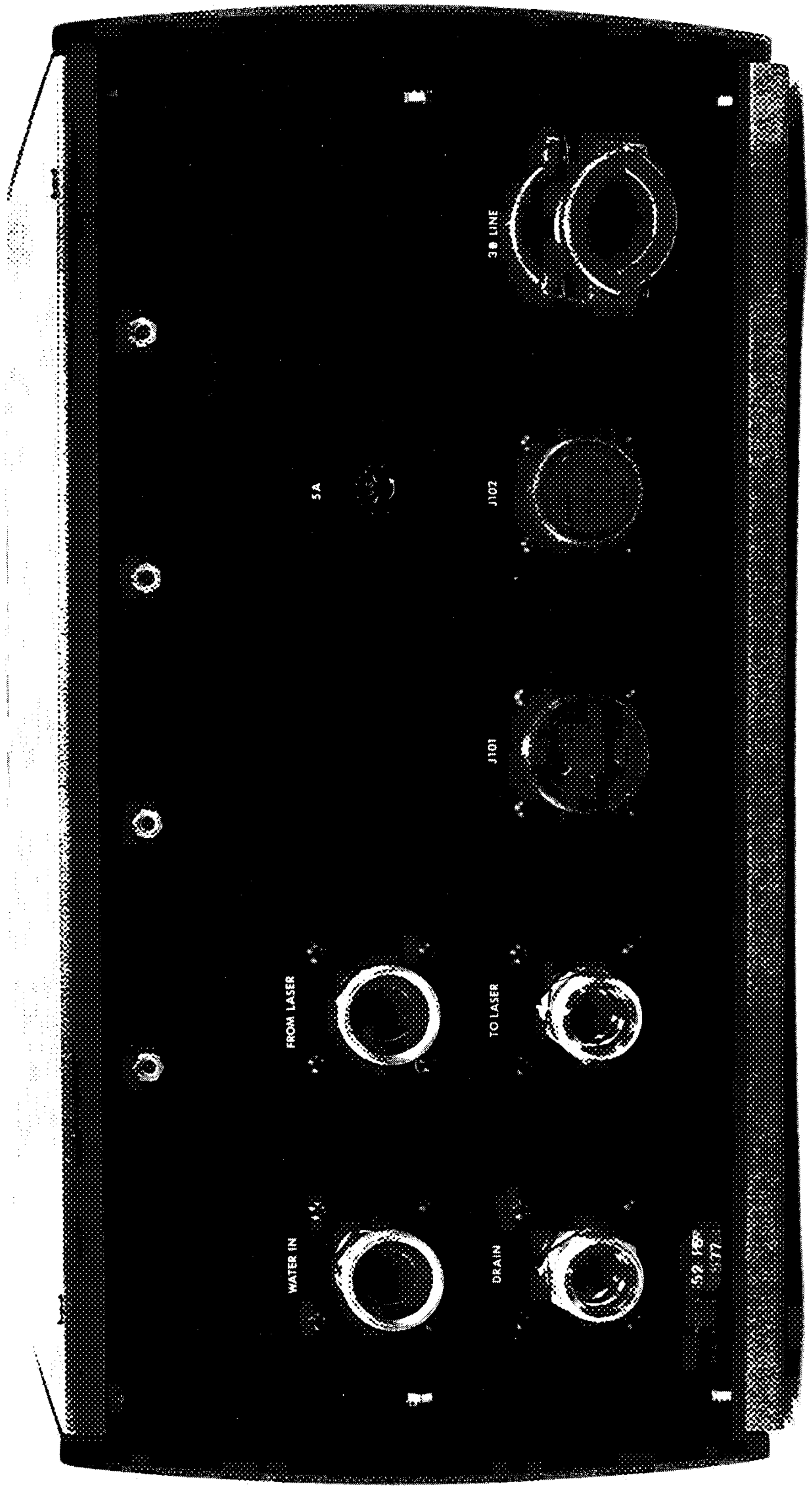


FIGURE 6.4.2

POWER SUPPLY, REAR PANEL

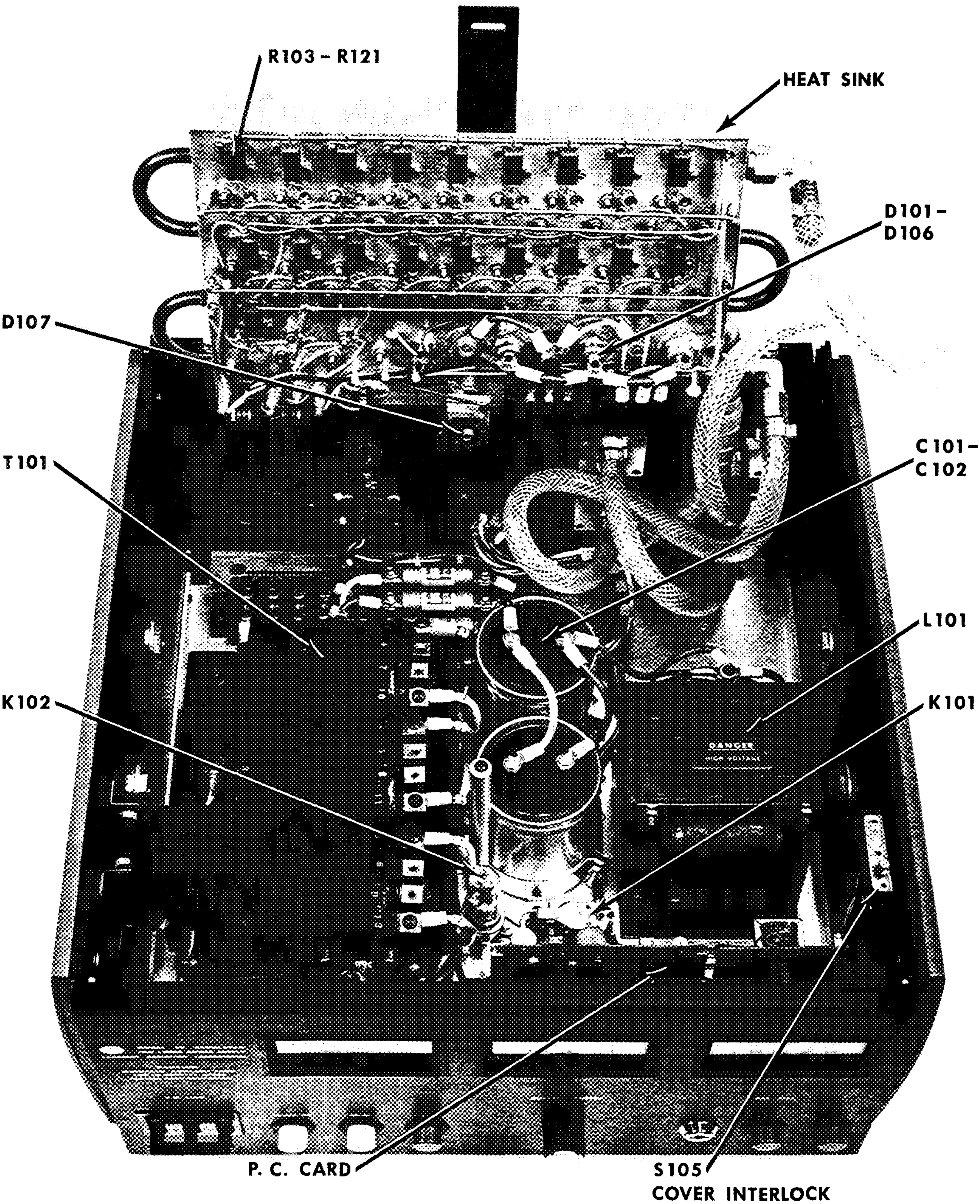
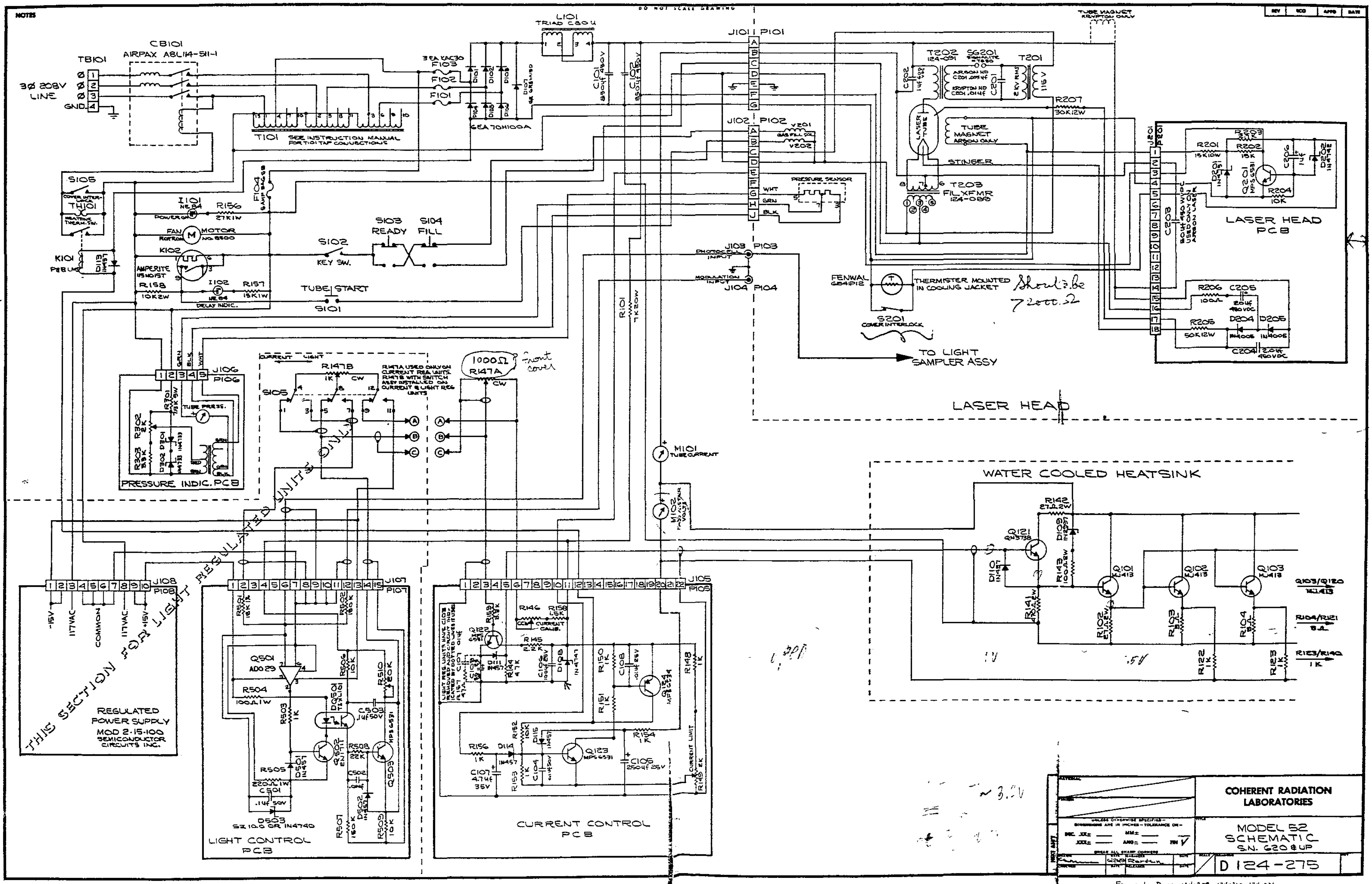


FIG. 6.4.3
POWER SUPPLY, INTERNAL VIEW



COHERENT RADIATION LABORATORIES
MODEL 52 SCHEMATIC
S.N. 620 & UP
D 124-275
Formerly Dwgs. 124-209, 124-210, 124-236
LASER HEAD
LASER HEAD PCB
WATER COOLED HEATSINK
CURRENT CONTROL PCB
LIGHT CONTROL PCB
PRESSURE INDIC. PCB
REGULATED POWER SUPPLY MOD 2-15-100 SEMICONDUCTOR CIRCUITS INC.
THIS SECTION FOR LIGHT REGULATED UNITS ONLY
3Ø 208V LINE
TB101
CB101 AIRPAX ABL114-511-1
T101 SEE INSTRUCTION MANUAL FOR T101 TAP CONNECTIONS
L101 TRIAD C80U
TO LIGHT SAMPLER ASSY
THERMISTER MOUNTED IN COOLING JACKET
Should be 7 Zett.Ω
1000Ω front cover

Current through the laser tube is controlled by means of a transistorized constant current circuit using 20 type MJ413 transistors in parallel. Current through these transistors is adjusted by means of the front panel output control. Two over-temperature protective devices are provided. One is a mechanical thermostat mounted on the pass transistor heat sink. The other is a thermistor mounted in the water jacket of the laser head. If the temperature at either point is excessive, power is applied to the trip out coil of the circuit breaker, turning off all power.

Another protective circuit is provided which acts in response to total laser current. If this current should be excessive for any reason such as failure of the current regulator or excessive line voltage (beyond the capability of the regulator) this circuit will apply voltage to the circuit breaker trip coil.

A time delay relay is provided which prevents application of starter voltage to the laser tube until the filament has had time to reach normal operating temperature.

A thermocouple vacuum gauge readout is mounted in the power supply for the purpose of reading laser gas pressure. Pushbutton switches are also provided for the purpose of actuating the gas refill system in the laser head.

7.0 DETAILED CIRCUIT DESCRIPTION

See Figure 7.1, Schematic Diagram.

7.1 Buck Boost Auto-Transformer

The Model 52 power supply is basically designed to operate from a 208/120 volt, 3-phase line. To accommodate variation in line voltage and laser tube voltage, an auto-transformer is provided. The three primaries of this transformer are wye connected. By interchanging line and load connections, it is possible to use this transformer to either step up or step down the incoming line voltage. The transformer is capable of adding or subtracting up to 15 volts to each line. Because only a small voltage change is required, this transformer is much smaller than an equivalent 2-winding transformer. It provides no isolation from the power line.

7.2 Rectifier Filter Circuit

Diodes D101 through D106 form a 3-phase, full wave bridge rectifier. Diode D107 is a selenium transient protector which protects Diodes D101 through D106 from excessive inverse voltages during switching transients. The rectifier output is filtered by a choke input LC filter consisting of L101, C101, and C102. This power is used for both the magnet and the laser tube. In the case of an argon tube, the magnet is connected directly across the filter capacitors C101 and C102. In the case of a krypton tube, the magnet is in series with the tube.

7.3 Current Regulator

The laser tube is connected in series with a transistorized current regulator. Transistors Q102 through Q120 have their collectors and bases tied in parallel. A separate 3-ohm resistor is connected in series with each emitter to equalize current to this transistor bank. Transistors Q101, Q121, and Q122 are emitter followers which multiply the current from the front panel output control to a value sufficient to drive the bases of the main pass transistors. Diode D109 is part of a protective circuit which prevents damage to the pass transistors in the event of excessive voltage. If the voltage at the transistor collectors exceeds 50 volts with respect to bases, this diode conducts and turns on the transistor bank at that level. Voltmeter M102 is provided to show the voltage being dropped across the transistor pass bank. Current will be regulated properly when this voltmeter indicates between approximately 10 volts and 40 volts. If this voltage range is exceeded, ripple may be expected on the laser tube current which will modulate the output. If the transistors are in saturation at approximately 3 to 5 volts on the pass transistor voltmeter or if the Zener diode is conducting at approximately 50 volts, the current regulator loses control and small line voltage variations result in relatively large laser tube current changes.

7.4 Starter Circuit

Power for the starter circuit passes through K102, a thermal time delay relay. When the contacts are open, neon lamp 1202 lights to indicate that the warm-up delay is not complete. After the contacts close, about 15 seconds after application of power, depressing the start button S101 sends power to the starter circuit in the laser head. Transformer T201 in the laser head is a small neon sign type transformer with a current limiting leakage reactance designed into the transformer. The secondary of T201 produces about 2000 volts AC which charges C201. This causes spark gap SG201 to break down every half cycle. Energy stored in C201 is then transferred to T202 which forms a resonant circuit with C201. This resonant circuit rings at about 1 megacycle. The secondary of T202 is connected in series with the anode of the laser tube. This applies radio-frequency voltage of about 6000 volts peak to the anode and causes breakdown of the gas in the laser tube. After breakdown, DC current flows through the secondary of T202 and through the laser.

7.5 Gas Supply Control Circuit

See Paragraph 6.2 for explanation of the gas supply system. A key switch and two pushbutton switches are provided on the power supply front panel to actuate this system. The key switch S102 must be closed to apply power to the rest of the system. The two pushbutton switches S103 and S104 must be depressed one at a time to actuate the two valves in the gas fill system. The contacts of these switches are so wired that simultaneous operation will result in an open circuit to both valves.

7.6 Over-Current Protection

The emitters of each transistor of the main pass bank are connected through 1K resistors R122 through R140 to a single summing point. This is connected to pin 20 of connector J103 and thence to the printed circuit card. This voltage is proportional to the current to the laser tube. It is filtered by means of R154 and C105 and applied to the base of Q123. A bias voltage is applied to Q123 by means of R149, the screwdriver adjustable current limit control. If the voltage at pin 20 is sufficient to cause Q123 to conduct, it, in turn, turns on Q124 and feedback through R152 causes both transistors to immediately switch to the full conducting state.

The collector of Q124 is connected through pin 12 of the connector to relay K101 and back to the negative power supply terminal. K101 is thus energized and its contacts close applying voltage to the trip coil on the main circuit breaker. The trip coil throws out the breaker, removing power from the entire system.

8.0 MAINTENANCE

8.1 Fault Isolation

When a fault occurs, a good deal of helpful information can be obtained by careful observation of the front panel controls and instruments. Additional tests can be conducted with a simple multimeter by opening the top cover of the power supply. If the supply is to be tested in the energized condition, the cover interlock plunger must be pulled out to override the interlock. The same is true for the laser head cover. Energized testing must be conducted cautiously as dangerous voltages and currents are present and the supply provides no isolation from the power line. The ground wire of grounded test equipment must not be connected to any live portion of the circuit. Fuses can best be tested with an ohmmeter with power disconnected. Use of isolated DC laboratory supplies is suggested for trouble shooting of the current regulator section.

Venu,
Please put this in the Manual.
AHK
28/11/70

COHERENT RADIATION 332 EAST MEADOW DRIVE PALO ALTO CALIFORNIA 94303 TELEPHONE (415) 328-[illegible]

Date: 25 November 1970

To: Ion Laser Owners

From: George A. Stephan

Subject: Faulty Transistor Troubleshooting Procedures

We are pleased to bring to your attention a new, simplified procedure for detecting faulty transistors in Model 52 power supplies. This procedure requires no activation of the power supply and no auxiliary power supplies. It involves measuring the DC resistance of transistors in all possible ways using only an ohmmeter. The procedure is as follows:

1. Check for emitter-collector short.
   a. Clip one ohmmeter lead to the buss bar, tying the collectors together.
   b. Use the other probe to contact successively each emitter and measure the DC resistance. Any transistor whose DC resistance is markedly different from the others is defective and should be replaced.
   c. Reverse the ohmmeter polarity and repeat Step b.
2. Check for emitter-base short.
   a. Unsolder a terminal of R102 (27 ohm, 2W resistor).
   b. Clip one ohmmeter lead to the base connection instead of the collector connection and do Steps b and c of Procedure 1 above.
   c. Connect R102 when finished.
3. Check for base-collector short. This is more difficult since the bases are tied together as are the collectors.
   a. Decouple the collectors by using a socket wrench to remove the nuts and lugs that connect the buss bars to the collectors.
   b. Clip one ohmmeter lead to the bases and successively test each collector.

Although this procedure will not identify all transistor failures, any transistor which is identified as faulty using this procedure should be replaced. If, after employing this procedure there is still some question about whether a transistor is faulty or not, the Coherent Radiation Service Department should be contacted.

We are grateful to Mr. Robert F. Benjamin of the Massachusetts Institute of Technology for bringing this simplified procedure to our attention.

Very truly yours,

COHERENT RADIATION

George A. Stephan

George A. Stephan
Vice-President, Marketing

GAS:df

LASER CURRENT ~ 10 A MAX
VOLTAGE 7.50 V

ONE OR MORE BAD
TRANSISTORS

CHECK TRANSISTORS AS
PER FACING PAGE, ESPECIALLY
#3. SEE P. 41 & P 50 OF
LASER LOG II

8.1.1 Trouble Shooting Chart

Symptoms	Probable Cause	Remedy
Laser current will not start	1. Voltage too low.	Shift taps per Para. 4.4.1
	2. Blown Fuses F101, 102, 103.	Test and replace with same type.
	3. No starter voltage.	a. Check all 3 phases of supply. b. Check F104. c. Remove laser cover; observe spark gap SG201 while pressing start button. d. Check starter transformer T202 for defect. Should product 6 KV at radio frequency.
Circuit breaker trips immediately	1. Open cover interlock.	Override interlocks on head and power supply or replace covers.
	2. Short circuit.	Test T101 and main rectifier circuit.
Circuit breaker trips after 5-10 seconds.	1. No cooling water in laser.	Obvious.
Circuit breaker trips when laser starts.	1. Voltage too high.	Shift taps per Para. 4.1.1
	2. Faulty current regulator.	Test and repair.
Circuit breaker trips after laser starts.	1. No coolant flow or insufficient flow.	Obvious.
No control of current; pass transistor voltage 50.	1. Printed circuit card not plugged in.	Obvious.
	2. Faulty component in current regulator.	Isolate and replace.
Restricted current control range, pass transistor voltage will not go above 10-20 volts.	1. Shorted transistor in pass bank.	Isolate as per 52,53 Maintenance Test Procedure and replace.

8.1.3 Fuses

If replacement of fuses is required, only the type of fuse specified for the equipment should be installed. Fuses F101, F102, and F103 are used to protect the rectifier circuit. These are special short time lag fuses. Ordinary power system fuses should not be used as the rectifiers would probably fail before the fuse blows. Blown fuses are usually caused by a fault elsewhere in the system. In the event of failure of the rectifier fuses F101 through F103, faulty rectifiers or filter capacitors should be suspected. The filter capacitors should be tested if possible by disconnecting them from the circuit and testing them at a voltage of at least 300 volts.

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INSTALLATION AND OPERATION of the MODEL 421 RESONATOR MODE SELECTOR

1.0 Installation

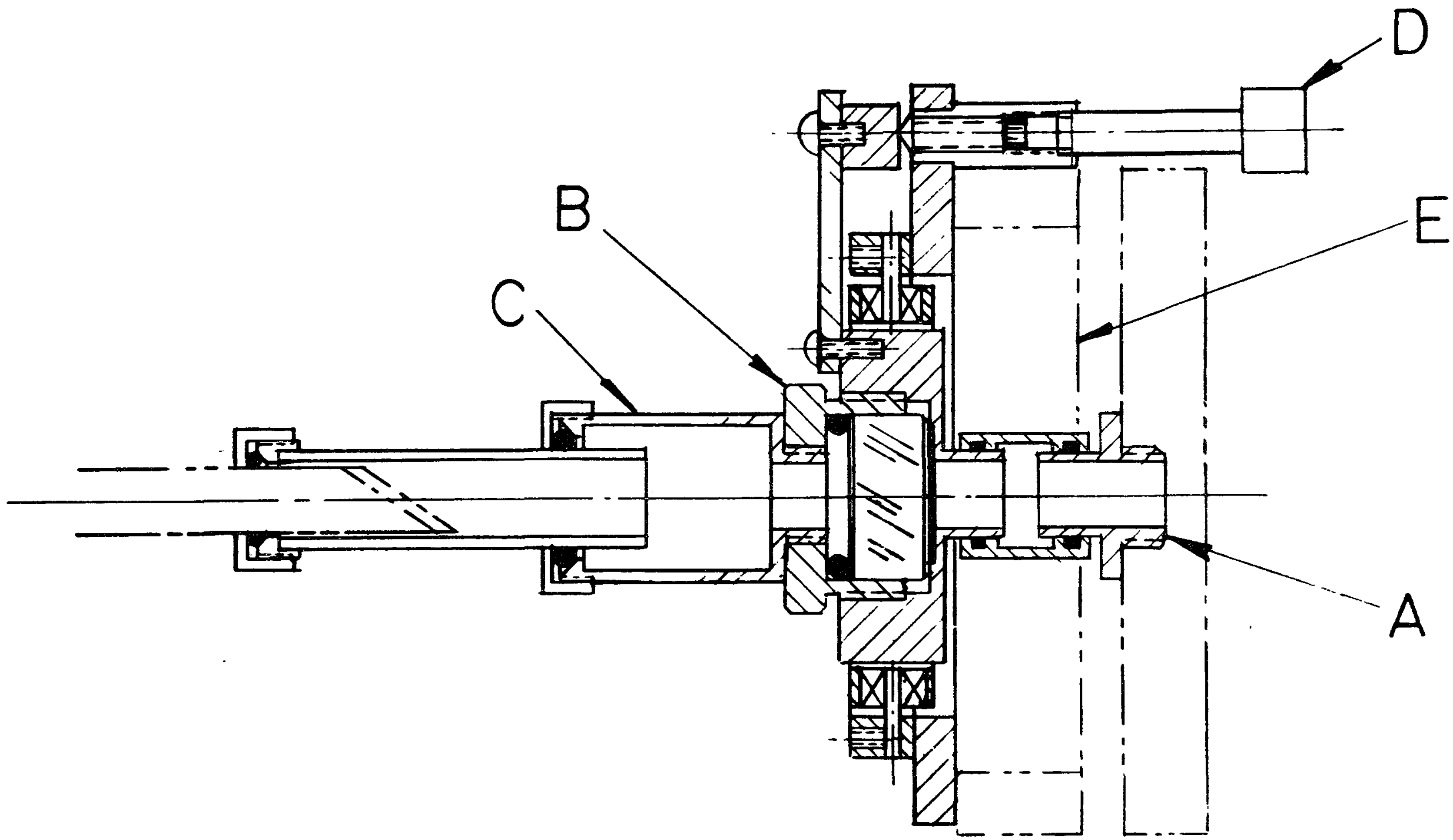
If the mode selector is factory installed, the etalon will be pre-aligned and it will only be necessary to adjust as explained in Section 3.0. If, however, the Model 421 is separated from the Model 52 head, it will be necessary to install and align it in the Model 52 head.

2.0 Instructions

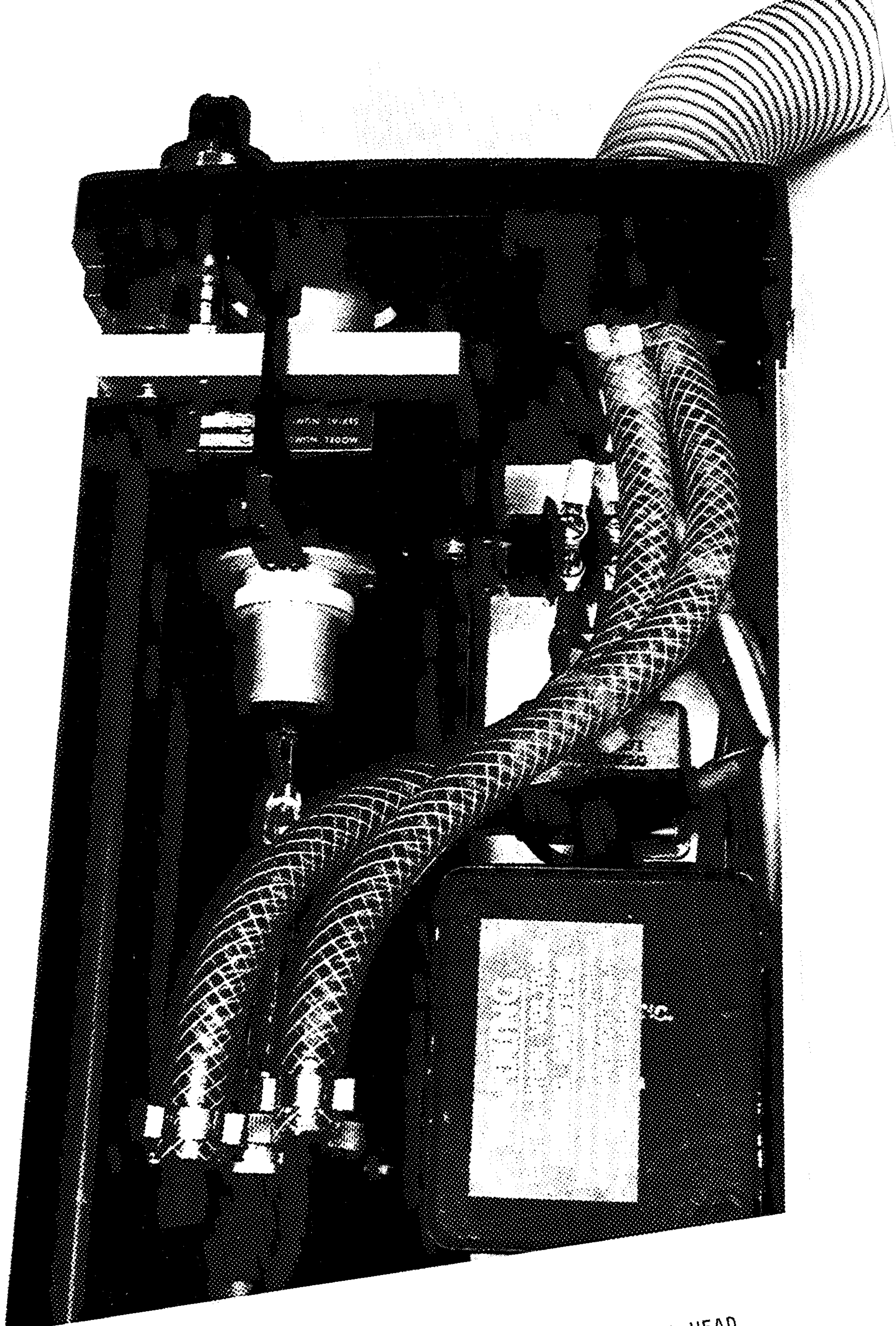
Remove existing dust shield, both glass and metal part, and discard. Screw threaded adapter A into mirror holder plate. Unscrew parts B, C and glass dust shield from etalon housing and lay to one side. Slip main frame of housing, cocked at 45° over part A and press home. The vertical adjust D should clear the top of the resonator end plate and be located centrally. Now secure the etalon housing to the resonator end plate E with the two 8-32 screws supplied. Install etalon, check surfaces for cleanliness, into part B and screw B into the main housing. Slide glass dust shield into part C as far as it will go. Carefully slip glass dust shield and C over Brewster window, from below. When horizontal, telescope C back towards B. Screw C into B. The installation is now complete.

3.0 Alignment

With the etalon in place, additional beams at an angle to the main resonator beam will be generated by multiple reflections within the etalon. These may be viewed in reflection from the anode Brewster window by holding a white target above the Brewster window and insuring that the dust cover is extended to a position where the reflection from the Brewster window passes through the glass tube. By inserting an Allen driver (3/32) into the vertical angle adjustment D or the corresponding horizontal adjustment, the angular position of the etalon may be adjusted to bring all of the multiply reflected spots to coincide with the main reflected beam. When this position is reached, an increase in output power from the laser will generally be noted and the laser power output will become more critically dependent on the etalon angular tuning. This angular position of the etalon is used as a reference point only, since in this position the etalon does not act as a rejection filter but reflects directly back into the resonator. If an optical spectrum analyzer is available, the oscillating modes will generally appear very noisy in this position. From this point, vary the angle of the etalon by using the vertical adjust only. Single axial mode operation will result after slight tilting with the vertical adjust and can be observed with the scanning interferometer. Small subsidiary modes may appear on either or both sides of the main mode. These can be tuned out by further slight adjustment of the vertical and horizontal angular controls. Highest single mode power is achieved by operating at the smallest angular deviation from the initial position which produces single mode operation.



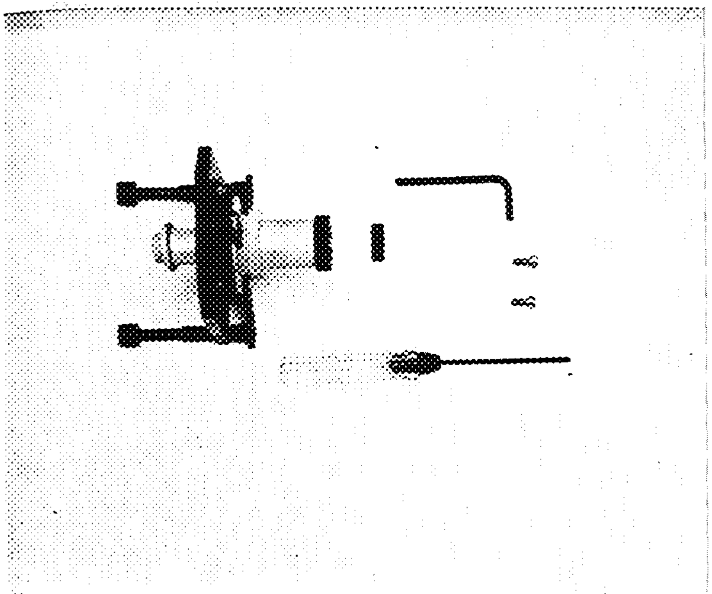
MODEL 421 ASSEMBLY DRAWING



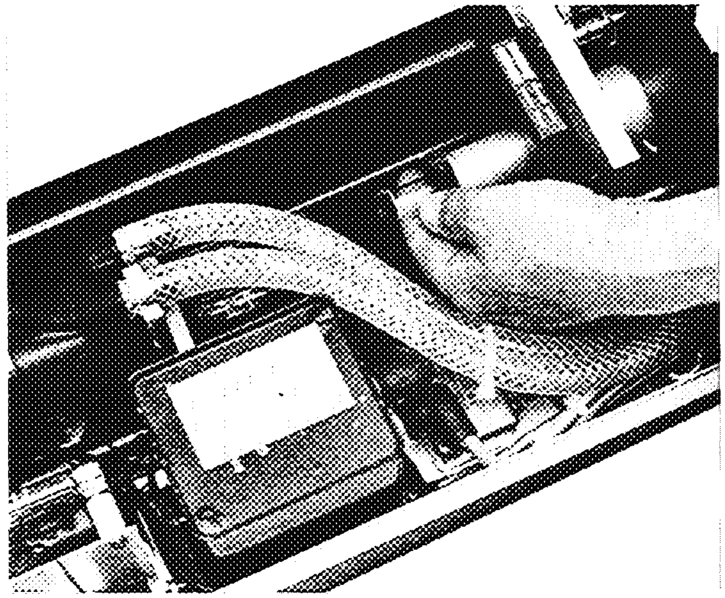
MODEL 421 INSTALLED IN MODEL 52 LASER HEAD

MODEL 421 INTRA-CAVITY ETALON

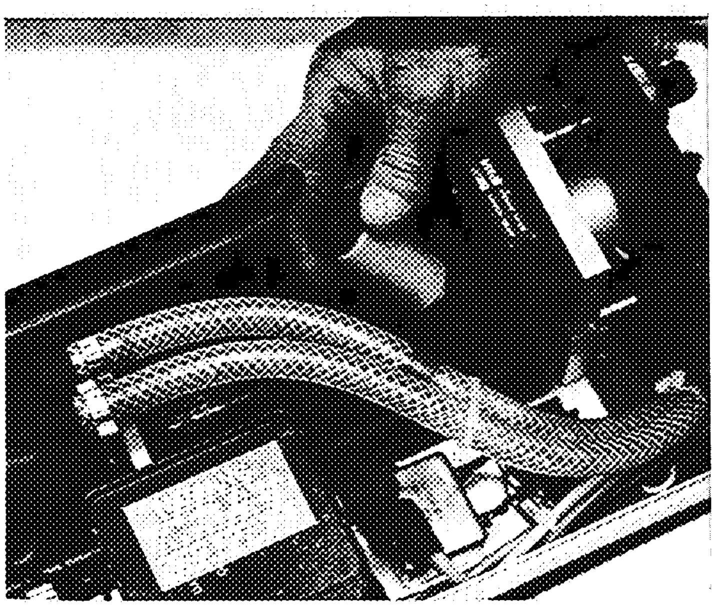
INSTALLATION PROCEDURE



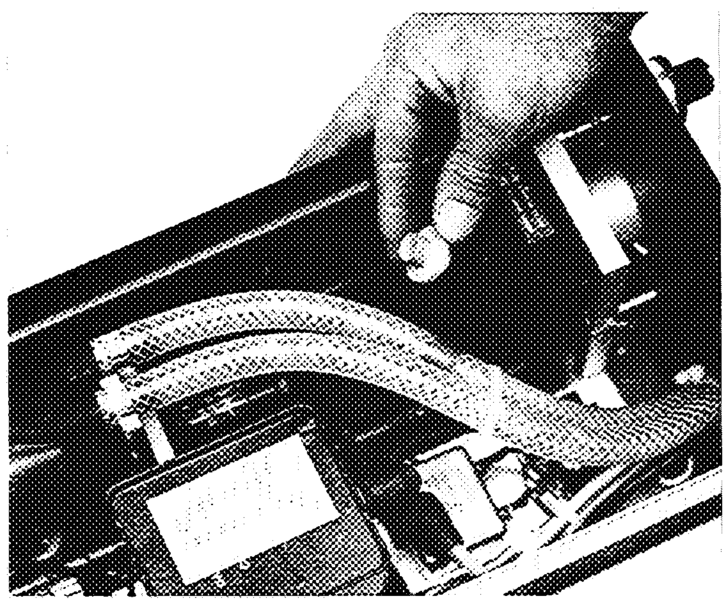
1. Parts List and Tools
   a. Etalon mount assembly with glass dust shield.
   b. 2 ea. 8-32 mounting screws.
   c. 9/64" Allen wrench.
   d. 3/32" adjustment Allen driver.



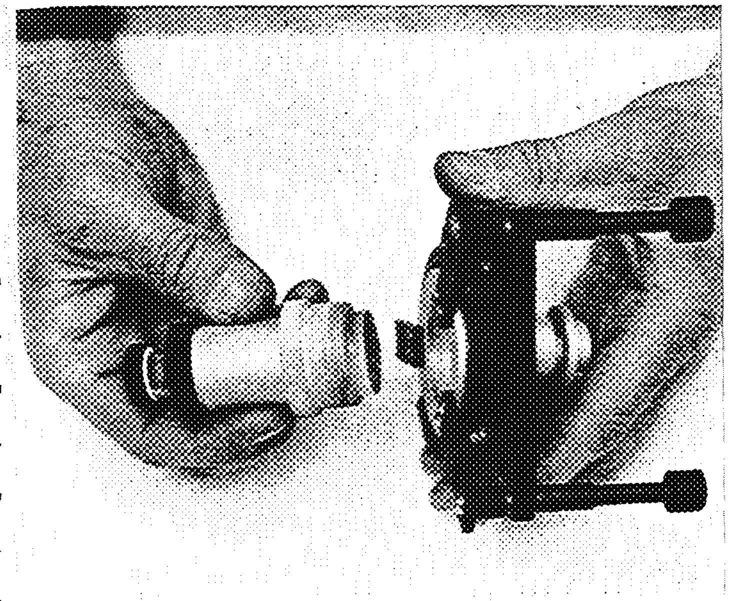
2. Loosen Brewster window dust shield retaining collar and slide dust shield clear of rear Brewster window.



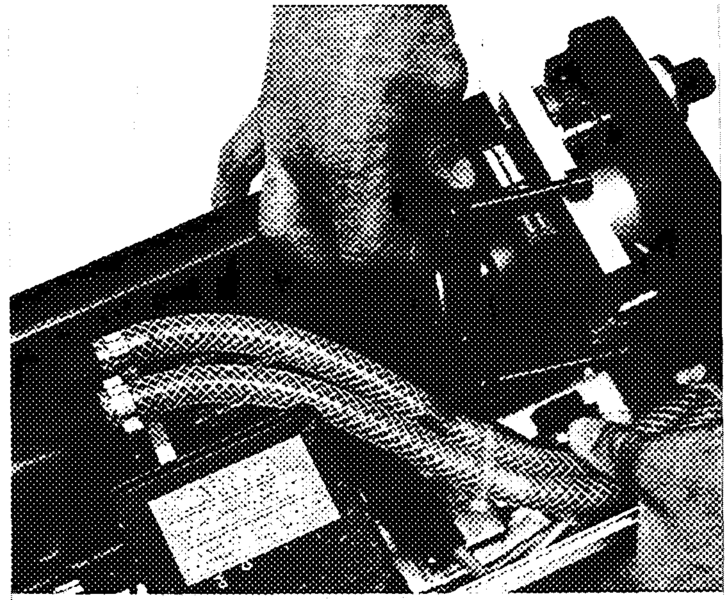
3. Unscrew and remove dust shield assembly.



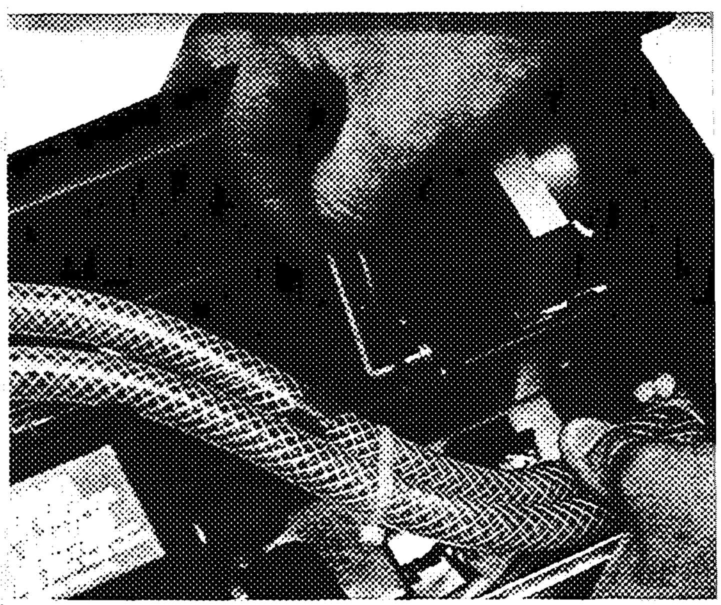
4. Screw etalon adapter fixture into dust shield assembly mounting hole.



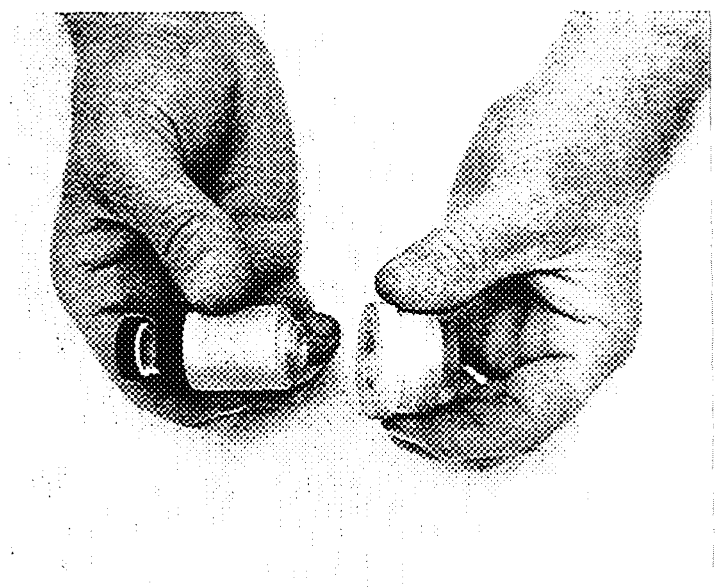
5. Unscrew and remove dust shield and etalon from etalon mount assembly.



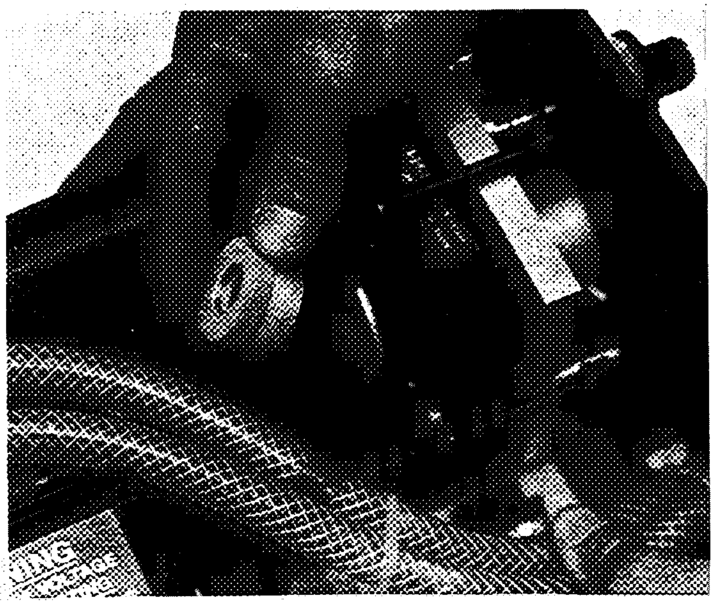
6. Install etalon adjustment assembly. Water hoses may be gently moved to the side to facilitate entry. Etalon adjustment assembly should be firmly pushed into etalon adapter.



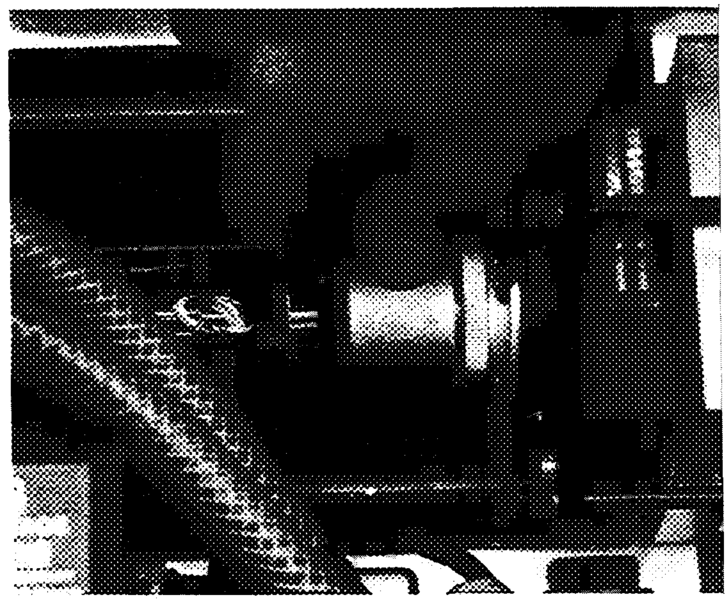
7. Secure etalon adjustment assembly with two 8-32 mounting screws.



8. Separate dust shield from etalon mount.



9. Install etalon and etalon mount in adjustment assembly.



10. Screw dust shield into etalon mount. Slide dust shield over Brewster window and secure.

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INSTALLATION AND OPERATION of the MODEL 431 PRISM WAVELENGTH SELECTOR

1.0 General

The Model 431 Brewster prism assembly supplied as an accessory to the Models 52 and 53 Ion Laser Systems is designed to allow easy interchangeability with the mirror holder assembly. Normally the assembly is supplied prealigned and ready for use. If not previously adjusted, however, initial alignment must be performed as follows.

2.0 Installing Wavelength Selector

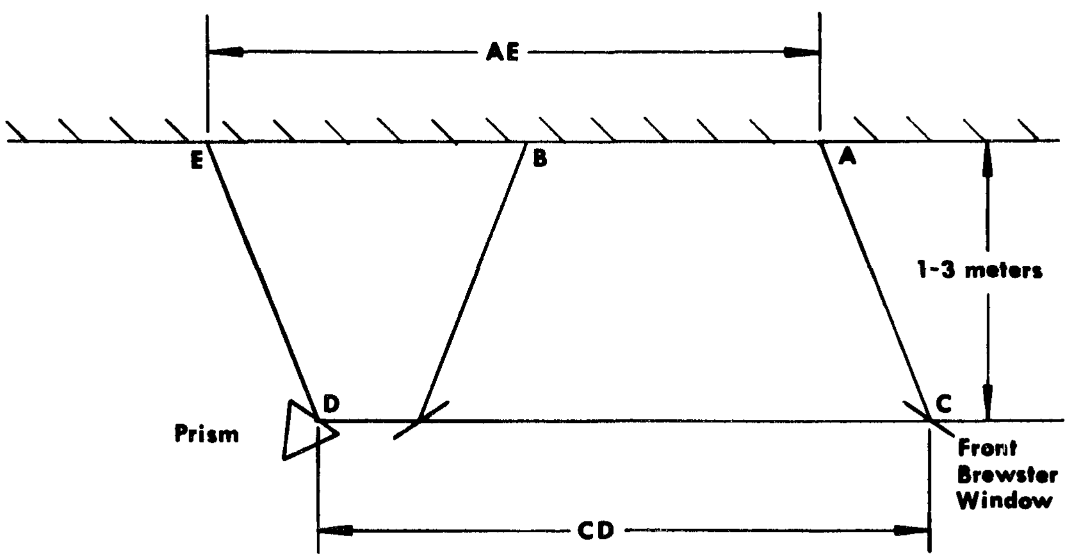
Tune the laser for optimum power by the procedures described in the Operations Manual.

Remove the laser top cover. Note the paths of the beams reflected from the Brewster windows. If these beams are obstructed by the dust shields, move the shields so that the beams pass through the glass tubes. If the water hose is in the way, it may be gently pushed to one side. Mark with a pencil the positions of the reflected beams A and B on the ceiling or other convenient surface above the head. From this point until the laser is in oscillation with the prism in place, the laser head and marked surface must not be moved.

Remove the rear mirror. Insert the prism wavelength selector into the rear mount. Remove the dust cover and the mirror holder from the prism selector assembly.

3.0 Alignment of Prism

Measure the distance CD between the front Brewster window C and the prism D. Mark a point E on the ceiling at a distance from A equal to CD. The reflection from the front surface of the prism should fall on E. With the room darkened so that the reflection of the plasma tube fluorescence may be seen on the ceiling, rotate the prism until the reflected spot falls on E. To rotate the prism, loosen a small set screw just above and to the side of the prism.

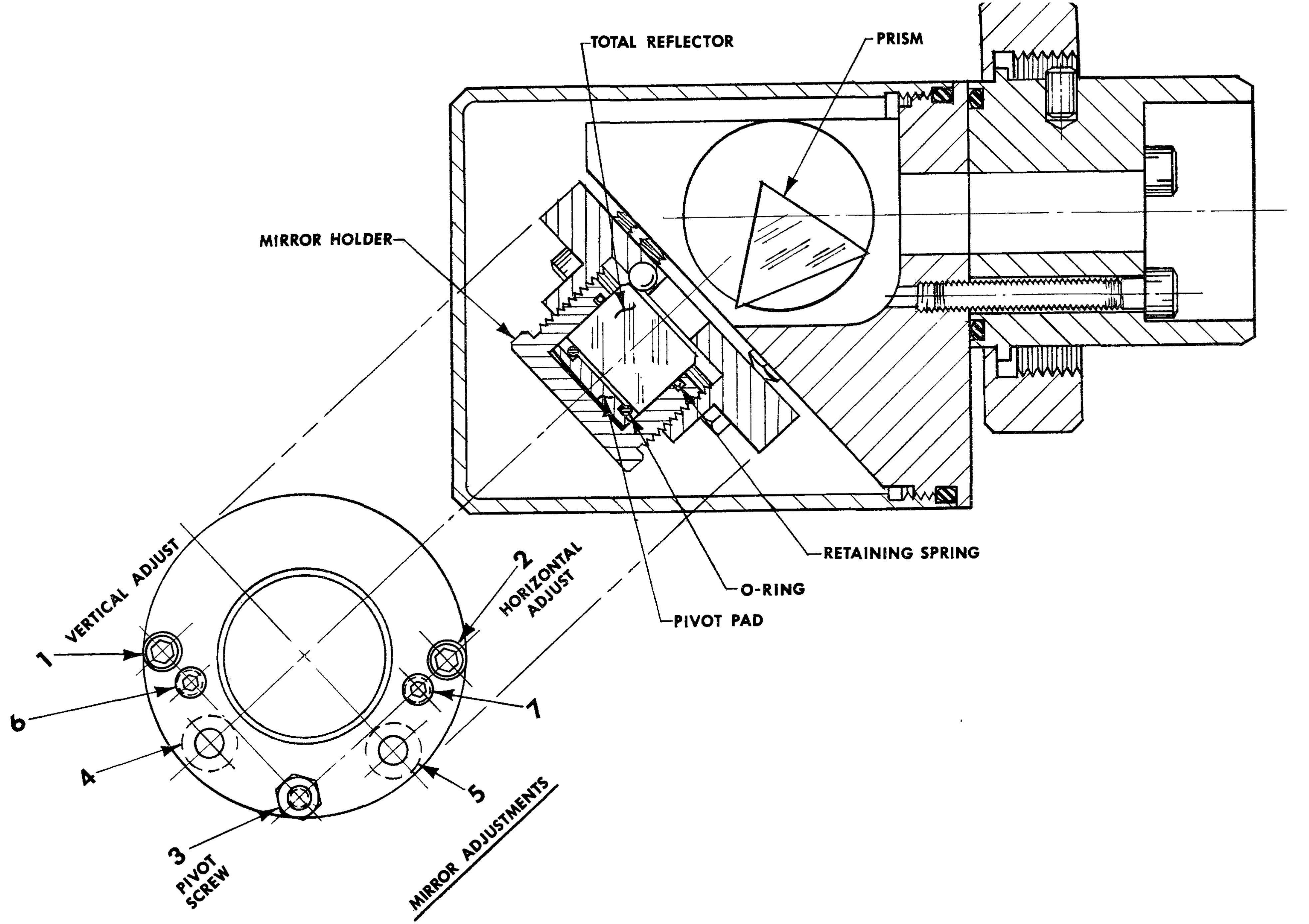


4.0 Alignment of Mirror

The totally reflecting mirror is now aligned as follows: Replace the mirror and mirror mount in selector assembly. The tilting of the mirror mount is accomplished by turning the screws 1 and 2 located on the flange. There is a pivot screw 3 which should not be touched. 1 is the vertical adjust screw and 2 is the horizontal adjust screw. These screws work against springs 4 and 5. The small locking screws 6 and 7 should be backed off for this adjustment. By adjustment of 1 and 2, position on spot B on the ceiling the plasma tube fluorescence which has been reflected from the mirror and the rear Brewster. Oscillation (lasing) should occur during this procedure. By adjustment of screw 1 the prism may be set to obtain oscillation as previously set on the wavelength selector. In the case of krypton tubes, the 568.2 output is, of course, recognized by its yellow color. In the case of argon tubes, the green 514.5 output is easily recognized by its high power (700 milliwatts) and green color. After final slight adjustments to maximize the power, the locking screws should be tightened down. Replace the dust cover. The fine angular controls may now be used for final optimizing of the power.

5.0 Changing Wavelength

When the output has been optimized, the vertical adjust may be varied to verify oscillation on the other specified spectral lines. In varying over the full output spectrum, some retuning of the output using the rear horizontal fine control is generally necessary.



MODEL 431 ASSEMBLY DRAWING

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MODEL 52, 53 MAINTENANCE

#1 Test Procedure to Locate Collector-Emitter or Three Electrode Short In Paralled Power Transistors

1. Disconnect the main power source.

2. Connect equipment as shown in Fig. 1. The test power supply must be current limiting or be used with a suitable resistance. Open circuit voltage should be 20-50 volts. Short circuit current should be 1-10 amperes.

3. Measure voltage across 3Ω resistors. The one with the highest voltage is connected to the faulty transistor. For C - E short, the other resistors will measure '0' volts (no current). For 3 electrode short (the most common) the voltage difference is usually 0.5-0.7 volts, but may be less.

4. Disconnect at least 2 connections to the suspected transistor. Measure collector voltage. It should be the open-circuit supply voltage. If not, repeat Step 3.

5. If all voltages are equal within 0.2 volts, the fault is probably a collector-base short. Use test procedure #2.

NOTES 1. COLLECTORS ARE CONNECTED THROUGH MOUNTING BOLTS.

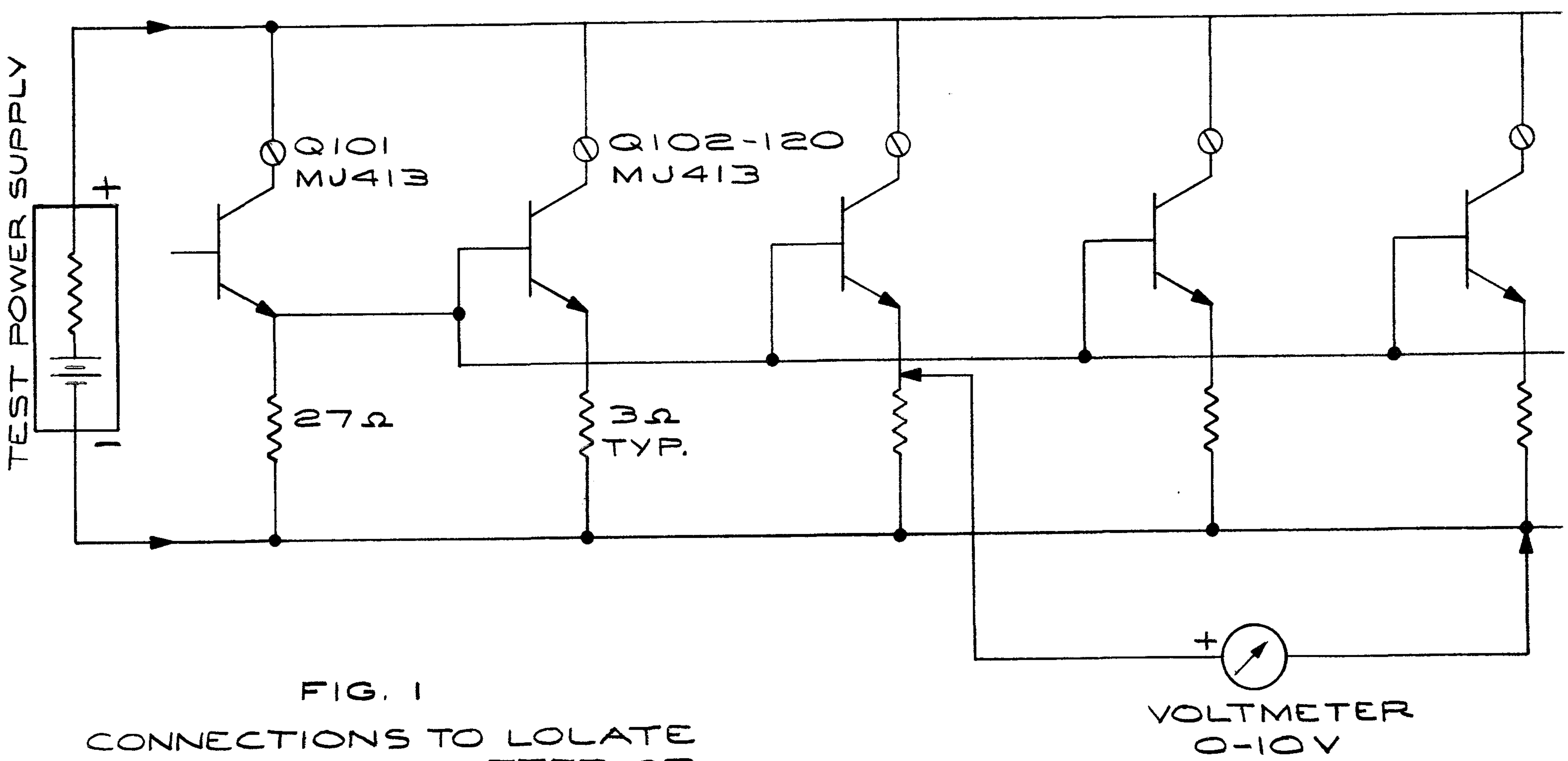


FIG. 1

CONNECTIONS TO LOLATE COLLECTOR-EMITTER OR 3 ELECTRODE SHORT.

#2 Procedure to Locate Collector-Base Short in Parallel Power Transistors

1. Disconnect the main power source.

2. Connect equipment as shown in Fig. 2. The same power supply used in Test #1 may be used. A meter which will show a noticeable deflection with an input of about 3 millivolts is required. Many multimeters will do this on the 50 or 60 microamp scale. The power supply and meter must be connected at opposite ends of the base buss.

3. Measure voltage between end of buss and each base, starting from the end nearest the meter positive connection. The first point at which the voltage is not zero is one transistor past the faulty one. Current from the faulty transistor causes a small voltage drop in the wire. The voltage drop will increase at each successive transistor because of increased wire length.

4. Disconnect at least 2 connections to the suspected transistor. The collector voltage should rise to the open-circuit output voltage of the supply. If not, repeat Step 3.

NOTES

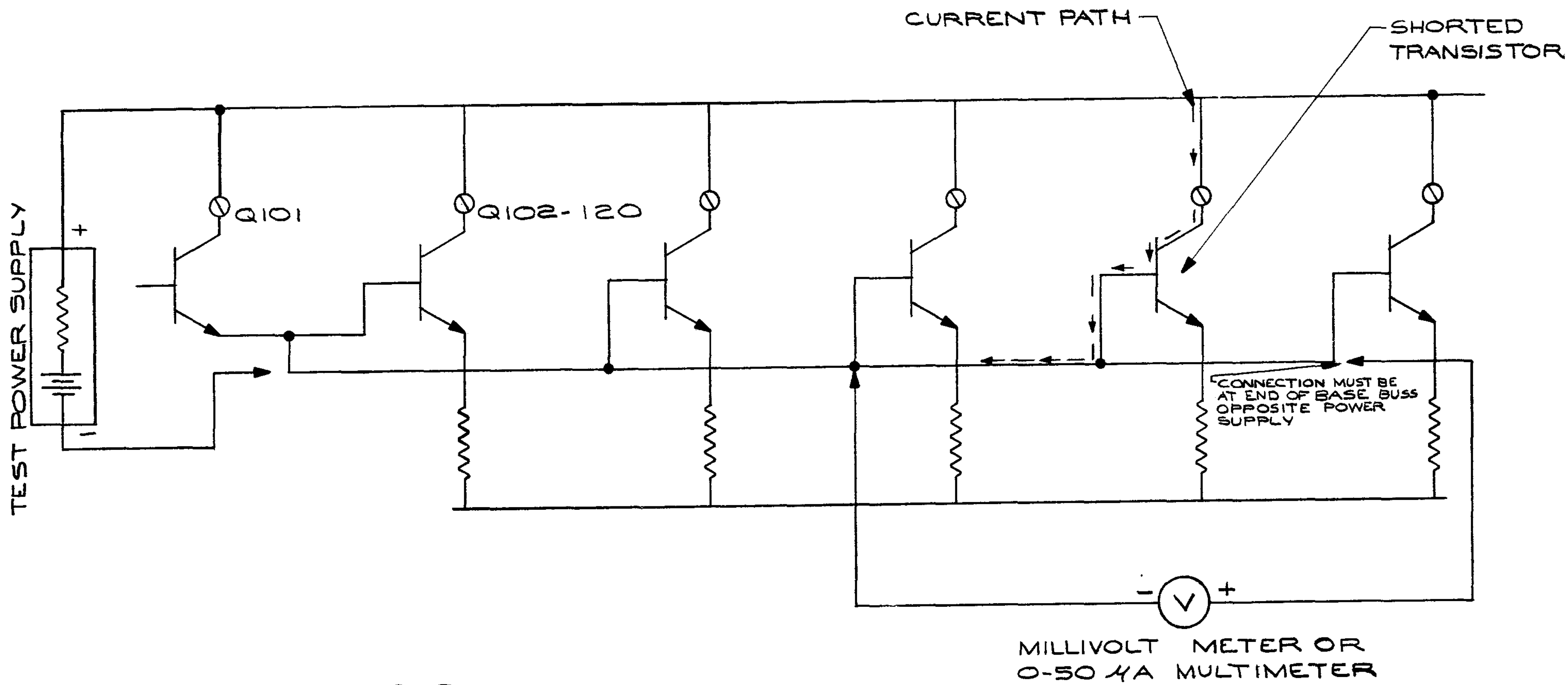
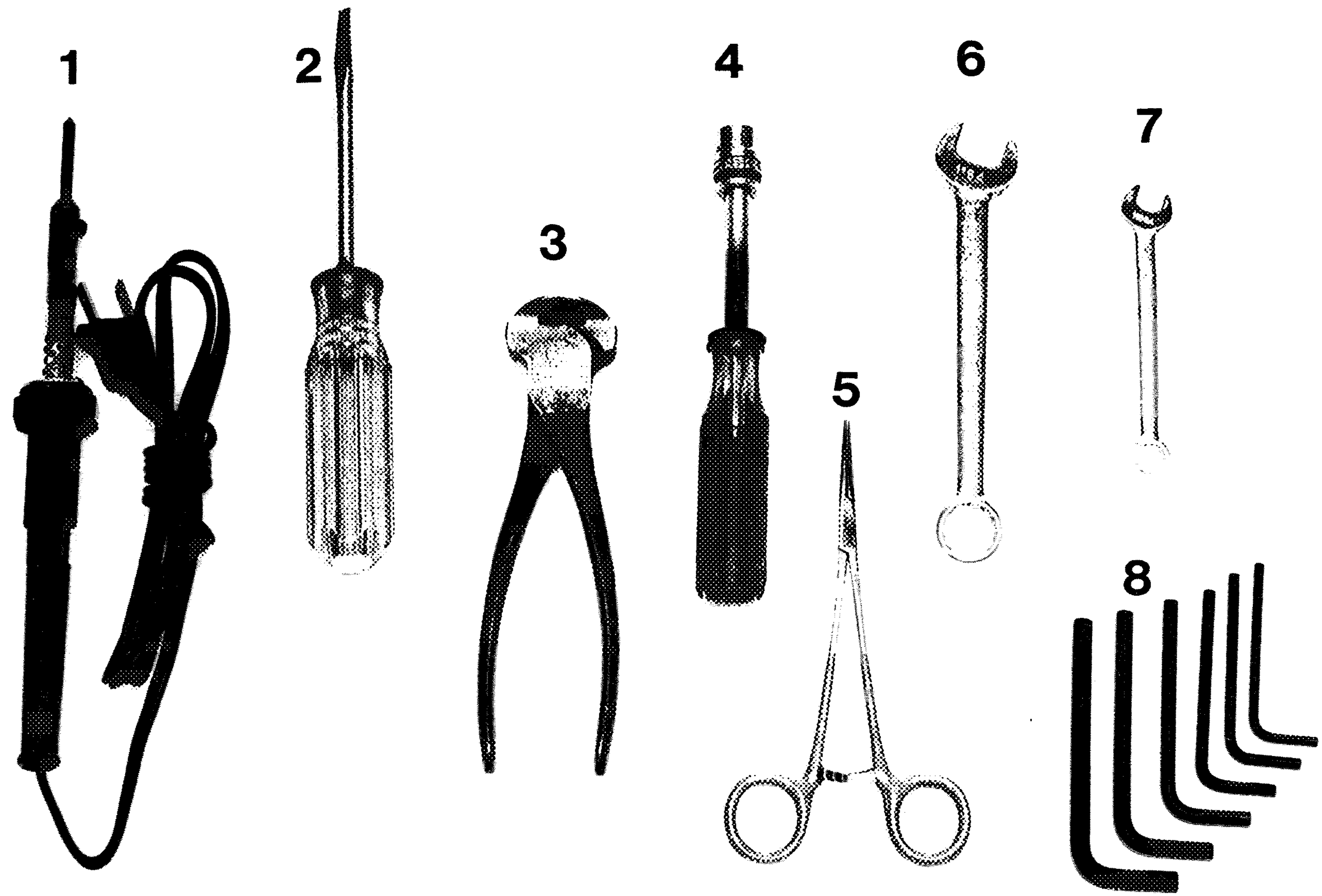


FIG. 2
CONNECTIONS TO LOCATE
COLLECTOR-BASE SHORT

MODEL 52 ARGON ION LASER SYSTEM

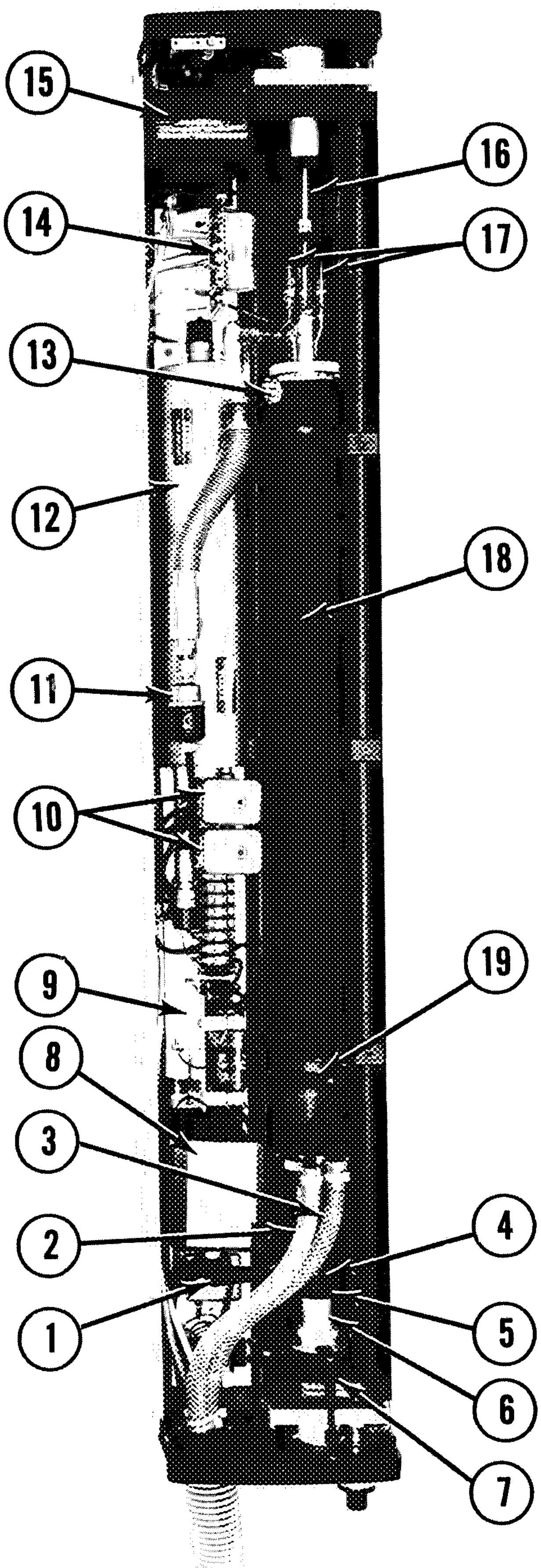
MAINTENANCE AND REPAIR SUPPLEMENT



Tools Required for Model 52 Plasma Tube Removal

1. Soldering Iron
2. Slot Screwdriver
3. End Cutters
4. 5/8" Socket Wrench
5. Hemostats
6. 5/8" Open End Wrench
7. 11/32" Open End Wrench
8. Allen Wrenches

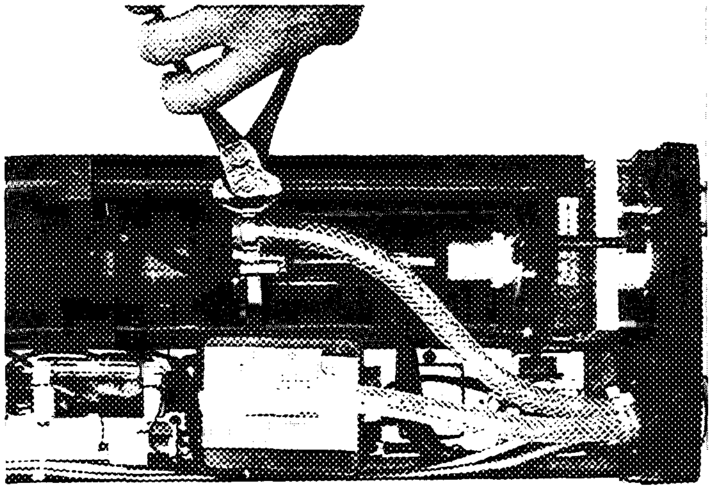
Model 52 Ion Laser Head
Key Parts

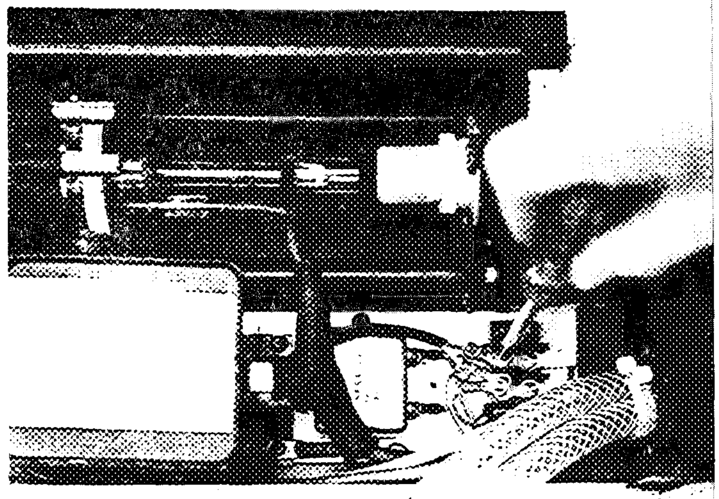


1. Anode Lead Connection
2. Outlet Water Hose
3. Inlet Water Hose
4. Brewster Window Dust Shield
5. Dust Shield Retaining Nut
6. Etalon Dust Shield
7. Etalon Mount
8. Starter Transformer
9. Starter Circuit Support
10. Gas Fill Solenoids
11. Thermocouple (TC) Gauge
12. Ballast Tank
13. Thermistor
14. P.C. Board
15. Filament Transformer
16. Brewster Window Dust Shield
17. Cathode Pin Leads
18. Solenoid Heat Sink
19. Solenoid Retaining Clamps

M O D E L 5 2 P L A S M A T U B E R E M O V A L P R O C E D U R E

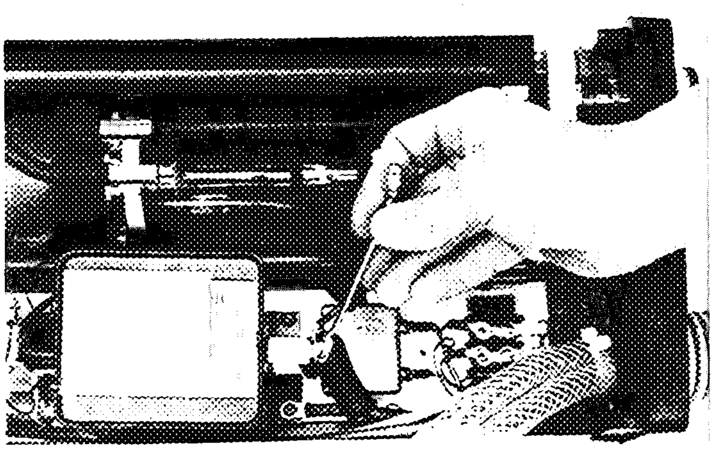
Step 1 - Remove laser head cover.
Step 2 - Blow out water lines. Wedge open check valves with pins or Allen wrenches. Air hose can be used if available. If not, lines can be blown by mouth.

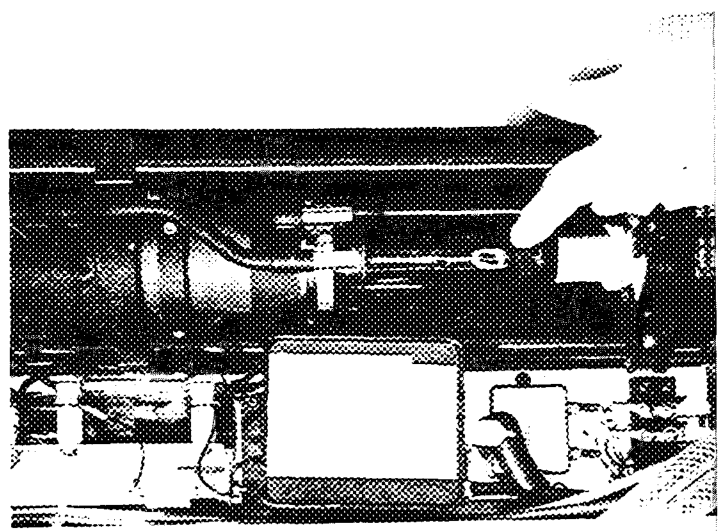




Step 3 - Remove Odiker clamps from two water lines. Hose with red band is water input line. Sturdy end cutters or diagonal cutters should be used. Fold water lines and tuck out of the way.

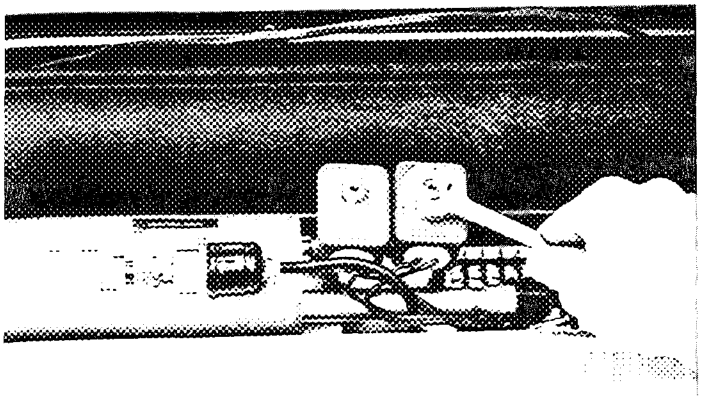
Step 4 - Disconnect solenoid leads (2 slot screws). Remove top leads only. Bottom leads should remain in place. Note: on reconnection on terminal strip: green lead goes with brown; red lead goes with white. Solenoid leads should be placed on top of solenoid shield for convenience.



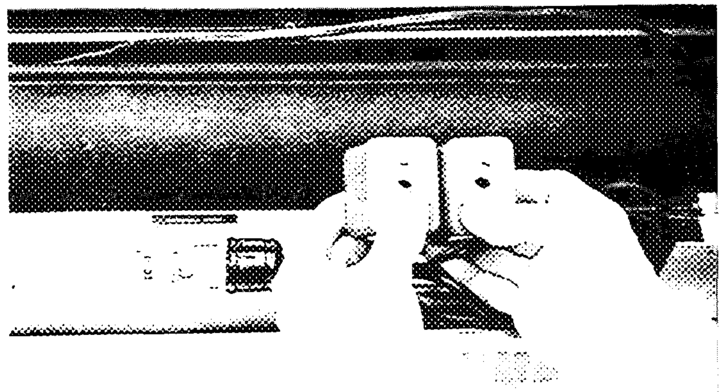


Step 5 - Remove anode lead from starter transformer post. Use 11/32" open end wrench or pliers. Return nut to post for later reconnection.

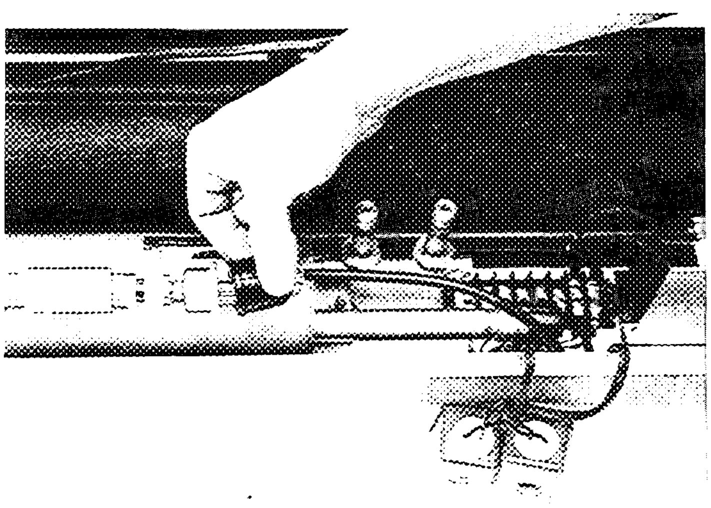
Step 6 - Loosen retaining nut on dust shield. Slide dust shield so that it clears Brewster window. Note: depicted laser includes etalon mount.



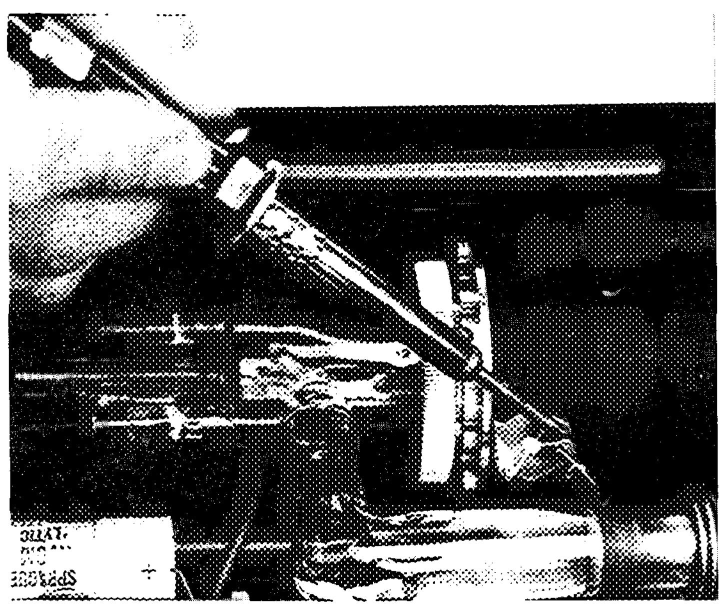
Step 7 - Remove 5/8" nuts and washers securing gas fill solenoids.



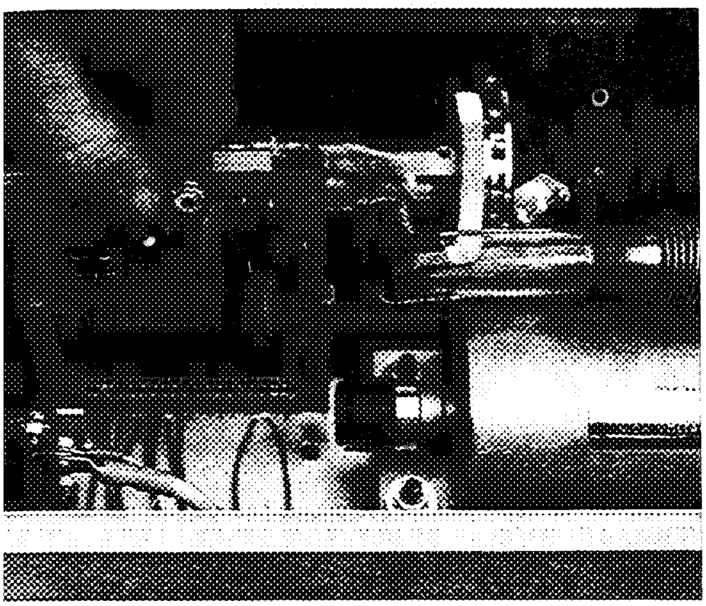
Step 8 - Remove both solenoids together.



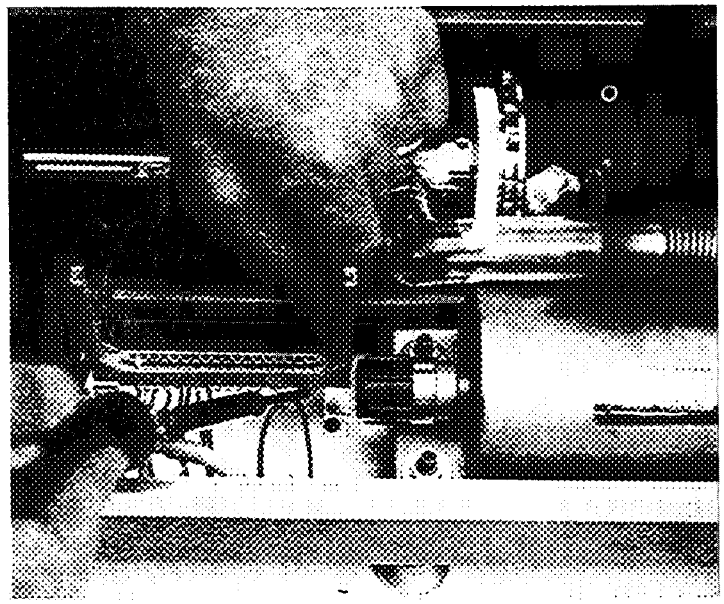
Step 9 - Drape solenoid valves over the side of casing. Remove thermocouple (TC) guage from end of connector pin.



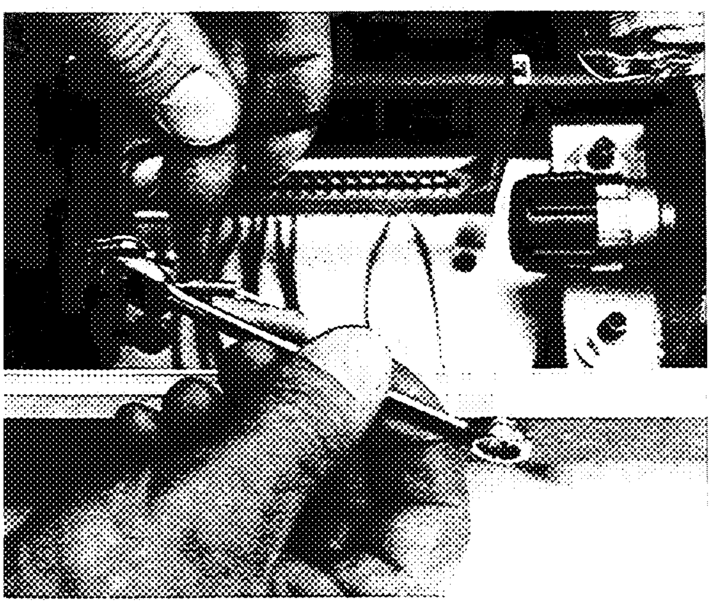
Step 10 - Unsolder two thermistor connections and remove leads.



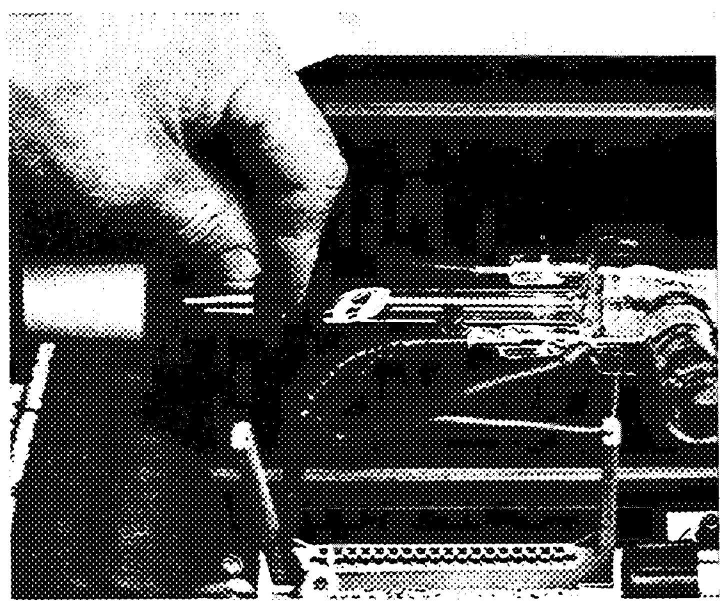
Step 11 - Remove P.C. card from socket. Note: on earlier models, P.C. card is not removable.



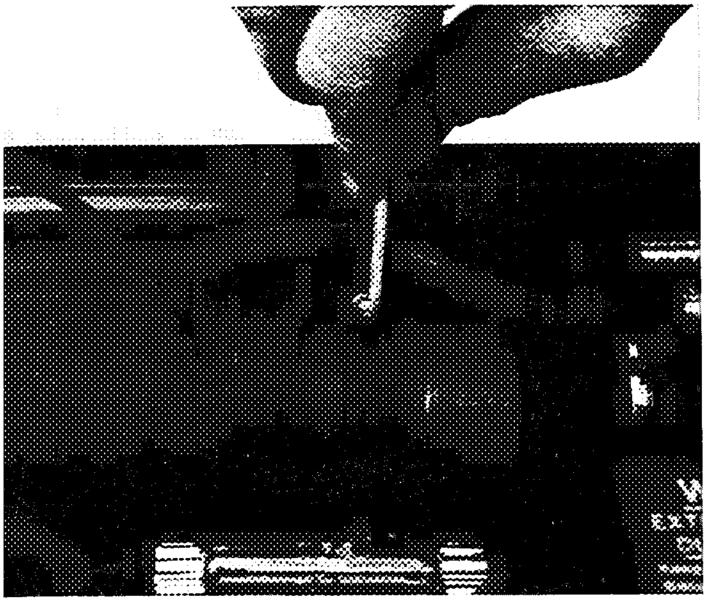
Step 12 - Desolder lead to cathode auxilliary discharge electrode. Also desolder similar connection at anode end.



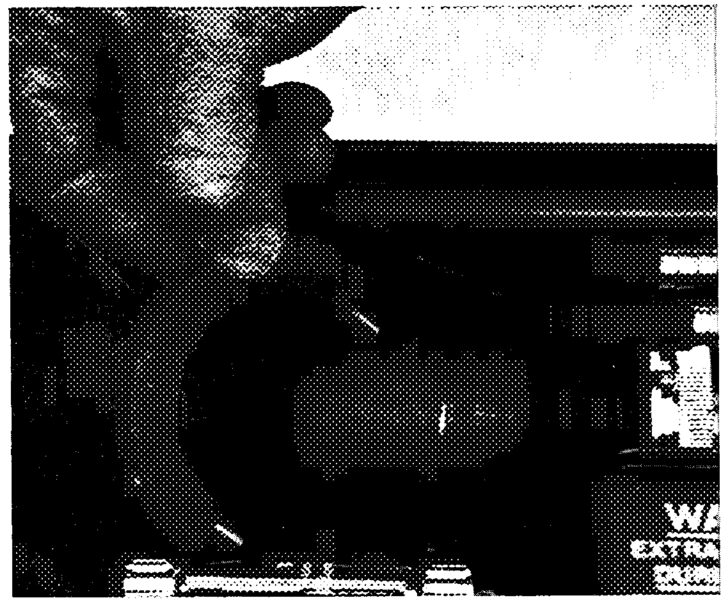
Step 13 - Remove 11/32" nuts securing cathode leads to filament transformer. Use Allen wrench and 11/32" open end wrench. Disconnect leads.



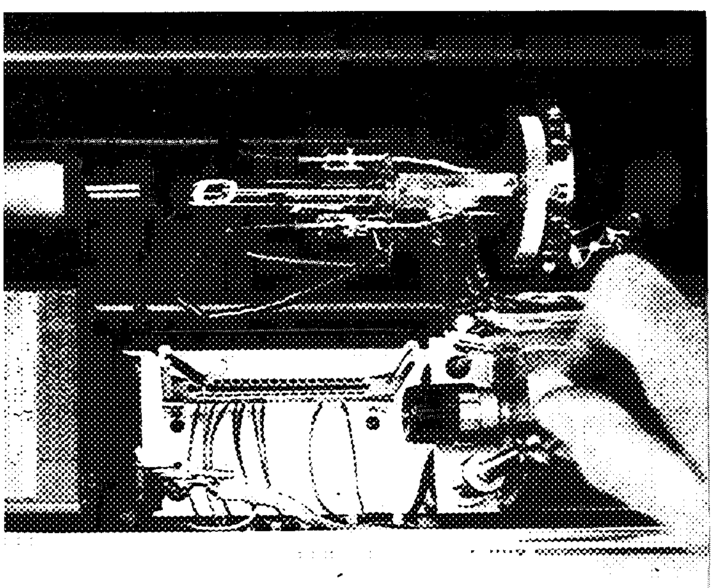
Step 14 - Loosen retaining collar and slide Brewster window dust shield clear of Brewster window.



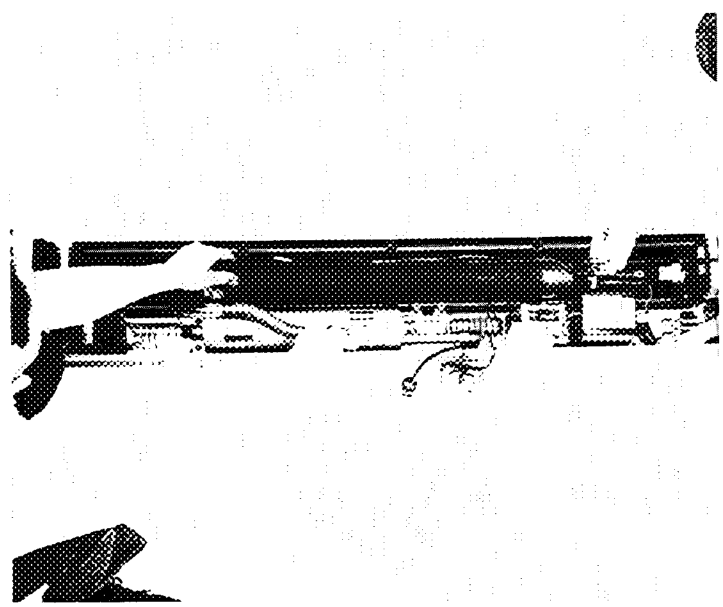
Step 15 - Loosen Allen screws holding solenoid in resonator.



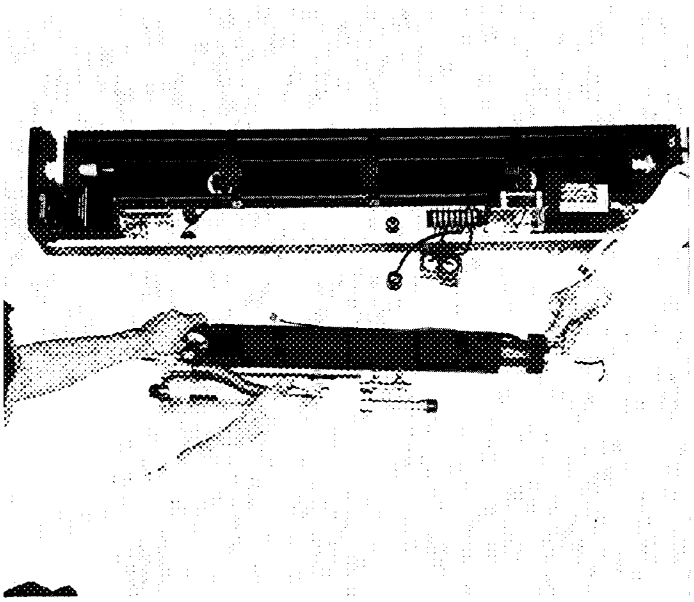
Step 16 - Remove clamps holding solenoid in resonator.



Step 17 - Remove nuts and lock washers (three) securing ballast tank to base plate. Use 7/16" socket wrench.



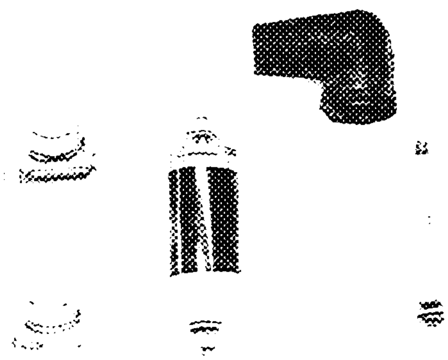
Step 18 - Remove plasma tube and solenoid assembly. Two men required. Important: note position of hands. Lift straight up. Take care to maintain the relative position of the ballast tank and plasma tube/solenoid assembly during lifting. Person lifting at the cathode end should guide this operation.



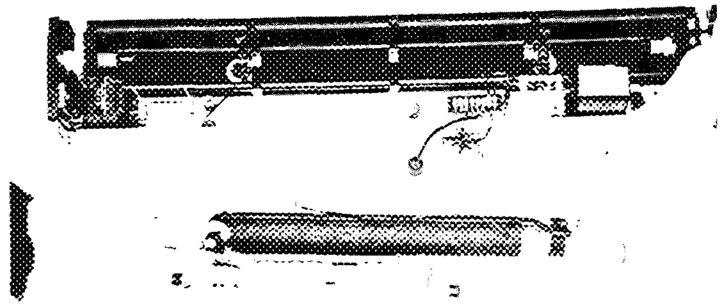
Step 19 - Set plasma tube and solenoid assembly aside. Maintain the relative position of the ballast tank and plasma tube/solenoid assembly.

New plasma tube installation: Reverse Steps 1 - 18, Take care to safeguard the Brewster windows during tube installation.

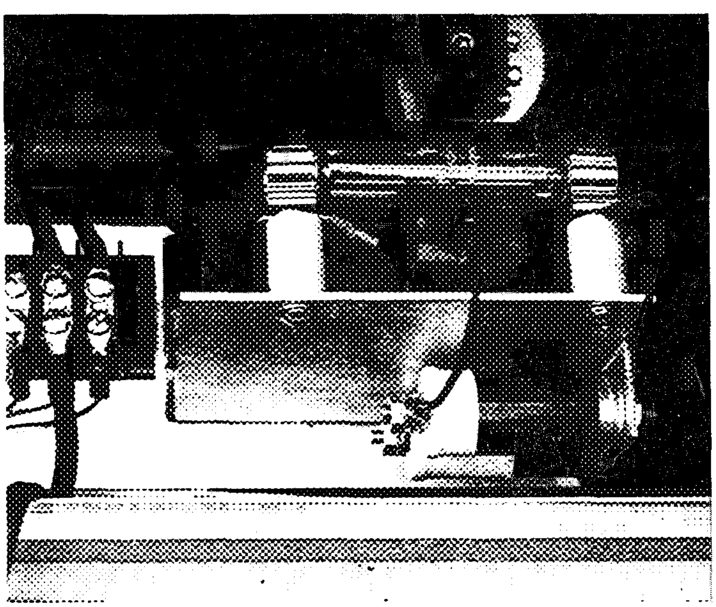
PROCEDURE FOR CONVERTING FROM ARGON TO KRYPTON OPERATION



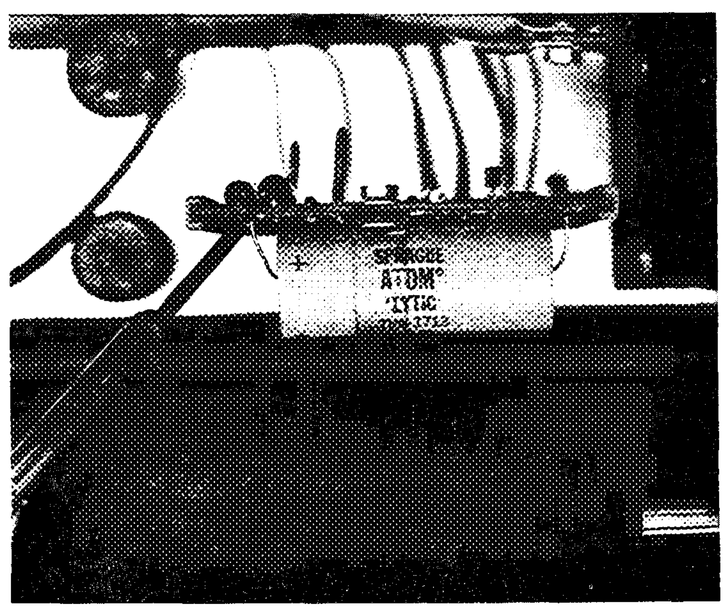
Step 1 - Parts List. 2 ea: aircraft type hose clamps. 1 ea: .005 mfd capacitor. 1 ea: capacitor connecting clip. 2 ea: washers. 1 ea: rubber insulator boot. 1 ea: ceramic stand off post.



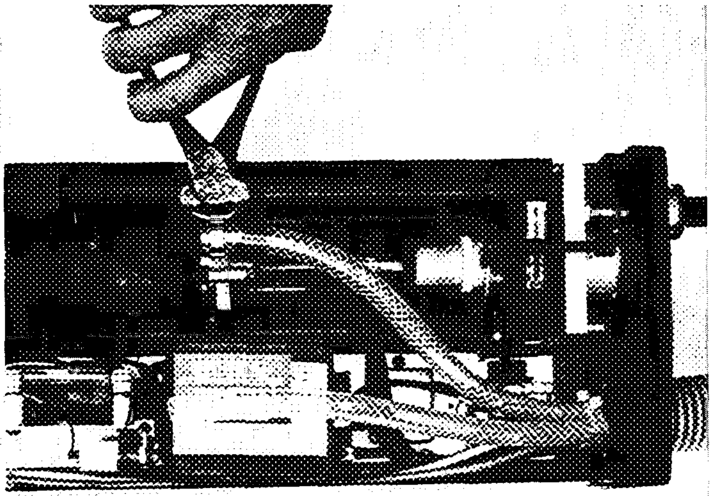
Step 2 - Remove Argon plasma tube. Follow plasma tube removal procedure.



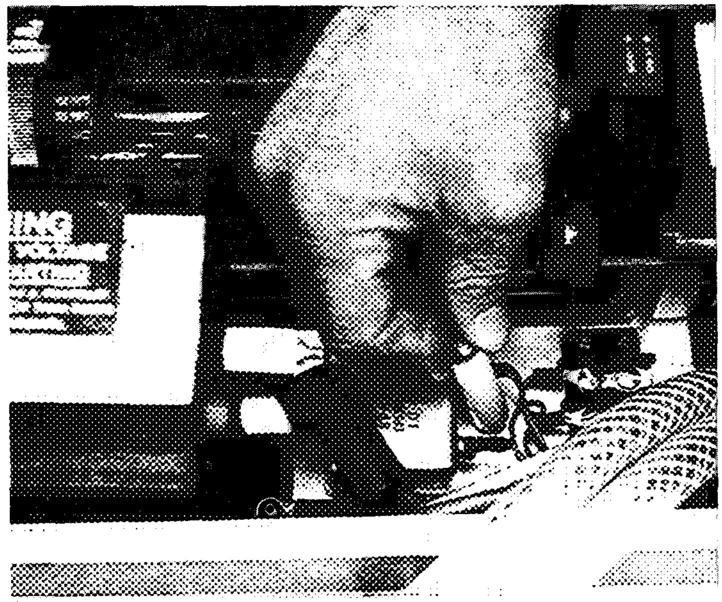
Step 3 - Install additional .005 mfd capacitor on starter circuit support. Mounting hole is provided. Electrically connect both capacitors using capacitor connecting clip. Transfer lead to top capacitor.



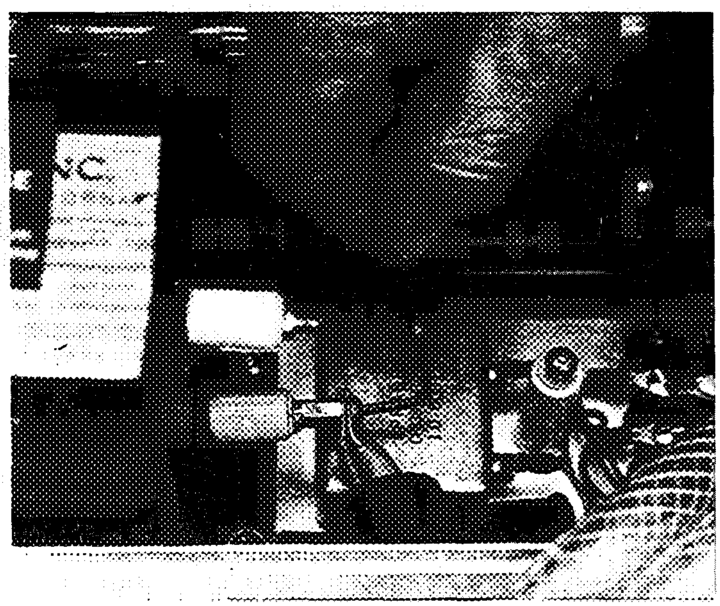
Step 4 - Unsolder and electrically disconnect 50 mfd capacitor on P. C. board. Do not remove capacitor from board as it must be reconnected if a return to Argon operation is later desired.



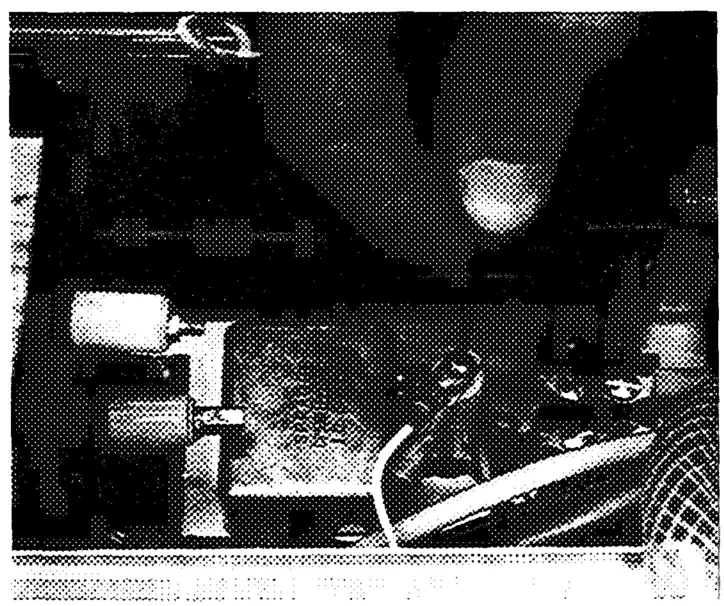
Step 5 - Install Krypton plasma tube and solenoid assembly by reversing the plasma tube removal procedure.



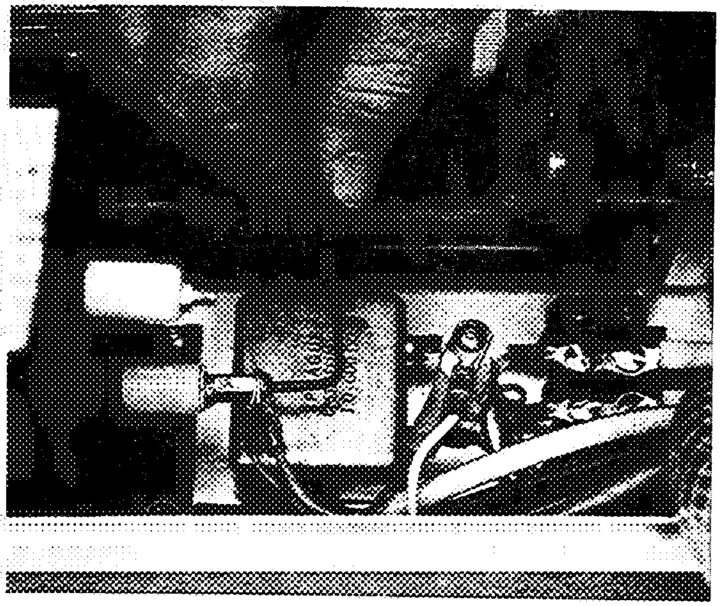
Step 6 - Install ceramic stand off. (Threaded hole provided in base plate in units after Serial #540). With earlier units, a 8/32" hole must be tapped and drilled.



Step 7 - Remove large green wire from lower post of starter transformer.



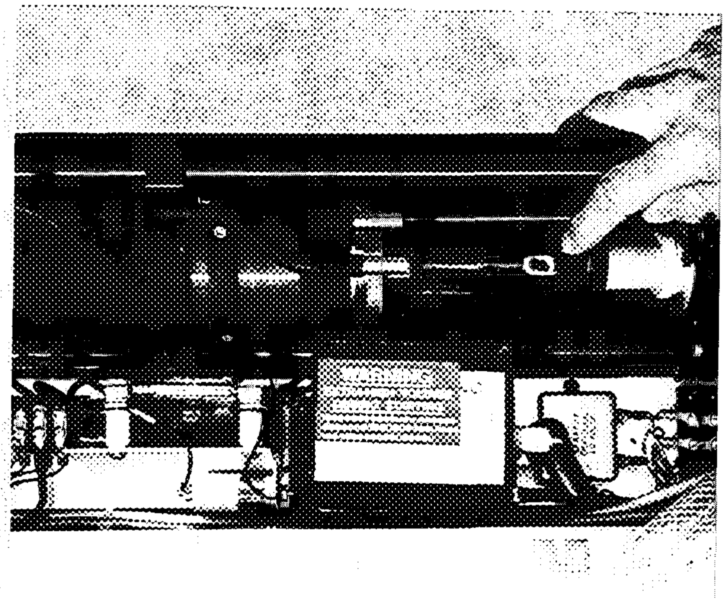
Step 8 - Install large green wire and one solenoid lead to stand off post.



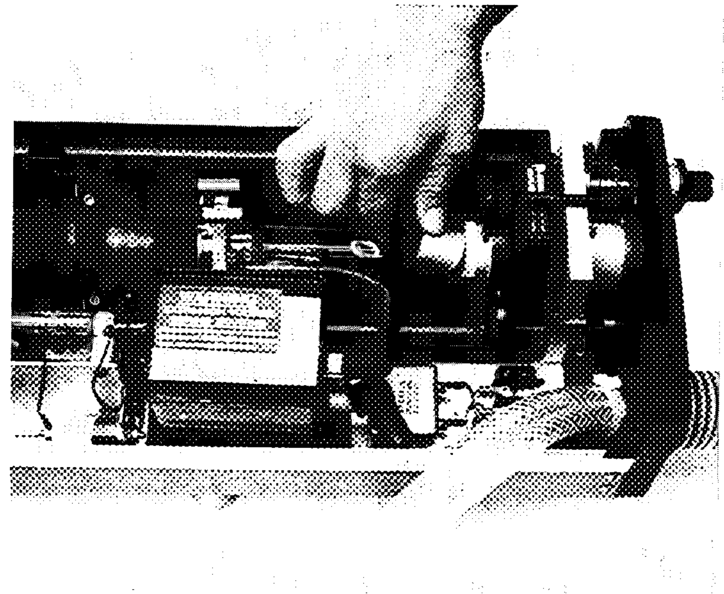
Step 9 - Install the other magnet lead and the small green wire to lower post of starter transformer.

Step 10 - Install Krypton broad band mirrors. The laser head is now ready for Krypton operation. To return to Argon operation, reverse this procedure.

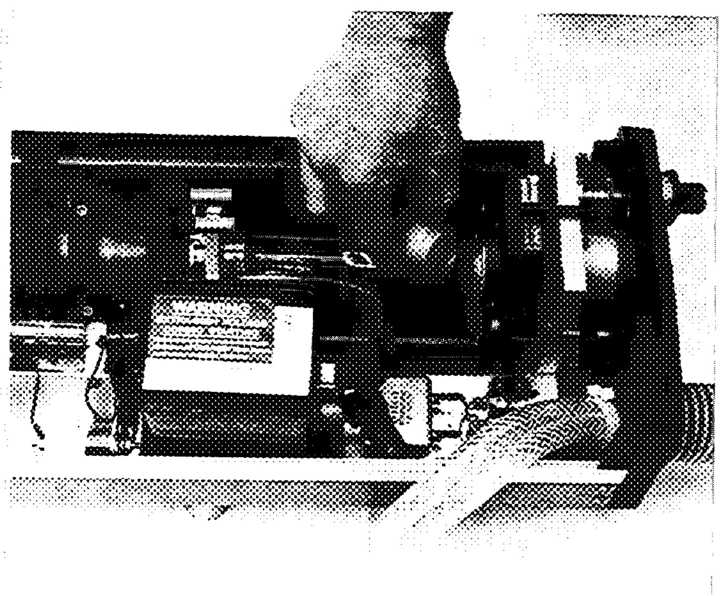
ETALON REMOVAL PROCEDURE



Step 1. Slide telescoping Brewster window dust shield back.

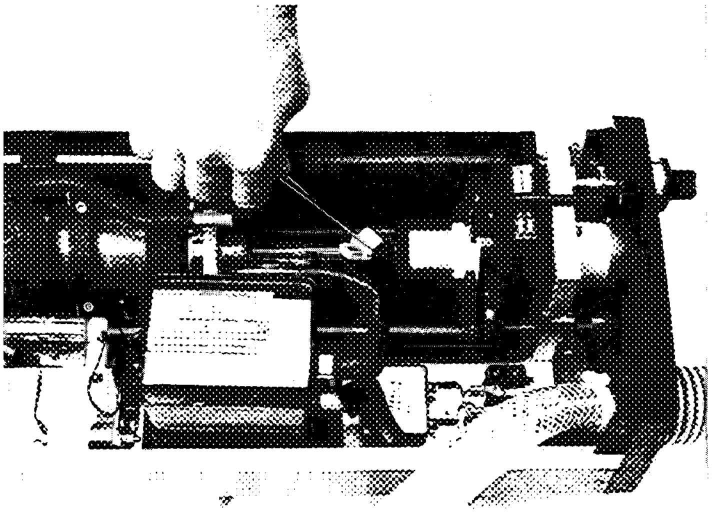


Step 2. Unscrew and remove etalon dust shield.

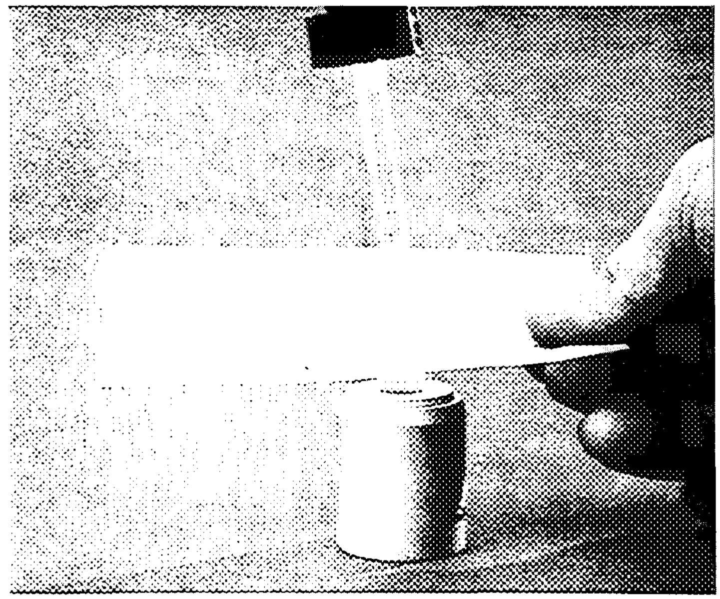


Step 3. Unscrew etalon holder and remove etalon. Reverse procedure to install dust shields for operation without etalon.

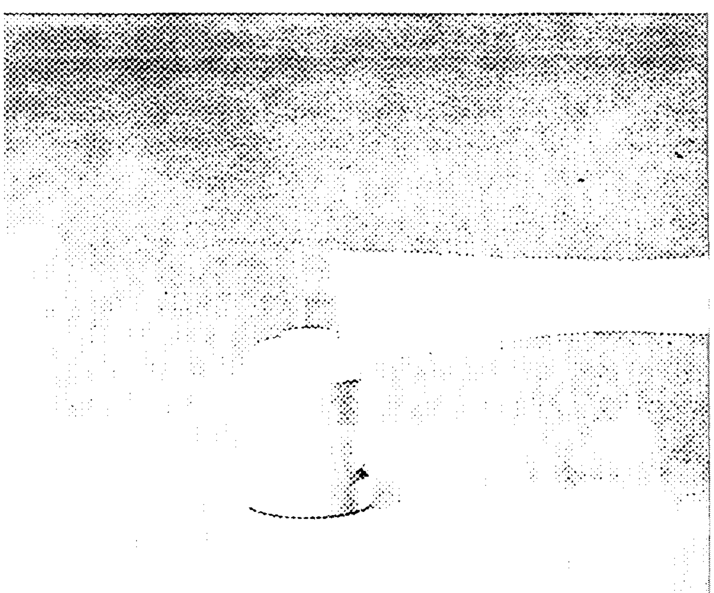
ION LASER OPTICS - CLEANING PROCEDURES



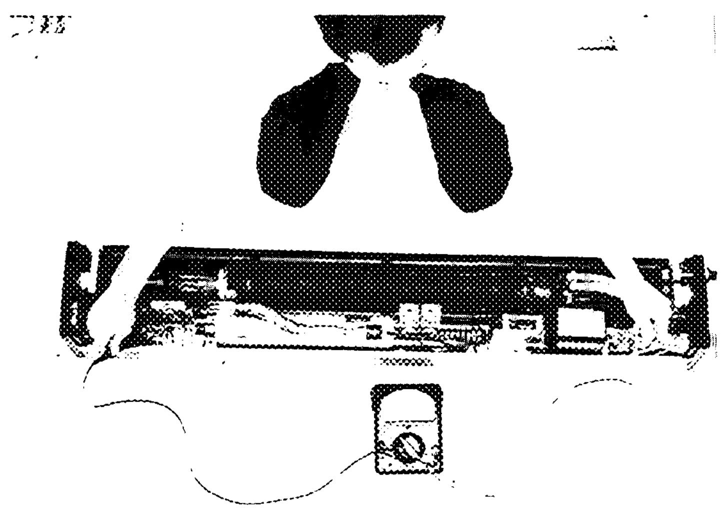
Brewster Windows. Clamp folded lens tissue in hemostat. Soak lens tissue in methanol. Shake off excess. Sweep across Brewster window with light pressure--one stroke only. (Water tubing disconnected for visibility purposes only.)



Reflector Cleaning (Step 1). Center clean lens tissue above reflector surface. Place a drop of methanol on tissue.



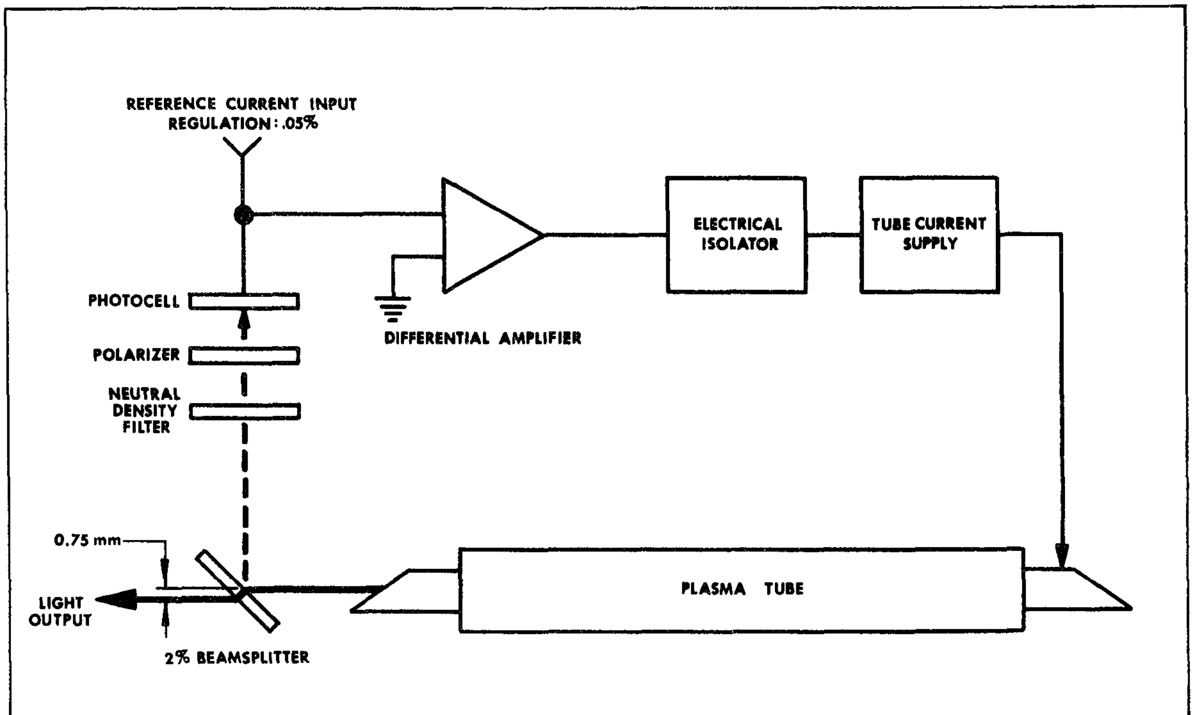
Reflector Cleaning (Step 2). Lower moist lens tissue onto reflector surface and pull tissue across the surface--one stroke only.



Tube Voltage Measurement. DC tube voltage should be measured from center tap of filament transformer (cathode) to upper tap of starter transformer (anode). With tube current off, voltage should be approximately 280V. Caution: Avoid touching high voltage points. Caution: Do not activate high voltage starter circuit while making measurement.

HERENT RADIATION LABORATORIES 932 EAST MEADOW DRIVE PALO ALTO CALIFORNIA 94303 TELEPHONE

MODEL 235 LIGHT SAMPLER AND AMPLITUDE STABILIZATION FEEDBACK LOOP



MODEL 235 LIGHT SAMPLER AND AMPLITUDE STABILIZATION FEEDBACK LOOP (SCHEMATIC)

General Description:

The Coherent Radiation Laboratories Model 235 Light Sampler and Amplitude Stabilization Feedback Loop is designed for use with both the Models 52 and 53 Argon/Krypton systems and functions to reduce the low frequency variation in light output.

Briefly, low frequency variation in power output is due to three main effects:

A ripple component at 60 and 360 Hz results from magnetic and electric pick-up. Without the 235, the amplitude of this component is typically between 0.5 and 1.0% rms, dependent on current level. With the 235, the level is reduced to less than 0.2% rms.

Low frequency, directly coupled and acoustically coupled vibration acts to modulate the power output by deforming the resonator structure. In a normal laboratory environment, modulation due to vibration is reduced to less than 0.2% rms.

Longer term drift results from temperature and stress variations in the resonator alignment, producing fluctuations of typically 1% rms over periods of an hour. This is reduced to better than 0.2% rms over one hour periods and 0.5% rms over 10 hour periods.

Principal of Operation:

The Model 235 is a sampling device which employs a 2% beam splitter located externally from the laser resonator. The sample beam passes through a neutral density filter and polarizer, and is detected at a photocell. The output of the photocell is compared to a stabilized reference current input through a differential amplifier, and small adjustments in tube current are made to stabilize the amplitude of the light output.

Specifications:

When the Model 235 is employed, the amplitude stabilization of either the Model 52 or Model 53 is as follows:

0.2% rms variation in the bandwidth 1 Hz to 1 KHz.

0.2% rms variation for periods between 1 second and 1 hour.

0.5% rms variation for periods between 1 second and 10 hours.

Every Model 52 and 53 ion laser is tested for noise in a 10 Hz to 2 MHz bandwidth (see data sheets). When the Model 235 is furnished, additional tests to the 235 specifications are performed and results included with the system. Detailed measurements of the noise spectrum are not performed on each laser. Figure 1, however, illustrates the noise spectrum of a typical laser.

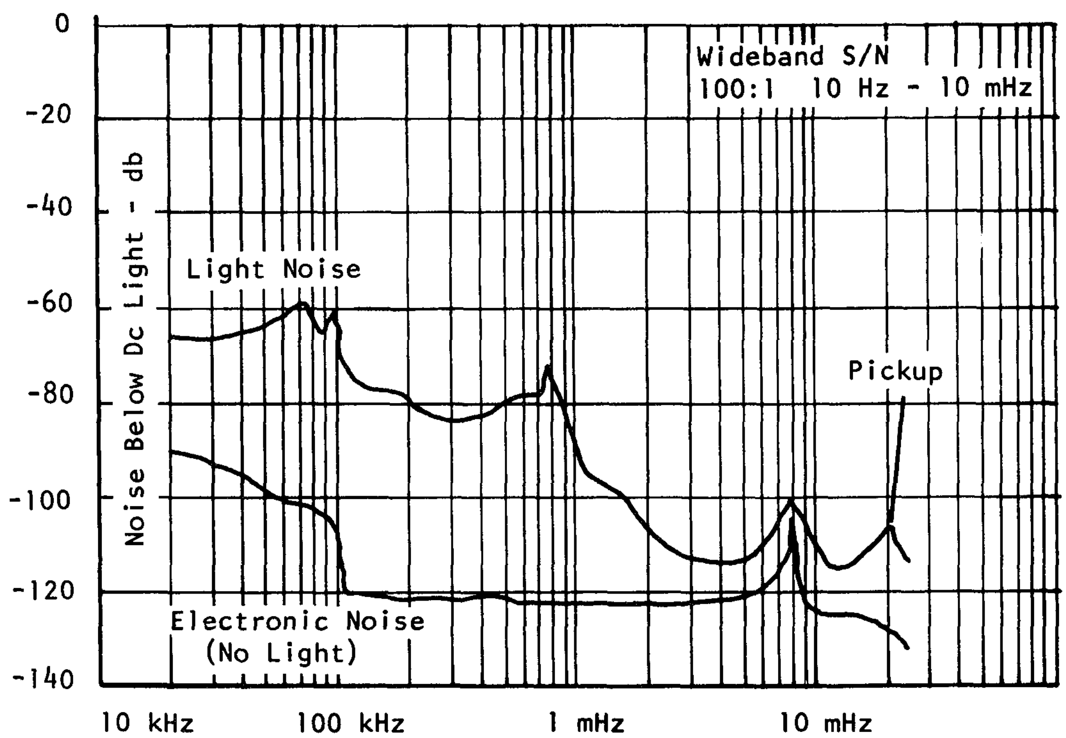


Figure 1. Coherent Radiation DC ion laser noise spectrum (Courtesy of B. C. Dickey). Measurements on Rohde and Schwartz frequency selective voltmeter, 5 KHz bandwidth.

Model 235 Light Sampler and Amplitude Stabilization Feedback Loop--------$ 925.
Delivery----------------------------------30 - 45 days after receipt of order.

INSTALLATION INSTRUCTIONS

MODEL 235 LIGHT REGULATOR

The light sampler assembly of the Model 235 Light Regulator is dismounted before shipment to avoid damage in shipping.

To install the light sampler, remove the knurled nut holding the output mirror. Remove the mirror and install it in the light sampler mirror holder. Install the light sampler in place of the nut, with the photocell assembly vertical. A locating pin is provided to maintain the orientation. The nut on the light sampler should be tightened with the fingers only.

Connect the coaxial cable protruding from the laser to the photocell assembly. This completes the installation.

ADJUSTMENT OF THE LIGHT SAMPLER

If the light sampler has not been adjusted to match the laser, the following procedure should be followed:

1. Remove the photocell by unscrewing it from the top of the vertical tube. Place a piece of transluscent material such as paper over the tube.
2. Turn on the laser in the "Current Regulation" mode.
3. If the light spots from the beam splitter are not centered

in the vertical tube, loosen the set screw clamping the beam splitter mount, and move the beam splitter to center the spots. A pair of 8-32 screws may be started into the beam splitter mount to facilitate moving it.

4. Insert the photocell and connect a milliammeter to the BNC fitting. Loosen the set screw clamping the vertical tube. With the laser operating, rotate the vertical to obtain a minimum current reading. Mark the tube and rotate it 90° from the minimum. This step assures minimum coupling of the photocell to light of the wrong polarization. A polarizer is mounted in the vertical tube.

5. Tighten the set screws and connect the cable to the photocell.

4.6 PUMPING DOWN THE PLASMA TUBE

(1) Remove cover of laser head.

(2) Remove circuit card and mounting screws on card connector.

(3) Remove front bezel.

(4) Remove filament transformer.

(only if necessary)

(5) Remove plastic cover on ballast tank.

(6) Connect Cryolab valve operator to the valve on the output end of the ballast tank.

(7) Connect vacuum source to valve.

(8) Evacuate line and valve operator. (large tank valve)

(9) Connect thermocouple gauge readout. It should agree with power supply readouts of 280-300 millitorr.

(10) Pressure in the pump line must be below tube pressure and there should be no leaks. (B&D says maybe 10 mT)

(11) At this point the Ar tank valve is ready to be opened.

(12) Great care is needed now since pumping too far can be dange...

(13) Just crack the valve into the ballast tank and close immediately.

CCW to open (use wrench to initially open seal)

2 turns or so

evacuate tube

↓

CW with valve to seal tube (slip type assembly after sealed)

(14) The pressure response is rather slow so DO NOT wait for the needle to move before shutting off the valve.

(15) If no response occurs in the pressure reading, repeat the above procedure with a slightly larger crack.

(16) There is an O-ring seal and some compression of the O-ring mu... be overcome.

(17) A pressure of 80 millitorr is needed here and ± 20 millitorr is no problem.

(18) Once the laser is running, gas can be added to bring pressure up "hot operating pressure" called out on the shipping data sheet.

4.7 FILLING THE GAS RESERVOIR

(1) Remove starting circuitry (the smaller of the two transformers and the capacitors) to allow clearance for the VALVE ASSEMBLY. Rest these parts on the larger transformer during the filling procedure.

(2) Remove the plastic cap covering the reservoir valve.

(3) Place the VALVE ASSEMBLY in the head and screw it onto the reservoir. It will seem loose but it is vacuum tight.

(4) Connect your vacuum pump to Valve #1 (black) on the VALVE ASSEMBLY. Use an appropriate connector.

(5) Open Valve #1 and pump down the vacuum line to approximately 10 millitorr or less. (If you cannot measure it, the pumping procedure will take about 5 minutes with a good vacuum pump.)

(6) Close Valve #1.

(7) Push in valve operator #4 until it catches in the notch of the valve.

(8) Unscrew valve operator #4 and pull it back about 1 inch, opening the reservoir to the VALVE ASSEMBLY.

(9) Open Valve #3.

(10) Close Valve #3.

(11) Open Valve #2.

(12) Close Valve #2.

(13) Close Valve #4 by screwing it in until it stops. It must be tight.

(14) Withdraw valve operator #4 by pulling it back.

(15) Remove the vacuum pump line and then the VALVE ASSEMBLY.

(16) Replace the electronics

(17) Start up the laser. If the amount per fill is not approximately 10 millitorr, repeat steps 1 through 16.

Please return the VALVE ASSEMBLY to Coherent Radiation.