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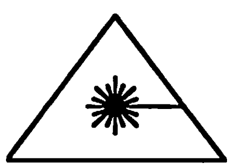
PREFACE

This manual consists of three sections. Section I of this manual contains user information for the 899-21 titanium:sapphire ring laser. Section II contains information for the 899-21 dye ring laser. Procedures for converting the laser from titanium:sapphire operation to dye operation (and vice versa) are located in Section III.

For those user's with a Model 895 etalon assembly installed, information including installation and tuning is located in Appendix D.

Read this manual carefully before operating the laser for the first time. Special attention should be given to the material in Chapter One, Laser Safety, that describes the safety features built into the 899 Laser.



Caution - Use of controls or adjustments or performance of procedures other than those specified in this manual may result in hazardous radiation exposure.

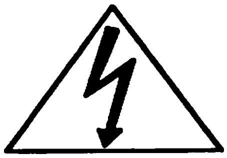
U.S. EXPORT CONTROL LAWS COMPLIANCE

It is the policy of Coherent to comply strictly with U.S. export control laws.

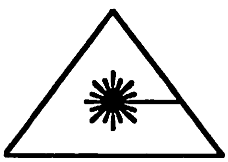
Export and re-export of lasers manufactured by Coherent are subject to U.S. Export Administration Regulations, which are administered by the Commerce Department. In addition, shipments of certain components are regulated by the State Department under the International Traffic in Arms Regulations.

The applicable restrictions vary depending on the specific product involved and its destination. In some cases, U.S. law requires that U.S. Government approval be obtained prior to resale, export or re-export of certain articles. When there is uncertainty about the obligations imposed by U.S. law, clarification should be obtained from Coherent or an appropriate U.S. Government agency.

SYMBOLS USED IN THIS DOCUMENT



The lightning flash with arrowhead symbol is intended to alert the operator to the presence of dangerous voltage within the product's enclosure that may be of sufficient magnitude to constitute a risk of electric shock to persons and to indicate possible risk of equipment damage.



The radiation symbol is intended to alert the operator to the danger of exposure to hazardous visible and invisible laser radiation.

The exclamation point is intended to alert the operator to potential dangers not arising directly from electrical or radiation hazards.

This symbol is also used to emphasize the presence of important operating and maintenance instructions in the documentation accompanying your laser system.

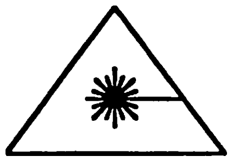
Operator's Manual

Chapter One
Laser Safety

COHERENT

OPTICAL SAFETY

Laser light, because of its special properties, poses safety hazards not associated with light from conventional sources. The safe use of lasers requires that all laser users, and everyone near the laser system, are aware of the dangers involved. The safe use of the laser depends upon the user being familiar with the instrument and the properties of coherent, intense beams of light.



Direct eye contact with the output beam from the laser will cause serious damage and possible blindness.

The greatest concern when using a laser is eye safety. In addition to the main beam, there are often many smaller beams present at various angles near the laser system. These beams are formed by specular reflections of the main beam at polished surfaces such as lenses or beamsplitters. While weaker than the main beam, such beams may still be sufficiently intense to cause eye damage.

Laser beams are powerful enough to burn skin, clothing or paint. They can ignite volatile substances such as alcohol, gasoline, ether and other solvents, and can damage light-sensitive elements in video cameras, photomultipliers and photodiodes. The laser beam can ignite substances in its path, even at some distance. The beam may also cause damage if contacted indirectly from reflective surfaces. For these reasons, and others, the user is advised to follow the precautions below.

1. Observe all safety precautions in the pre-installation and operator's manual.
2. Extreme caution should be exercised when using solvents in the area of the laser.
3. Limit access to the laser to qualified users who are familiar with laser safety practices and who are aware of the dangers involved.
4. Never look directly into the laser light source or at scattered laser light from any reflective surface. Never sight down the beam into the source. Do not stare into the dye jet.
5. Maintain experimental setups at low heights to prevent inadvertent beam-eye encounter at eye level.

Laser safety glasses can present a hazard as well as a benefit; while they protect the eye from potentially damaging exposure, they block light at the laser wavelengths, which prevents the operator from seeing the beam. Therefore, use extreme caution even when using safety glasses.

6 As a precaution against accidental exposure to the output beam or its reflection, those using the system should wear laser safety glasses as required by the wavelength being generated.

7 Avoid direct exposure to the laser light. The intensity of the beam can easily cause flesh burns or ignite clothing.

8 Use the laser in an enclosed room. Laser light will remain collimated over long distances and therefore presents a potential hazard if not confined.

9 Post warning signs in the area of the laser beam to alert those present.

10 Advise all those using the laser of these precautions. It is good practice to operate the laser in a room with controlled and restricted access.

ELECTRICAL SAFETY

The 899-21 uses lethal AC and DC voltages in the dye circulator, laser head, and control box. All units are designed to be operated with the protective covers in place. Certain procedures in this manual require removal of the protective covers. These procedures are normally used by a qualified trained service personnel. Safety information contained in the procedures must be strictly observed by anyone using these procedures

PUMP SOURCE

Observe all safety precautions associated with the pump laser. Refer to the Operator's Manual for additional safety precautions.

CDRH COMPLIANCE

The following safety features incorporated in the 899 laser conform to United States Government requirements 21 CFR Subchapter J as administered by the Center for Devices and Radiological Health (CDRH).

PROTECTIVE HOUSING

The laser head is enclosed in a protective housing which prevents human access in excess of the limits of class one radiation as specified in the Federal Register, July 31, 1975, Part II, Section 1040.10 (f) (1) and table 1-A except for the output beam which is class 4.

HAZARDOUS RADIATION EXPOSURE

Caution - use of controls or adjustments or performance of procedures other than those specified in the manual may result in hazardous radiation exposure.

LOCATION OF CDRH COMPLIANCE LABELS

Refer to Figure 9 for a description and location of all CDRH required labels. These include warning labels indicating removable or displaceable protective housings, apertures through which laser radiation is emitted and labels of certification and identification. (CFR 1040.10(g)), (CFR 1040.10(g)), (CFR 1040.10(g)(5)), (CFR 1010.2))

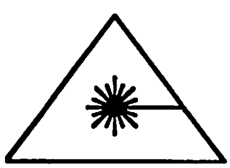
- When the pumping beam is allowed to impinge on the dye jet, both laser and collateral radiation are produced. The laser beam is emitted from the laser aperture which is clearly labeled:

  Avoid Exposure

  Visible and Invisible Laser Radiation is emitted from this aperture.

- The laser is designed to be used with the cover in position and this cover shields the operator from all collateral radiation. During initial alignment and maintenance operations, such as mirror alignment or nozzle adjustment, it will be necessary to remove the cover. The cover is not interlocked with the circuitry of the pumping laser but a label provides a warning about exposure to the radiation.

The bulk of the collateral radiation is contained within a secondary shield around the jet, but care should be taken not to stare at the radiation scattered in the jet area.



Operation of the laser with the protective housing removed will allow access to hazardous visible and invisible radiation. The laser housings should only be opened for the purposes of maintenance and service by trained personnel cognizant of the hazards involved.

Extreme caution must be observed in operating the laser with the cover removed. There are high-power reflections which may exit at unpredictable angles from the laser head. These beams have sufficient energy density to cause permanent eye damage or blindness.

The Center for Devices and Radiological Health regulations apply only within the United States.

HANDLING DYE

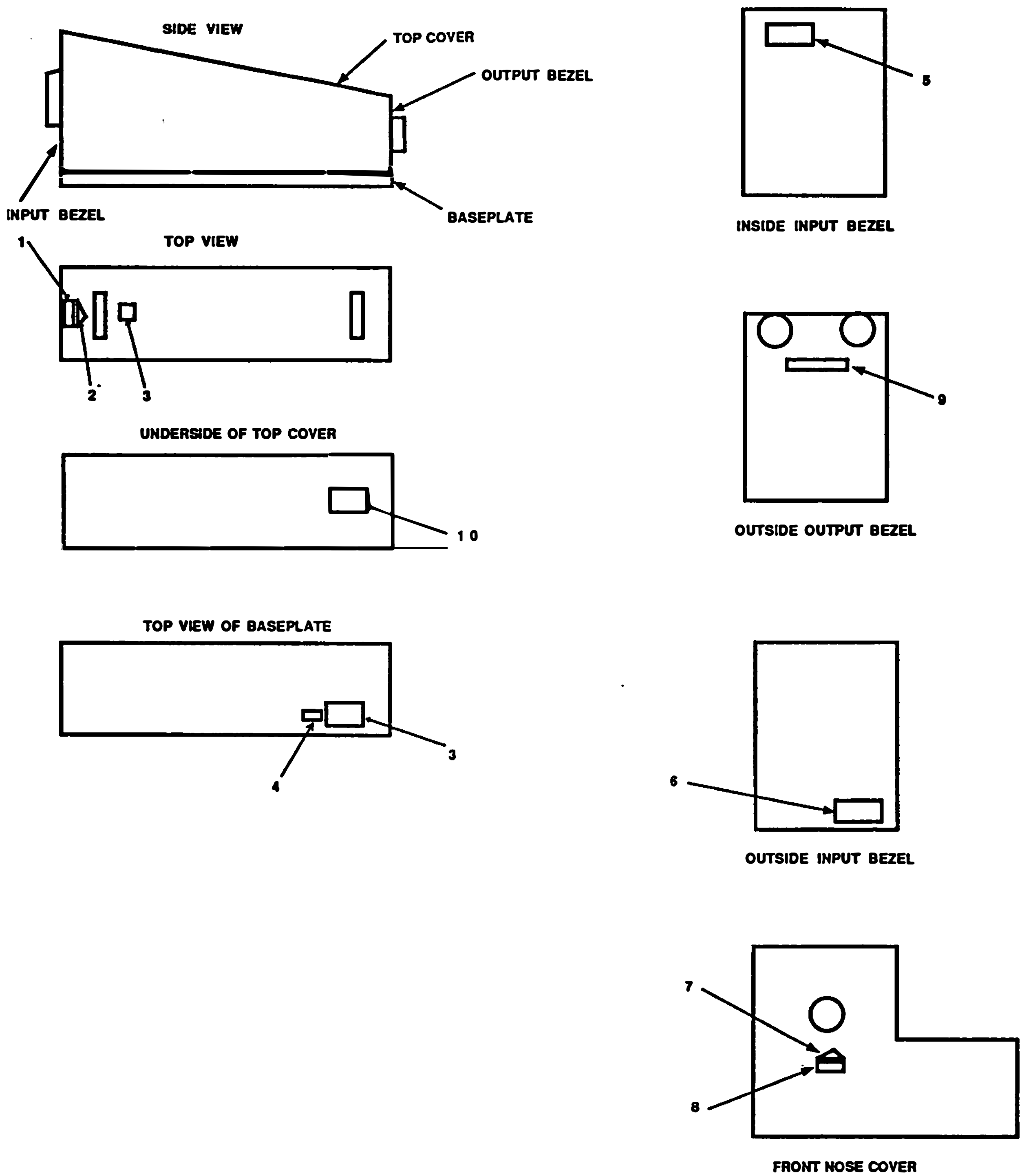
Laser dyes, solvents and additives are toxic chemicals. It is recommended that all dyes be considered dangerous and the precautions listed below observed.

1 Use plastic gloves when handling dye. Avoid contact with eyes, skin, and clothing. Wash thoroughly after handling.

2 Open, weigh and mix dyes under a fume hood. Avoid breathing dust or vapor.

3 Treat dyes as a toxic chemical. Dispose of used dyes in a safe manner and in accordance with local or federal regulations.

Figure 1-1. Safety Features and Labels (Sheet 1 of 2)



Key to Figure 1-1.

Figure 1-1. Safety Features and Labels (Sheet 1 of 2)

Operator's Manual

Chapter Two
Description

Coherent

SYSTEM DESCRIPTION

The Model 899-21 Ring Laser System is a flexible, convertible ring laser that can operate as a conventional dye ring laser, or it can operate as a solid state ring laser using titanium:sapphire as the gain medium. It is tunable from 375 to 890 nm in dye operation.

The 899-21 consists of the laser head, Figure 2-1, and a Model 5920 dye circulator, Figure 2-2, when dye is the gain media. The 899-21 can use a low power pump laser such as the Coherent Innova 306 6 W argon Ion laser or a high power pump laser such as the Innova 200, 20 W argon Ion laser as the pump source.

The conversion from titanium:sapphire to dye or dye to titanium:sapphire is simply a matter of changing the position of three mounts, interchanging gain media and optics, and realigning. As mentioned earlier the 899-21 is designed for low and high power pumping in the titanium:sapphire configuration and accomplishes this by using a low or high transmissive output coupler along with a variable focus pump geometry.

The 899-21 can be upgraded to a passive or actively-stabilized, scanning single-frequency ring laser in titanium:sapphire with or without computer controlled scanning.

LASER HEAD

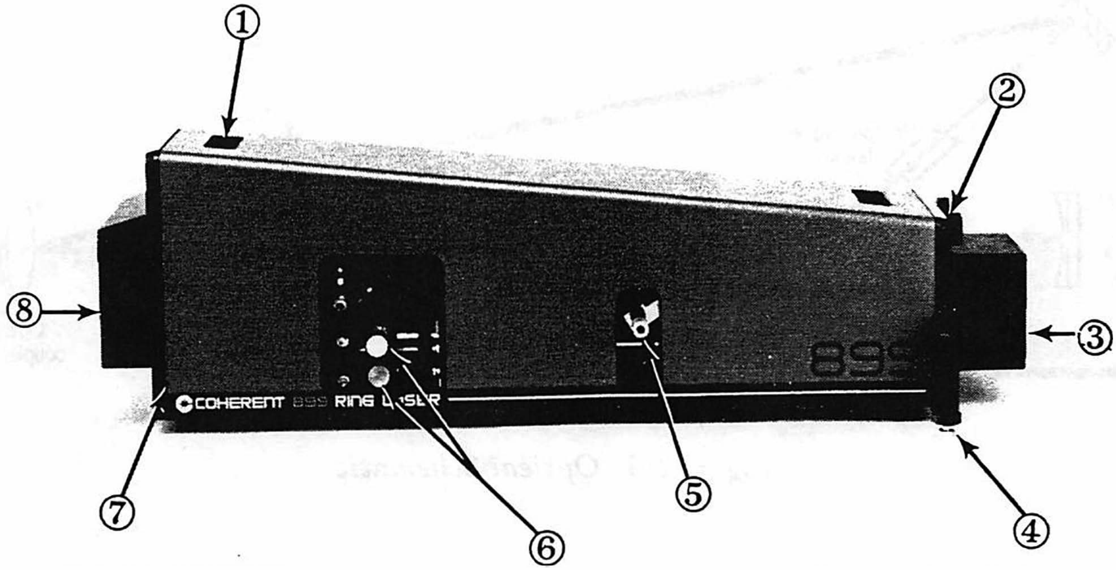
To facilitate understanding of the optical resonator, an optical diagram of the dye configuration is shown in Figure 2-3.

Laser head controls that are used frequently during daily operations are accessible without removing the covers. The function of all controls is described in Chapter Three.

Major laser head components in the 899-21 dye configuration are illustrated in Figure 2-4. All components and stages are mounted directly or indirectly to a 2-inch Invar bar that provides mechanical strength and length stability due to a low coefficient of expansion. This results in passive cavity length thermal stabilization of less than 1 micron/degree centigrade.

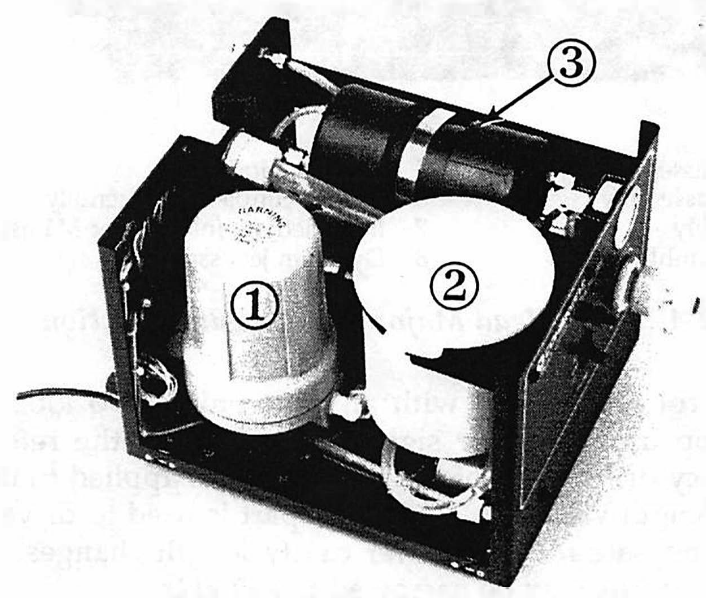
Unidirectional lasing is achieved with an optical diode shown in Figure 2-4. The device achieves lasing in a single direction by utilizing optical activity and the Faraday effect.

Passive frequency control is achieved with a series of intracavity frequency filters also depicted in Figure 2-4. The three plate birefringent filter allows broadband operation over approximately 2 GHz. This filter is uncoated and mounted at Brewster's angle to ensure maximum tuning range. With the insertion of the intracavity etalon assembly (ICA), which consists of a thick and thin etalon, the operational bandwidth may be narrowed to 10 MHz. The coated etalons are of low finesse to allow broadband coverage.



1 Cover hand holds (2)
2 Output coupler horizontal and vertical tilt adjustment
3 Output beam aperture
4 Laser head height/level adjustment screws (3)
5 Birefringent filter adjust
6 Pump mirror tilt adjustment controls
7 Screws (2) securing cover
8 Input pump beam aperture

Figure 2-1. Laser Head



1 Filter Cover
2 Reservoir
3 Heat exchanger

Figure 2-2. Model 5920 Dye Circulator

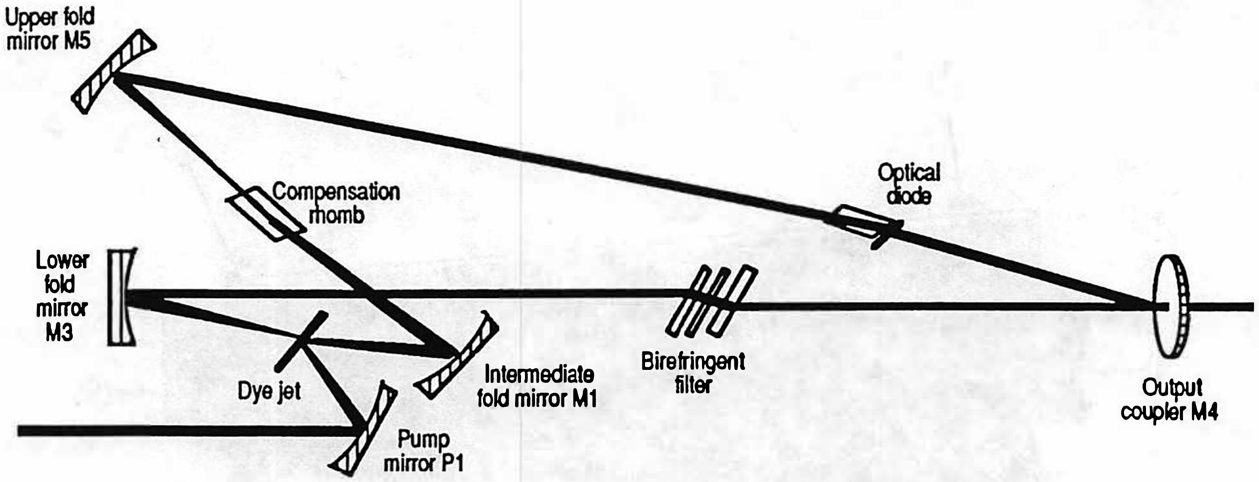
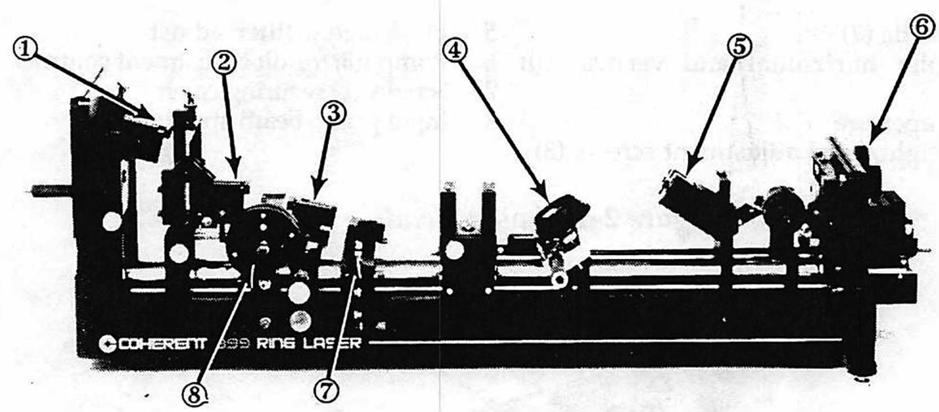


Figure 2-3. Optical Schematic



1	Upper fold mirror M5 assembly	5	Optical diode
2	Lower fold mirror M1 assembly	6	Output coupler M4 assembly
3	Pump mirror P1 assembly	7	Intermediate fold mirror M1 assembly
4	Birefringent filter assembly	8	Dye gain jet assembly

Figure 2-4. Laser Head Major Components Location

Active frequency control is achieved with an electronic servo loop & reference cavity. The servo loop uses an error signal derived from the reference cavity when the laser frequency drifts. Part of the error signal is applied to the tweeter to correct for fast cavity length variation. The other part is used to drive the rotating Brewster plate to compensate for the slower cavity length changes. With active frequency control, line widths may be narrowed to 500 kHz.

Single mode frequency scanning in ranges up to 30 GHz is possible by continuously varying the cavity length with the rotating galvanometer driven Brewster plate. The Brewster plate is mounted at the vertex of the optical beam path. This design minimizes displacement of the intra-cavity beam while maintaining a constant reflection loss of about 0.4% during a scan.

The thickness of the thick etalon may be varied with the piezoelectric transducer in order to track the laser frequency as it is scanned. The thin etalon is tuned by a galvanometer drive which controls the tip angle.

MODEL 5920 DYE CIRCULATOR

The Model 5920 dye circulator cools, filters, and pumps the dye. It also controls the dye jet pressure and contains a reservoir for the dye. A schematic diagram of the dye circulator is shown in Figure 2-5.

The main volume of dye solution is held in a reservoir, while a positive displacement pump is used to force the dye solution through the outlet hose and out of the jet nozzle. A return hose catches the jet stream and returns the dye solution to the reservoir.

As the pump operates it introduces heat into the dye solution which, unless removed, will elevate the dye temperature and degrade laser performance. The dye circulator includes a heat exchanger to permit water cooling of the dye. In most applications, laser performance will be noticeably enhanced by cooling the dye to approximately 4° C.

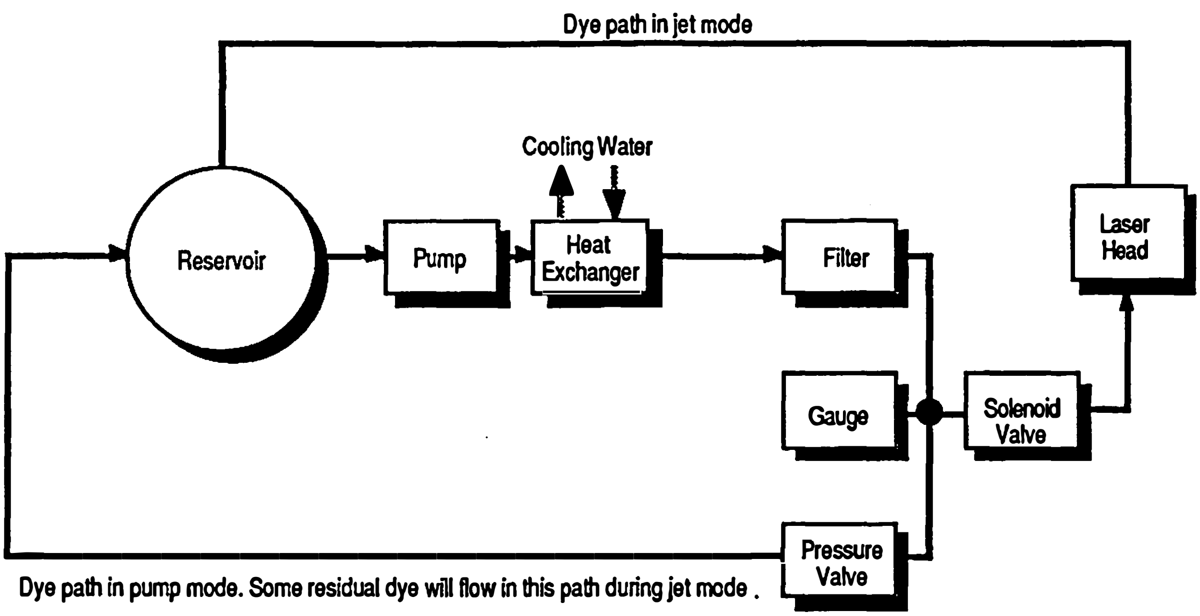
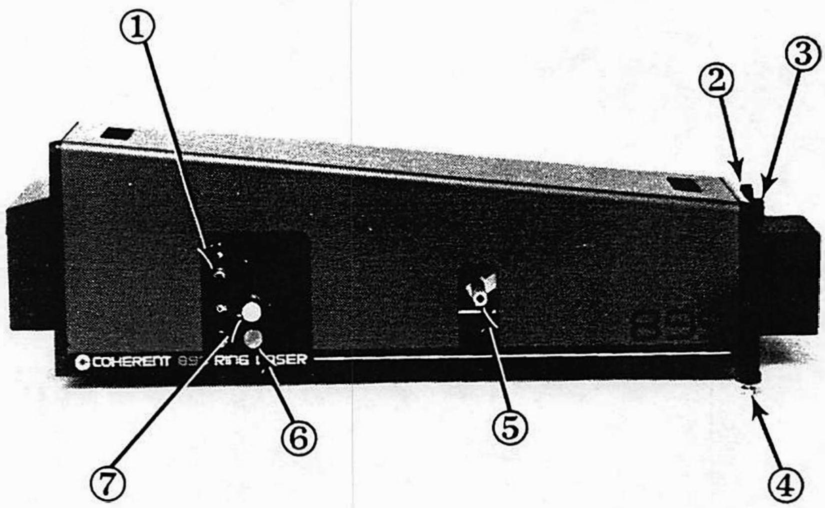


Figure 2-5. Dye Circulator Block Diagram

Operator's Manual

Chapter Three
899-21 Controls

COHERENT

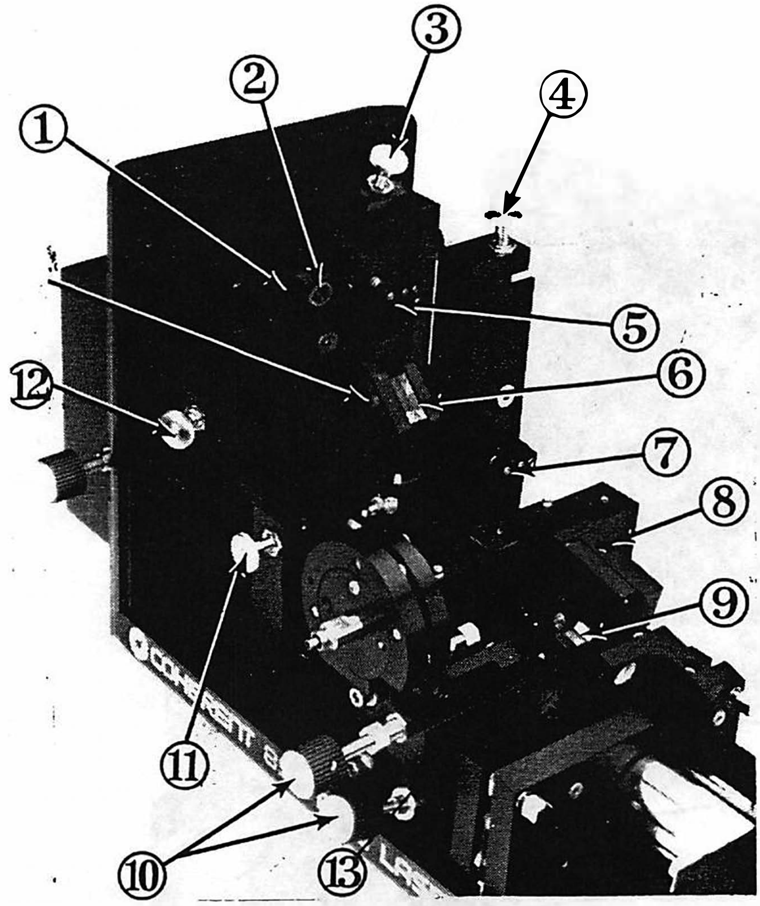


1 Dye jet input connector
2 Output coupler vertical tilt adjust
3 Output coupler horizontal tilt adjust
4 Laser head height/level adjustment screws (3)
5 Birefringent filter adjust
6 Pump mirror P1 vertical tilt adjust
7 Pump mirror P1 horizontal tilt adjust

Figure 3-1. Laser Head Controls (Cover Installed)

CONTROL	FUNCTION
Pump mirror P1 horizontal and vertical tilt adjust	Allows horizontal and vertical tilt adjustments of pump mirror P1. This adjustment steers the pump beam and affects the intersection of the pump beam and dye jet.
Birefringent filter (BRF) adjust	Allows for tuning the birefringent filter during initial alignment and during daily operation.
Output coupler M4 horizontal and vertical tilt adjust.	Allows horizontal and vertical tilt adjustment of the output coupler. Controls are used during initial alignment and daily operation. Allows optimizing output power and beam mode when the cover is in position.
Dye jet input connector	Connector for 1/8 in. (ID), 1/4 in. (OD) plastic tubing that transports dye from the dye circulator to the dye jet.
Dye drip return connector	Connector for 1/4 in. (ID) inch plastic tubing to catch any dye drips from the dye jet inside the laser head. The tube may require occasional emptying. Connector is not visible on Figure 3-1.
Dye jet return connector.	Connector for 1/2 in. (ID), 5/8 in. (OD) plastic tubing that returns dye from the laser head to the dye circulator. Connector is not visible on Figure 3-1.
Laser head height/level adjustment screws.	Three adjustment screws (two at the output end of the laser head and one at the input end) are provided to adjust the height and to level the laser head.

Table 3-1. Laser Head Controls (Cover Installed)

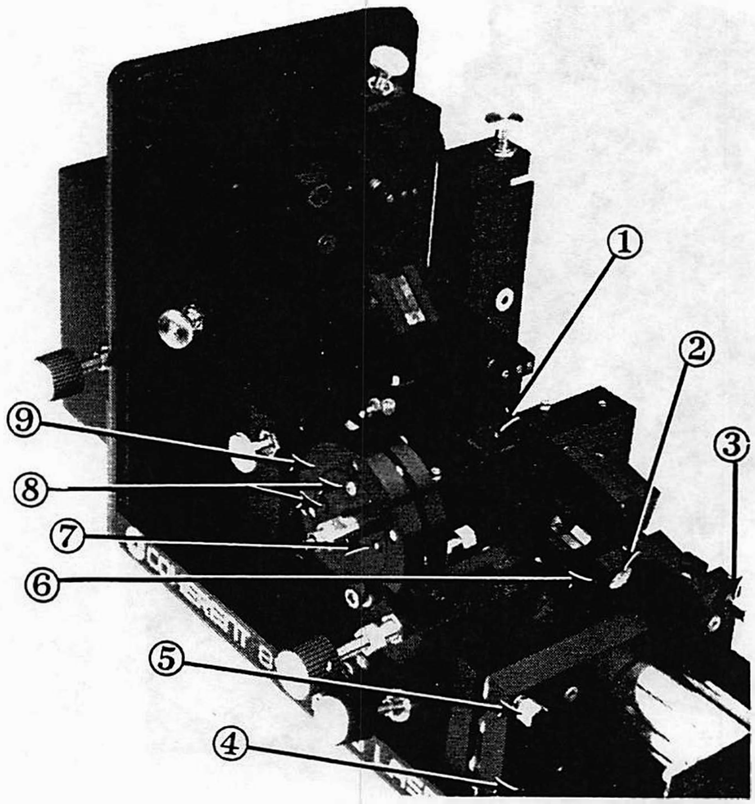


1 Setscrew securing M5 optic
2 Upper fold mirror M5
3 M5 vertical tilt adjust
4 M3 vertical tilt adjust
5 M5 Focus adjust
6 Astigmatic compensation rhomb
7 M3 Focus adjust
8 P1 coarse horizontal rotational adjustment
9 Pump mirror P1
10 Pump mirror P1 controls (refer to Table 3-1)
11 M3 horizontal tilt adjust
12 M5 horizontal tilt adjust
13 P1 coarse vertical rotational adjustment

Figure 3-2. M3/M5/Compensation Rhomb Adjustment Controls

CONTROL	FUNCTION
M5 vertical and horizontal tilt adjust.	Positions the fluorescent spot at the output coupler M4 during optical alignment. Also used for power optimization during alignment. Refer to Figure 2-3 for an optical path diagram.
M5 focus adjust.	Controls the size of the fluorescent spot during optical alignment. Used to optimize power and mode.
M3 vertical and horizontal tilt adjust.	Positions the fluorescent spot at the output coupler M4 during optical alignment. Also used for power optimization during alignment. Refer to Figure 2-3 for an optical path diagram.
M3 focus adjust.	Determines size and position of beam waist. Refer to Figure 2-3 for an optical path diagram.
P1 coarse horizontal and vertical rotational adjust.	Provides for coarse pump beam steering during full alignment.

Table 3-2. M3/M5/Compensation Rhomb Adjustment Controls

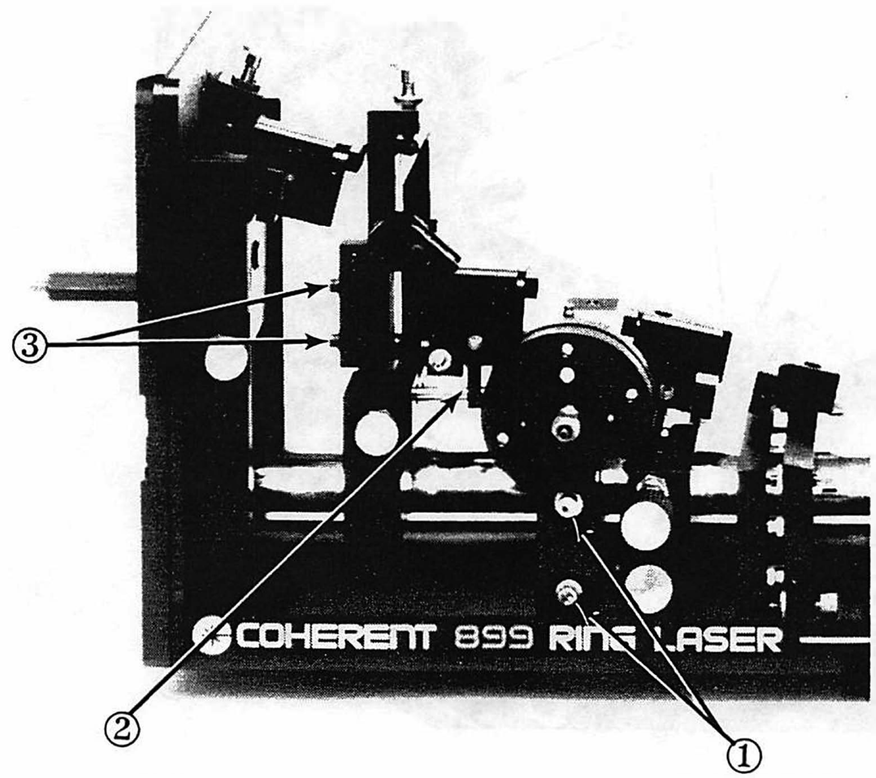


1 Neutral density filter
2 Intermediate fold mirror M1
3 M1 horizontal tilt adjust
4 M1 vertical tilt adjust
5 M1 pivot
6 Setscrew securing M1 optic
7 Alignment dowel pin
8 Screws securing dye jet nozzle holder
9 Dye jet tip plate

Figure 3-3. M1 Adjustment Controls

CONTROL	FUNCTION
M1 vertical and horizontal tilt adjust.	Positions the fluorescent spot or beam on M5 during optical alignment. Refer to Figure 2-3 for an optical path diagram.
Pivot for M1 horizontal and vertical tilt adjustment.	Used in conjunction with the M1 horizontal and vertical adjustment controls, to translate M1 along the optical axis. This adjustment is used to establish the correct distance between M1 and the dye jet during the conversion from titanium:sapphire to dye.
Jet nozzle assembly dowel pin.	Allows the dye jet holder to be installed only one way which keeps the jet nozzle at Brewster's angle.
Neutral density filter.	Allows the intersection of the dye jet and the pump beam to be viewed.

Table 3-3. M1 Adjustment Controls

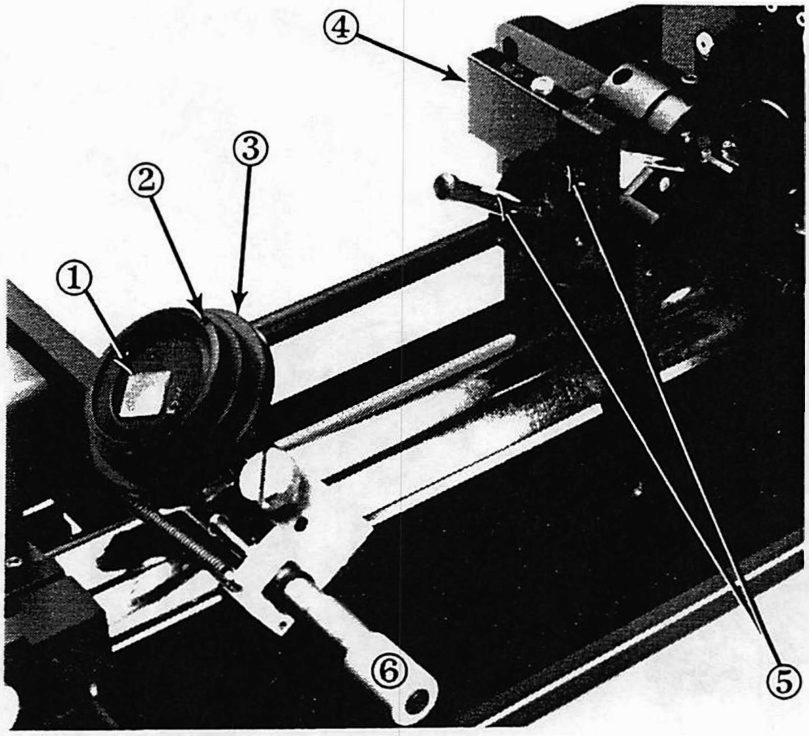


1 Dye jet bracket height adjustment screws (2)
2 Pump beam stop
3 Compensation rhomb height adjustment screws (2)

Figure 3-4. Dye Jet Tip Plate Height Adjust/Compensation Rhomb Height Adjust/Pump Beam Stop

CONTROL	FUNCTION
Dye jet tip plate height adjustment.	Loosening the two screws allows height adjustment of the entire gain jet assembly during initial alignment.
Compensation rhomb height adjustment.	Loosening the two screws allows height adjustment of the compensation rhomb assembly during initial alignment.
Pump beam stop.	This stop blocks the pump beam which could otherwise cause heat build-up on the M3 mount. The stop is removed in the titanium:sapphire configuration by loosening the setscrew securing it.

Table 3-4. Dye Jet Tip Plate Height Adjust/Compensation Rhomb Height Adjust/Pump Beam Stop

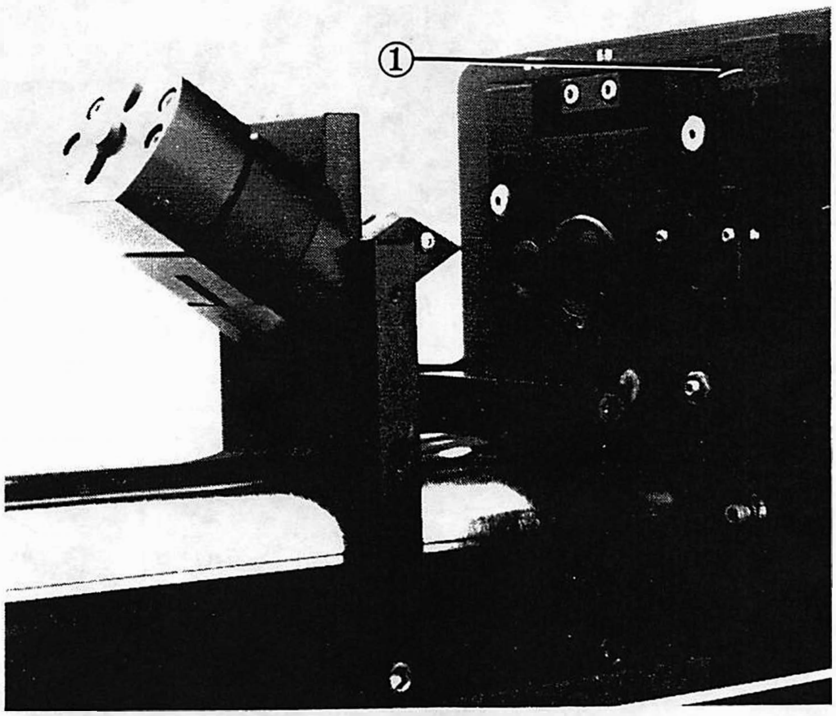


1	Notches	4	Optical rotator dust cover
2	Mount notch	5	Faraday and optical rotator
3	Birefringent filter assembly	6	Birefringent filter adjust

Figure 3-5. Birefringent Filter/Optical Diode

CONTROL	FUNCTION
Birefringent filter adjust.	Refer to Table 3-1. The notches (2) on the filter should be opposite the adjustment control (with the mount notch at approximately the 11:00 position) during initial alignment when attempting to establish oscillation. The birefringent filter adjust can then be adjusted to a tuning order after oscillation is established.
Optical diode dust cover.	This cover can be moved to one side (as shown in the Figure) for cleaning. The cover should be returned to the closed position after cleaning.
Faraday and optical rotator	Comprises the optical diode which forces the 899 to lase in one direction.

Table 3-5. Birefringent Filter/Optical Diode



1. Output Coupler Lever Arm

Figure 3-6. Output Coupler Lever Arm

CONTROL	FUNCTION
Output coupler lever arm.	Pressing this arm rocks the output coupler mount vertically.

Table 3-6. Output Coupler Lever Arm

Rear Panel

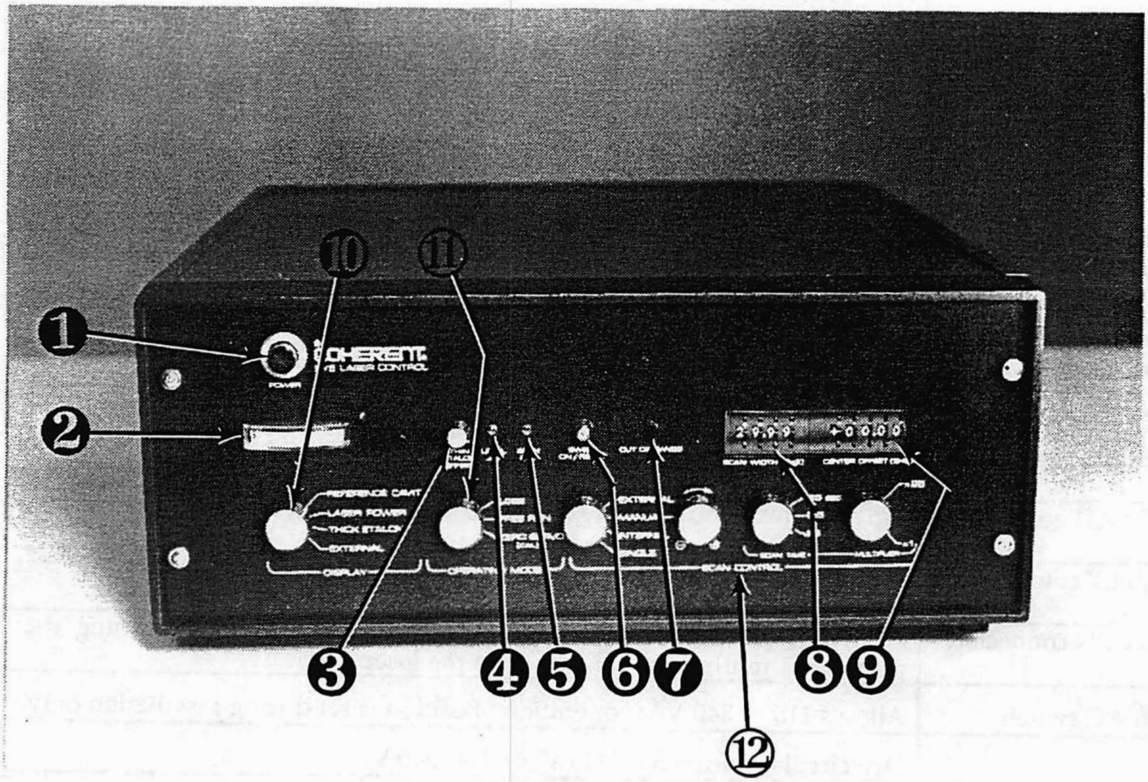
Front Panel

1 Pressure indicator
2 115/240 VAC switch
3 Fuse
4 ON/OFF indicator

Figure 3-7. Dye Circulator Controls and Indicators

CONTROL	FUNCTION
FRONT PANEL	
FLOW switch.	Controls operation of the dye circulator pump and controls circulation of dye through the laser head jet. PUMP position Turns on the dye circulator pump. The dye will loop within the dye circulator as shown in Figure 2-5 but will not flow through the laser head jet in this position. This position should be used for a few seconds before setting the FLOW switch to JET. This allows dye pressure build-up and eliminates bubbles. The PUMP position can be used to check for leaks and as an interim position to adjust the PRESSURE knob before setting the FLOW switch to JET. JET position Allows dye to flow to the laser head jet.
PRESSURE regulator knob.	Controls dye pressure when the FLOW switch is in either the PUMP or JET position.
Pressure indicator.	Indicates dye pressure.
On/Off indicator.	Lit when FLOW switch is in the PUMP or JET position.
REAR PANEL	
WATER IN connector.	Provides for connecting 1/8 in. (ID) plastic tubing for the input cooling water supply from a facility source or from a separate water conditioner.
WATER OUT connector.	Provides for connecting 1/8 in. (ID) plastic tubing for the cooling water supply return.
JET SUPPLY connector.	Provides for connecting 1/8 in. (ID), 1/4 in. (OD) plastic tubing that supplies dye to the jet in the laser head.
JET RETURN connector.	Provides for connecting 1/2 in. (ID), 5/8 in. (OD) plastic tubing that provides a return path for dye from the laser head.
115/240 AC switch.	Allows 115 or 240 VAC operation. Position is set during installation only.
Fuse.	Dye circulator fuse, 5 A (115 V) or 3 A (240 V).

Table 3-7. Dye Circulator Controls and Indicators



1	POWER Switch/Indicator	7	OUT OF RANGE Indicator
2	Ammeter	8	SCAN WIDTH (GHz) Selector
3	THIN ETALON OFFSET Adjust Knob	9	CENTER OFFSET (GHz) Selector
4	LEVEL SET Potentiometer	10	DISPLAY Select Switch
5	SCAN CAL Potentiometer	11	OPERATING MODE Select Switch
6	SWEEP ON/READY Indicator	12	SCAN CONTROL Switches

Figure 3-8. Control Box Front Panel Controls And Indicators

	CONTROL	FUNCTION
1	POWER switch/indicator	Pushbutton switch controls power to the control box. The indicator lights when power is applied.
	Potentiometer	The pot (located on the control box front panel under the ammeter) allows adjustment of the light power output signal level. The light power output signal is available at the control box rear panel OUT/LIGHT POWER BNC connector.
2	Ammeter	Displays the signal selected by the DISPLAY select switch.
3	THIN ETALON OFFSET adjust knob	Provides DC adjustment of thin etalon position to allow centering of the thin etalon peak with thick etalon peak transmission.
4	LEVEL SET trimpot adjust	Provides adjustment of the laser power signal that is fed to the servo electronics to establish the proper lock point for the laser frequency servo loop. Refer to the description of the DISPLAY select switch (REFERENCE CAVITY position) for additional information.
5	SCAN CAL trimpot adjust	Provides calibration for SCAN WIDTH and CENTER OFFSET controls by setting scan drive voltages.
6	SWEEP ON/READY pushbutton/indicator	When the SCAN CONTROL select switch is in the SINGLE position, pressing the SWEEP ON/READY pushbutton/indicator will activate the internal scan generator only once after pressing the pushbutton once for sweep and once again for retrace.
7	OUT OF RANGE indicator	Lights up whenever any combination of the control box front panel SCAN WIDTH and CENTER OFFSET thumbwheels adds up to more than ±15 GHz from the center position.
8	SCAN WIDTH (GHZ) thumbwheel selector	Selects the scan width (in GHz). The center frequency of the scan is determined by the neutral of the Brewster window and etalons. Maximum scan is ±15 GHz - a total of 30 GHz.
9	CENTER OFFSET (GHZ) thumbwheel selector	Selects the offset from the center of the scan. For example, if 20 GHz is selected on the SCAN WIDTH thumbwheel selector and 0 GHz is selected on the CENTER OFFSET (GHZ) thumbwheel selector, the scan will be ±10 GHz from the center frequency. If 20 GHz is selected on the SCAN WIDTH thumbwheel selector and 4 GHz is selected on the CENTER OFFSET (GHZ) thumbwheel selector, the scan will be +14 GHz and -6 GHz about the center frequency.

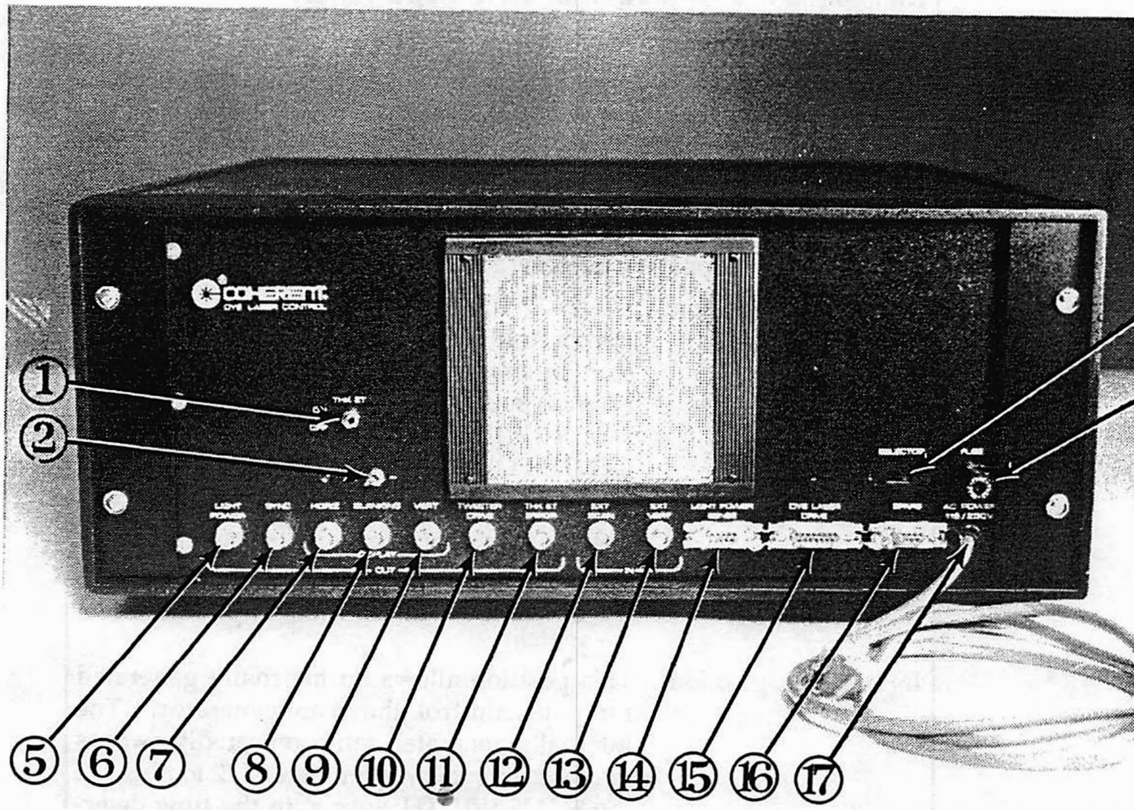
Table 3-8. Control Box Front Panel Controls And Indicators

10	DISPLAY select switch	Selects the signal available at the OUT/DISPLAY/VERT BNC connector located on the control box rear panel, and selects the signal displayed on the ammeter located directly above the display select switch. **REFERENCE CAVITY position:** Selecting this position results in the following: • The reference cavity error signal is applied at the control box rear panel OUT/DISPLAY/VERT BNC connector. The LEVEL SET pot located on the control box front panel allows adjustment of the reference level, and R117 (differential amplifier CCA, 1A9) allows adjustment of the offset of the reference cavity error signal. • The ICA galvanometer offset signal is displayed on the ammeter. R119 (differential amplifier CCA, 1A9) allows adjustment of the signal level. **LASER POWER position:** Selecting this position results in the following: • The light power output signal is applied to the control box rear panel OUT/LIGHT POWER BNC connector. The pot (located on the control box front panel under the ammeter) allows adjustment of the light power output signal level. • The light power output signal is also applied to the control box rear panel OUT/DISPLAY/VERT BNC connector. The pot (located on the control box front panel under the ammeter) allows adjustment of the light power output signal level. • The light power output signal is displayed on the ammeter. **THICK ETALON position:** Selecting this position results in the following: • The thick etalon error signal is applied to the control box rear panel OUT/DISPLAY/VERT BNC connector. RX (located on the PZT driver CCA, 1A1) allows adjustment of the level of the thick etalon error signal. • The thick etalon error signal is displayed on the control box front panel ammeter. • The thick etalon error signal is always applied to the control box rear panel OUT/THK ET ERROR BNC connector independent of the DISPLAY select switch position. **EXTERNAL position:** Selecting this position results in the following: • The OUT/DISPLAY/VERT BNC connector is electrically connected to the IN/EXT VERT BNC connector on the control box rear panel. • The ammeter reads zero - no signal can be displayed.

Table 3-8. Control Box Front Panel Controls And Indicators (Continued)

11	OPERATING MODE select switch	Determines the operating mode of the laser servo system. **LOCK position:** All servo loops are closed. **FREE RUN position:** The SCAN CONTROL knobs are fully operational with respect to all components and the thick etalon servo loop is closed. **ZERO SERVO (CAL) position:** All servo loops are open and the SCAN CONTROL knobs disabled with one exception. In the INTERNAL scan mode, only the reference cavity is scanned at the 0.25 second rate and over a 5 GHz range.
12	SCAN CONTROL switches SCAN CONTROL select switch:	Selects the drive for the scan generator as described below. EXTERNAL position: The EXT SCAN BNC connector (located on the control box rear panel) is connected to the scan generator. Plus or minus 5 V from an external source causes the scan to be ±half a SCAN WIDTH setting away from the CENTER OFFSET value. MANUAL position: This position allows the + / – switch to control the scan generator. Full sweep, as set by the SCAN WIDTH thumbwheel, is accomplished by full clockwise rotation of the + / – switch. INTERNAL position: This position allows an internally generated ramp to con-trol the scan generator. The internally generated ramp repeatedly sweeps dye laser frequency from minus 1/2 to plus 1/2 the SCAN WIDTH setting, in the time determined by the SCAN TIME and MULTIPLIER knobs. Retrace always takes approximately 0.25 second. SINGLE position: In this position, the internal scan is activated only once, after depressing the SWEEP ON/READY button once for sweep and once again for retrace.
	+ / – switch	When the SCAN CONTROL selector switch is in the MANUAL position, this switch controls the scan generator. Full sweep, as set by the SCAN WIDTH thumbwheel, is accomplished by full clockwise rotation of the + / – switch.
	SCAN TIME select switch	This switch controls the rate that the scan generator: 25, 2,5, or 0.25 seconds. The scan generator scan rate is also affected by the MULTIPLIER control knob.
	MULTIPLIER control knob	This switch multiplies the SCAN TIME select switch by a factor of from 1 to 25.

Table 3-8. Control Box Front Panel Controls And Indicators (Continued)



1 THK ET ON/OFF switch
2 + – select switch
3 SELECTOR switch
4 FUSE
5 LIGHT POWER connector
6 SYNC connector
7 HORIZ connector
8 BLANKING connector
9 VERT connector
10 TWEETER DRIVE connector
11 THK ET ERROR connector
12 EXT SCAN connector
13 EXT VERT connector
14 LIGHT POWER SENSE connector
15 DYE LASER DRIVE connector
16 SPARE connector
17 AC POWER 115/230V power cord

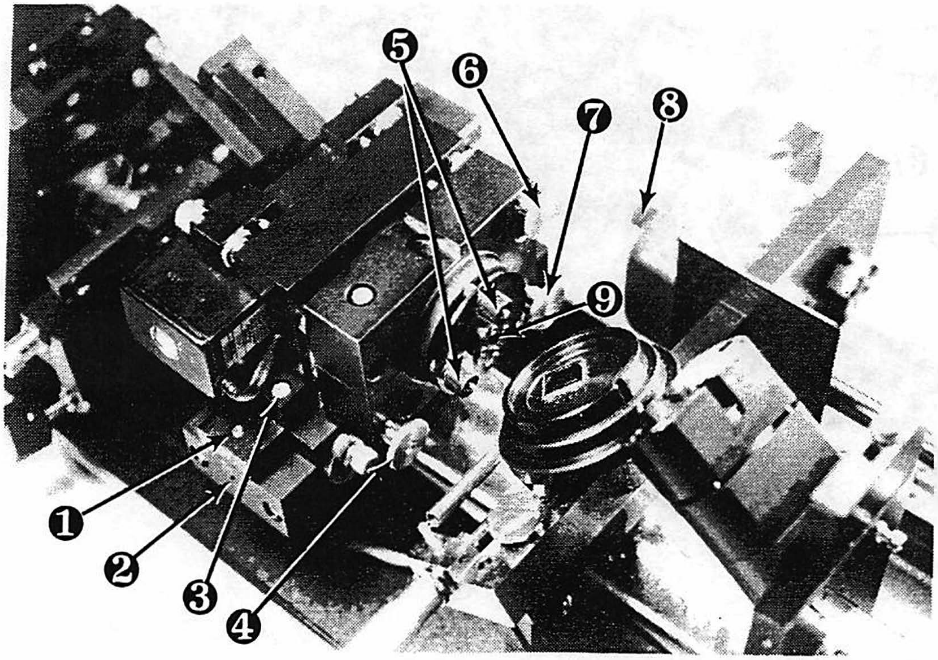
Figure 3-9. Control Box Rear Panel

	CONTROL	FUNCTION
1	THK ET ON/OFF switch	Disconnects thick etalon scan controls; turns servo on and off.
2	+ – select switch	This switch determines the polarity of the blanking signal that is available at the BLANKING connector.
3	SELECTOR switch	Sets control box for 115V or 230V facility power operation.
4	FUSE	Control box 3 ampere line fuse
5	LIGHT POWER BNC connector	An adjustable positive DC signal proportional to dye laser output power is available at this connector. Typically about +7.5 mV/mW at 600 nm. Attenuated by the front panel pot located beneath the ammeter. Refer to the control box front panel controls under DISPLAY select switch, LASER POWER position for additional information on adjusting the level of this signal.
6	SYNC BNC connector	A negative going pulse (approximately -5 V with a 5 msec time constant at start of internal scan) is available at this connector.
7	HORIZ BNC connector	A DC signal proportional to scan drive signals is available at this connector. This signal is used as an input to an oscilloscope horizontal drive. This signal is adjusted by the horizontal display attenuator located above the HORIZ BNC connector.
8	BLANKING BNC connector	A ±12V (approximately) blanking signal that is applied on out-of-range conditions and internal scan retraces is available at this connector. The polarity is determined by the blanking polarity switch (+/–) located above the BLANKING connector.
9	VERT BNC connector	The signal available at this connector is dependant on the position of the control box front panel DISPLAY select switch. Refer to the DISPLAY select switch description in Table 3-8.
10	TWEETER DRIVE BNC connector	A zero to 38VDC signal that is proportional to the zero to 550VDC drive to the tweeter fold mirror PZT element is available at this connector.
11	THK ET ERROR BNC connector	The thick etalon error signal is available at this connector. This signal is also displayed on the control box front panel ammeter. RX (located on the PZT driver CCA, 1A1) allows adjustment of the level of the thick etalon error signal. The thick etalon error signal is also available at the OUT/DISPLAY/VERT BNC connector when the DISPLAY select switch is set to the THICK ETALON position.
12	EXT SCAN BNC connector	The EXT SCAN BNC connector is connected to the scan generator. Plus or minus 5 V from an external source causes the scan to be ±half a SCAN WIDTH setting away from the CENTER OFFSET value.
13	EXT VERT BNC connector	When the control box front panel DISPLAY select switch is set to the EXTERNAL position, this connector is electrically connected to the the OUT/DISPLAY/VERT BNC connector. The ammeter reads zero - no signal can be displayed.
14	LIGHT POWER SENSE connector	This connector is the interface for the cable connection to the laser head.

Table 3-9. Control Box Rear Panel

15	DYE LASER DRIVE connector	This connector is the interface for the cable connection to the laser head.
16	SPARE connector	Unused 15-pin connector.
17	AC POWER 115/230V power cord	Used to apply power to the control box. . A proper plug for 230 V operation will need to be wired on.

Table 3-9. Control Box Rear Panel (Continued)

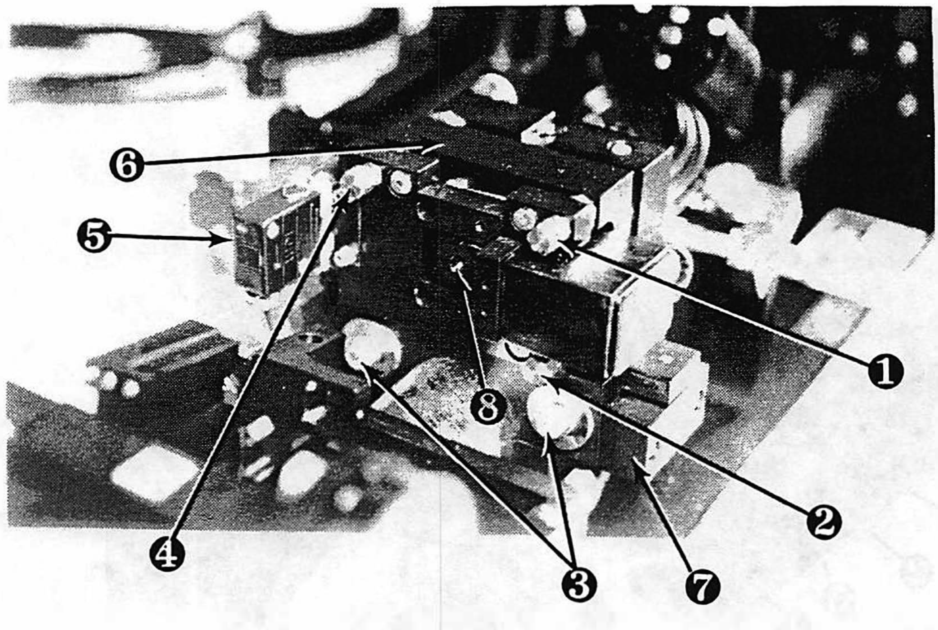


1 ICA vertical translation screw (one on other side)
2 ICA horizontal translation screw (one on other side)
3 Screw securing ICA assembly (two on other side)
4 Thick etalon horizontal control
5 Thick etalon horizontal and vertical tilt adjusts (used for power optimization
6 Thick etalon vertical control
7 Thick etalon pivot control
8 Screw securing detector block
9 ICA output aperture at the thick etalon

Figure 3-10. Thick Etalon Controls

	CONTROL	FUNCTION
1	ICA vertical translation screws	Allow for vertical translation of the ICA assembly
2	ICA horizontal translation screws	Allow for horizontal translation of the ICA assembly
3	Screws securing ICA assembly	Secure the ICA assembly to the cradle assembly
4	Thick etalon horizontal control	Tips the thick etalon assembly horizontally
5	Thick etalon horizontal and vertical tilt adjusts	Tips one of the prisms comprising the thick etalon. Used for power optimization when horizontally walking off the thick etalon
6	Thick etalon vertical control	Tips the thick etalon assembly vertically
7	Thick etalon pivot control	Is the pivot point for the horizontal and vertical controls of the thick etalon
8	Screw securing detector block	Black knurled screw that allows removal of the detector block
9	ICA output aperture at the thick etalon	Dye laser beam travels through this aperture

Table 3-10. Thick Etalon Controls

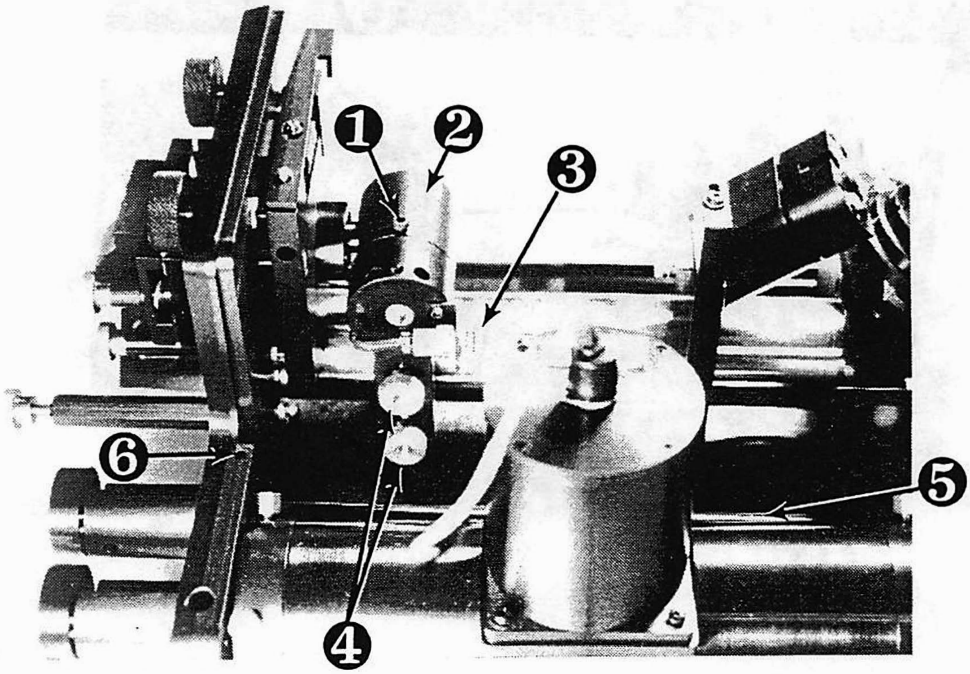


1 Thin etalon pivot control
2 Thin etalon vertical control
3 3/16 inch Allen head screws securing the ICA cradle
4 Thin etalon horizontal control
5 ICA plug
6 ICA assembly
7 Cradle assembly
8 ICA input aperture at the thin etalon

Figure 3-11. Thin Etalon Controls

	CONTROL	FUNCTION
1	Thin etalon pivot control	Is the pivot point for the thin etalon horizontal and vertical controls
2	Thin etalon .vertical control	Tips the thin etalon assembly vertically
3	3/16 inch Allen head screws securing the ICA cradle	These secure the ICA assembly from moving. When loosened, the ICA can be translated horizontally and vertically
4	Thin etalon horizontal control	Tips the thin etalon assembly horizontally
5	ICA plug	Carries the drive voltages to the thin and thick etalon
6	ICA assembly	Comprises the thin and thick etalon with their housing
7	Cradle assembly	ICA assembly mounts to this
8	ICA input aperture at the thin etalon	Dye beam travels through this aperture

Table 3-11. Thin Etalon Controls

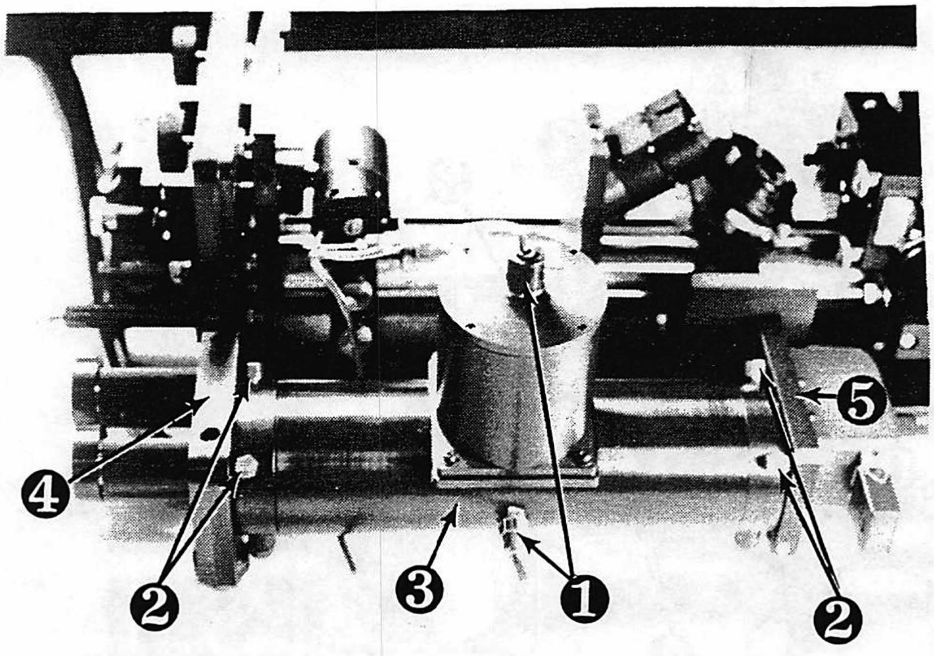


1 Screw securing Brewster plate cover
2 Brewster plate cover
3 Brewster plate plug
4 Thumbnuts securing Brewster plate
5 Draft tube for normalizing beam
6 Setscrew securing draft tube

Figure 3-12. Brewster Galvo Controls

	CONTROL	FUNCTION
1	Screw securing Brewster plate cover	Secures the dust cover to the Brewster plate assembly
2	Brewster plate cover	Prevents dust contamination of the Brewster plate
3	Brewster plate plug	Carries the drive voltage to the Brewster plate
4	Thumbnuts securing Brewster plate	When loosened, these allow the Brewster plate assembly to be translated vertically
5	Draft tube for normalizing beam	Protects the normalizing beam from environmental interference
6	Setscrew securing draft tube	Can be loosened to allow rotation of the draft tube when doing the electronic alignment procedure

Table 3-12. Brewster Galvo Controls

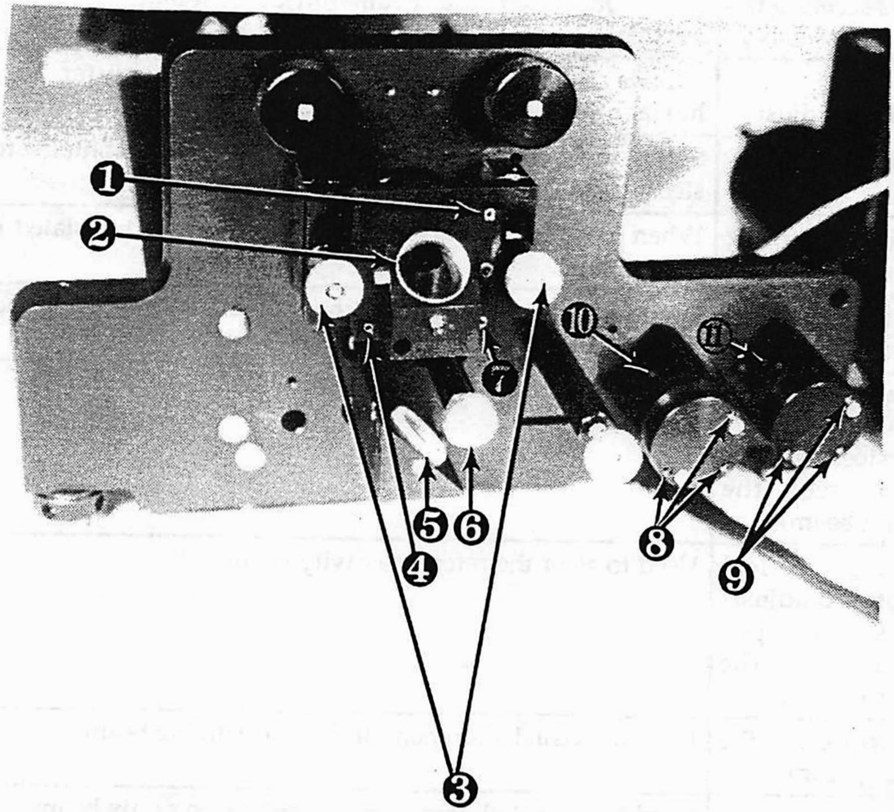


1 Reference cavity plugs
2 Reference cavity adjustment controls
3 Reference cavity assembly
4 Front plate with input apertures for normalizing and reference cavity beams
5 Rear plate with exit apertures for normalizing and reference cavity beams

Figure 3-13. Reference Cavity Controls

	CONTROL	FUNCTION
1	Reference cavity plugs	These carry drive voltage signals for the reference galvo and heater circuit
2	Reference cavity adjustment controls	Allow for horizontal, vertical and rotational adjustment of the reference cavity during the electronic alignment procedure
3	Reference cavity assembly	Comprises the reference cavity galvo, optics and housing
4	Front plate with input apertures for normalizing and reference cavity beams	This plate contains two input apertures for alignment of the normalizing and reference cavity beams.
5	Rear plate with exit apertures for normalizing and reference cavity beams	This plate contains two exit apertures for alignment of the normalizing and reference cavity beams

Table 3-13. Reference Cavity Controls



1	Beamsplitter vertical tilt adjust	7	Beamsplitter pivot tilt adjust
2	Beamsplitter optic	8	Horizontal, vertical and pivot tilt adjusts for small steering optic.(Used to steer normalizing beam)
3	Thumbscrews securing beamsplitter assembly	9	Horizontal, vertical and pivot tilt adjusts for small steering optic.(Used to steer the reference cavity beam)
4	Beamsplitter horizontal tilt adjust	10	Input aperture for normalizing beam
5	Large steering optic	11	Input aperture for reference cavity beam
6	Thumbnut securing large steering optic		

Figure 3-14. Front End Controls

	CONTROL	FUNCTION
1	Beamsplitter vertical tilt adjust	Allows the beams split from the beamsplitter to be moved vertically
2	Beamsplitter optic	Splits two beams down from the cavity beam
3	Thumbnuts securing the beamsplitter assembly	When loosened the beamsplitter assembly can be translated vertically
4	Beamsplitter horizontal tilt adjust	Allows the beams split from the beamsplitter to be moved horizontally
5	Large steering optic	Steers the beams from the beamsplitter, horizontally to the small steering optics
6	Thumbnut securing large steering optic	When loosened the large steering optic can be translated horizontally
7	Beamsplitter pivot tilt adjust	Used in conjunction with the horizontal and vertical tilt adjust screws to steer the beams from the beamsplitter
8	Horizontal, vertical and pivot tilt adjusts for small steering optic (Used to steer the normalizing beam)	Used to steer the normalizing beam
9	Horizontal, vertical and pivot tilt adjusts for small steering optic (Used to steer the reference cavity beam)	Used to steer the reference cavity beam
10	Input aperture for the normalizing beam	Used for visual alignment of the normalizing beam
11	Input aperture for the reference cavity beam	Used for visual alignment of the reference cavity beam

Table 3-14. Front End Controls

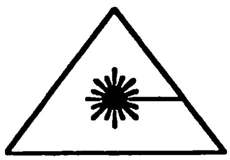
Operator's Manual

Chapter Four
Guide to Daily Operation

Coherent

DAILY TURN ON

The following procedures are intended for use when the system has been completely shutdown, such as overnight.



Wear safety glasses to protect against the radiation generated from the 899 laser and the pump laser. Refer to the fact sheets for the specific 899 wavelengths being generated. Refer to the pump laser manual for safety precautions and wavelengths generated from the pump laser. It is assumed that the operator has read Chapter One, Safety, and is familiar with laser safety practices and the dangers involved.

Both the 899 and the pump laser are designed to be operated with the covers in place. Operation of the laser with the protective housing removed will allow access to hazardous visible and invisible radiation. The laser housings should only be opened for the purposes of maintenance and service by trained personnel cognizant of the hazards involved.

Extreme caution must be observed in operating the laser with the cover removed. There are high-power reflections which may exit at unpredictable angles from the laser head. These beams have sufficient energy density to cause permanent eye damage or blindness.

1 Turn on the cooling water for the Ion laser.

2 Turn on the Ion laser.

3 Optimize the Ion laser output power and ensure it is at the proper level.

4 Use a suitable power meter to measure the 899 output power.

5 If the system lases, optimize the output power by adjusting the following controls.

   - Pump mirror P1 controls
   - Output coupler M4 controls
   - BRF control

   Repeat this sequence until no further power increase can be obtained.

6 If the system does not lase, remove the 899 head cover and perform step 7.

7 Make small adjustments on the following controls to obtain lasing.

   - Upper fold M5 horizontal and vertical tilt adjusts.
   - Lower fold M3 horizontal and vertical tilt adjusts.
   - Output coupler M4 horizontal and vertical tilt adjusts.

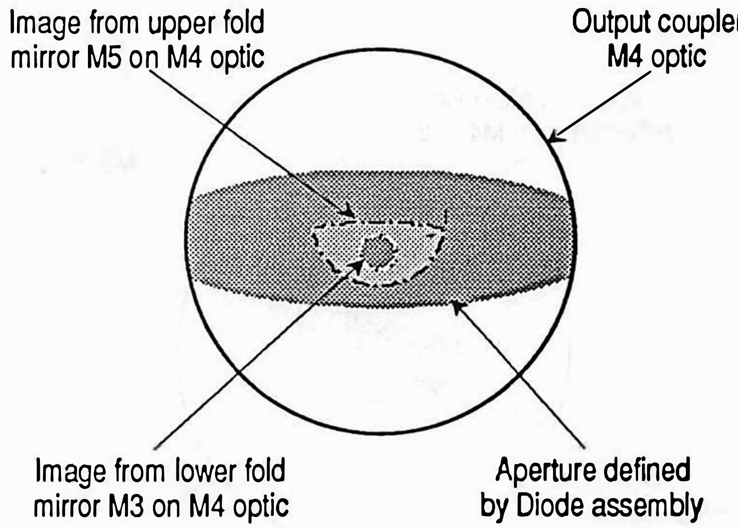
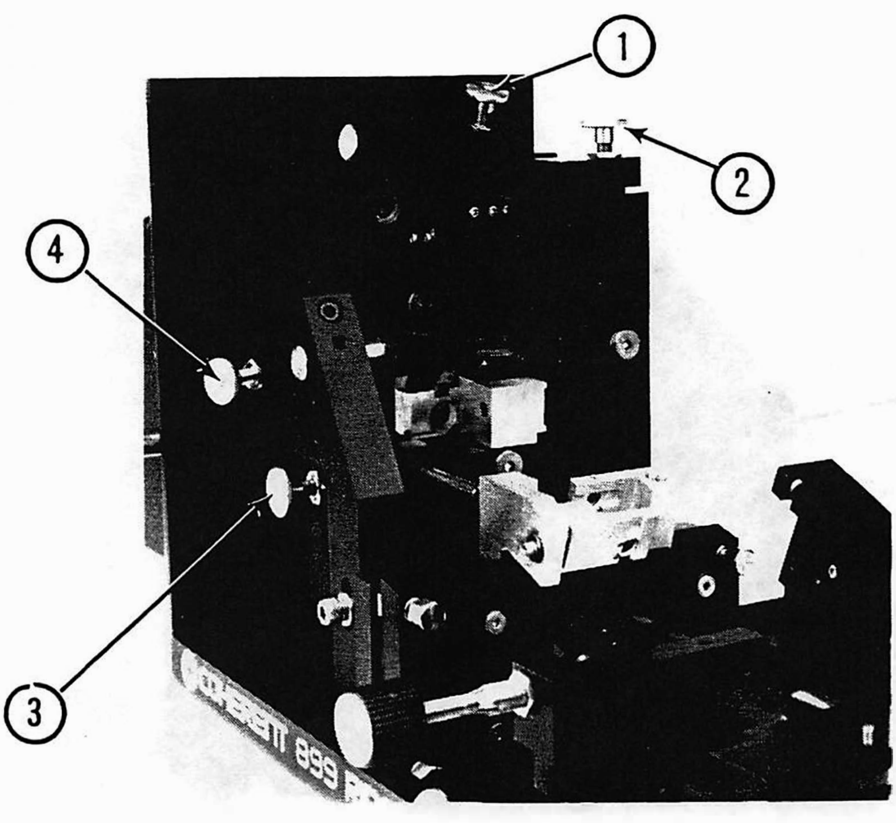


Figure 4-1. Position of M3 and M5 Fluorescent Image on M4



1 M5 vertical tilt adjust
2 M3 vertical tilt adjust
3 M3 horizontal tilt adjust
4 M5 horizontal tilt adjust

Figure 4-2. Horizontal and Vertical Controls of M3 and M5

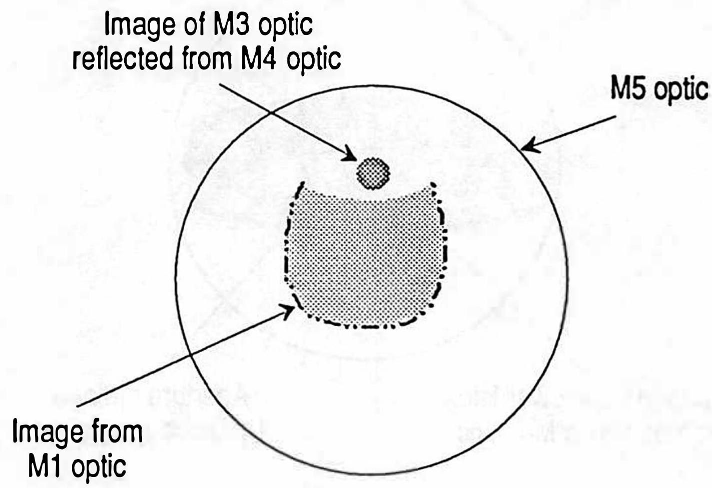
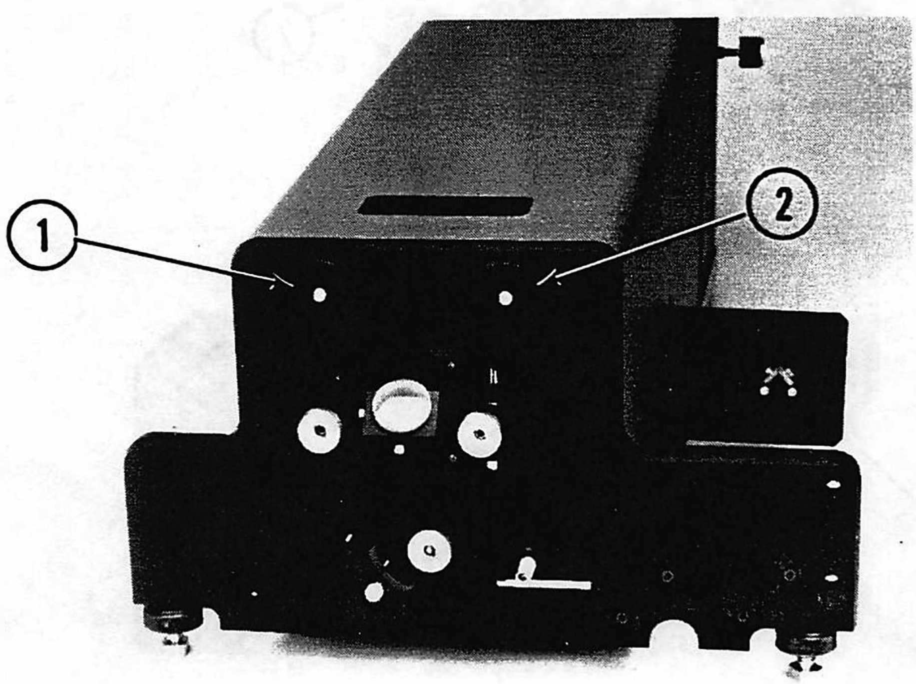


Figure 4-3. Position of M1 Image and M3 Image (via M4) on M5



1 Output coupler horizontal tilt adjust   2 Output coupler vertical tilt adjust

Figure 4-4. Horizontal and Vertical Output Coupler Controls

4 If system fails to oscillate, scan the M5 vertical adjustment and rock M4 vertically. As the fluorescent spot that moves with M4 passes through the upper stationary spot, watch for the appearance of a third dim spot in the same area. Using the M5 horizontal control and the M4 Horizontal control, align the stationary spot, the second moving spot and the third dim spot into a vertical line. Rock the M4 mount vertically and scan M5 vertically until the laser flashes. Establish continuous oscillation with the M4 vertical control and continue with "Optimizing the Laser Power" below.

5 If system does not lase, recheck the spot sizes in front of the magnet stack, the pump laser power and dye absorption. Realign spots at M4 and continue with Step 1.

OPTIMIZING OUTPUT POWER

Once the system is lasing, peak the controls in the following order:

- Output coupler M4 horizontal and vertical tilt adjust.
- Upper fold M5 horizontal and vertical tilt adjust.
- Lower fold M3 horizontal and vertical tilt adjust.
- Pump mirror P1 horizontal and vertical tilt adjust.

Several iterations of the above adjustments will need to be made to maximize output power.

Refer to Chapter 6 for photos for the following procedures.

SETTING UP THE 899 TO OPERATE AS A SCANNING SINGLE FREQUENCY LASER.

These procedures assume that the 899 is optimized in the broadband configuration. If an infrared dye is being used, an IR viewer may be needed to perform this procedure.

INSERTING THE INTRACAVITY ASSEMBLY (ICA)

Whenever the ICA is not mounted in the 899 cavity, tape should be placed over the openings at both ends of the ICA. This will prevent contamination of the thick and thin etalon.

1 The ICA, Figure 6-15, mounts to the cradle assembly, Figure 6-15, which is in turn connected to the Invar bar. The thick etalon faces the output coupler when the ICA is installed as shown in Figure 6-16. Two pins protrude up from the cradle assembly to guide the ICA into place. Three 9/64 inch Allen screws shown in Figure 6-16, secure the ICA to the cradle assembly. Install the ICA and tighten the three 9/64 inch screws to secure the ICA in place.

2 A plug rests inside the 899 head near the ICA. Connect it to the ICA as shown in Figure 6-15. This provides drive voltages to the thin and thick etalons.

3 The ICA input aperture, at the thin etalon, and output aperture, at the thick etalon, Figures 6-15 and 6-16, need to be roughly centered on the fluorescent images passing through them. Hold a piece of tissue paper up to the apertures and check for the fluorescence position. Use the translation screws described below to approximately center the ICA input and output apertures on the fluorescence images. To move the ICA vertically and horizontally the four 3/16 inch Allen screws shown in Figure 6-15, which lock the cradle assembly in place, must be loosened. Four 5/64 inch Allen screws, shown in Figure 6-16, are used to move the ICA. The two horizontal translation screws, Figure 6-16, work in a push and pull fashion. One has to be loosened and the other tightened to move the ICA horizontally. The two vertical translation screws, Figure 6-16, must both be turned clockwise to raise the ICA and counterclockwise to lower the ICA. **(The cradle assembly that the ICA mounts to, may have to be pushed down if the vertical translation screws are turned counterclockwise).**

4 Tighten the four 3/16 inch Allen screws down to lock the cradle assembly and ICA in place.

5 Ensure the 899-21 control box front panel knobs are in the Reference cavity, zero servo and manual positions. Press the 899-21 control box red "Power" button on the front panel to energize the box.

FLASHING AND WALKING OFF THE THIN AND THICK ETALON

1 With the ICA in place, there will be three sets of reflections off of the BRF that can be seen on the ceiling. They are the laser cavity, thick etalon and thin etalon reflections. If the system is lasing, the cavity reflections will be bright spots. The other nearby reflections which are off the thin and thick etalon will be much dimmer than the cavity reflections. If the system is not lasing then the cavity reflections on the ceiling will also be dim.

2 Rotate the thin etalon offset knob Figure 6-17, on the front panel of the control box and locate the reflections on the ceiling that are moving. These are the thin etalon reflections. Rotate the thin etalon offset knob to move these

3 Use the thick etalon horizontal and vertical controls, Figure 6-16, to steer the thick etalon reflections viewed on the ceiling so they overlap the cavity reflections. When this is accomplished, the thick etalon is at flash (e.g.-it is at normal incidence to the cavity beam). The system should be lasing at this point. If not, continue with step 4 below. If so, peak the output coupler M4, upper fold mirror M5 and lower fold mirror M3 horizontal and vertical tilt adjusts for maximum output power. If the thick etalon is at flash,the system will be lasing bi-directionally and the cavity and thick etalon reflections on the ceiling will be bright. Adjust the thick etalon horizontal control to "walk off" the thick etalon reflections on the ceiling approximately three cavity reflection diameters away. The system will lase unidirectionally and the output power should approximately double in value

If the system stops lasing when the thick etalon is walked off, then the thick etalon horizontal and vertical tilt adjusts near the thick etalon, Figure 6-16, may be out of alignment. Walk off the thick etalon until the system power drops in half. Now rotate these two knobs to peak the output power. Continue this until the thick etalon can be walked off the amount mentioned above.

4 Rotate the thin etalon offset knob on the front panel of the control box to locate the thin etalon reflections on the ceiling. Now rotate this knob completely counterclockwise. Adjust the thin etalon horizontal and vertical controls, Figure 6-15, to steer the thin etalon reflections onto the cavity reflections (When the output power drops in half then the thin etalon is at flash). If the system still will not lase, continue with step 5. If the system is lasing, peak the output coupler M4, upper fold mirror M5 and lower fold mirror M3 horizontal and vertical tilt adjusts for maximum output power, which will be approximately half that before the thin etalon was flashed. Now rotate the thin etalon offset knob clockwise for maximum power. Power should approximately double when the thin

etalon is taken out of flash. Continue with "Installation of the Scanning Brewster Plate" below.

5 Recheck the cavity fluorescent image position through the ICA and ensure it is not clipped.

6 Make small adjustments on the lower fold mirror M3 vertical and horizontal tilt adjusts which will usually initiate laser oscillation. If the system lases, continue with step 8, otherwise perform step 7.

7 Turn the output coupler M4 vertical tilt adjust, Figure 4-4, 1/2 turn counterclockwise. Rock the M4 mount using the lever arm shown inside the cavity, while slowly moving the upper fold mirror M5 vertical tilt adjust. Watch for laser oscillation. If the laser flashes, turn the M4 vertical tilt adjust clockwise until continuous oscillation occurs. Continue with step 8. If the system still will not lase, remove the ICA and establish broadband operation. Once this is done, repeat the ICA installation procedure.

8 If the system is now lasing, peak the M5, M3 and M4 mirrors for maximum output power. Rotate the thin etalon offset knob clockwise to bring it out of flash. Adjust the thick etalon horizontal control, Figure 6-16, to "walk off" the thick etalon reflection three cavity reflection diameters. The system should now be lasing unidirectionally. Peak the M5, M3 and M4 mirror horizontal and vertical tilt adjusts for maximum power.

NOTE:TYPICAL CONVERSION PERFORMANCE FOR THE 899 ICA IS 60-70% OF THE BROADBAND POWER, BUT THIS WILL VARY SLIGHTLY BETWEEN SYSTEMS.

INSTALLATION OF SCANNING BREWSTER PLATE (899-05, 899-21)

If the system is being run in an IR dye, an IR viewer may be needed to perform the following procedures.

1 Loosen the 9/64 inch Allen screw, Figure 6-18, to remove the Brewster plate dust cover.

2 Clean both sides of the Brewster plate with methanol and then acetone.

3 Loosen the two thumb nuts on the Brewster plate mounting bracket, Figure 6-18, and slide the Brewster plate into a vertical position such that the laser oscillates through the plate. Tighten the two thumbnuts.

4 Optimize the output power by adjusting the upper fold M5, lower fold M3 and output coupler M4 horizontal and vertical tilt adjusts.

5 Slightly loosen the thumbscrews and make a small vertical adjustment to center the beams through the Brewster plate. Repeat step 4.

6 Turn off the 899 control box and connect the plug sitting next to the Brewster plate inside the head to the Brewster plug. Turn the control box back on.

CHECKING THE INFORMATION BEAM ALIGNMENT

The information beam sent to the detector block should not be misaligned. To check this, follow the procedure below.

1 Connect an oscilloscope with X-Y capabilities to the control box back panel as follows:

-Horizontal output display BNC from control box to the x channel of the oscilloscope.

-Vertical output display BNC from control box to the y channel of the oscilloscope.

2 Set the control knobs to the following settings:

-Display knob to "reference cavity"
-Operating mode knob to "zero servo"
-Scan control knob to "internal"
-Scan speed knob to ".25 sec"
-Multiplier knob to "1"

3 Set the oscilloscope to X-Y mode and ground the vertical channel.

4 Adjust the horizontal or X channel gain of the oscilloscope for a full scale sweep. If the sweep is not full scale, adjust the trim pot on the back of the control box that is located just above the horizontal display BNC for a full scale sweep.

5 Set the oscilloscope vertical or Y channel gain for 2.0 Volts/Division and d.c. coupled.

6 The reference cavity fringes should now be seen on the oscilloscope. There will be approximately 5 peaks.

If the reference cavity peaks cannot be seen, follow the "Aligning Information Beams" procedure in Chapter Six. Otherwise, continue with the "Reference Level Set" procedure below.

Reference Level Set

1 Insert a white card between the two small steering optics which will block the signal to the reference cavity.

2 The signal on the oscilloscope should be approximately -5 Volts DC.

If this level fluctuates , the light level to the normalizing detector may be too low. It may be necessary to use a coated beamsplitter or there may be a misalignment of the normalizing beam.

3 Remove the white card and observe the reference cavity fringes on the oscilloscope.

4 Use the **scan cal** trim pot on the front of the 899 control box to adjust the drive voltage to the reference cavity such that the fringes of the reference cavity on the oscilloscope are two divisions apart on a ten division scope.

5 Use the **level set** trim pot on the front of the 899 control box to adjust the level of the fringes for +5 volts DC. If the trim pot runs out of travel, re-center the trim pot and remove the detector block by loosening the black knurled knob securing it as shown in Figure 6-16. Loosen the attenuator, Figure 6-21 by using a small Phillips head screwdriver and move the attenuator a small amount. Tighten the Phillips head screw down and connect the detector block. Check the level of the fringes. Repeat this procedure until the reference cavity fringes have a +5 volt DC amplitude.

Setting The Feed Forwards For Locking And Scanning Up To 30 GHz

The feed forward signals are drive signals fed to the thick etalon, the thin etalon and the scanning Brewster plate to help maintain locking. These are set up in the factory when the system is tested, but may need slight adjustment.

1 Set the 899 control box knobs to the following settings:

-Display to "Reference cavity"
-Operating mode to "Zero servo"
-Scan control to "Internal"
-Scan time to ".25"
-Scan width to "10.99 GHz"

Ensure the reference cavity five mode display is smooth and continuous. If it is breaking up, then excessive noise may be coupling into the cavity. Float the table

the laser is on if possible. Ensure the system is staying single frequency by monitoring the output on an optical spectrum analyzer.

2 Set the operating knob on the control box to "Free Run". The oscilloscope display will change. The signal moving across the oscilloscope should be as flat as possible. This is the reference cavity error signal. If there are peaks in this signal, the scanning Brewster plate feed forward needs adjustment. Remove the four screws securing the control box front panel to the frame. Pull the control box out so the PCB's can be accessed. Locate the 1A4 PCB (e.g.-The fourth board from the left), Figure 6-17, and adjust the potentiometer for as flat a signal as possible on the oscilloscope.

3 Set the control box operating knob to "Lock". This will close the frequency servo loops. The signal on the oscilloscope should be a flat and continuous line at the ground point which indicates little frequency error. If the signal is breaking up, this indicates the system is mode hopping and the thin etalon may be out of adjustment. Make small adjustments on the thin etalon offset knob, Figure 6-17, to see if the oscilloscope trace can be made continuous. If not, then the thin etalon feed forward signal may need adjustment. Locate the 1A5 PCB (e.g.-The fifth board from the left), Figure 6-17, and adjust the potentiometer for a continuous line with no breaks. If this is not possible, set the operating knob to "Zero Servo" to allow the electronic signals to relax. Now switch the operating knob to "Lock" and adjust the potentiometer on the 1A5 PCB for a smooth, continuous signal.

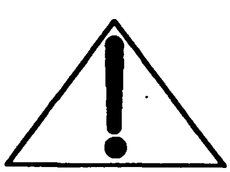
4 Set the display knob to "Thick Etalon" which displays the thick etalon error signal. This will be a flat line or have a slight oval shape. The two ends of the signal should be level with respect to each other. If not, locate the 1A1 PCB and adjust R107, Figure 6-23, so the signal is level. Set the display knob back to "Reference Cavity" and the operating mode knob to "Zero Servo". Increase the scan width 5.00 GHz and repeat steps 2, 3 and 4. Do this until the scan width is 29.99 GHz. This is the maximum scan width possible.

SHUTDOWN

1 Close the ion laser shutter.

2 Turn off the ion laser and allow the tube to cool off for five minutes.

3 Turn off the cooling water flow to the ion laser.



Leave the 899 control box on.

Operator's Manual

Chapter Five
Changing Wavelength Ranges

Coherent

INTRODUCTION

This chapter contains the procedure for changing the 899-21 wavelength range in dye configuration. Realignment procedures are included for use after changing the wavelength range.

WAVELENGTH CHANGES

The major steps to accomplish a wavelength change are summarized below. Detailed procedures for implementing the wavelength change are provided in the following paragraphs.

- Break system down from an 899-21 to 899-01.
- Replace optics as required based on the fact sheets in Appendix A and the charts in the following procedure.
- Drain, clean, and fill the system with new dye for the new wavelength.
- Re-establish oscillation.
- Adjust the laser for optimum power and mode.
- Build system up from an 899-01 to 899-21.

EQUIPMENT USED DURING WAVELENGTH CHANGE

- Optics set for new operating wavelength range.
- Maintenance kit supplied with laser.
- Power meter, Coherent Model 210 or equivalent (0 to 10 W).
- Laser safety glasses to protect against the wavelength exiting the 899 laser head and to protect against the pump beam wavelength. Refer to the dye fact sheets in Appendix A for specific wavelengths associated with each dye.
- IR Viewer if using an infrared dye.
- Oscilloscope with x-y capability.

BREAKING SYSTEM DOWN FROM AN 899-21 TO 899-01

REMOVING THE INTRACAVITY ASSEMBLY (ICA) AND SCANNING BREWSTER PLATE

1 Ensure that the pump beam from the ion laser is blocked.

2 Loosen the three 9/64 inch Allen screws shown in Figure 6-16, that secure the Intracavity Assembly to the cradle assembly. Grasp the ICA by the sides and lift it out of the 899 head and set it to the side.

3 Loosen the 9/64 inch Allen screw securing the Brewster plate dust cover and remove the cover. This is shown in Figure 6-18.

4 Loosen the two thumb screws securing the Brewster plate assembly, Figure 6-18, and remove the assembly from the cavity.

5 Loosen the two thumb screws securing the beamsplitter assembly, Figure 6-19, and remove the assembly and set aside.

OPTICS REPLACEMENT

The following procedure describes optic replacement for the purpose of changing wavelength ranges in dye operation. Refer to Appendix A for the part numbers of the optics for the dye that will be used. Note the position and orientation of an optic prior to removal so the new optic can be installed in the same position and orientation. Replace only those optics required by the fact sheets to implement the wavelength change. Close the pump laser shutter or block the pump beam prior to optic replacement.

Note: Use extreme care when removing optics from their mounts and take care not to touch the coated surface.

INTERMEDIATE FOLD M1 REMOVAL AND INSTALLATION

Loosen the setscrew on the side of the intermediate fold M1 mount, Figure 5-2, and remove the optic. Store the optic in its appropriate plastic container. Install the new optic and tighten the setscrew. Clean the front surface of the optic.

The lower fold mirror M3 has a 7.5 or 10.0 cm radius of curvature depending on the dye being used. Check Table 5-1 to see if the radius will change when the wavelength region is changed. If so, the new lower fold M3 mount and optic will mount in a different screw hole on the M3 translation stage. Use the appropriate lower fold M3 removal and installation procedure below.

LOWER FOLD M3 REMOVAL AND INSTALLATION (M3 OPTIC RADIUS DOES NOT CHANGE)

Loosen the screw securing the lower fold M3 mount, Figure 5-2, to the translation stage. Store the mount in a clean, dry place. Install the new mount to the same screw hole used before and clean the optic with methanol.

LOWER FOLD M3 REMOVAL AND INSTALLATION (M3 OPTIC RADIUS DOES CHANGE)

Loosen the screw securing the lower fold M3 mount, Figure 5-2, to the translation stage. Store the mount in a clean, dry place. Refer to Figure 5-1, to determine which screw hole the new M3 optic mount will connect to. Install the new mount to this screw hole and clean the optic with methanol.

Output Coupler M4 Removal and Installation

Unscrew the retainer cap located at the front end of the laser. Remove the output coupler mount and spacer. Grasp the M4 optic by its side and remove from the holder. Store the optic in its appropriate plastic container. Clean both sides of the new M4 optic before inserting it into the holder. The optic has an arrow on the side of it and this should point into the 899 head when installed. Reinstall the output coupler holder and spacer and tighten the retainer cap.

Upper Fold M5 Removal and Installation

Loosen the setscrew on the side of the upper fold M5 mount, Figure 5-2, and remove the optic. Store the optic in its appropriate plastic container. Install the new optic and tighten the setscrew. Clean the front surface of the optic.

Pump mirror P1 will have to change when going to certain dyes. The pump mirror P1 has a 7.5 or 10.0 cm radius of curvature depending on the dye being used. Check Table 5-1, to see if the radius will change when the wavelength region is changed. If so, the P1 optic mount will change positions. Use the appropriate P1 removal and installation procedure below.

Pump Mirror P1 Removal and Installation (P1 Optic Radius Does Not Change)

Loosen the setscrew on the side of the pump mirror P1 mount, Figure 5-2, and remove the optic. Store the optic in its appropriate plastic container. Install and clean the new optic.

Pump Mirror P1 Removal and Installation (P1 Optic Radius Does Change)

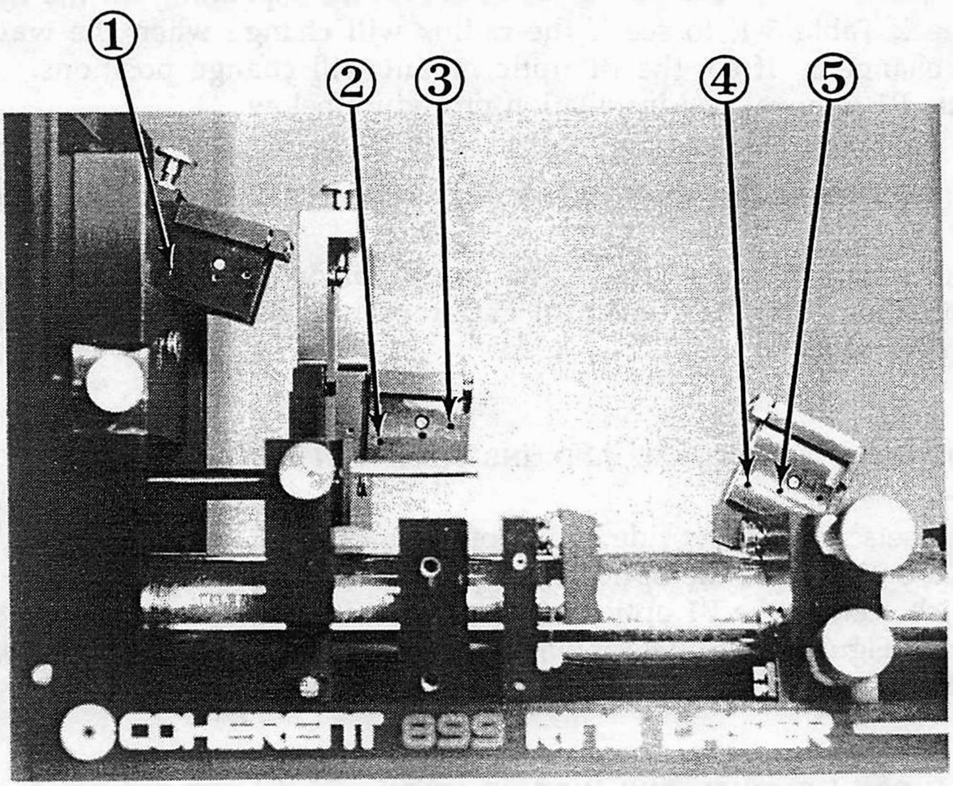
Loosen the setscrew on the side of the pump mirror P1 mount, Figure 5-2, and remove the optic. Store the optic in its appropriate plastic container. Loosen the screw which secures the P1 optic mount to the translation stage shown in Figure 5-2. Refer to Figure 5-1, to determine which screw hole the mount will connect to and install the mount. Install and clean the new pump optic in the mount.

Optical Diode Removal and Installation

The optical diode consists of a Faraday rotator and optical rotator. Table 5-2 lists the Faraday rotator and optical rotator part numbers associated with each dye.

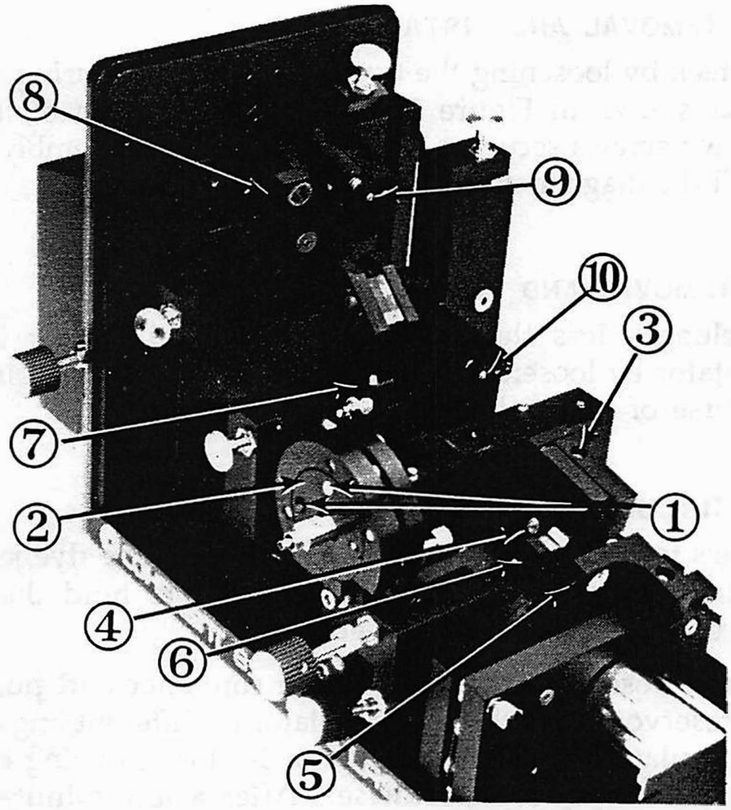
Dye	Pump Mirror P1	Lower Fold Mirror M3
Polyphenyl 2	7.5 cm	7.5 cm
Exalite 392	7.5 cm	7.5 cm
Stilbene 1	10.0 cm	7.5 cm
Stilbene 3	10.0 cm	7.5 cm
Coumarin 102	10.0 cm	7.5 cm
Coumarin 30	10.0 cm	7.5 cm
Coumarin 6	10.0 cm	7.5 cm
Rhodamine 110	10.0 cm	10.0 cm
Rhodamine 6G	10.0 cm	10.0 cm
Kiton Red	10.0 cm	10.0 cm
DCM Special	10.0 cm	10.0 cm
Pyridine 2	10.0 cm	7.5 cm
LD 700	10.0 cm	10.0 cm
Styryl 8	10.0 cm	7.5 cm
Styryl 9M	10.0 cm	7.5 cm

Table 5-1. Pump mirror and lower fold mirror radius of curvatures



1 Upper fold M5 mount always connects to this hole
2 Lower fold M3 7.5 cm radius connects here
3 Lower fold M3 10.0 cm radius connects here
4 Pump P1 7.5 cm radius connects here
5 Pump P1 10.0 cm radius connects here

Figure 5-1. Lower fold M3, Pump Mirror P1 Optic Mount Locations



1 Screws securing dye jet holder to tip plate
2 Dye jet tip plate
3 Screw securing translation stage for pump mirror
4 Screw securing pump mirror P1 mount
5 Intermediate fold M1 setscrew
6 Pump P1 setscrew
7 Lower fold M3 setscrew
8 Upper fold M5 setscrew
9 Upper fold M5 focus adjust
10 Lower fold M3 focus adjust

Figure 5-2. Jet Tip Plate and Dye Mount Setscrews

DYE	OPTICAL ROTATOR	FARADAY ROTATOR
Stilbene 1	None	0406-542-02
Exalite 392	None	0406-542-02
Stilbene 3	None	0406-542-02
Coumarin 102	None	0406-542-02
Coumarin 6	0406-544-00	0406-542-01
Rhodamine 110	0406-544-00	0406-542-01
Rhodamine 6G	0406-544-00	0406-542-01
Kiton red	0406-544-00	0406-542-01
DCM	0406-544-00	0406-542-01
Pyridine 2	0406-544-00	0406-542-01
LD 700	0406-544-00	0406-542-01
Styryl 8	0406-544-00	0406-542-01
Styryl 9M	0406-544-00	0406-542-01

Table 5-2 Optical and Faraday Rotators For Different Dyes

Faraday Rotator Removal and Installation

Remove the magnet stack by loosening the two Allen screws securing it to expose the Faraday rotator as shown in Figure 5-3. Note the position of the Faraday rotator. Remove the two screws securing the Faraday rotator assembly and install the proper one. Install the magnet stack.

Optical Rotator Removal and Installation

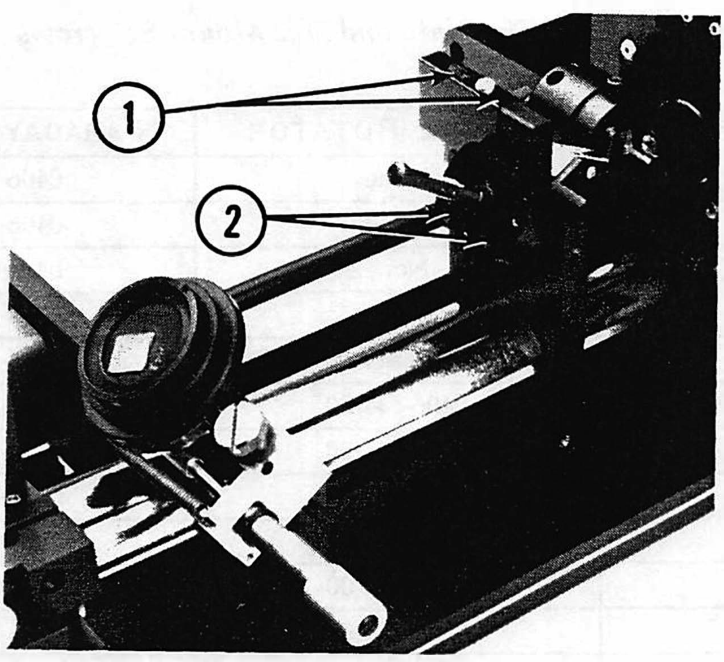
For blue dyes, wavelength less than 500 nm, an optical rotator is not used. Remove the optical rotator by loosening the two Allen screws shown in Figure 5-3. Installation is the reverse of removal.

Cleaning the Dye Circulator

1 Remove the brass ferrule securing the jet feed hose to the dye jet holder by using a 7/16 in. wrench. Use a 3/8 in. wrench to hold the jet nozzle housing in place while removing the feed hose.

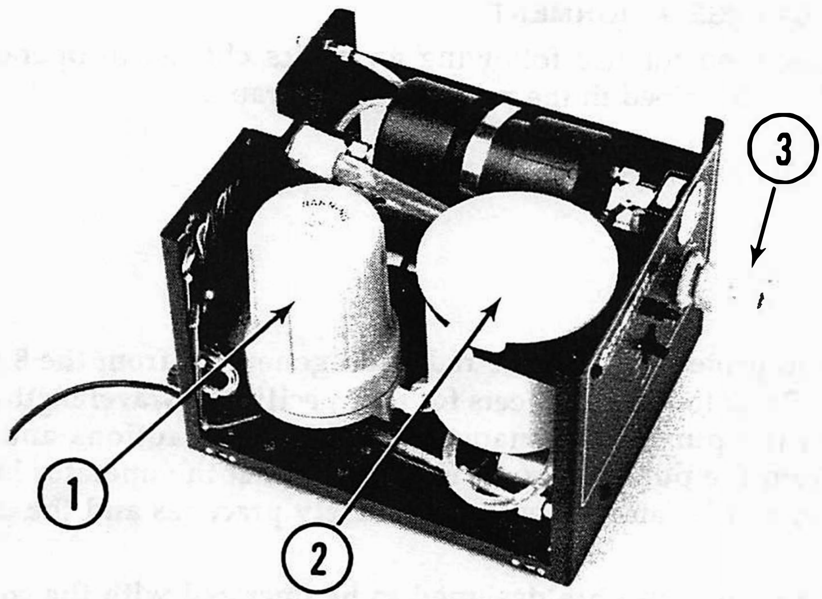
2 Insert the jet feed hose into a suitable waste container and pump out the old dye in the reservoir. Tilt the dye circulator at different angles to aid in emptying the circulator. Once the circulator is close to being empty, turn the pressure knob completely clockwise. After a few minutes, turn the pressure knob counterclockwise several turns and turn off the module.

3 Unscrew the blue filter housing, Figure 5-4, and remove the dye filter. Put the blue filter housing back in place.



1 Screws securing optical rotator 2 Screws securing Faraday rotator

Figure 5-3. Optical Diode Removal and Installation



1 Blue filter housing
2 Dye reservoir
3 Pressure control knob

Figure 5-4. Model 5920 Dye Circulator

4 Fill the dye reservoir with warm water and repeat step 2 above. Do this until the fluid being pumped out is clear.

5 Fill the dye reservoir with ethylene glycol and repeat step 2 above. Do this two times to rid the pump module of water.

6 Unscrew the blue filter housing and insert a new dye filter. Put the blue filter housing back in place and ensure it is tightened down.

7 Remove the catcher hose from the dye head and circulator. Rinse out the catcher hose with ethylene glycol and connect it back to the pump module and dye head.

CLEANING THE JET NOZZLE ASSEMBLY

1 Remove the dye jet holder by removing the two 5/64 inch screws securing it to the dye jet tip plate as shown in Figure 5-2.

2 Put the dye jet holder into an ultrasonic bath of the appropriate chemical used to mix the old dye. Allow to sit for approximately 20 minutes.

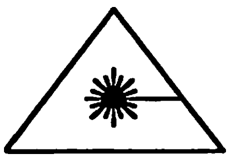
3 Put the dye jet holder back in place and connect the dye jet feed hose removed earlier.

4 Put the appropriate amount of solvent for the dye being used into the dye circulator reservoir. Refer to the dye fact sheets in Appendix A.

5 Turn the dye circulator to the pump position so the solvent circulates internally. Turn the pressure knob clockwise so the pressure rises to 80 psi and then turn the knob so it drops to 30 psi. Do this three times to help bleed air bubbles out of the circulator.

Dye Wavelength Change Alignment

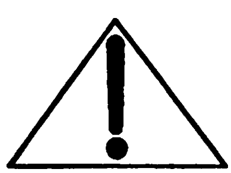
This procedure is intended for use following an optics change to operate in a different wavelength as described in the preceding paragraph.



Wear safety glasses to protect against the radiation generated from the 899 laser and the pump laser. Refer to the fact sheets for the specific 899 wavelengths being generated. Refer to the pump laser manual for safety precautions and wavelengths generated from the pump laser. It is assumed that the operator has read Chapter One, Safety, and is familiar with laser safety practices and the dangers involved.

Both the 899 and the pump laser are designed to be operated with the covers in place. Operation of the laser with the protective housing removed will allow access to hazardous visible and invisible radiation. The laser housings should only be opened for the purposes of maintenance and service by trained personnel cognizant of the hazards involved.

1 Lower the pump power to 100 mW and allow it to enter the 899 head. Rotate the pump beam stop out of the way so the pump beam strikes the M3 aperture plate. Check to see if the pump beam reflected from P1 is aligned horizontally and one spot diameter vertically above the M3 aperture as shown in Figure 5-5. Large adjustments vertically can be made by loosening the screw securing the pump mirror mount to the translation stage and rotating the mount. Large adjustments horizontally can be made by loosening the screw securing the translation stage and rotating the entire pump mirror assembly about the pivot point. Refer to Figure 5-2 for the location of these screws. Rotate the pump beam stop back in place.



Improper jet to catcher tube alignment can cause excessive turbulence in the jet stream. Minimizing this turbulence is important for reducing laser jitter.

2 Turn on the cooling water to the pump module.

3 Turn the dye circulator front panel switch to the pump position. Adjust the pressure knob so the pressure gauge reads 50 psi. Flip the switch to the jet position to establish a jet stream. Set the pressure to 40 psi. Look at the jet stream through the neutral density filter and determine if the pump

beam is striking the center of the jet stream. If not, turn the dye circulator switch to the pump position. Loosen the two 3/16 inch Allen screws securing the dye jet tip plate and move the jet tip plate in the proper vertical direction. Turn the jet stream back on and check to see if the pump beam is centered on the dye jet stream. Tighten the 3/16 inch screws when it is. Block pump beam.

4 Mix the dye concentrate according to the dye fact sheet recipes in Appendix A. Add approximately 10 ml of the concentrate to the dye circulator reservoir. Allow it to circulate for a few minutes and continue with setting the dye absorption below.

Setting the Absorption of the Dye

1 Raise the pump power to the desired operating level.

2 Measure the pump power entering the 899 head.

3 A percentage of the pump beam will pass through the dye jet stream and strike the pump beam stop. To get 80% absorption into the dye jet stream, 20% of the total pump power entering the 899 head (measured in step 2), must not be absorbed by the jet stream. Use a curved optic that is coated for the particular pump beam wavelength being used and reflect the portion of the pump beam not absorbed by the jet stream into a power meter.

4 Add dye concentrate to the pump module reservoir until the pump beam reflected in step 3 is approximately 20% of the total pump power measured in step 2. For example, if the total pump power into the dye laser head is 5 watts, then add dye concentrate until 1 watt of the reflected beam is seen on the power meter.

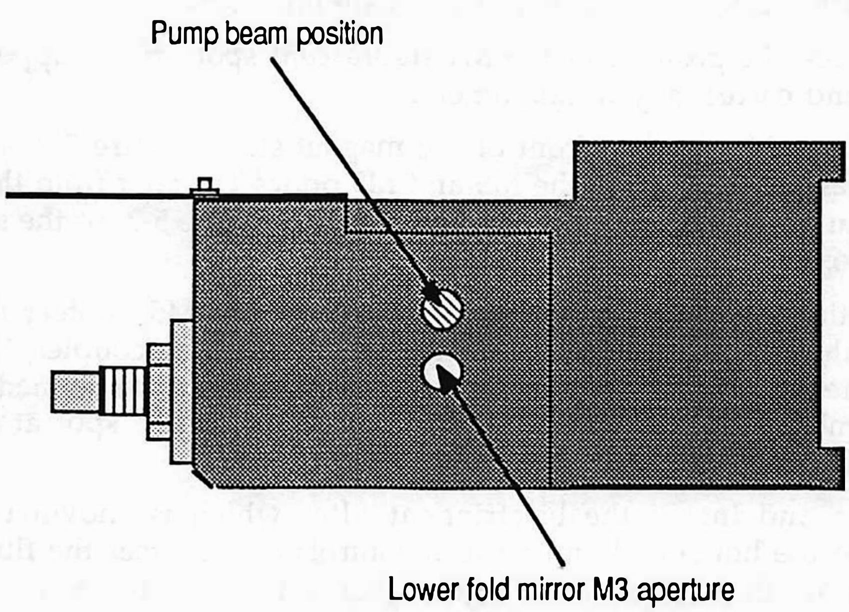


Figure 5-5. Position of Pump Beam on M3 Aperture

Initial Pump Focus Adjustment

1 Observe the pump beam spot transmitted through the dye jet stream to the pump beam stop. Adjust the pump focus P1 by turning the cap screw on the pump focus stage, so the transmitted pump spot begins to distort. (The image will vary with pump laser power and wavelength as well as with dye type, concentration and nozzle pressure.) Use the vertical pump mirror adjust, (Lower control), to re-center the pump beam on the dye jet.

Alignment of Spots in the Cavity

To perform this procedure in infrared dyes, an infrared viewer may be needed to locate the fluorescent spots.

1 Place a white card in front of the upper fold mirror M5 and locate the spot from M1. (The spot will not necessarily be round.)

2 Use the horizontal and vertical adjustments on the M1 tilt plate, to steer the fluorescent image from M1, through the compensating rhomb to M5. The image should be centered horizontally and slightly above center vertically on M5 as shown in Figure 5-6.

3 Set the distance between the optical surface of M1 to the point where the pump beam strikes the dye stream for approximately 80 mm. This is accomplished by turning the three M1 adjustment controls equal amounts in the same direction which will translate this mirror.

4 Recheck the position of the M1 fluorescent spot on the upper fold mirror M5 and correct any misalignment.

5 Hold a white card in front of the magnet stack, Figure 5-7, and locate the fluorescent spots from the M5 and M3 optics.The spot from the M5 optic is the larger of the two. Adjust the M5 focus, Figure 5-2, so the spot from it is approximately 4 mm in width.

6 Use the horizontal and vertical adjustments of M5 to steer the spot from M5 through the magnet assembly to the output coupler M4. Refer to Figure 5-7. Ensure the spot is centered in the aperture defined by the diode assembly. Hold a white card in front of M4. The spot at M4 will look similar to Figure 5-8.

7 Clean and install the birefringent filter which is shown in Figure 5-9. Using the horizontal and vertical controls of M3, steer the fluorescent spot from M3 through the birefringent filter to the magnet stack.

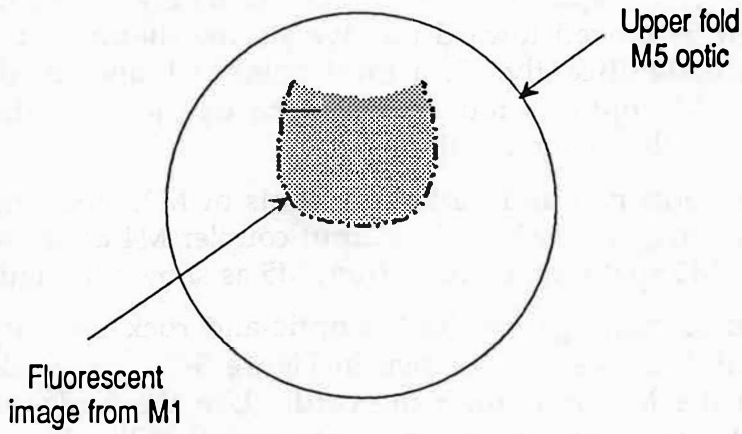
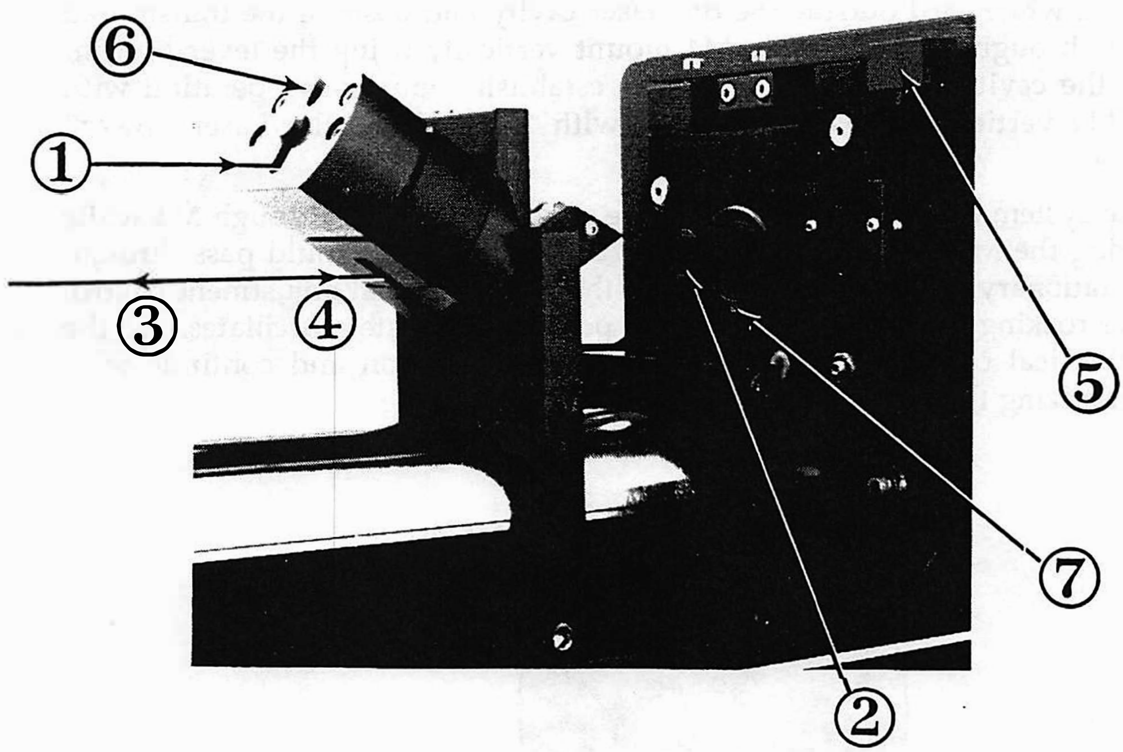


Figure 5-6. Image from M1 on M5



1	Fluorescent image from M5	5	M4 lever arm
2	Output coupler optic	6	Magnet stack
3	Fluorescent image from M4	7	Output bezel alignment hole
4	Fluorescent image from M3		

Figure 5-7. Fluorescent Image Path for M5, M3 and M4 optics/M4 Lever Arm/Output Bezel alignment Hole

8 Hold a white card in front of the magnet stack and adjust the M3 focus, Figure 5-2, so the spot from M3 is approximately 2.5-3.0 mm in diameter. As the card is moved toward the dye jet, the fluorescent spot should not change size significantly. If a focal point is found inside the dye laser cavity, the M3 optic is too far from the dye jet and should be moved forward until the image is collimated.

9 Using the horizontal and vertical controls of M3, steer the spot from M3 through the magnet stack to the output coupler M4 as shown in Figure 5-7. Center the M3 spot on the image from M5 as shown in Figure 5-10.

10 Hold a white card against the M5 optic and rock the output coupler M4 mount with the lever arm shown in Figure 5-7. Locate the return reflection from the M4 optic onto the card. Use the horizontal and vertical knobs of M4 to place the reflection into a vertical line just above the image from M1 as shown in Figure 5-11. **This reflection should be a small spot less than 1 mm in diameter. If not, then M3 or P1 is improperly focussed.**

ESTABLISHING INITIAL OSCILLATION

1 Place a white card outside the dye laser cavity and observe the transmitted spots through M4. Rock the M4 mount vertically using the lever arm inside the cavity. If oscillation occurs, establish continuous operation with the M4 vertical knob and continue with "Optimizing the Laser Power" below.

2 If the system fails to oscillate, view the spots transmitted through M4 while rocking the M4 mount. The spot that moves with M4 should pass through the stationary upper spot. If not, use the M4 horizontal adjustment control while rocking vertically to correct the position. If system oscillates, use the M4 vertical control to establish continuous operation and continue with "Optimizing the Laser Power" below.

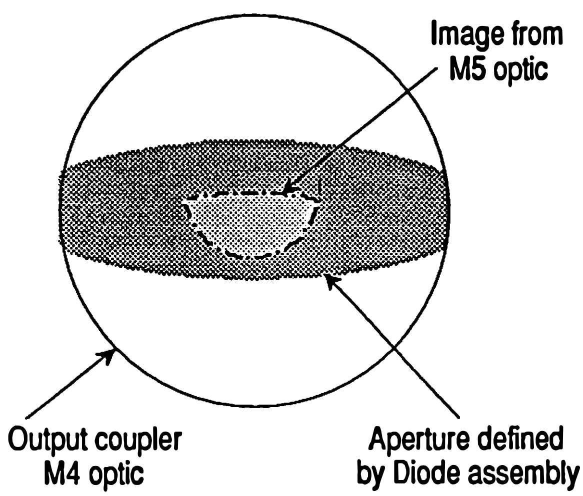
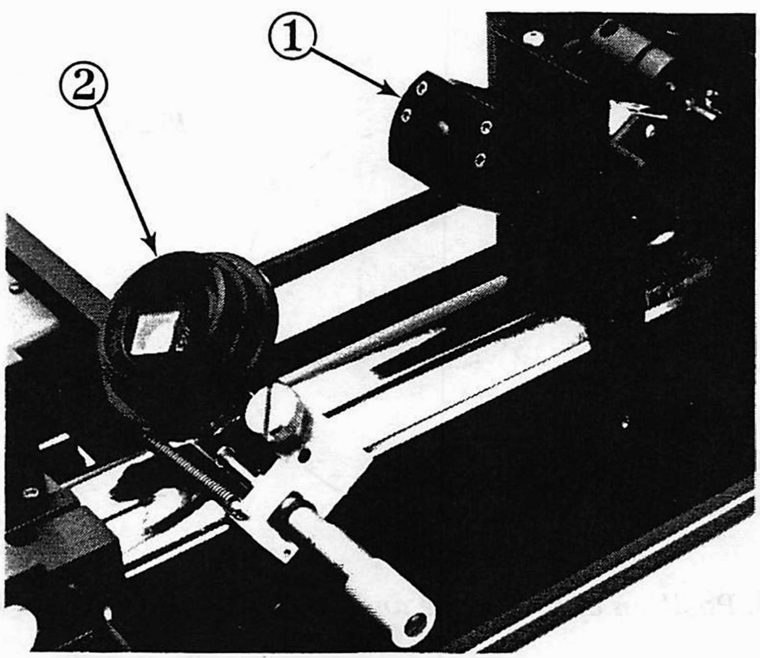


Figure 5-8. Image from M5 on M4

3 If the system fails to oscillate, scan the M5 vertical adjustment slowly while rocking M4 vertically. If system oscillates, establish continuous oscillation with the M4 vertical control and continue with "Optimizing the Laser Power" below.

4 If system fails to oscillate, scan the M5 vertical adjustment and rock M4 vertically. As the fluorescent spot that moves with M4 passes through the upper stationary spot, watch for the appearance of a third dim spot in the same area. Using the M5 horizontal control and the M4 Horizontal control, align the stationary spot, the second moving spot and the third dim spot into a vertical line. Rock the M4 mount vertically and scan M5 vertically until the laser flashes. Establish continuous oscillation with the M4 vertical control and continue with "Optimizing the Laser Power" below.

5 If system does not lase, recheck the spot sizes in front of the magnet stack, the pump laser power and dye absorption. Realign spots at M4 and continue with Step 1.



1 Magnet stack 2 Birefringent filter

Figure 5-9. Magnet Stack and Birefringent Filter

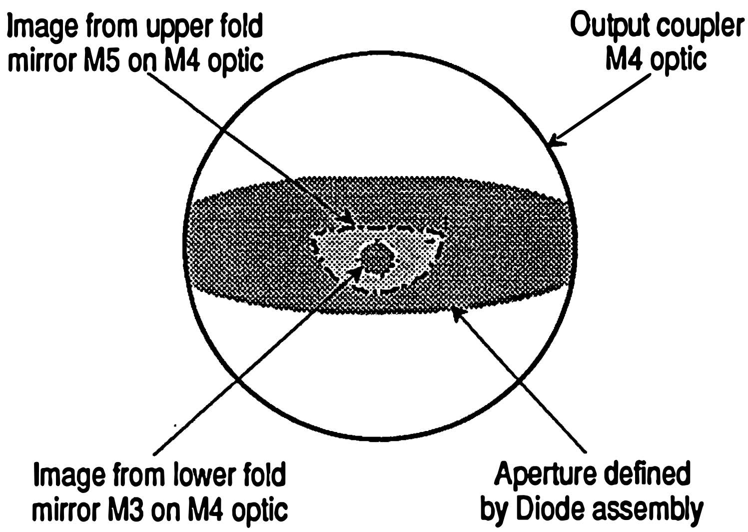


Figure 5-10. Position of M3 and M5 Image on M4

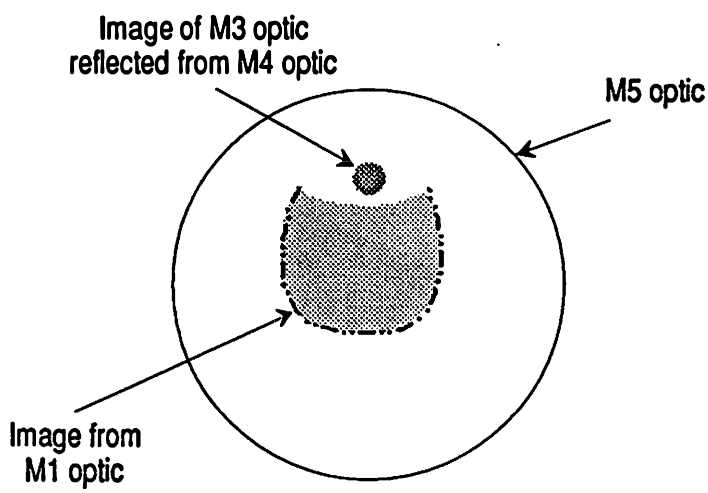


Figure 5-11. Position of M1 Image and M3 Image (via M4) on M5

Optimizing the Laser Power

1 Using a power meter (Coherent model 210 or equivalent), peak the laser controls for maximum power in the following order:

- Output coupler M4 controls
- Upper fold mirror M5 controls
- Pump mirror P1 controls
- Lower fold mirror M3 controls

2 Repeat this sequence until no further power can be obtained.

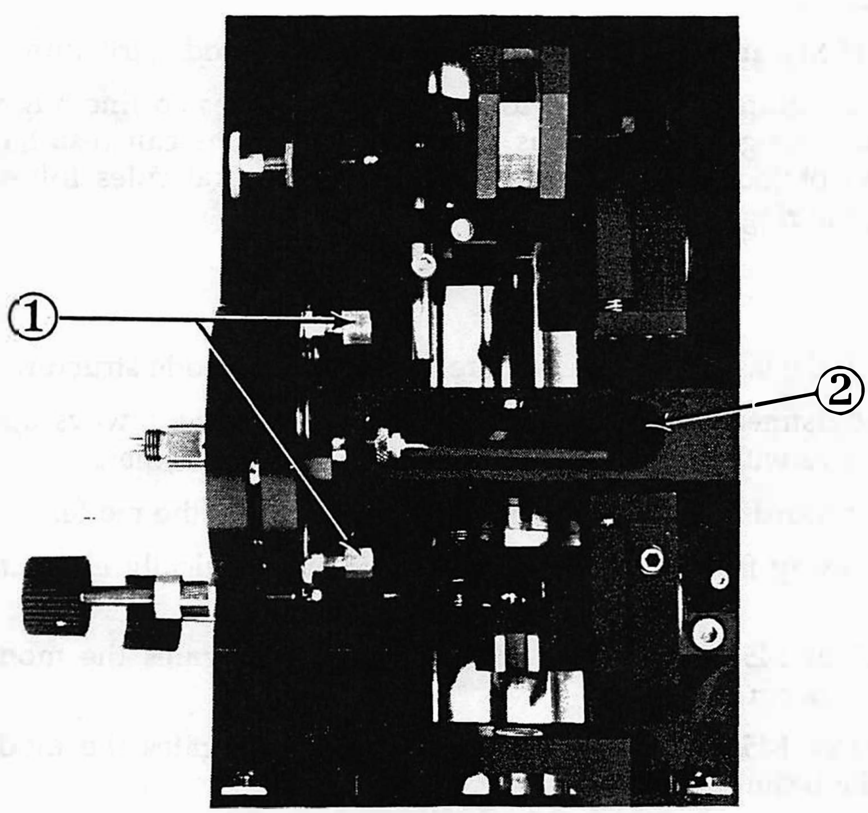
When performing this procedure, bright fluorescence from the dye jet will be present. It is important that you wear safety glasses which protect against wavelengths emitted by the particular dye used.

Dye Jet Stream Alignment

1 Remove the neutral density filter cover shown in Figure 5-12 by removing the two screws securing it.

2 Remove the magnet stack, Figure 5-9, and view the spots reflected from the jet onto the ceiling. If the two spots appear separated, bring them together with the jet pointing adjustment screws shown in Figure 5-12. An interference pattern will appear when the spots overlap. Peak the laser while doing this using the pump control knobs.

3 Replace the magnet stack and peak the laser for maximum power.



1 Jet pointing adjustment screws

2 Neutral density filter cover removed

Figure 5-12. Pointing Jet Adjustment Screws

Fine Alignment of Laser for Best Mode

With the dye laser peaked for power, expand the output beam and project it on the wall or ceiling. Observe the mode structure and power distribution. Use the following examples as a guide for improving discrepancies in the mode structure:

- If mode is diffuse, vertically elongated and power is low, but stable, P1 is too far from the jet. Pull in the pump focus.
- If mode is diffuse, elongated, the power is low and unstable and there is a bright reflection from the top surface of the compensation rhomb, then the rhomb is not at Brewster's angle. Use the alignment tent to set up Brewster's angle for the rhomb.
- If mode has a hot center, good power; stable or unstable, but it is a "D" shaped mode, then P1 is too close to the jet. Back the pump focus off.
- If mode is diffuse with good power, but unstable and possibly horizontally elongated, then M3 or M5 is too close to the jet.
- If mode has a hot center, but vertical elongation and a "star" shape with unstable power, then M3 or M5 is too far from the jet.
- If mode shape is TEM_{01}, then pump source is also TEM_{01} or dye laser cavity optics are not fully peaked for power.There could also be a contaminated or absorbing optic.
- If mode is TEM_{00} and stable, then this is the optimal mode structure.

  The mode structures shown are to serve as guidelines to fine align your 899 system. The general, various mode configurations can result from a combination of focal misalignments. A list of general rules follows for optimizing the ring laser.

General Rules

- Always peak the laser for power before observing the mode structure.
- When an adjustment is made in the position of an optic, always optimize the laser power with the same optic before adjusting any others.
- Moving P1 towards the jet increases power and flattens the mode.
- Moving P1 away from the jet reduces power and vertically elongates the mode.
- Moving M3 or M5 towards the jet horizontally elongates the mode and increases the beam diameter.
- Moving M3 or M5 away from the jet vertically elongates the mode and decreases the beam diameter.

SETTING UP THE 899 TO OPERATE AS A SCANNING SINGLE FREQUENCY LASER.

These procedures assume that the 899 is optimized in the broadband configuration. Note: If an infrared dye is being used, an IR viewer may be needed to perform this procedure.

Refer to Chapter 6 for photos for the following procedure.

CONNECTING THE CONTROL BOX

1 The wiring harness which carries all the control signals for the 899 is located near the front of the laser head. There are two plugs at the end of the wiring harness. These connect to the back of the control box. Connect the smaller plug to the "light power sense" connector and the larger plug to the "dye laser drive" connector. Plug the control box into an outlet and ensure it is turned off (The red power button is not lit and the analog light power display is sitting at zero).

INSERTING THE INTRACAVITY ASSEMBLY (ICA)

Note: Whenever the ICA is not mounted in the 899 cavity, tape should be placed over the openings at both ends of the ICA. This will prevent contamination of the thick and thin etalon.

1 The ICA, Figure 6-15, mounts to the cradle assembly, Figure 6-15, which is in turn connected to the Invar bar. The thick etalon faces the output coupler when the ICA is installed as shown in Figure 6-16. Two pins protrude up from the cradle assembly to guide the ICA into place. Three 9/64 inch Allen screws shown in Figure 6-16, secure the ICA to the cradle assembly. Install the ICA and tighten the three 9/64 inch screws to secure the ICA in place.

2 A plug rests inside the 899 head near the ICA. Connect it to the ICA as shown in Figure 6-15. This provides drive voltages to the thin and thick etalon.

3 The ICA input aperture, at the thin etalon, and output aperture, at the thick etalon, Figures 6-15 and 6-16, need to be roughly centered on the fluorescent images passing through them. Hold a piece of tissue paper up to the apertures and check for the fluorescence position. Use the translation screws described below to center the ICA input and output apertures on the fluorescence images. To move the ICA vertically and horizontally the four 3/16 inch Allen screws shown in Figure 6-15, which lock the cradle assembly in place, must be loosened. Four 5/64 inch Allen screws, shown in Figure 6-16, are used to move the ICA. The two horizontal translation screws, Figure 6-16, work in a push and pull fashion. One has to be loosened and the other tightened to move the ICA horizontally. The two vertical translation screws, Figure 6-16, must both be turned clockwise to raise the ICA and counterclockwise to lower the ICA.

The plate that the ICA mounts to, may have to be pushed down if the vertical translation screws are turned counterclockwise.

4 Tighten the four 3/16 inch Allen screws down to lock the cradle assembly and ICA in place.

5 Ensure the 899-21 control box front panel knobs are in the "reference cavity", "zero servo", and "manual" positions. Press the 899-21 control box red "Power" button on the front panel to energize the box.

FLASHING AND WALKING OFF THE THIN AND THICK ETALON

1 With the ICA in place, there will be three sets of reflections off of the BRF that can be seen on the ceiling. They are the laser cavity, thick etalon and thin etalon reflections. If the system is lasing, the cavity reflections will be bright spots. The other nearby reflections which are from the thick and thin etalon will be much dimmer than the cavity reflections. If the system is not lasing then the cavity reflections on the ceiling will also be dim.

2 Rotate the thin etalon offset knob Figure 6-17, on the front panel of the control box and locate the reflections on the ceiling that are moving. These are the thin etalon reflections. Rotate the thin etalon offset knob to move these reflections away from the laser cavity reflections.

3 Use the thick etalon horizontal and vertical controls, Figure 6-16, to steer the thick etalon reflections viewed on the ceiling so they overlap the cavity reflections. When this is accomplished, the thick etalon is at flash (e.g.-it is at normal incidence to the cavity beam). The system should be lasing at this point. If not, continue with step 4 below. Peak the output coupler M4, upper fold mirror M5 and lower fold mirror M3 horizontal and vertical tilt adjusts for maximum output power. If the thick etalon is at flash,the system will be lasing bi-directionally and the cavity and thick etalon reflections on the ceiling will be bright. Adjust the thick etalon horizontal control to "walk off" the thick etalon reflections on the ceiling approximately three cavity reflection diameters away. The system will lase unidirectionally and the output power should approximately double in value.

If the system stops lasing when the thick etalon is walked off, then the thick etalon horizontal and vertical tilt adjusts near the thick etalon, Figure 6-16, may be out of alignment. Walk off the thick etalon until the system power drops in half. Now rotate these two knobs to peak the output power. Continue this until the thick etalon can be walked off the amount mentioned above.

4 Rotate the thin etalon offset knob on the front panel of the control box to locate the thin etalon reflections on the ceiling. Now rotate this knob completely counterclockwise. Adjust the thin etalon horizontal and vertical controls, Figure 6-15, to steer the thin etalon reflections onto the cavity reflections. When the output power drops in half then the thin etalon is at flash. If the system still will not lase, continue with step 5. If the system is lasing, peak the output coupler M4, upper fold mirror M5 and lower fold mirror M3 horizontal and vertical tilt adjusts for maximum output power, which will be approximately half that before the thin etalon was flashed. Now rotate the thin etalon offset knob clockwise for maximum power

Power should approximately double when the thin etalon is taken out of flash. Continue with "Installing the Scanning Brewster Galvo" below.

5 Recheck the cavity fluorescent image position through the ICA and ensure it is not clipped.

6 Make small adjustments on the lower fold mirror M3 vertical and horizontal tilt adjusts which will usually initiate laser oscillation. If the system lases, continue with step 8, otherwise perform step 7.

7 Turn the output coupler M4 vertical tilt adjust, Figure 6-5, 1/2 turn counterclockwise. Rock the M4 mount using the lever arm shown in Figure 6-4 while slowly moving the upper fold mirror M5 vertical tilt adjust. Watch for laser oscillation. If the laser flashes, turn the M4 vertical tilt adjust clockwise until continuous oscillation occurs. Continue with step 8. If the system still will not lase, remove the ICA and establish broadband operation. Once this is done repeat the ICA installation procedure.

8 If the system is now lasing, peak the M5, M3 and M4 mirrors for maximum output power. Rotate the thin etalon offset knob clockwise to bring it out of flash. Adjust the thick etalon horizontal control, Figure 6-16, to "walk off" the thick etalon reflection three cavity reflection diameters. The system should now be lasing unidirectionally. Peak the M5, M3 and M4 mirror horizontal and vertical tilt adjusts for maximum power.

Typical conversion performance for the 899 ICA is 60-70% of the broadband power, but this will vary slightly between systems.

INSTALLATION OF SCANNING BREWSTER PLATE (899-05, 899-21)

If the system is being run in an IR dye, an IR viewer may be needed to perform the following procedures.

Refer to Figure 6-18 for Brewster plate description.

1 Loosen the 9/64 inch Allen screw to remove the Brewster plate dust cover.

2 Clean both sides of the Brewster plate with methanol and then methanol.

3 Loosen the two thumb nuts on the Brewster plate mounting bracket and slide the Brewster plate into a vertical position such that the laser oscillates through the plate. Tighten the two thumbnuts.

4 Optimize the output power by adjusting the upper fold M5, lower fold M3 and output coupler M4 horizontal and vertical tilt adjusts.

5 Slightly loosen the thumbscrews and make a small vertical adjustment of the Brewster plate to center the beams through the Brewster plate. Repeat step 4.

6 Turn off the 899 control box and connect the plug sitting next to the Brewster plate inside the head to the Brewster plug. Turn the control box back on.

ALIGNING THE INFORMATION BEAMS (899-05, 899-21)

1 The beamsplitter assembly is shown in Figure 6-19. Clean both sides of the optic and install the beamsplitter with the two thumb nuts shown in Figure 6-19. Leave the thumbnuts loose enough for the beamsplitter assembly to slide up and down.

2 Two beams will be sent downward from the beamsplitter to the large steering optic. The two beams will be directed sideways to the smaller steering optics. Slightly loosen the thumb nut, Figure 6-19, that secures the large steering optic.

3 Adjust the beamsplitter assembly vertically and the large steering optic assembly horizontally to position the two beams near the center of the two small steering optics. Tighten the thumb screws for the beamsplitter and large steering optic assembly.

4 Remove the detector block by unscrewing the black knurled knob as shown in Figure 6-16.

5 If the reference cavity, Figure 6-20, is in place, turn off the control box and remove it from the laser head by disconnecting the two plugs connected to it and lifting the assembly out.

6 There are two apertures for the reference cavity beam and their location is shown in Figure 6-20. Place a white card in front of the exit aperture. A beam should be seen on the card. If it isn't, use the beamsplitter horizontal and vertical Allen screw tilt adjusts, Figure 6-19, to steer the beam through the input aperture to the white card.

7 Hold a piece of lens tissue between the small steering optics. The image of the input aperture in relation to the beam passing through it should be seen on the white card. Use the beamsplitter horizontal and vertical Allen screw tilt adjustments, Figure 6-19, to center the beam through the input aperture.

8 Place the white card after the exit aperture. Now hold a piece of lens tissue just after the input aperture. The image of the exit aperture in relation to the beam passing through it should be seen on the white card. Use the horizontal and vertical Allen screw tilt adjustments of the small steering optic for the reference cavity beam, Figure 6-19, to center the beam through the exit aperture.

9 Repeat steps 7 and 8 until the reference cavity information beam is centered through the input and exit apertures.

10 Hold a white card after the exit aperture of the normalizing beam. The beam travels through a draft tube as shown in Figure 6-18. Use the horizontal and vertical Allen screw tilt adjustments of the small steering optic that directs the beam through the draft tube, Figure 6-19, to steer the beam through the tube and onto the white card.

11 Loosen the 5/64 inch screw, Figure 6-18, securing the draft tube. Rotate the tube and check to see if the image on the white card moves. If the image moves, it is a reflected image and the steering optic must be realigned. Use the horizontal and vertical of this steering optic to cleanly direct the beam through the draft tube. Tighten the retaining screw down.

Reference Cavity Assembly (RCA) Installation and Alignment

1 Gently lower the reference cavity into position with the heater connector (on the side of the unit) facing away from the laser as shown in Figure 6-20.

2 Turn off the 899-21 control box. Attach the reference cavity galvo drive and heater plugs, Figure 6-20, and turn the control box on. Ensure that the control box knob settings are at "reference cavity", "zero servo" and "manual".

3 With the reference cavity in place, hold a white card 15 cm from the exit aperture of the reference cavity. Two spots should be seen.

4 Using the four adjustment controls on the RCA, Figure 6-20, position the RCA such that the two transmitted spots are clear and sharp.

5 Continue adjusting the four screws until the RCA is on axis with respect to the beam passing through it. This will be the case when the two spots are completely overlapped. Move the white card 30 cm away from the exit aperture and ensure the spots are still overlapped.

6 Connect the detector block as shown in Figure 6-16.

7 Connect an oscilloscope with X-Y capabilities to the control box back panel as follows:

-Horizontal output display BNC from control box to the x channel of the oscilloscope.

-Vertical output display BNC from the control box to the y channel of the oscilloscope.

8 Set the control knobs to the following settings:

-Display knob to "reference cavity"

-Operating mode knob to "zero servo"

-Scan control knob to "internal"

-Scan speed knob to ".25 sec"

-Multiplier knob to "1"

9 Set the oscilloscope to X-Y mode and ground the vertical channel.

10 Adjust the horizontal or X channel gain of the oscilloscope for a full scale sweep. If the sweep is not full scale. Adjust the trim pot on the back of the control box located just above the horizontal display BNC for a full scale sweep.

11 Set the oscilloscope vertical or Y channel gain for 2.0 Volts/Division and DC coupled.

12 The reference cavity fringes should now be seen on the oscilloscope. There will be approximately 5 peaks. Use the four adjustment controls of the RCA to minimize every other fringe as shown in Figure 6-22.

13 Once this is done, adjust the 5/64" vertical tilt adjust of the reference cavity small steering optic, Figure 6-19, to cause all the fringes to be of equal amplitude.

Reference Level Set

1 Insert a white card between the two small steering optics. This will block the signal to the reference cavity.

2 The signal on the oscilloscope should be approximately -5 Volts DC.

If this level fluctuates, the light level to the normalizing detector may be too low. It may be necessary to use a coated beamsplitter or there may be a misalignment of the normalizing beam.

3 Remove the white card and observe the reference cavity fringes on the oscilloscope.

4 Use the scan cal trim pot on the front of the 899 control box to adjust the drive voltage to the reference cavity such that the fringes of the reference cavity on the oscilloscope are two divisions apart on a ten division scope.

5 Use the level set trim pot on the front of the 899 control box to adjust the level of the fringes for +5 volts DC. If the trim pot runs out of travel, re-center the trim pot and remove the detector block by loosening the black knurled knob securing it as shown in Figure 6-16. Loosen the attenuator, Figure 6-21, by using a small Phillips head screwdriver and move the attenuator a small amount. Tighten the Phillips head screw down and connect the detector block. Check the level of the fringes. Repeat this procedure until the reference cavity fringes have a +5 volt DC amplitude.

SETTING UP THE FEED FORWARDS FOR LOCKING AND SCANNING UP TO 30 GHZ

The feed forward signals are drive signals fed to the thick etalon, the thin etalon and the scanning Brewster plate to help maintain locking. These are set up in the factory when the system is tested, but may need slight adjustment.

1 Set the 899 control box knobs to the following settings:

-Display to "Reference cavity"

-Operating mode to "Zero servo"

-Scan control to "Internal"

-Scan time to ".25"

-Scan width to "10.99 GHz"

Ensure the reference cavity five mode display is smooth and continuous. If it is breaking up, then excessive noise may be coupling into the cavity. Float the table the laser is on if possible. Ensure the system is staying single frequency by monitoring the output on an optical spectrum analyzer.

2 Set the operating knob to "Free Run". The oscilloscope display will change. The signal moving across the oscilloscope should be as flat as possible. This is the reference cavity error signal. If there are peaks in this signal, the scanning Brewster plate feed forward needs adjustment. Remove the four screws securing the control box front panel to the frame. Pull the control box out so the PCBs can be accessed. Locate the 1A4 PCB (e.g., the fourth board from the left), Figure 6-17, and adjust the potentiometer for as flat a signal as possible on the oscilloscope.

3 Set the operating knob to "Lock" This will close the frequency servo loops. The signal on the oscilloscope should be a flat and continuous line at the ground point which indicates little frequency error. If the signal is breaking up, this indicates the system is mode hopping and the thin etalon may be out of adjustment. Make small adjustments on the thin etalon offset knob, Figure 6-17, to see if the oscilloscope trace can be made continuous. If not, then the thin etalon feed forward may need adjustment. Locate the 1A5 PCB (e.g., the fifth board from the left), Figure 6-17, and adjust the potentiometer for a continuous line with no breaks. If this is not possible, set the operating knob to "zero servo" to allow the frequency servos to relax. Now switch the operating knob to "Lock" and adjust the potentiometer on the 1A5 PCB for a smooth, continuous signal.

4 Set the display knob to "Thick Etalon" which displays the thick etalon error signal. This will be a flat line or have a slight oval shape. The two ends of the signal should be level with respect to each other. If not, locate the 1A1 PCB and adjust the R107, Figure 6-23, so the signal is level. Set the display knob back to "reference cavity" and the operating mode knob to "zero servo". Increase the scan width 5.00 GHz and repeat steps 2, 3 and 4. Do this until the scan width is 29.99 GHz. This is the maximum scan width possible.

Operator's Manual

Chapter Six
Installation Alignment

COHERENT

INTRODUCTION

Installation alignment procedures contained in this chapter are intended for use during initial installation or if the Ion laser or 899 laser head has been moved. Re-alignment after an optics change or after a dye to titanium:sapphire (and vice versa) conversion are contained in the applicable chapter. Refer to Chapter Three as required for the location of all 899 controls used in this chapter.

EQUIPMENT USED DURING INSTALLATION ALIGNMENT

- Power meter, Coherent Model 210 or equivalent (0 to 10 W).
- Power meter, Coherent Model 212 or equivalent (0.1 μW to 100 mW).
- Laser safety glasses to protect against the wavelength exiting the 899 laser head and to protect against the pump beam wavelength. Refer to the dye fact sheets in Appendix A for specific wavelengths associated with the 899-21.
- IR viewer
- Small spirit bubble level.

DYE INSTALLATION ALIGNMENT PROCEDURE

The following procedure is intended for use during initial installation or if the Ion laser or 899 laser head has been moved. Re-alignment after an optics change or after a titanium:sapphire to dye conversion are contained in the applicable chapter.

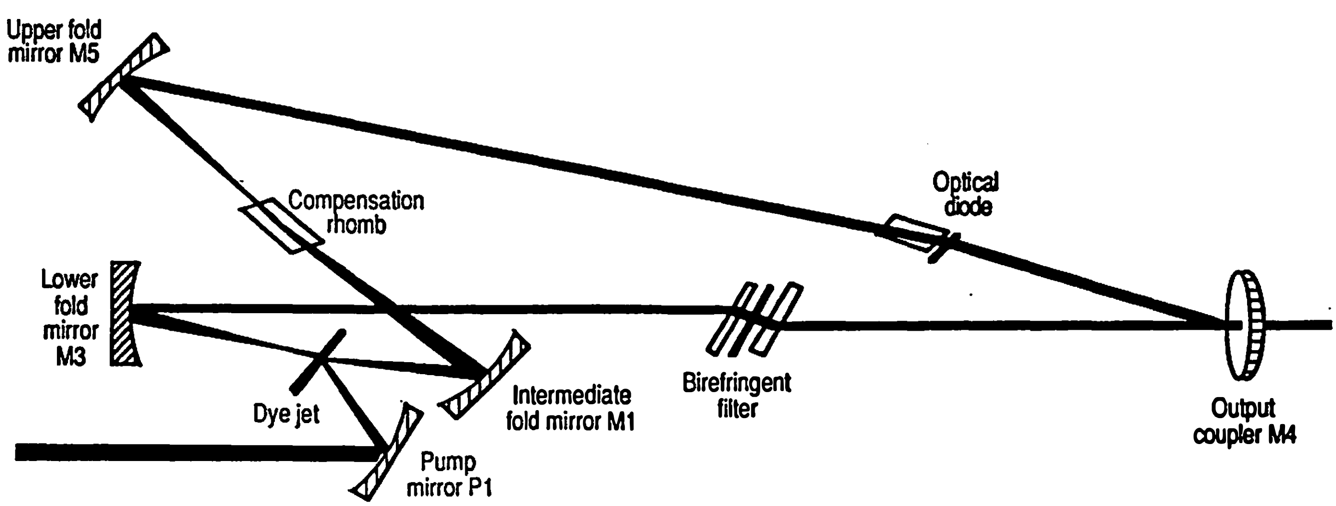


Figure 6-1. Optical Schematic

It is recommended that argon safety glasses are used when performing this alignment because stray beams could be present.

1 Ensure the pump laser has been optimized for power and mode. The pump laser beam should be running in a stable, TEM_{00} mode and be level to the table. Clamp down the ion laser head and lower the output power to less than 100 mW.

It is not recommended that beam steering mirrors for long distances between the ion and dye laser be used. The use could result in pump beam power loss, mode degradation and beam divergence which will impair the performance of the 899.

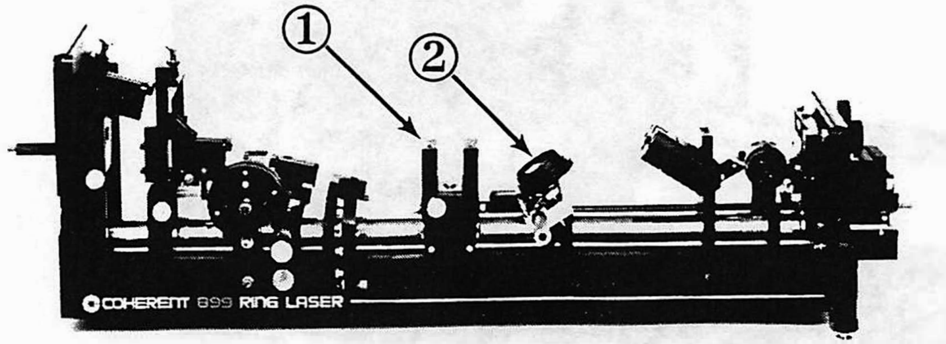
2 Place the 899 head about 20-50 centimeters in front of the ion laser. Allow room for a power meter head to measure the pump power. Remove the following:

- Birefringent filter assembly. This is shown in Figure 6-2. Loosen the large knurled screw on the birefringent filter assembly to remove it.
- Pump mirror P1 and intermediate fold mount M1. Remove these mounts by loosening the screws securing them.
- Intracavity assembly (ICA). This is shown in Figure 6-16. Three 9/64 inch Allen head screws secure the ICA. Remove the screws and lift the ICA assembly out of the cavity.
- Scanning Brewster plate. This is shown in Figure 6-18. Loosen the 9/64 inch Allen head screws securing the dust cover and remove the dust cover. Loosen the two thumbnuts that secure the Brewster plate assembly to its mount and remove the Brewster plate assembly from the cavity.
- Beamsplitter assembly. This is shown in Figure 6-19. Unscrew the two thumbscrews securing the beamsplitter assembly and remove it from the laser head.

3 Using the three height adjust screws shown in Figures 6-3 and 6-5, adjust the height of the 899 head so the pump beam enters the input bezel aperture centered and strikes the output bezel alignment hole shown in Figure 6-4. Ensure the beam is not clipped. You can use tissue paper at the

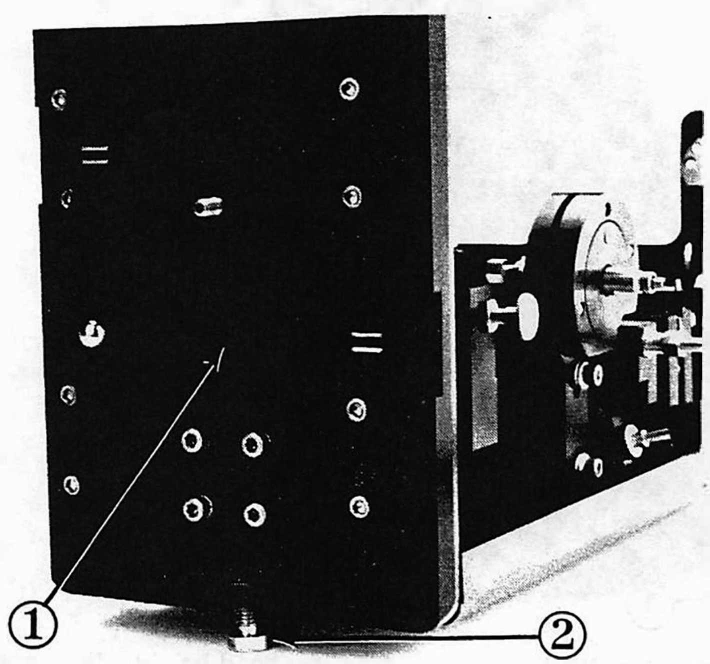
input bezel to see how well the pump beam is centered through that aperture. Once these adjustments are made, clamp the 899 head down to the table. Recheck alignment after tightening the clamps.

4 Block the pump beam.



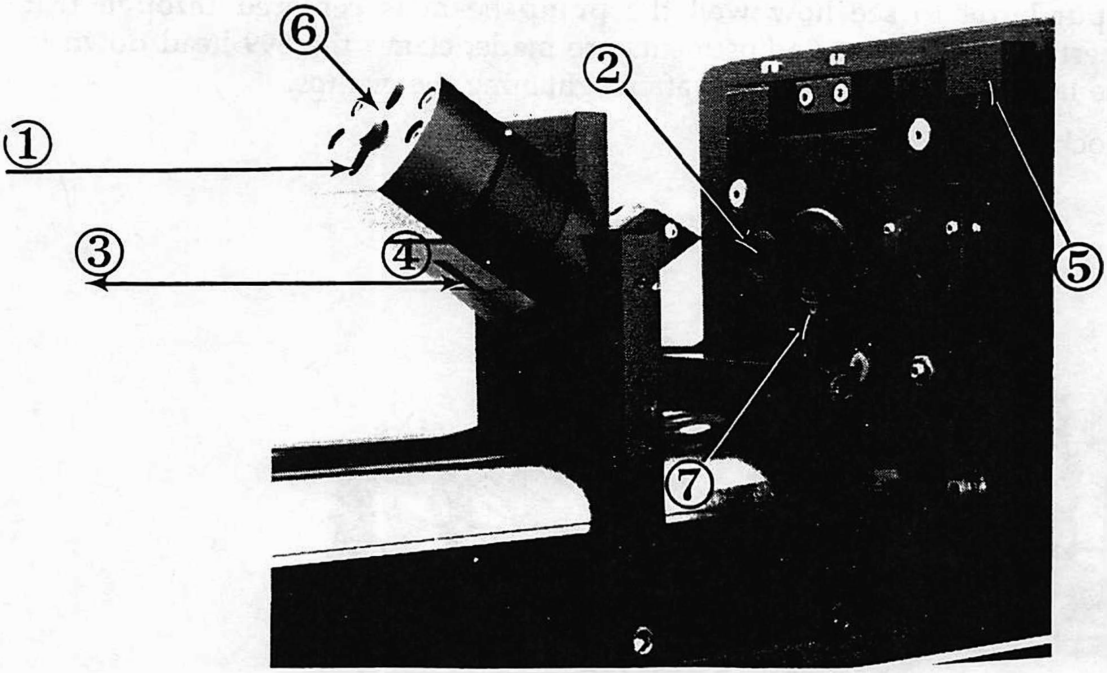
1 895 etalon 2 Birefringent filter

Figure 6-2. Laser Head Showing Birefringent Filter and Optional 895 Etalon



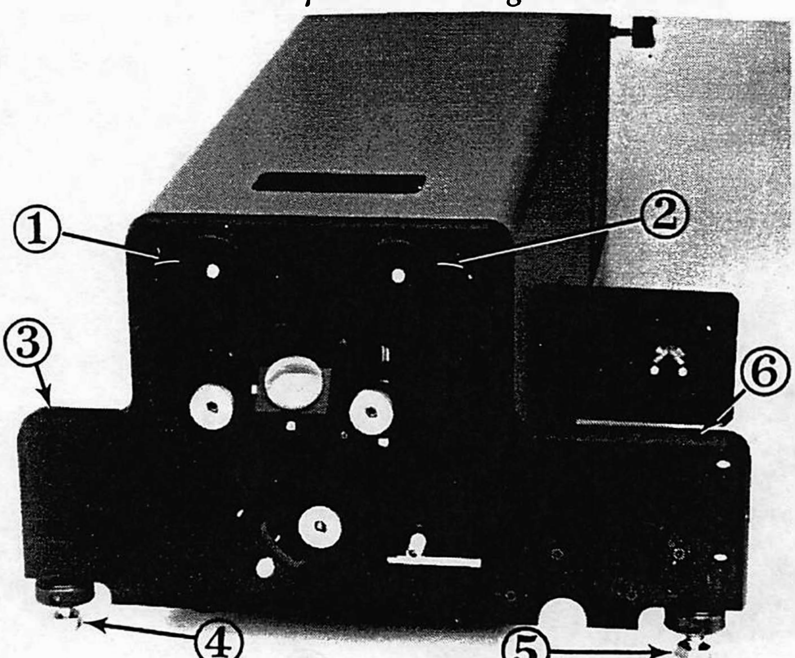
1 Input bezel pump beam alignment aperture 2 Height adjust screw (use wrench)

Figure 6-3. Input Bezel Alignment Aperture and Height Adjustment Screw



1 Fluorescent image from M5
2 Output coupler optic
3 Fluorescent image from M4
4 Fluorescent image from M3
5 M4 lever arm
6 Magnet stack
7 Output bezel alignment hole

Figure 6-4. Fluorescent Image Path for M5, M3 and M4 Optics; M4 Lever Arm and Output Bezel Alignment Hole



1 Output coupler horizontal tilt adjust
2 Output coupler vertical tilt adjust
3 Height adjust access hole
4 Laser head height adjust screw
5 Laser head height adjust screw
6 Height adjust access hole

Figure 6-5. Laser Head Height Adjust Screws and Output Coupler Horizontal and Vertical Controls

Pump Beam Alignment

1 Install the pump mirror and intermediate fold mirror mounts.

2 Unblock the pump beam. Rotate the pump beam stop, Figure 6-6, out of the way so the pump beam strikes the M3 aperture plate. Check to see if the pump beam reflected from P1 is aligned horizontally and one spot diameter vertically above the M3 aperture as shown in Figure 6-7. Large adjustments vertically can be made by loosening the screw securing the P1 mount to the translation stage and rotating the mount. Large adjustments horizontally can be made by loosening a screw and rotating the entire pump mirror assembly about the pivot point. Refer to Figure 6-6 for the location of the screws. Rotate the pump beam stop back in place.

Improper jet to catcher tube alignment can cause excessive turbulence in the jet stream. Minimizing this turbulence is important for reducing laser jitter.

3 Turn on the cooling water to the pump module.

4 Establish the dye flow at the proper pressure; usually 30-40 psi. Looking at the jet stream through the neutral density filter, Figure 6-6, determine if the pump beam is striking the dye jet in the center. If not, turn off the jet stream and loosen the two 3/16 inch Allen screws securing the dye jet tip plate shown in Figure 6-6 and move the jet tip plate in the proper vertical direction. Turn the jet stream back on and check to see if the pump beam is centered on the dye jet stream. If so, tighten the 3/16 in. screws.

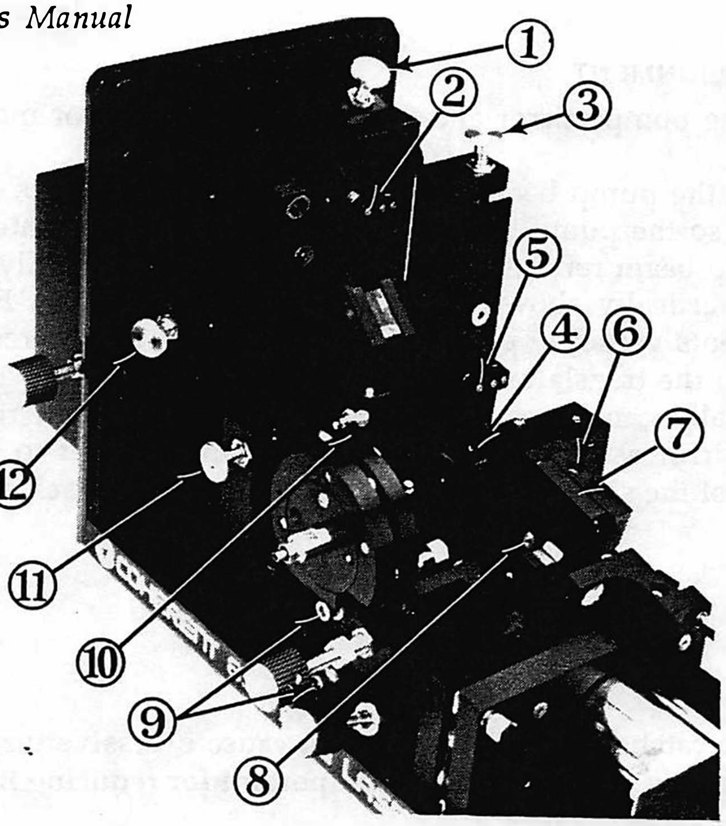
Setting the Absorption of the Dye

1 Raise the pump power to the desired operating level.

2 Measure the pump power entering the 899 head.

3 A percentage of the pump beam will pass through the dye jet stream and strike the pump beam stop. Use a curved optic that is coated for the particular pump beam wavelength and reflect the portion of the pump beam that passes through the dye jet back into a power meter.

4 Add the dye concentrate to the pump module reservoir until the pump beam reflected in step 3 is approximately 20% of the total pump power entering the 899 head. For example, if the total pump power into the dye laser is 5 W, then to get 80% absorption we must get 1 W reflected into the power meter.



1	M5 vertical tilt adjust	7	Pump focus stage
2	M5 focus adjust	8	Loosen to adjust pump beam reflection vertically
3	M3 vertical tilt adjust	9	3/16 in. Screws securing dye jet tip plate
4	Neutral density filter	10	Pump beam stop
5	M3 focus adjust	11	M3 horizontal tilt adjust
6	Loosen to adjust pump beam reflection horizontally	12	M5 horizontal tilt adjust

Figure 6-6. M5, M3, P1 and M1 Mounts and Controls

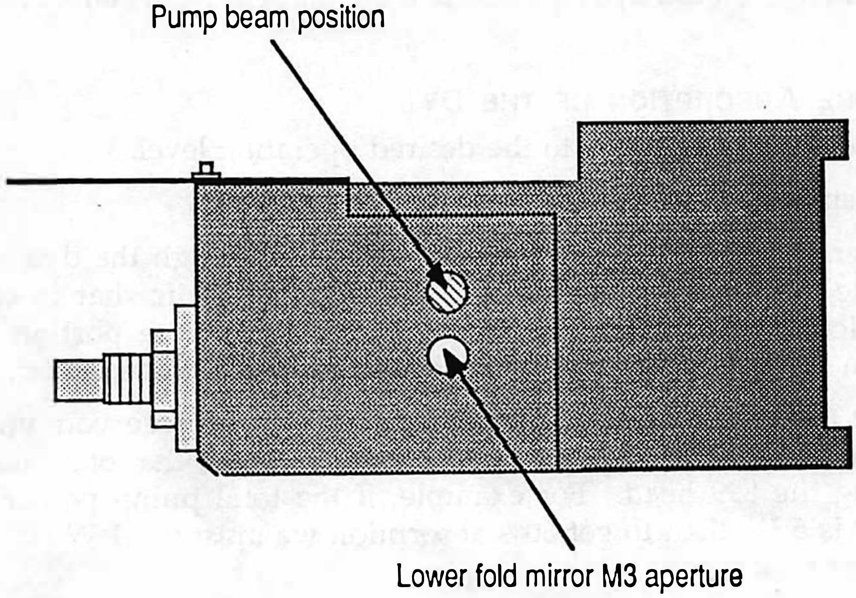


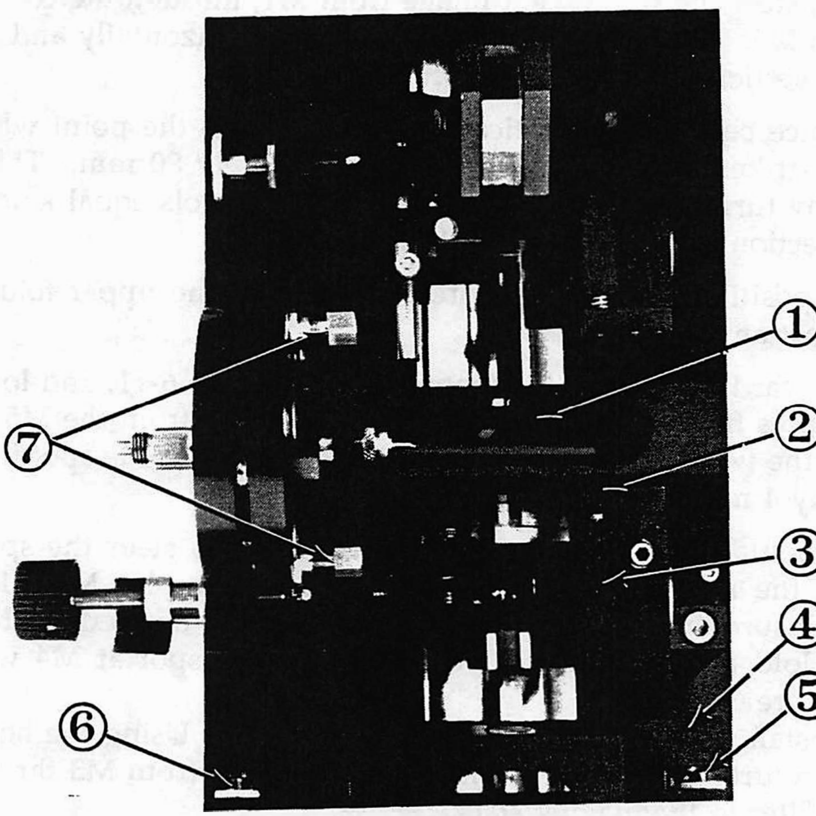
Figure 6-7. Position of Pump Beam on M3 Aperture

INITIAL PUMP FOCUS ADJUSTMENT

1 Raise the pump beam power to the proper operating level. Observe the pump beam spot transmitted through the dye jet stream to the pump beam stop. Adjust the pump focus P1 by turning the cap screw on the pump focus stage shown in Figure 6-8, so the transmitted pump spot begins to distort. (The image will vary with pump laser power and wavelength as well as with dye type, concentration and nozzle pressure.)

2 Ensure the pump beam is still centered on the dye jet stream. If not, use the vertical pump control to obtain this.

3 Clean all dye cavity optics, including the rhombs.



1 Neutral density filter cover removed
2 Pump focus cap screw
3 Pump focus stage
4 M1 tilt plate
5 M1 pivot (M1 vertical tilt adjust located below pivot)
6 M1 horizontal tilt adjust
7 Jet pointing adjustment screws

Figure 6-8. Pump Mirror P1 Focus Stage, M1 Tilt Plate Adjustments

ALIGNMENT OF SPOTS IN THE CAVITY

To perform this procedure in infrared dyes, an infrared viewer may be needed to locate the fluorescent spots.

1 Place a white card in front of the upper fold mirror M5 and locate the spot from M1. (The spot will not necessarily be round.)

2 Using the horizontal and vertical adjustments on the M1 tilt plate shown in Figure 6-8, steer the fluorescent image from M1, through the compensating rhomb to M5. The image should be centered horizontally and slightly above center vertically on M5 as shown in Figure 6-9.

3 Set the distance between the optical surface of M1 to the point where the pump beam strikes the dye stream for approximately 80 mm. This is accomplished by turning the three M1 adjustment controls equal amounts in the same direction which will translate this mirror.

4 Recheck the position of the M1 fluorescent spot on the upper fold mirror M5 and correct any misalignment.

5 Hold a white card in front of the magnet stack, Figure 6-11, and locate the fluorescent spots from the M5 and M3 optics.The spot from the M5 optic is the larger of the two. Adjust the M5 focus, Figure 6-6, so the spot from it is approximately 4 mm in width.

6 Use the horizontal and vertical adjustments of M5 to steer the spot from M5 through the magnet assembly to the output coupler M4. Refer to Figure 6-4. Ensure the spot is centered in the aperture defined by the diode assembly. Hold a white card in front of M4. The spot at M4 will look similar to Figure 6-10.

7 Clean and install the birefringent filter (Figure 6-11). Using the horizontal and vertical controls of M3, steer the fluorescent spot from M3 through the birefringent filter to the magnet stack.

8 Hold a white card in front of the magnet stack (Figure 6-11) and adjust the M3 focus, Figure 6-6, so the spot from M3 is approximately 2.5-3.0 mm in diameter. As the card is moved toward the dye jet, the fluorescent spot should not change size significantly. If a focal point is found inside the dye laser cavity, the M3 optic is too far from the dye jet and should be moved forward until the image is collimated.

9 Using the horizontal and vertical controls of M3, Figure 6-6, steer the spot from M3 through the magnet stack to the output coupler M4 as shown in Figure 6-4. Center the M3 spot on the image from M5 as shown in Figure 6-12.

10 Hold a white card against the M5 optic and rock the output coupler M4 mount with the lever arm shown in Figure 6-4. Locate the return reflection from the M4 optic onto the card. Use the horizontal and vertical knobs of M4, Figure 6-5, to place the reflection into a vertical line just above the image from M1 as shown in Figure 6-13. (Note: This reflection should be a small spot less than 1 mm in diameter. If not then M3 or P1 is improperly focussed.)

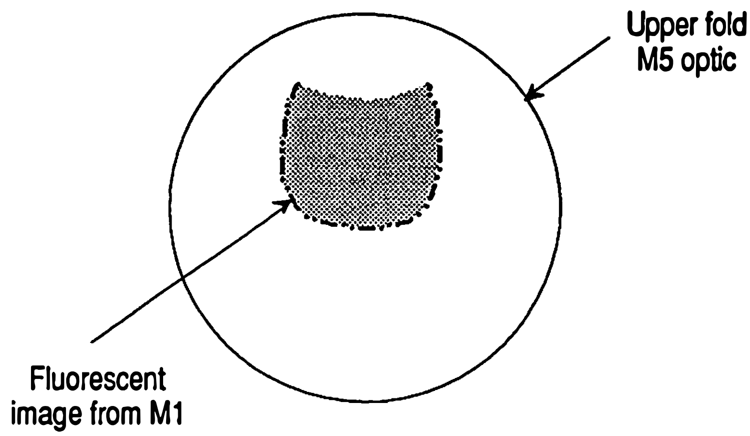


Figure 6-9. Image from M1 on M5

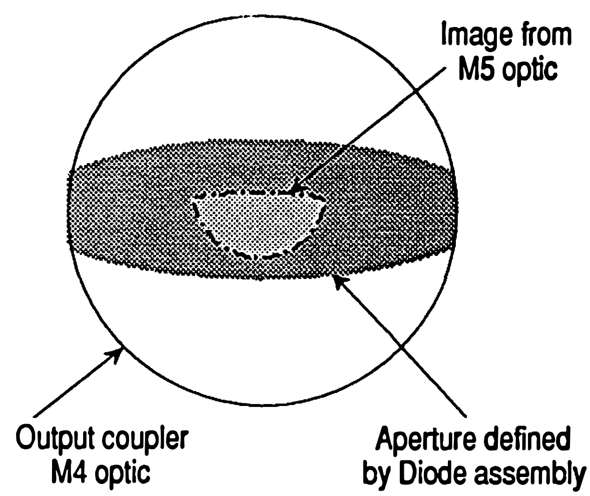
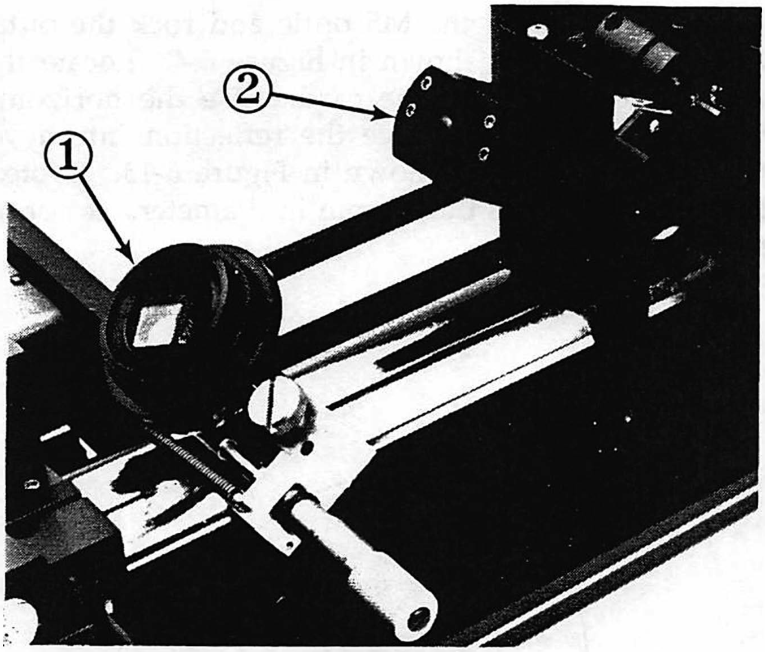


Figure 6-10. Image from M5 on M4



1 Birefringent filter 2 Magnet stack

Figure 6-11. Magnet Stack and Birefringent Filter

ESTABLISHING INITIAL OSCILLATION

1 Place a white card outside the dye laser cavity and observe the transmitted spots through M4. Rock the M4 mount vertically using the lever arm inside the cavity. If oscillation occurs, establish continuous operation with the M4 vertical knob and continue with "Optimizing the Laser Power" below.

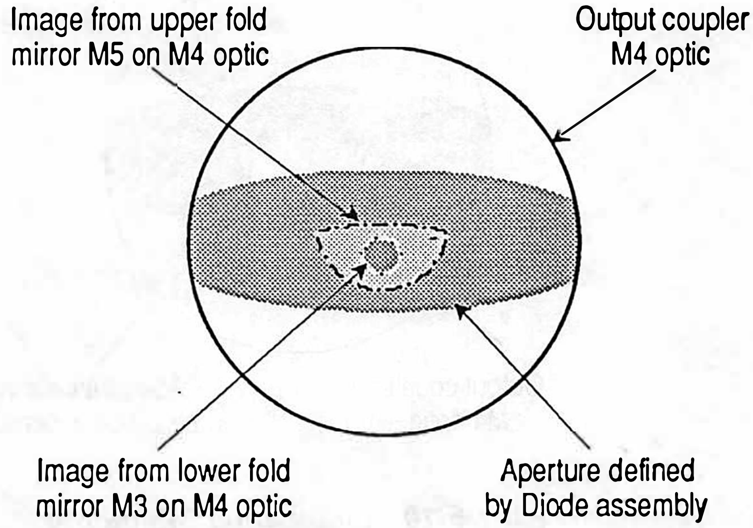


Figure 6-12. Position of M3 Image on M4

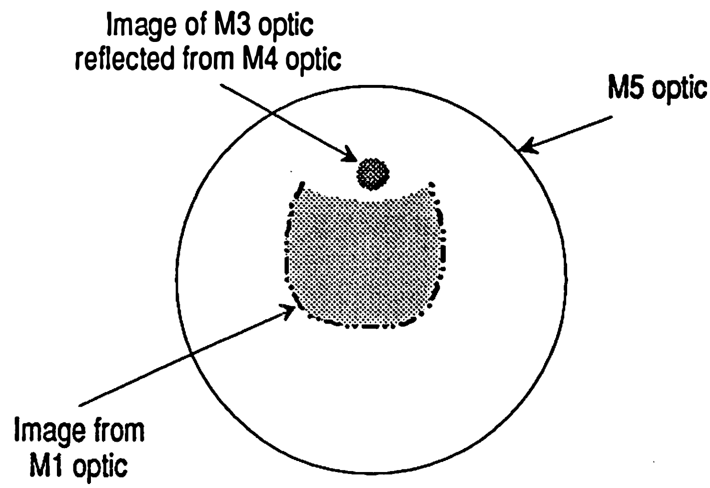


Figure 6-13. Position of M1 Image and M3 Image (via M4) on M5

2 If the system fails to oscillate, view the spots transmitted through M4 while rocking the M4 mount. The spot that moves with M4 should pass through the stationary upper spot. If not, use the M4 horizontal adjustment control while rocking vertically to correct the position. If system oscillates, use the M4 vertical control to establish continuous operation and continue with "Optimizing the Laser Power" below.

3 If the system fails to oscillate, scan the M5 vertical adjustment slowly while rocking M4 vertically. If system oscillates, establish continuous oscillation with the M4 vertical control and continue with "Optimizing the Laser Power" below.

4 If system fails to oscillate, scan the M5 vertical adjustment and rock M4 vertically. As the fluorescent spot that moves with M4 passes through the upper stationary spot, watch for the appearance of a third dim spot in the same area. Using the M5 horizontal control and the M4 Horizontal control, align the stationary spot, the second moving spot and the third dim spot into a vertical line. Rock the M4 mount vertically and scan M5 vertically until the laser flashes. Establish continuous oscillation with the M4 vertical control and continue with "Optimizing the Laser Power" below.

5 If system does not lase, recheck the spot sizes in front of the magnet stack, the pump laser power and dye absorption. Realign spots at M4 and continue with Step 1.

Optimizing the Laser Power

1 Using a power meter (Coherent model 210 or equivalent), peak the laser controls for maximum power in the following order:

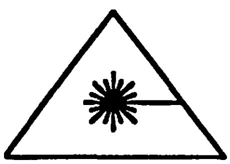
- Output coupler M4 controls
- Upper fold mirror M5 controls

- Lower fold mirror M3 controls
- Pump mirror P1 controls

2 Repeat this sequence until no further power can be obtained.

3 Adjust the focus stages (Pump mirror P1, lower fold M3, and upper fold M5) for maximum power and best mode. When a focus is adjusted, peak all controls for maximum power.

DYE JET STREAM ALIGNMENT



When performing this procedure, bright fluorescence from the dye jet will be present. It is important that you wear safety glasses which protect against wavelengths emitted by the particular dye used.

1 Remove the neutral density filter cover, Figure 6-14, by removing the two screws securing it.

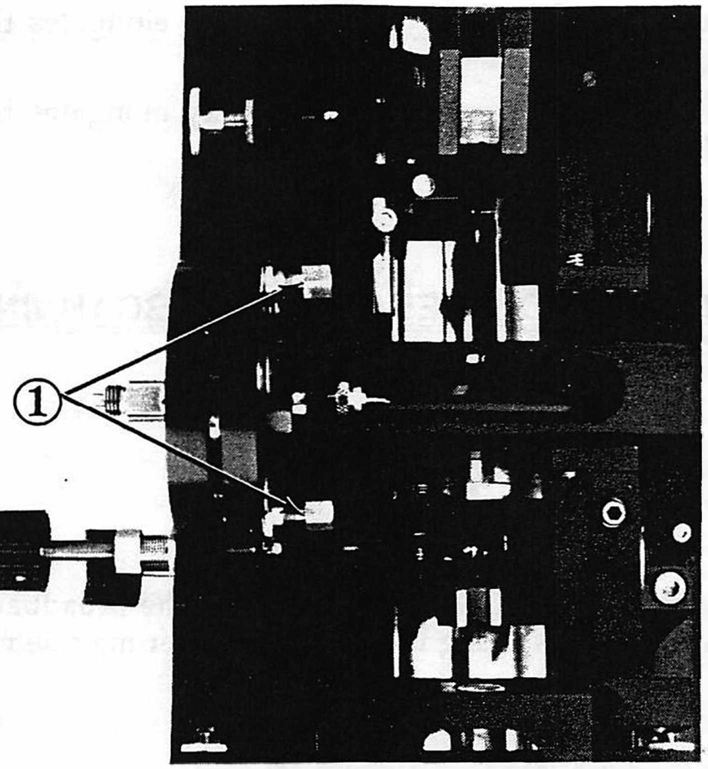
2 Remove the magnet assembly, Figure 6-4, and view the spots reflected from the jet onto the ceiling. If the two spots appear separated, bring them together with the jet pointing adjustment shown in Figure 6-8. An interference pattern will appear when the spots overlap. Re-peak the laser using the pump control knobs.

3 Replace the magnet assembly and peak the laser for maximum power.

FINE ALIGNMENT OF LASER FOR BEST MODE

With the dye laser peaked for power, expand the output beam and project it on the wall or ceiling. Observe the mode structure and power distribution. Use the following examples as a guide for improving discrepancies in the mode structure:

- If mode is diffuse, vertically elongated and power is low, but stable, P1 is too far from the jet. Pull in the pump focus.
- If mode is diffuse, elongated, the power is low and unstable and there is a bright reflection from the top surface of the compensation rhomb, then the rhomb is not at Brewster's angle. Use the alignment tent to set up Brewster's angle for the rhomb.
- If mode has a hot center, good power; stable or unstable, but it is a "D" shaped mode, then P1 is too close to the jet. Back the pump focus off.
- If mode is diffuse with good power, but unstable and possibly horizontally elongated, then M3 or M5 is too close to the jet.



1 Jet pointing screws

Figure 6-14. Jet pointing screws

- If mode has a hot center, but vertical elongation and a "star" shape with unstable power, then M3 or M5 is too far from the jet.
- If mode shape is TEM_{01}, then pump source is also TEM_{01} or dye laser cavity optics are not fully peaked for power. There could also be a contaminated or absorbing optic.
- If mode is TEM_{00} and stable, then this is the optimal mode structure.

  The mode structures shown are to serve as guidelines to fine align your 899 system. The general, various mode configurations can result from a combination of focal misalignments. A list of general rules follows for optimizing the ring laser.

General Rules

- Always peak the laser for power before observing the mode structure.
- When an adjustment is made in the position of an optic, always optimize the laser power with the same optic before adjusting any others.
- Moving P1 towards the jet increases power and flattens the mode.
- Moving P1 away from the jet reduces power and vertically elongates the mode.

- Moving M3 or M5 towards the jet horizontally elongates the mode and increases the beam diameter.
- Moving M3 or M5 away from the jet vertically elongates the mode and decreases the beam diameter.

SETTING UP THE 899 TO OPERATE AS A SCANNING SINGLE FREQUENCY LASER.

These procedures assume that the 899 is optimized in the broadband configuration. Note: If an infrared dye is being used, an IR viewer may be needed to perform this procedure.

CONNECTING THE CONTROL BOX

1 The wiring harness which carries all the control signals for the 899 is located near the front of the laser head. There are two plugs at the end of the wiring harness. These connect to the back of the control box. Connect the smaller plug to the "light power sense" connector and the larger plug to the "dye laser drive" connector. Plug the control box into an outlet and ensure it is turned off (The red power button is not lit and the analog light power display is sitting at zero).

INSERTING THE INTRACAVITY ASSEMBLY (ICA)

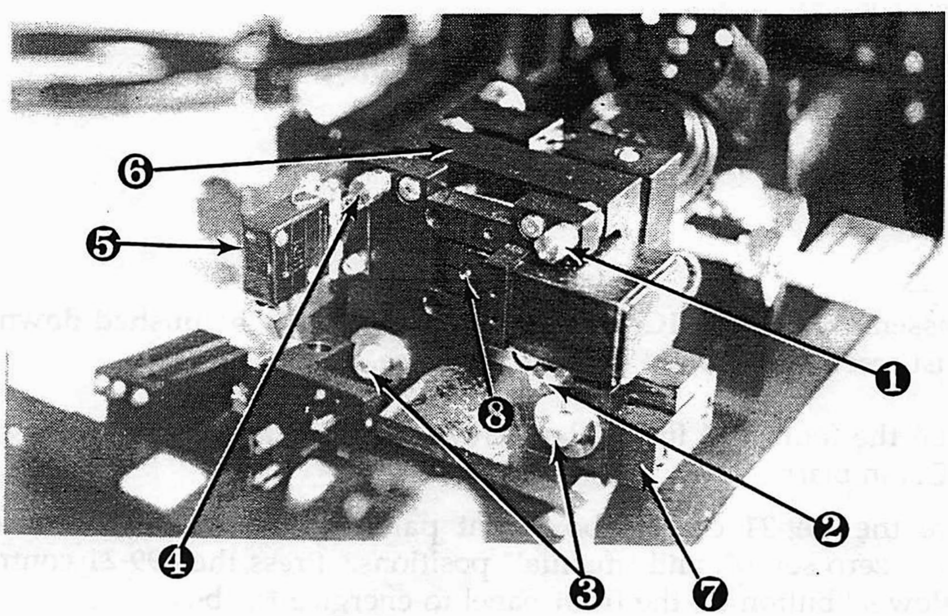
Whenever the ICA is not mounted in the 899 cavity, tape should be placed over the openings at both ends of the ICA. This will prevent contamination of the thick and thin etalon.

1 The ICA, Figure 6-15, mounts to the cradle assembly which is in turn connected to the Invar bar. The thick etalon faces the output coupler when the ICA is installed as shown in Figure 6-16. Two pins protrude up from the cradle assembly to guide the ICA into place. Three 9/64 inch Allen head screws shown in Figure 6-16, secure the ICA to the cradle assembly.

Install the ICA and tighten the three 9/64 inch screws to secure the ICA in place.

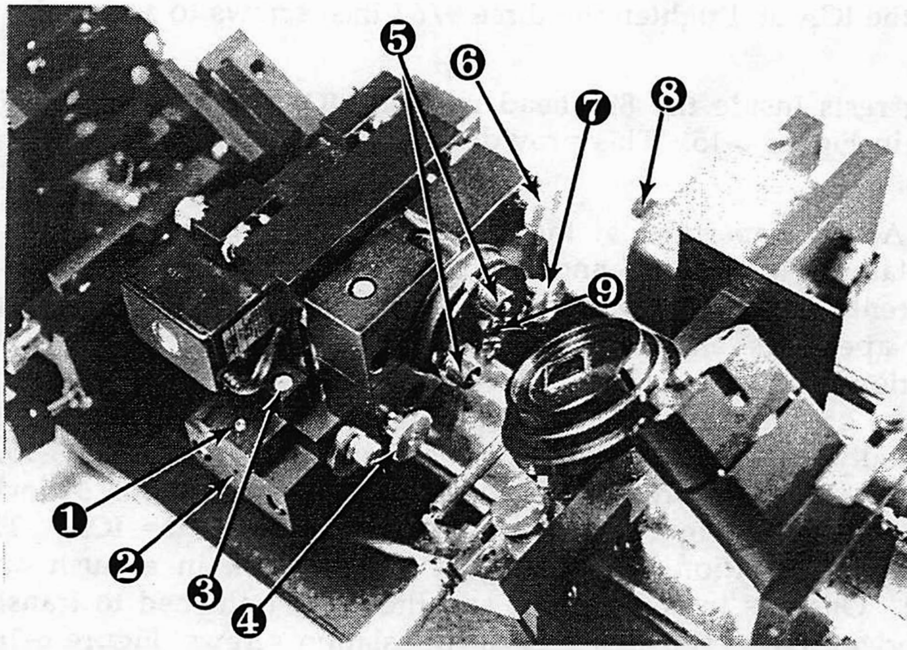
2 A plug rests inside the 899 head near the ICA. Connect it to the ICA shown in Figure 6-15. This provides drive voltages to the thin and thick etalons.

3 The ICA input aperture, at the thin etalon, and output aperture, at the thick etalon, Figures 6-15 and 6-16, need to be roughly centered on the fluorescent images passing through them. Hold a piece of tissue paper up to the apertures and check for the fluorescence position. Use the translation screws described below to center the ICA input and output apertures on the fluorescence images. To move the ICA vertically and horizontally the four 3/16 inch Allen screws shown in Figure 6-15, which lock the cradle assembly in place, must be loosened. Four 5/64 inch Allen screws, shown in Figure 6-16, are used to translate the ICA. The two horizontal translation screws, Figure 6-16, work in a push and pull fashion. One has to be loosened and the other tightened to translate the ICA horizontally. The two vertical translation screws, Figure 6-16, must both be turned clockwise to raise the ICA and counterclockwise to lower the ICA.



1 Thin etalon pivot control
2 Thin etalon vertical control
3 3/16 inch Allen head screws securing the ICA cradle
4 Thin etalon horizontal control
5 ICA plug
6 ICA assembly
7 Cradle assembly
8 ICA input aperture at the thin etalon

Figure 6-15. ICA And Thin Etalon Controls



1 ICA vertical translation screw (one on other side)
2 ICA horizontal translation screw (one on other side)
3 Screw securing ICA assembly (two on other side)
4 Thick etalon horizontal control
5 Thick etalon horizontal and vertical tilt adjusts (used for power optimization
6 Thick etalon vertical control
7 Thick etalon pivot control
8 Screw securing detector block
9 ICA output aperture at the thick etalon

Figure 6-16. ICA And Thick Etalon Controls

The cradle assembly that the ICA mounts to, may have to be pushed down if the vertical adjust screws are turned counterclockwise.

4 Tighten the four 3/16 inch Allen screws down to lock the cradle assembly and ICA in place.

5 Ensure the 899-21 control box front panel knobs are in the "reference cavity", "zero servo", and "manual" positions. Press the 899-21 control box red "Power" button on the front panel to energize the box.

FLASHING AND WALKING OFF THE THIN AND THICK ETALON

1 With the ICA in place, there will be three sets of reflections off of the BRF that can be seen on the ceiling. They are the laser cavity, thick etalon and thin etalon reflections. If the system is lasing, the cavity reflections will be bright spots. The other nearby reflections which are from the thick and thin etalon, will be much dimmer than the cavity reflections. If the system is not lasing then the cavity reflections on the ceiling will be dim.

2 Rotate the thin etalon offset knob (Figure 6-17, item 4) on the front panel of the control box and locate the reflections on the ceiling that are moving. These are the thin etalon reflections. Rotate the thin etalon offset knob to move these reflections away from the laser cavity reflections.

3 Use the thick etalon horizontal and vertical controls, Figure 6-16, to steer the thick etalon reflections viewed on the ceiling so they overlap the cavity reflections. When this is accomplished, the thick etalon is at flash(e.g.-it is at normal incidence to the cavity beam). The system should be lasing at this point. If not, continue with step 4 below. Peak the output coupler M4, upper fold mirror M5 and lower fold mirror M3 horizontal and vertical tilt adjusts for maximum output power. If the thick etalon is at flash,the system will be lasing bi-directionally and the cavity and thick etalon reflections on the ceiling will be bright. Adjust the thick etalon horizontal control to "walk off" the thick etalon reflections on the ceiling approximately three cavity reflection diameters away. The system will lase unidirectionally and the output power should approximately double in value.

If the system stops lasing when the thick etalon is walked off, the thick etalon horizontal and vertical tilt adjustments near the thick etalon, Figure 6-16, may be out of alignment. Walk off the thick etalon until the system power drops in half. Now rotate these two knobs to peak the output power. Continue this until the thick etalon can be walked off the amount mentioned above.

4 Rotate the thin etalon offset knob on the front panel of the control box to locate the thin etalon reflections on the ceiling. Now rotate this knob completely counterclockwise. Adjust the thin etalon horizontal and vertical controls, Figure 6-15, to steer the thin etalon reflections onto the cavity reflections. (When the output power drops in half then the thin etalon is at flash). If the system still will not lase, continue with step 5. If the system is lasing, peak the output coupler M4, upper fold mirror M5 and lower fold mirror M3 horizontal and vertical tilt adjusts for maximum output power, which will be approximately half that before the thin etalon was flashed. Now rotate the thin etalon offset knob clockwise for maximum power

Power should approximately double when the thin etalon is taken out of flash. Continue with "Installing the Scanning Brewster Galvo" below.

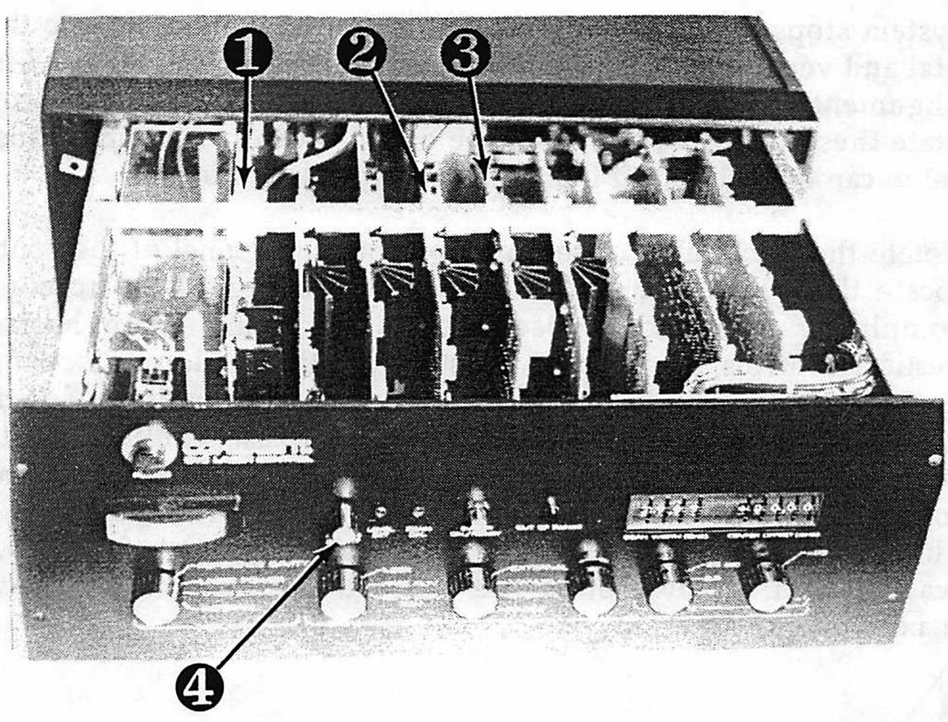
5 Recheck the cavity fluorescent image position through the ICA and ensure it is not clipped.

6 Make small adjustments on the lower fold mirror M3 vertical and horizontal tilt adjusts which will usually initiate laser oscillation. If the system lases, continue with step 8, otherwise perform step 7.

7 Turn the output coupler M4 vertical tilt adjust, Figure 6-5, 1/2 turn counterclockwise. Rock the M4 mount using the lever arm shown in Figure 6-4, while slowly moving the upper fold mirror M5 vertical tilt adjust. Watch for laser oscillation. If the laser flashes, turn the M4 vertical tilt adjust clockwise until continuous oscillation occurs. Continue with step 8. If the system still will not lase, remove the ICA and establish broadband operation. Once this is done repeat the ICA installation procedure.

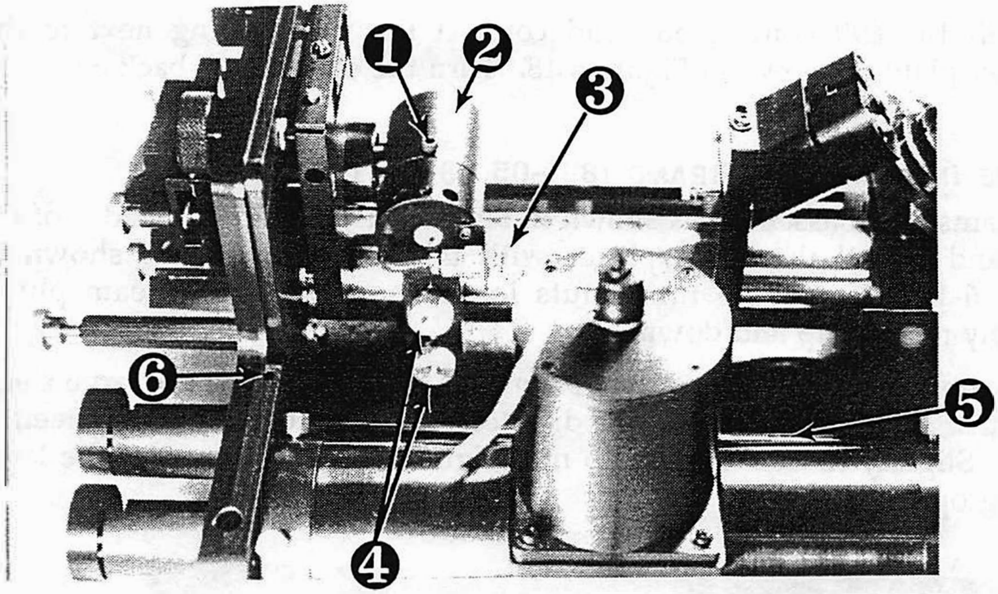
8 If the system is now lasing, peak the M5, M3 and M4 mirrors for maximum output power. Rotate the thin etalon offset knob clockwise to bring it out of flash. Adjust the thick etalon horizontal control, Figure 6-16, to "walk off" the thick etalon reflection three cavity reflection diameters. The system should now be lasing unidirectionally. Peak the M5, M3 and M4 mirror horizontal and vertical tilt adjusts for maximum power.

Typical conversion performance for the 899 ICA is 60-70% of the broadband power, but this will vary slightly between systems.



1 1A1 PCB (for thick etalon feed forward
2 1A4 PCB (for Brewster plate feed forward
3 1A1 PCB (for thin etalon feed forward
4 Thin etalon offset knob

Figure 6-17. Control Box Printed Circuit Boards



1	Screw securing Brewster plate cover	4	Thumbnuts securing Brewster plate
2	Brewster plate cover	5	Draft tube for normalizing beam
3	Brewster plate plug	6	Setscrew securing draft tube

Figure 6-18. Brewster Plate and Draft Tube

INSTALLATION OF SCANNING BREWSTER PLATE (899-05, 899-21)

If the system is being run in an IR dye, an IR viewer may be needed to perform the following procedures.

1 Loosen the 9/64 inch Allen screw shown in Figure 6-18 to remove the Brewster plate dust cover.

2 Clean both sides of the Brewster plate with methanol and then acetone.

3 Loosen the two thumb nuts on the Brewster plate mounting bracket shown in Figure 6-18 and slide the Brewster plate into a vertical position such that the laser oscillates through the plate. Tighten the two thumbnuts.

4 Optimize the output power by adjusting the upper fold M5, lower fold M3 and output coupler M4 horizontal and vertical tilt adjusts.

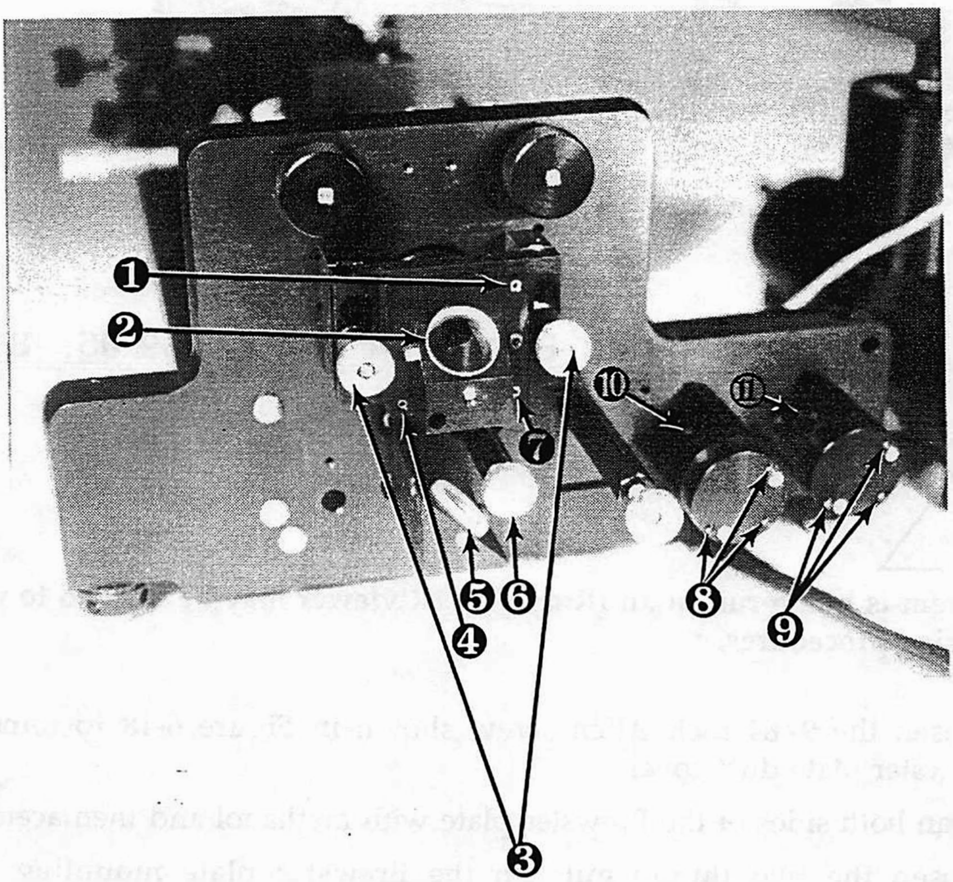
5 Slightly loosen the thumbscrews and make a small vertical adjustment of the Brewster plate to center the beams through the Brewster plate. Repeat step 4.

6 Turn off the 899 control box and connect the plug sitting next to the Brewster plate as shown in Figure 6-18. Turn the control box back on.

ALIGNING THE INFORMATION BEAMS (899-05, 899-21)

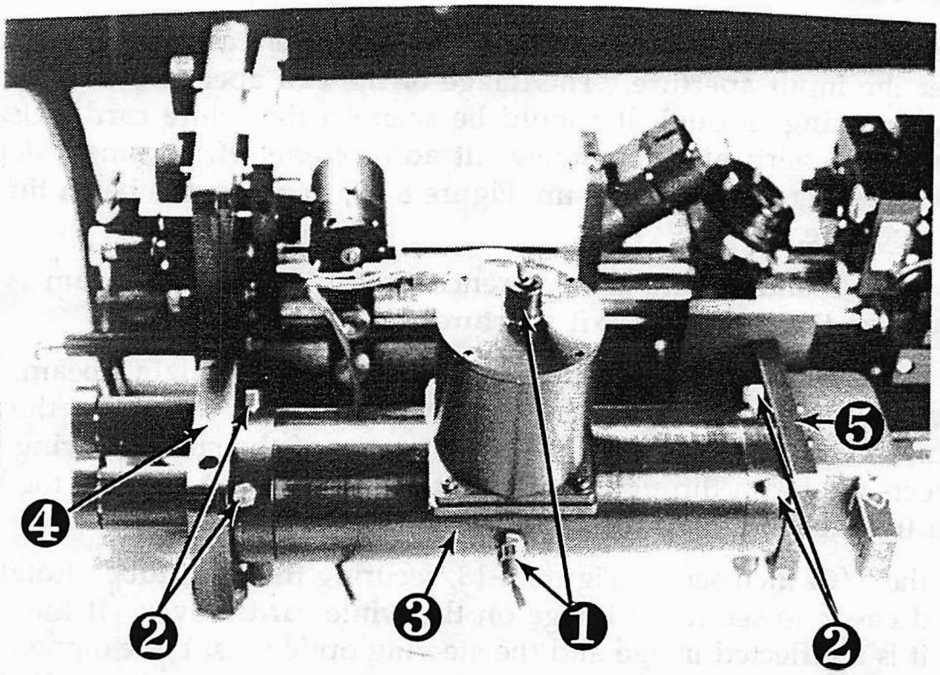
1 The beamsplitter assembly is shown in Figure 6-19. Clean both sides of the optic and install the beamsplitter with the two thumb nuts shown in Figure 6-19. Leave the thumbnuts loose enough for the beamsplitter assembly to slide up and down.

2 Two beams will be sent downward from the beamsplitter to the large steering optic. The two beams will be directed sideways to the smaller steering optics. Slightly loosen the thumb nut, Figure 6-19, that secures the large steering optic.



1 Beamsplitter vertical tilt adjust
2 Beamsplitter optic
3 Thumbnuts (2) securing the beamsplitter assembly
4 Beamsplitter horizontal tilt adjust
5 Large steering optic
6 Thumbnut securing large steering optic
7 Beamsplitter pivot tilt adjust
8 Horizontal, vertical and pivot tilt adjusts for small steering optic (used to steer the normalizing beam)
9 Horizontal, vertical and pivot tilt adjusts for small steering optic (used to steer reference cavity beam)
10 Input aperture for the normalizing beam
11 Input aperture for the reference cavity beam

Figure 6-19. Beamsplitter and Steering Optic Controls



1 Reference cavity plugs
2 Reference cavity adjustment controls
3 Reference cavity assembly
4 Front plate with input apertures for normalizing and reference cavity beams
5 Rear plate with exit apertures for normalizing and reference cavity beams

Figure 6-20. Reference Cavity Controls

3 Adjust the beamsplitter assembly vertically and the large steering optic assembly horizontally to position the two beams near the center of the two small steering optics. Tighten the thumb screws for the beamsplitter and large steering optic assembly.

4 Remove the detector block by unscrewing the black knurled knob as shown in Figure 6-16.

5 If the reference cavity, Figure 6-20, is in place, turn off the control box and remove it from the laser head by disconnecting the two plugs Figure 6-20, connected to it and lifting the assembly out.

6 There are two apertures for the reference cavity beam and their location is shown in Figure 6-20. Place a white card in front of the exit aperture. A beam should be seen on the card. If it isn't, use the beamsplitter horizontal and vertical Allen screw tilt adjusts, figure 6-19, to steer the beam through the input aperture to the white card.

7 Hold a piece of lens tissue between the small steering optics. The image of the input aperture in relation to the beam passing through it should be seen on the white card. Use the beamsplitter horizontal and vertical Allen screw tilt adjustments, Figure 6-19, to center the beam through the input aperture.

8 Place the white card after the exit aperture. Now hold a piece of lens tissue just after the input aperture. The image of the exit aperture in relation to the beam passing through it should be seen on the white card. Use the horizontal and vertical Allen screw tilt adjustments of the small steering optic for the reference cavity beam, Figure 6-19, to center the beam through the exit aperture.

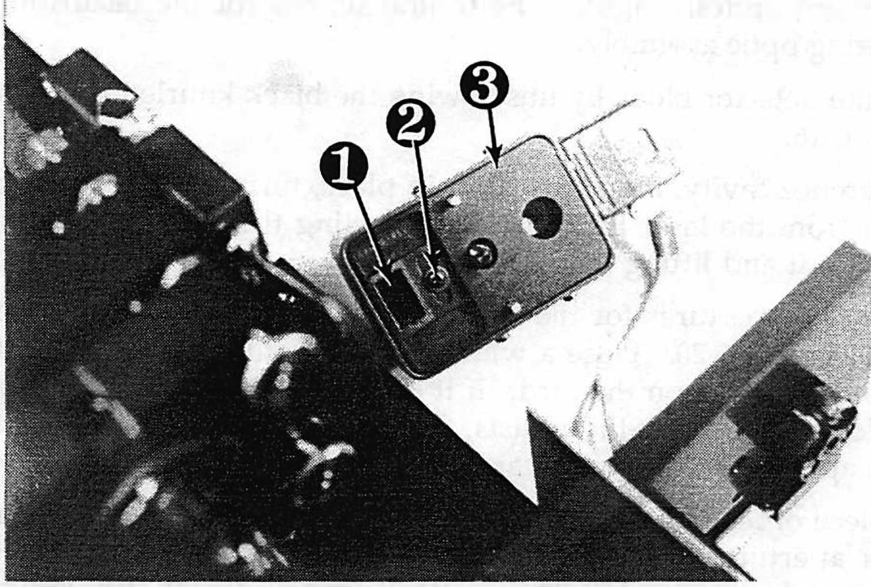
9 Repeat steps 7 and 8 until the reference cavity information beam is centered through the input and exit apertures.

10 Hold a white card after the exit aperture of the normalizing beam. The beam travels through a draft tube as shown in Figure 6-18. Use the horizontal and vertical Allen screw tilt adjustments of the small steering optic that directs the beam through the draft tube, Figure 6-19, to steer the beam through the tube and onto the white card.

11 Loosen the 5/64 inch screw, Figure 6-18, securing the draft tube. Rotate the tube and check to see if the image on the white card moves. If the image moves, it is a reflected image and the steering optic must be realigned. Use the horizontal and vertical of this steering optic to cleanly direct the beam through the draft tube. Tighten the retaining screw down.

Reference Cavity Assembly (RCA) Installation and Alignment

1 Gently lower the reference cavity into position with the heater connector (on the side of the unit) facing away from the laser as shown in Figure 6-20.



1 Attenuator
2 Screw securing attenuator
3 Detector block assembly

Figure 6-21. Detector Block

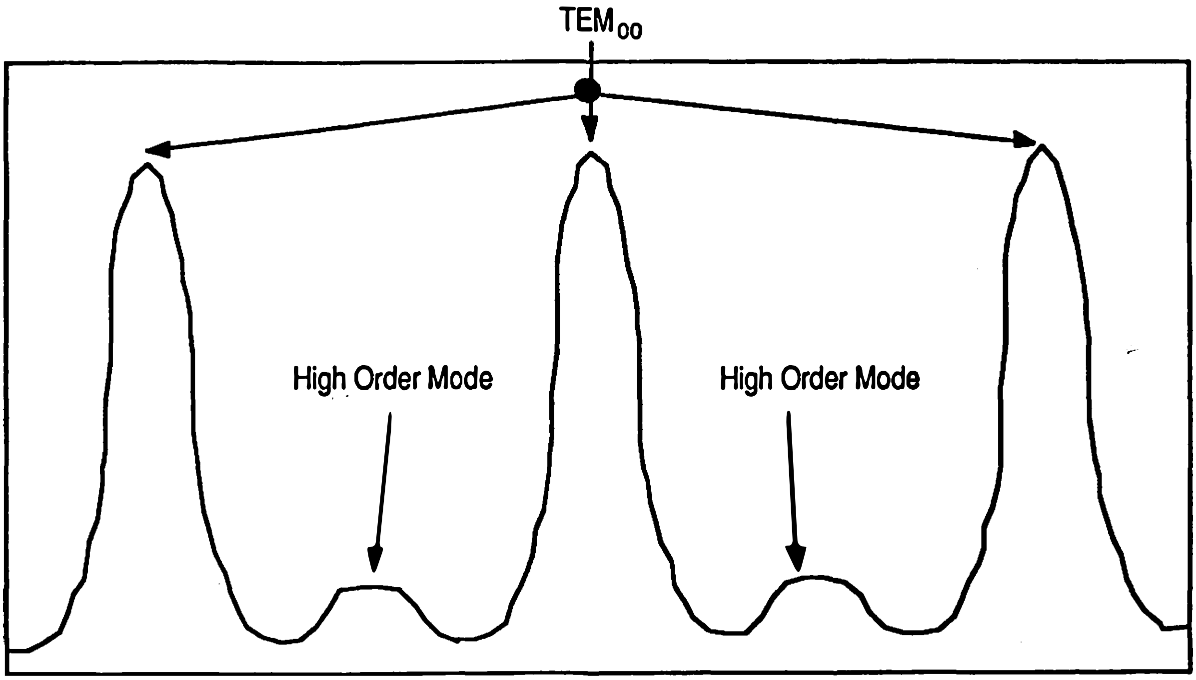


Figure 6-22. Reference Cavity Fringes

2 Turn off the 899-21 control box. Attach the reference cavity galvo drive and heater plugs, Figure 6-20 and turn the control box on. Ensure that the control box knob settings are at "reference cavity", "zero servo" and "manual".

3 With the reference cavity in place, hold a white card 15 cm from the exit aperture of the reference cavity. Two spots should be seen.

4 Using the four adjustment controls on the RCA, Figure 6-20, position the RCA such that the two transmitted spots are clear and sharp.

5 Continue adjusting the four controls until the RCA is on axis with respect to the beam passing through it. This will be the case when the two spots are completely overlapped. Move the white card 30 cm away from the exit aperture and ensure the spots are still overlapped.

6 Connect the detector block as shown in Figure 6-16.

7 Connect an oscilloscope with X-Y capabilities to the control box back panel as follows:

-Horizontal output display BNC from control box to the x channel of the oscilloscope.

-Vertical output display BNC from the control box to the y channel of the oscilloscope.

8 Set the control knobs to the following settings:

-Display knob to "reference cavity"

-Operating mode knob to "zero servo"

-Scan control knob to "internal"

-Scan speed knob to ".25 sec"

-Multiplier knob to "1"

9 Set the oscilloscope to X-Y mode and ground the vertical channel.

10 Adjust the horizontal or X channel gain of the oscilloscope for a full scale sweep. If the sweep is not full scale. Adjust the trim pot on the back of the control box located just above the horizontal display BNC for a full scale sweep.

11 Set the oscilloscope vertical or Y channel gain for 2.0 Volts/Division and DC coupled.

12 The reference cavity fringes should now be seen on the oscilloscope. There will be approximately 5 peaks. Use the four adjustment controls of the RCA to minimize every other fringe as shown in Figure 6-22.

13 Once this is done, adjust the 5/64" vertical tilt adjust of the reference cavity small steering optic, Figure 6-19, to cause all the fringes to be of equal amplitude.

Reference Level Set

1 Insert a white card between the two small steering optics. This will block the signal to the reference cavity.

2 The signal on the oscilloscope should be approximately -5 Volts DC.

If this level fluctuates, the light level to the normalizing detector may be too low. It may be necessary to use a coated beamsplitter or there may be a misalignment of the normalizing beam.

3 Remove the white card and observe the reference cavity fringes on the oscilloscope.

4 Use the scan cal trim pot on the front of the 899 control box to adjust the drive voltage to the reference cavity such that the fringes of the reference cavity on the oscilloscope are two divisions apart on a ten division scope.

5 Use the level set trim pot on the front of the 899 control box to adjust the level of the fringes for +5 volts DC. If the trim pot runs out of travel, re-center the trim pot and remove the detector block by loosening the black knurled knob securing it as shown in Figure 6-16. Loosen the attenuator

,Figure 6-21, by using a small Phillips head screwdriver and move the attenuator a small amount. Tighten the Phillips head screw down and connect the detector block. Check the level of the fringes. Repeat this procedure until the reference cavity fringes have a +5 volt DC amplitude.

SETTING THE FEED FORWARDS FOR LOCKING AND SCANNING UP TO 30 GHZ

The feed forward signals are drive signals fed to the thick etalon, the thin etalon and the scanning Brewster plate to help maintain locking. These are set up in the factory when the system is tested, but may need slight adjustment.

1 Set the 899 control box knobs to the following settings:

-Display to "Reference cavity"

-Operating mode to "Zero servo"

-Scan control to "Internal"

-Scan time to ".25"

-Scan width to "10.99 GHz"

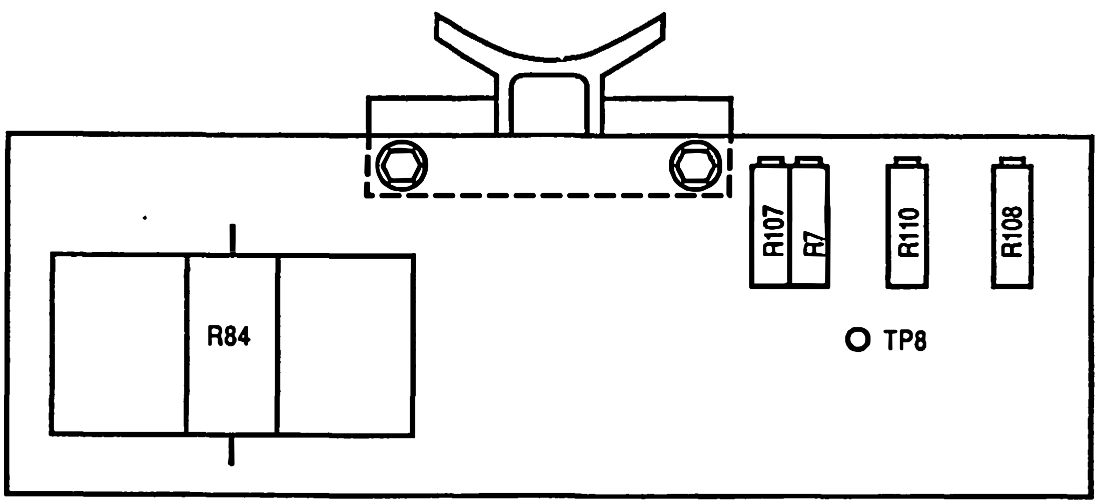


Figure 6-23. Drawing Showing Potentiometer Location on 1A1 Printed Circuit Board(Used For Adjustment of Thick Etalon Feed Forward signal)

Ensure the reference cavity five mode display is smooth and continuous. If it is "breaking up", then excessive noise may be coupling into the cavity. Float the table the laser is on if possible. Ensure the system is staying single frequency by monitoring the output on an optical spectrum analyzer.

2 Set the operating mode control knob on the control box to "Free Run". The oscilloscope display will change. The signal moving across the

oscilloscope should be as flat as possible. This is the reference cavity error signal. If there are peaks in this signal, the scanning Brewster plate feed forward needs adjustment. Remove the four screws securing the control box front panel to the frame. Pull the control box out so the PCBs can be accessed. Locate the 1A4 PCB (e.g., the fourth board from the left), Figure 6-17, and adjust the potentiometer for as flat a signal as possible on the oscilloscope.

3 Set the operating control knob to "Lock" This will close the frequency servo loops. The signal on the oscilloscope should be a flat and continuous line at the ground point which indicates little frequency error. If the signal is breaking up, this indicates the system is mode hopping and the thin etalon may be out of adjustment. Make small adjustments on the thin etalon offset knob, Figure 6-17, to see if the oscilloscope trace can be made continuous. If not, then the thin etalon feed forward signal may need adjustment. Locate the 1A5 PCB (e.g., the fifth board from the left), Figure 6-17, and adjust the potentiometer for a continuous line with no breaks. If this is not possible, set the operating knob to "zero servo" to allow the frequency servos to relax. Now switch the operating knob to "Lock" and adjust the potentiometer on the 1A5 PCB for a smooth, continuous signal.

4 Set the display knob to "Thick Etalon" which displays the thick etalon error signal. This will be a flat line or have a slight oval shape. The two ends of the signal should be level with respect to each other. If not, locate the 1A1 PCB and adjust R107, Figure 6-23, so the signal is level. Set the display knob back to "reference cavity" and the operating mode knob to "zero servo". Increase the scan width 5.00 GHz and repeat steps 2, 3 and 4. Do this until the scan width is 29.99 GHz. This is the maximum scan width possible.