Spectra-Physics

Model 450 Interferometer

Instruction Manual

A/450 5/77

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LIST OF ILLUSTRATIONS

UNITS

System International (SI) units, abbreviations, and prefixes are used in this manual:

Prefixes		
tera	(10^{12})	T
giga	(10^{9})	G
mega	(10^{6})	M
kilo	(10^{3})	k
deci	(10^{-1})	d
centi	(10^{-2})	c
milli	(10^{-3})	m
micro	(10^{-6})	μ
nano	(10^{-9})	n
pico	(10^{-12})	p
femto	(10^{-15})	f
atto	(10^{-18})	a

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

Model 450 Optical Spectrum Analyzer

SECTION ONE—INTRODUCTION

UNPACKING

The Model 450 Spectrum Analyzer was carefully packed for shipment. **If the packing box is damaged, have the shipper's agent present for unpacking.**

The 450 is shipped with the mirrors prealigned and tested at the factory. It is packed with a threaded 50.8 mm (2 inch) mounting ring and adapter cable.

DESCRIPTION

The Spectra-Physics 450 Optical Spectrum Analyzer is a spherical mirror Fabry-Perot interferometer for use in high-resolution optical spectroscopy. Specifically, it is a confocal, mode-degenerate interferometer which does not need to be mode-matched to the incident laser beam. As a result, alignment of the analyzer head to the incident beam is easily accomplished. The 450 interferometer is factory aligned and needs no adjustment during use.

The Model 450 is available with two different free spectral ranges, 2 and 10 GHz. Two overlapping mirror coatings give full coverage to the visible spectrum, from 450 to 550 nm and 550 to 650 nm.

DEFINITION OF TERMS

d = Mirror separation = radius of curvature

λ = Wavelength

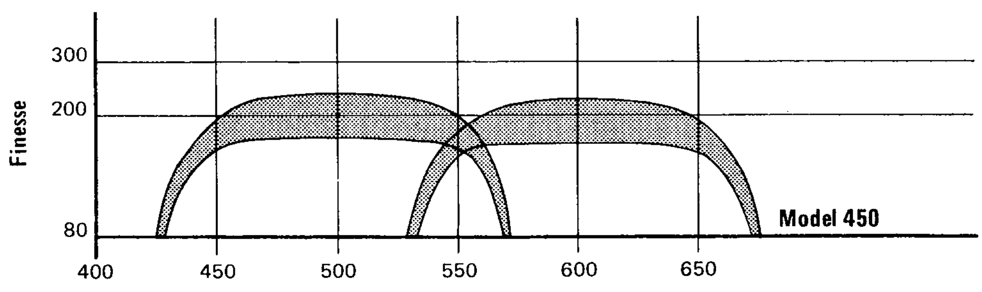
F.S.R. = Free Spectral Range

F = Finesse

c = Speed of light = 2.9979×10^{10} cm/sec

SPECIFICATIONS

Model	Wavelength Range	Free Spectral Range	Bandwidth	Finesse	Aperture
450–01	450–550 nm	2 GHz	10 MHz	200	.75 mm
450–02	450–550 nm	10 GHz	50 MHz	200	.75 mm
450–03	550–650 nm	2 GHz	10 MHz	200	.75 mm
450–04	550–650 nm	10 GHz	50 MHz	200	.75 mm



Model	450–01, –03	450–02, –04
Thermal Stability	200 MHz/°C (.1 FSR/°C)	1.0 GHz/°C (.1 FSR/°C)
Entrance Aperture	.75 mm diameter	.75 mm dia.
Required Wavefront at Entrance Aperture	Plane	Plane
Minimum Beam Diameter at Analyzer Entrance Aperture (Between $1/e^2$ points) to meet above specifications	.05 mm	.1 mm

Figure 1-1 shows a typical scanning confocal interferometer. It consists of two spherical mirrors, separated by a distance equal to their radius of curvature. The back surfaces of the mirrors are made such that the mirrors are self-collimating: that is, a plane wavefront incident on the interferometer will be transformed into a spherical wavefront whose radius of curvature matches that of the transverse modes of the interferometer. The interior concave surfaces of the mirrors are coated with high-reflectance multilayer films, and the external convex surfaces are coated with anti-reflection films to eliminate spurious interferometer resonances involving the back surfaces of the mirrors.

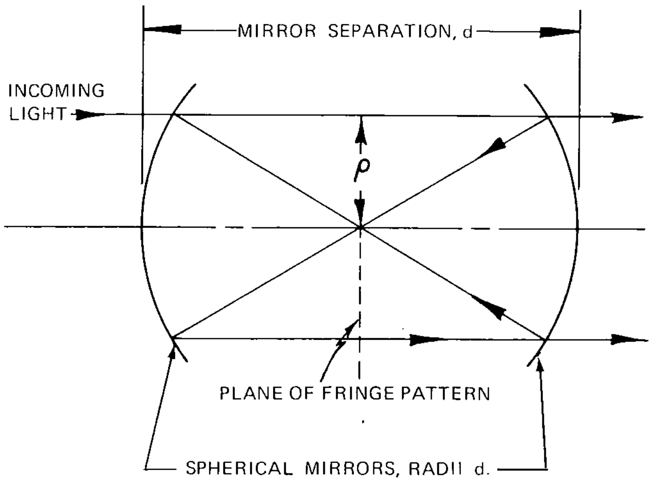


Figure 1-1 Spherical Mirror Fabry-Perot Interferometer

The mirrors are mounted in cells which are separated by a piezoelectric spacer. By applying a potential difference of a few hundred volts to the piezoelectric spacer, the separation of the mirrors can be varied by a few wavelengths of light. In practice, a sawtooth waveform is usually applied to the piezoelectric spacer to vary the separation of the interferometer mirrors linearly as a function of time. For a confocal interferometer, a change in separation of the mirrors of one-fourth wavelength scans the interferometer through one free spectral range.

An aperture is placed outside the entrance mirror to limit the diameter of the incident beam. The upper limit on the aperture size (h) can be determined by using the equation

$$h < \left(\frac{\lambda\, d^3}{F} \right)^{1/4}$$

where d is the mirror separation and F is the finesse of the interferometer. This is necessary to reduce the amount of mode-mismatch caused by any spherical aberration of the mirrors. If the beam entering the interferometer is collimated, no further apertures are required.

The light transmitted by the interferometer is detected by a photocell, and the output signal is recorded on an oscilloscope as a function of the voltage applied to the piezoelectric spacer. The oscilloscope thus displays a signal which is roughly equivalent to the laser mode intensity vs optical frequency.

A number of characteristics of a spherical mirror Fabry-Perot interferometer are conveniently illustrated by the transmission vs frequency curve. (Figure 1-2)

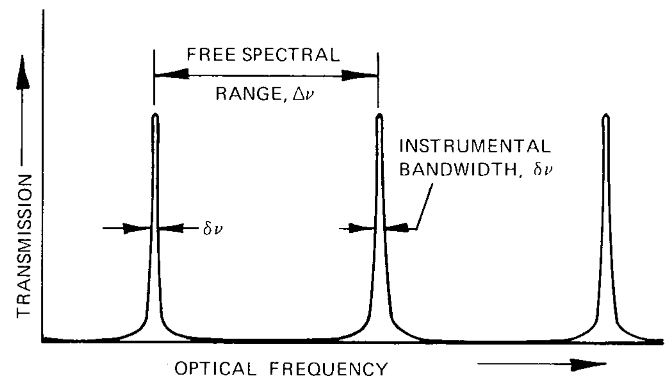


Figure 1-2 Transmission vs. Frequency of a Fabry-Perot Interferometer

FREE SPECTRAL RANGE (F.S.R.)

The FSR of an interferometer is the separation between corresponding transmission maxima of adjacent 'orders'; hence the maximum spectral bandwidth of incoming light which can be observed without overlapping orders (optical frequencies other than those which fall within one free spectral range of the interferometer). Expressions for the free spectral range of a confocal spherical mirror interferometer of spacing d are given below:

$$\Delta\nu = \frac{c}{4d} \text{ (frequency)}$$

$$\Delta\sigma = \frac{1}{4d} \text{ (wave number)}$$

INSTRUMENTAL BANDWIDTH

The apparent or observed spectral width of a true monochromatic spectral line is shown in Figure 1-2 identified as $\delta\nu$.

FINESSE

The finesse of a multiple-beam interferometer may be defined as the ratio of the free spectral range to the instrumental bandwidth. As such, it is a fundamental measure of the spectral resolving capability of the instrument. The finesse may be interpreted as the effective number of beams contributing to the multiple beam interference, and is thus analogous to the number of rulings on a diffraction grating.

$$F = \Delta\nu/\delta\nu = \Delta\sigma \,/\, \delta\sigma$$

The finesse of an instrument is determined by a number of factors, among which are the reflectivity (R) of the mirrors and the surface figure of the mirrors. The reflection-limited finesse approximation is given by:

$$F \approx \frac{\pi}{2\,(1-R)}$$

The surface figure of the mirrors of a spherical-mirror (confocal) interferometer is less important than that of a plane-parallel interferometer because only a small area (typically less than 1 mm^2) of the spherical-mirror interferometer is utilized. The diffraction loss is orders of magnitude lower than that of a plane-parallel Fabry-Perot interferometer and is usually small enough to be negligible. Mirrors which are good to within 1/20 wavelength over their entire area contain small areas having a figure of better than 1/200 wavelength.

SPECTRAL RESOLVING POWER

This is defined as the ratio of the transmitted frequency (or wavelength) to the instrumental bandwidth in frequency (or wavelength) units:

$$RP = \frac{\nu}{\delta\nu} = \frac{\sigma}{\delta\sigma}$$

BIBLIOGRAPHY

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A. L. Bloom, *Properties of Laser Resonators Giving Uniphase WaveFronts,* Spectra-Physics Laser Technical Bulletin No. 2, Mountain View, California (1963).

D. R. Herriott, H. Kogelnik, and R. Kompfner, *Off-Axis Paths in Spherical-Mirror Interferometers,* Appl. Optics 3, 523 (1964).

D. C. Sinclair, *Scanning Spherical-Mirror Interferometers for the Analysis of Laser Mode Structure,* Spectra-Physics Laser Technical Bulletin No. 6, Mountain View, California (1968).

SECTION THREE—OPERATION

INITIAL ALIGNMENT

The threaded adapter ring packed with the Model 450 should be installed in a suitable angular orientation mount, such as the Spectra-Physics Model 381 optical mount. Thread the analyzer head into the adapter ring securely. The five-pin Amphenol plug is designed to mate directly to the adapter cable supplied with the 450. The adapter cable converts the Amphenol plug to two BNC connectors labeled "scan" and "photo det.". The scan connector can be connected to a source of ramp voltage of up to 300 volts, such as the Spectra-Physics Model 476 scanning interferometer driver. The "photo det." connector should be connected to the vertical amplifier (photodetector input) of the Model 476 to take advantage of the built-in blanking circuit.

> WARNING: If the photodetector and scan connectors are inadvertently reversed, the photodetector may be destroyed, necessitating costly repair work.

NOTE: The 5-pin Amphenol plug connects directly to the now obsolete Model 420 oscilloscope plug in.

If the photodetector of the Model 450 is to be monitored directly by an oscilloscope, a load resistor of approximately 1.5 kΩ should be placed across the oscilloscope terminals to convert the current from the photodiode into a voltage. Sensitivity of the photodetector is approximately 600 mV/mW in the red and 100 mV/mW in the blue across the 1.5 kΩ resistor. Polarity of center conductor of photodector cable is positive. The detector will saturate at 100–150 mV. A mulliwatt of incident power is sufficient to operate the Model 450 spectrum analyzer.

> WARNING: To avoid possible damage to the detector, never direct more than 100 mW directly into the analyzer head.

The alignment procedure requires the use of a laser which operates within the operating wavelength range of the interferometer.

Approximately center the laser beam onto the aperture of the spectrum analyzer. Place a flat piece of glass (microscope

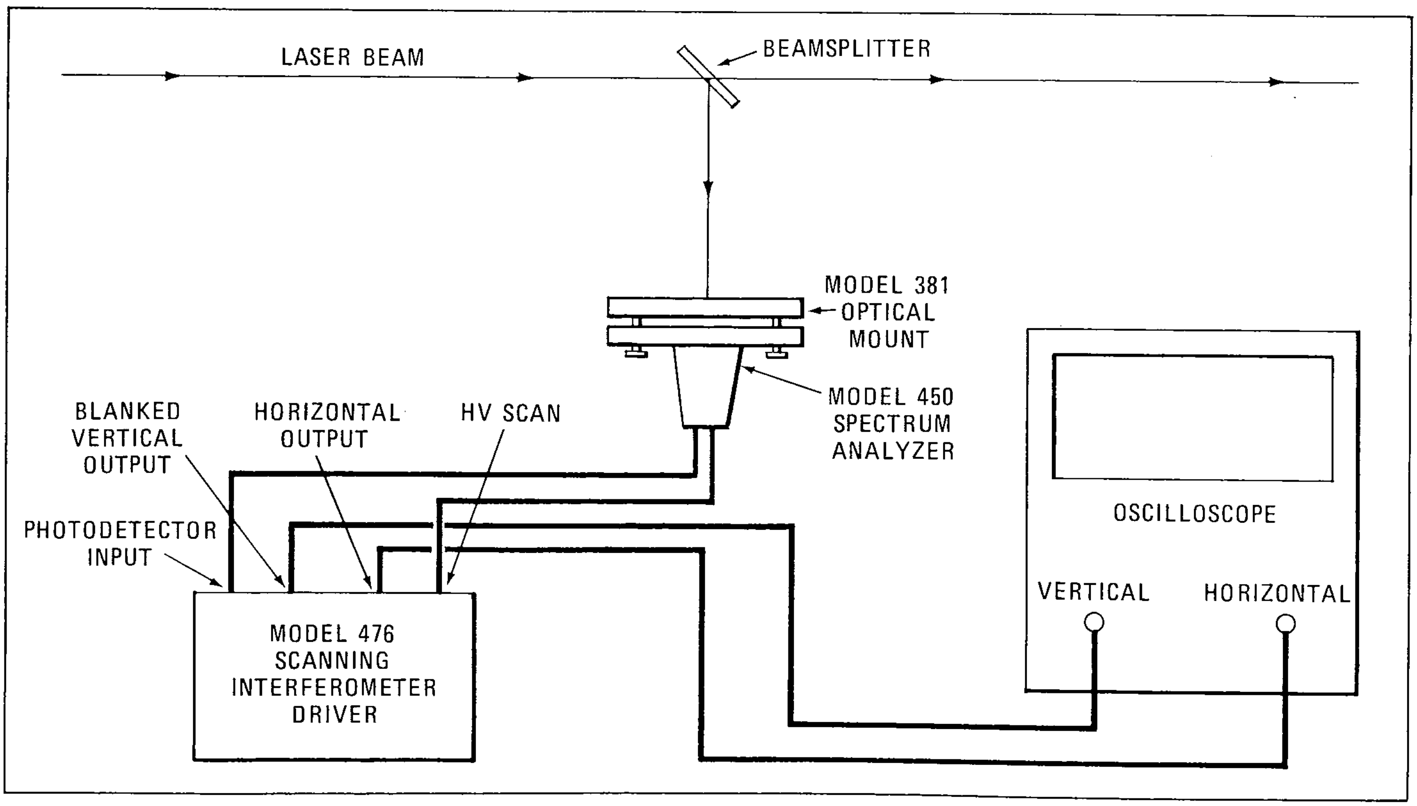

Figure 3-1 Recommended Setup

slide) on the bright annular ring of the adapter, and adjust the optical mount to retroreflect the laser beam back on itself. Check to see that the beam is still well centered. There should be a spectrum displayed on the oscilloscope. If no spectrum is displayed on the oscilloscope, the retroreflection from the analyzer itself should be used for alignment.

Once the initial spectral display is obtained, the alignment of the spectrum analyzer relative to the laser source can be optimized (maximum signal height) by fine adjustments to the optical mount.

> NOTE: The spectrum analyzer aperture should be slightly off-center to prevent the reflected beam from reentering the laser cavity. If it does reenter, it will perturb the laser and cause the amplitude of the various modes to be erratic. In single-frequency dye lasers (Spectra-Physics Model 580 or 580A) this feedback can cause mode hopping.

If the Model 476 scanning interferometer driver is used, the spectral dispersion, position of the displayed spectra, repetition rate, and amplitude of the signal can be varied over a continuous range.

To achieve calibrated operation with the Model 476, the ocsilloscope should be driven by the horizontal output of the Model 476 with the horizontal input set a 1 volt/cm. The horizontal size control on the Model 476 is then used to set the scope display to be just slightly wider than the oscilloscope screen.

The vertical amplifier of the oscilloscope should also be set at 1V/cm and driven by the vertical amplifier output.

DISPERSION CALIBRATION

When using the Model 476, accurate linewidth measurements can be made by using the known free spectral range of the analyzer head.

Model 450 Option	Free Spectral Range	Accuracy
−01 + 03 −02 + 04	106 Hz 26 Hz	± 20 MHz ± 100 MHz

Observe the spectral patterns on the oscilloscope (approximately two free spectral ranges are shown with the variable DISPERSION control set at maximum and the DISPERSION SWITCH set at X1). Adjust the VARIABLE DISPERSION and CENTER FREQUENCY controls to position a specific mode at the first vertical line (left side) on the oscilloscope and its equivalent next order mode at the tenth line (right side). The oscilloscope is now calibrated and the variable dispersion control **MUST NOT** be changed. The display may now be moved to the center of the screen with the centering control and the calibration changed incrementally with the dispersion switch (X1, X2, X5, X10, X20, X50) while maintaining the original calibration.

FINESSE CHECK

With the analyzer head properly aligned and DISPERSION calibration completed as in the previous steps, a finesse check can be made as follows: Adjust the Center Frequency Control to center a transmission peak on the CRT screen. Set the calibrated dispersion control to the X10 position (10 divisions = 0.1 FSR). The full-width at half-maximum should be no more than 0.5 division for a finesse of 200.

$$F = \frac{\text{FSR}}{\text{bandwidth}}$$

$$= \frac{10\text{x}(10 \text{ divisions})}{.5 \text{ divisions}}$$

$$= 200$$

This assumes of course that the laser output beam is a good approximation to a single frequency and is not jittering about in frequency.

SECTION FOUR—APPLICATIONS

The optical spectrum analyzer provides important information on the spectral distribution of a laser output beam. It has the ability to resolve fine structure in the output as well as the entire gain bandwidth of common gas lasers. Care must be exercised when using the Model 450 to spectrum analyze a dye laser since the gain bandwidth of the dye laser is many times the free spectral range of the spectrum analyzer. Laser output beyond a single free spectral range will be displayed on the oscilloscope but will have an unknown frequency relationship to the other laser modes being displayed. To determine the frequency of the modes other than the central mode being observed, a larger free spectral range device must be used. Instruments such as the Model 410 plane parallel interferometer, a reversion spectroscope, or monochrometer are suitable for this measurement.

The following photographs are examples of laser measurements using the Model 450 optical spectrum analyzer and include:

- Observation of the output of single-frequency lasers
- Detection of TEM_{00} laser operation
- Observation of mode-locking effects
- Observation of frequency jitter

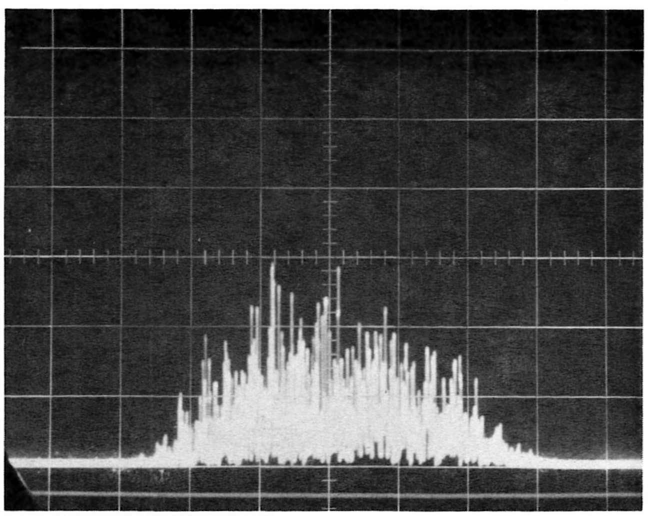

Figure 4-1 Spectra-Physics Model 125A He-Ne Laser, Free Running

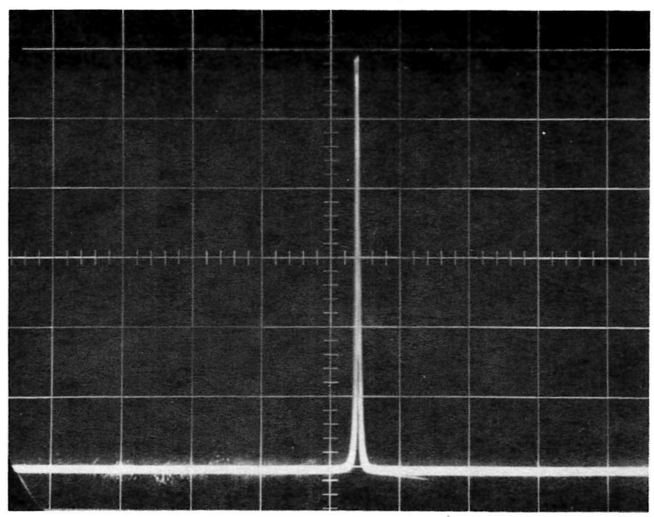

Figure 4-2 Model 125A He-Ne Laser with Model 585 Etalon Installed

MONITORING THE OUTPUT OF SINGLE-FREQUENCY LASERS

Lasers which are supposed to produce single-frequency beams occasionally oscillate at two (or more) frequencies. Such multi-frequency operation is easily detectable using the Model 450 Optical Spectrum Analyzer. Tilt and spacing of etalon may also be adjusted to place the single longitudinal mode at the center of the gain curve while using the Model 450 to monitor performance.

Figures 4-1 and 4-2 were obtained with Model 450-03 Spectrum Analyzer, (2 GHz FSR, 550–650 nm spectral range) driven by a Model 476. Calibration was 200 MHz/Division.

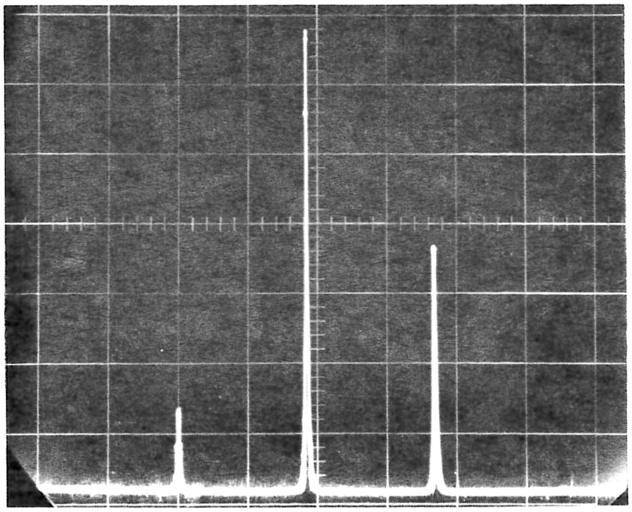

Figure 4-3 Spectra-Physics Model 120 Laser Operating in the TEM_{00} Mode

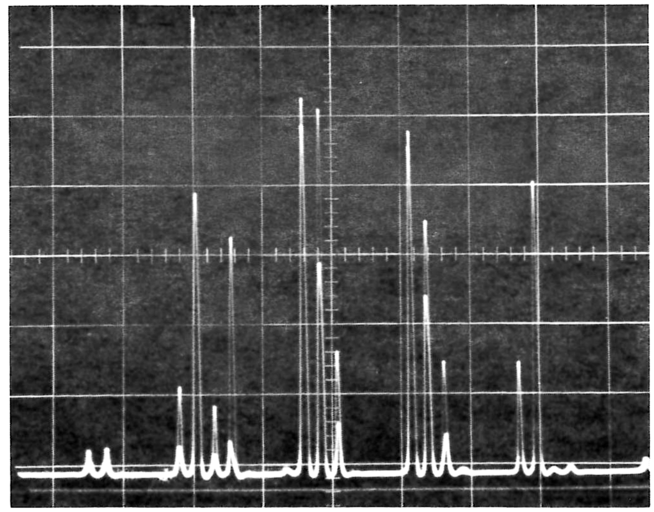

Figure 4-4 Spectra-Physics Model 120 Laser Operating in the TEM_{11} Transverse Mode

DETECTION OF TEM_{00} LASER OPERATION

The adjustment of lasers to produce TEM_{00} radiation can be considerably simplified by observing the output beam with the Model 450 Optical Spectrum Analyzer while aligning the laser.

Figures 4-3 and 4-4 were obtained with Model 450-03 Spectrum Analyzer, (2 GHz FSR, 550–650 nm spectral range) driven by a Model 476. Calibration was 200 MHz/Division.

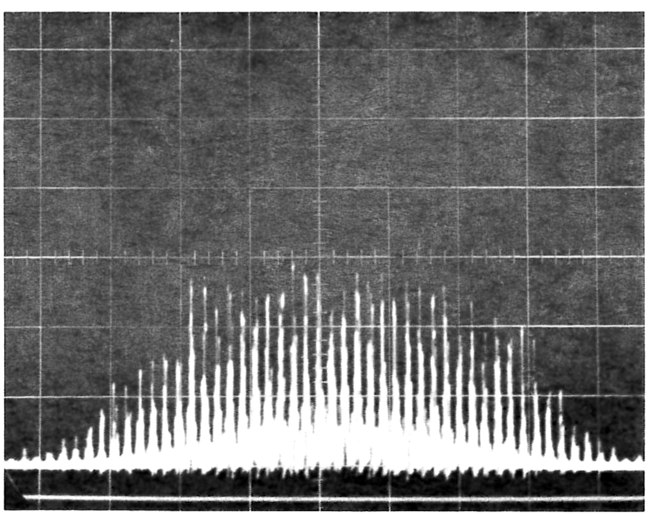

Figure 4-5 Spectra-Physics Model 165 Argon Ion Laser at 514.5 nm, Free Running

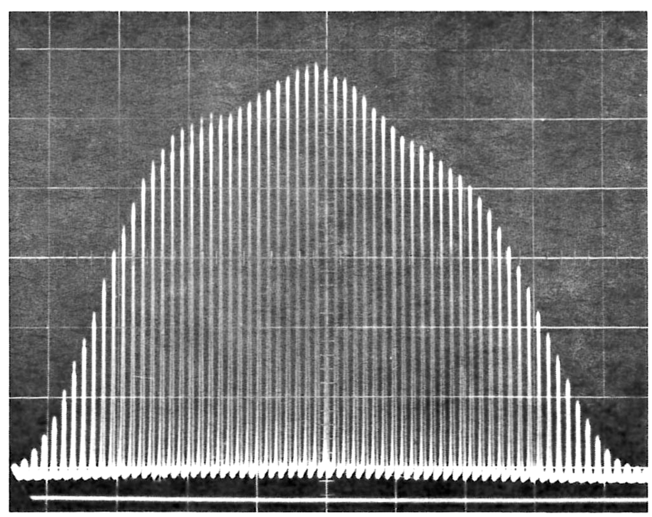

Figure 4-6 Spectra-Physics Model 165 Argon Ion Laser at 514.5 nm, Mode-Locked

DETECTION OF MODE-LOCKING EFFECTS

When the modes of a laser are phase and frequency locked, the mode amplitudes will be steady in time. When the laser is free-running, the mode amplitudes will fluctuate. Thus, by observing the time behavior of the modes of a laser, one can detect mode-locking effects.

Figures 4-5 and 4-6 were obtained with Model 450-02 Spectrum Analyzer, (10 GHz FSR, 450–550 nm spectral range) driven by a Model 476. Calibration was 1 GHz/Division.

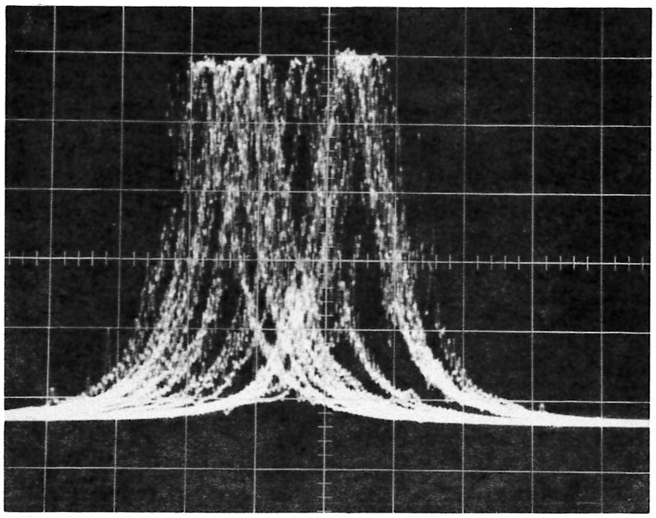

Figure 4-7 Model 580A Single-Frequency Dye Laser at 600 nm, Showing Excessive Jitter Caused by Very Poor Vibration Environment

OBSERVATION OF FREQUENCY JITTER

In Figure 4-7, the Model 450-03 spectrum analyzer (2 GHz FSR, 550–650 nm spectral range) was driven by the Model 476 and set for a scale expansion of twenty (10 MHz/Div, FSR = 26 Hz). The exposure time was 1 second during which time the Model 450 was scanned through its FSR about 30 times. The exact operating frequency of the laser was then recorded at the time of each scan and shows the jitter to be ± 15 MHz over a 1 second period.

MODEL 381 OPTICAL MOUNT

The Model 381 Optical Mount does a superb job of orienting the analyzer. Due to its sensitivity, it can be used as an excellent all-purpose precision mirror mount. The analyzer mounts easily into the 381.

MODEL 476 SCANNING INTERFEROMETER DRIVER

An all-purpose scanner for use with virtually any piezoelectrically-spaced interferometer, the Model 476 is designed for fast, simple high-resolution measurements. Its unique combination of features includes frequency scanning, photodetector amplifier with blanking, and oven regulator circuitry for reduction of frequency drifts in high-resolution experiments. The oven is only available as a standard feature on the Model 410 plane parallel interferometer.

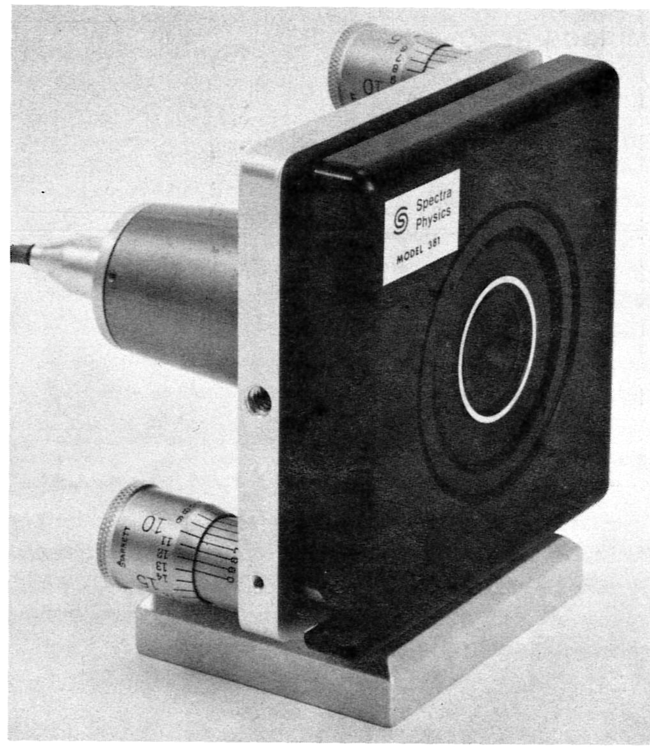

Figure 5-1 Model 450 Spectrum Analyzer Mounted in Model 381 Mirror Mount (Optional)

Figure 5-2 Model 476 Scanning Interferometer Driver

SECTION SIX–MIRRORS

MIRROR REMOVAL AND REPLACEMENT

Although it is possible to remove and replace mirror sets in the Model 450 in order to change to operating spectral range (not the free spectral range) or to gain access to the mirrors for cleaning, the probability of encountering difficulty is high unless the operator has had prior experience with this procedure. We recommend that, if possible, the instrument be returned to Spectra-Physics for mirror changing or cleaning whenever it becomes necessary; see Section Eight "Return of the Instrument for Repair". If return to Spectra-Physics is not possible, proceed cautiously, being especially careful to avoid damage to the piezoelectric element.

The analyzer head cavity length is factory-adjusted for best finesse and, even if these instructions are carefully followed, it may be necessary to readjust the cavity length if a new mirror set is installed. This is particularly true of the 7.5 mm mirror radius, 10 GHz analyzer.

1. Remove photodetector by loosening three allen head screws. Pull photodetector assembly clear of the rear of the housing, being careful not to break the wires attached.

2. Gently pull on the end of the cavity assembly with a hooked-end tool in either or both of the radial holes in the metal end of the assembly. The entire cavity assembly is suspended on two "O" rings within the outer housing and should slip out readily.

3. Looking in the rear (output) end of the cavity assembly, a threaded insert with two spanner wrench holes will be observed. In the center of this insert is a mirror nut with a screwdriver slot. To remove the mirror, the mirror nut must be removed *without* turning the insert which adjusts the *length* of the cavity. A pair of off-set tweezers will enable the insert to be held in place while unscrewing the mirror nut. After removing the mirror nut and small "O" ring, the mirror should fall out when the cavity is up-ended over a *padded* surface.

4. The front mirror is removed in the same way. There is no insert in the front of the assembly to adjust cavity length.

5. The mirrors to be inserted should be cleaned in accordance with the cleaning instructions prior to re-assembly. Tighten the mirror nuts firmly against the "O" rings. Be *very careful* not to move the cavity-length insert when tightening the rear mirror.

After reassembly, the analyzer should be placed in a single-frequency laser beam whose wavelength is within the range of the spectrum analyzer coatings. The spectrum of the laser should be displayed and a measurement of finesse should be obtained. Follow the procedure in Section Three. If the finesse is less than specified, adjust the cavity length a fraction of a turn and remeasure. Repeat until the finesse is maximized. This is a critical adjustment; the cavity length adjusting screw should *never* be turned more than one-half turn. A single-frequency laser must be used when adjusting finesse. The finesse should be adjusted for maximum signal "sharpness" and a minimum width at half amplitude.

Another method for adjusting cavity length, and thus finesse, approximately, is to visually observe the light transmitted through the cavity on a screen of white paper (hold the photodetector to one side). One should see two spots of light of equal intensity and possibly a less intense spot of light which is a second surface reflection from a mirror. If the cavity length is poorly adjusted the two bright light spots will have comet tails as shown below:

Well Adjusted *Poorly Adjusted*

Figure 6-1 Cavity Length Adjustment

This method of adjustment can be useful if no TEM_{00} laser is available.

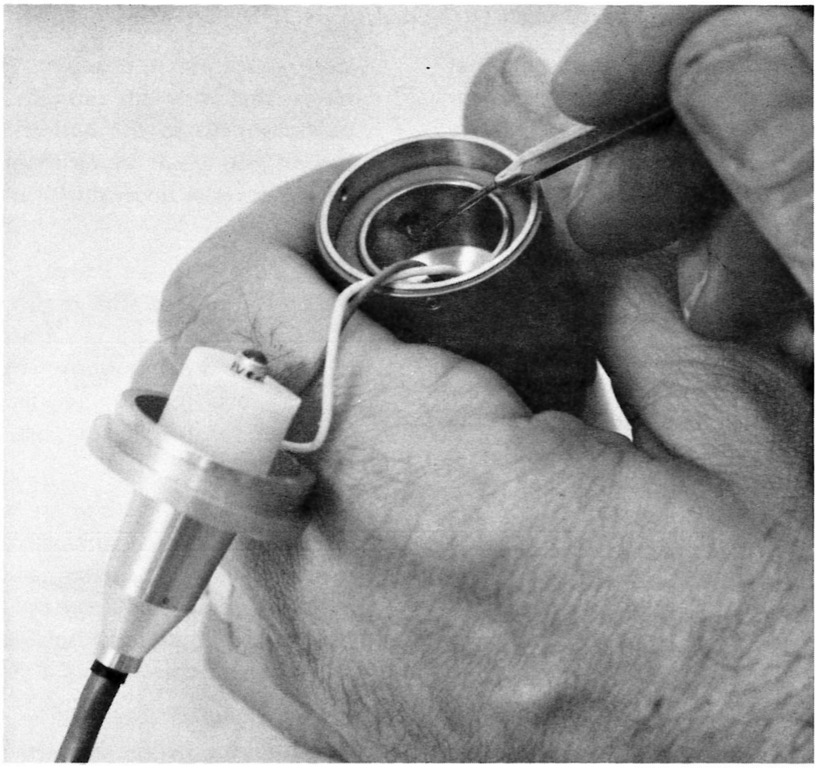

Figure 6-2 Disassembly Technique

Figure 6-3 Model 450 Disassembled

MIRROR CLEANING

The inner, curved surfaces of the mirrors are somewhat sealed by the "O" rings under the mirror nuts; the outer surfaces, however, are exposed to air and could accumulate dirt. It may be necessary at some time to clean the mirrors.

Mirror cleaning requires mirror removal, a difficult procedure; see beginning of this section.

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

Equipment Required

- Lens Tissue
- Spectrographic-grade Acetone
- Pair of Hemostats
- Eye Dropper

The steps in cleaning an optical surface are as follows:

Wash your hands thoroughly. This step is important for the reason that body oils and contaminants on the fingers can be transferred to the optical surface during the cleaning process and result in recontamination. The use of clean plastic gloves or finger shields is recommended.

Using a dry, clean gas source, blow away any dust or lint on the optical surface. This is also very important as any dust or lint left *on* the optical surface can result in a scratch that will damage it *permanently.* If a dry gas source is not available, a rubber bulb can be used to generate a low pressure air stream for the same purpose.

Draw some acetone into an eyedropper and squeeze out one drop on the flat surface of the mirror. Place a lens tissue on the wetted surface, and gently draw it across the mirror to remove any contaminants that have dissolved or floated to the cleaning solvent surface. Use a lens tissue only once and then discard it. Repeat as necessary.

To clean the curved surface, fold a cleaning tissue to a small cross section and grasp it a few millimeters from the end with the hemostats. Saturate the tissue end with acetone and shake off the excess. Wipe the tissue across the curved mirror surface once and discard the tissue. Repeat if necessary.

SECTION SEVEN–TROUBLESHOOTING

PROBLEM	CAUSE	REPAIR
No Signal	Poor alignment	See Section Three for alignment instructions
Loss of Signal	476 Scan generator in hold position	Switch to free run
	Interferometer has been bumped out of position	Realign
	Adapter cable has been inadvertently crossed up when connecting to the scan generator, therefore putting up to 300 volts across the photodetector (and destroying it)	Loosen the three allen set screws at the back of the analyzer and gently remove the photocell assembly. Assure proper hook-up of cable and turn scan generator on. Increase the gain of the vertical amplifier. The oscilloscope will display 60 Hz "noise" from the florescent overhead lights. If no signal, return to factory for repair.
Excessive jitter of scan on X10 dispersion setting	Mechanical hysteresis, caused by a loose mirror or laser jitter.	Tighten mirror nuts by following instructions in Section Five.
Low Finesse	Misalignment or "dirty" mirrors.	Realign angular mount or clean mirrors per Section Six.

In the event that you encounter problems in performance or alignment, or you have any questions which have been left unresolved by this manual, please contact your nearest service center.

SECTION EIGHT—CUSTOMER SERVICE

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

WARRANTY

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

The customer must ship the instrument to a Spectra-Physics service facility prepaid; Spectra-Physics pays the return shipment charges. The customer may have warranty repair performed at his facility, upon request, for an additional charge.

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

The warranty of instruments purchased within the United States normally only covers repairs performed within the United States. Extension of warranty to cover instruments transferred outside the United States is available. Contact the Mountain View service center for details.

REPLACEMENT PARTS

Replacement parts should be ordered directly from your nearest Spectra-Physics service facility. Please provide a description and Spectra-Physics part number for each replacement part ordered, and also include the instrument model number and serial number.

RETURN OF THE INSTRUMENT FOR REPAIR

Contact your nearest Spectra-Physics service facility for shipping instructions and forward the instrument *prepaid* to the destination indicated. Special Spectra-Physics packing boxes designed to securely hold instruments during shipment should be used. If shipping boxes have been lost or destroyed, we recommend that new ones be obtained from Spectra-Physics.

Include a description of the problem and the address and telephone number of the person to be contacted for repair authorization.

SERVICE CENTERS

Western United States

Spectra-Physics, Inc.	Tel:	(415) 961-2550
1250 West Middlefield Road	TWX:	(910) 379-6941
Mountain View, CA 94042	Telex:	348488
USA		

Eastern United States

Spectra-Physics, Inc.	Tel:	(210) 981-0390
366 South Randolphville Road		(800) 631-5693
Piscataway, NJ 08854	TWX:	(710) 997-9506
USA		

Canada

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