COHERENT®

MODEL 200

SINGLE FREQUENCY HENE LASER

OPERATOR MANUAL

COHERENT®
COMPONENTS GROUP

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COHERENT MODEL 200

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1. SYSTEM OVERVIEW/INTRODUCTION

The Model 200 is an actively stabilized, single frequency, Helium-Neon laser. It is ideally suited for interferometry, holography, or distance measurement, all requiring a stabilized, true single-frequency laser.

This second generation model represents a significant advance in design, based on the latest technology in hard-seal tube construction. These improvements eliminate problems from high heat and humidity — an especially desirable quality due to the necessity of maintaining stability at increased temperatures.

2. THEORY OF OPERATION

The operation of the Model 200 is briefly described in three parts. First, the problem of the laser's frequency stability is discussed in terms of temperature control. Second, inherent characteristics of the laser beam used to implement frequency control are described. Third, the actual control circuit is outlined.

2.1 FREQUENCY STABILITY AS A FUNCTION OF TEMPERATURE

The instantaneous frequency of the laser's output beam is a function of the laser's cavity length, which in turn is a function of cavity temperature. A few thousandths of a degree change in ambient temperature can alter cavity length by a fraction of a micrometer, enough to shift the frequency of the laser's output. To obtain a single frequency output, it is necessary to precisely control cavity length.

The Model 200 restricts the output beam to a single, continuous frequency by sensing any frequency change in the beam and compensating cavity temperature. This is accomplished by regulating current to a heater element enclosing the laser cavity. This servo-control process limits frequency drift in the laser's output to ± 1 MHz per five-minute interval.

2.2 GAIN PROFILE CHARACTERISTICS

The spectrum of all possible light-frequencies the laser can generate (its gain profile) is shown in Figure 1, Section 6.1 (pg. 9). The Model 200 has a center wavelength of 633 nm and a bandwidth of 1500 MHz. At any instant in time, the laser's beam consists of only two modes, or frequency components, which remain fixed at 685 MHz apart. Their relative position on the gain profile is dependent upon temperature. If the ambient temperature is warming, the modes will drift to the left, eventually reappearing on the far right of the curve, as shown in Figure 2, Section 6.2 (pg 9). This process will continue until ambient temperature is ideally stabilized.

As the two modes swing through the gain profile in response to variations in ambient temperature, their frequencies the intensities vary, but their separation remains constant. This characteristic of the laser's beam provides an error signal—the difference in intensity between modes—with which heater temperature can be controlled. When the modes are positioned and stabilized for normal operation as in Figure 3, Section 6.3 (pg. 10) the error signal equals zero; if modes slide left or right, an error signal is available to regulate heater current.

The final output beam of the Model 200 consists of only one mode. The two modes are orthogonally polarized and separation is accomplished through a beam-splitting prism. In this manner, the final single-frequency output of the Model 200 is obtained.

2.3 CONTROL CIRCUIT PRINCIPLES

Refer to the simplified block diagram of the Model 200 control circuit in Figure 4, Section 6.4 (pg 10). The controller consists of two main circuits; one circuit is responsible for the "WAIT" status of the controller, the other for "READY" status. Either one OR the other is activated at any given time.

The Timer and Comparator controls a solid state switch that determines which of the two circuits — "READY or WAIT"—is operational. The Timer and Comparator continuously inspects the position of the two laser beam modes as they pass through the gain curve described in Section 2.2 (Pg 1). If they have not made a complete pass through the curve within a preset time interval (fixed in controller's circuitry), the Timer and Comparator activates the "READY" circuit, meaning that the stable thermal environment required by the "READY" circuit has been reached (modes drifting slowly). If it has taken less than the predetermined time interval for the two modes to cycle through, the "WAIT" circuit is in control.

The "WAIT" circuit consists of the loop containing the Pre-Heating Control, "WAIT" light, Current Source, Heating Element, Temperature Sensor, and Laser Tube. When the Model 200 is initially turned on, this circuit is enabled by the Timer and Comparator due to instability of mode positions. The purpose of the "WAIT' circuit is to establish a quiescent current to the Heater Element (which can then be varied by the "READY" circuit described below).

The voltage at the Heater Element, corresponding directly to its temperature, is plotted with respect to time in Figure 5, Section 6.5 (Pg.11). The Temperature Sensor on the Heating Element provides a feedback signal to the Pre-Heating Control, causing the Heating Element to respond as illustrated in Figure 5.

After approximately 15 - 20 minutes, the rate of change in temperature at the Laser Tube has decreased enough to cause mode cycling-time to be greater than the controller's preset time interval. At this point, the Timer and Comparator will switch the controller into

"READY" status.

The "READY" circuit consists Amplifier A, Amplifier B, the Differential Amplifier, "READY" light, Currrent Source, Heating Element, and Laser Tube. The purpose of the"READY" circuit is to generate a continuous control signal to regulate Heater Element temperature and thus laser output frequency.

Mode A and Mode B are separated through a beam-splitting prism and directed toward two photodiodes at the inputs of Amplifier A and Amplifier B. The photodiodes serve as light-to-voltage transducers. The outputs of Amplifiers A and B represent the relative intensities of Modes A and B, and their difference is the error signal.

The Differential Amplifier is sensitive only to this error signal. It amplifies the error signal and drives the Current Source proportionately, thereby providing greater or less current to the heater. If Mode A and Mode B are positioned for normal as in Figure 3, Section 6.3 (pg 10) — no error signal will be generated and heater current is not varied. However, if the modes do not exist on the gain curve in their proper position, an error signal is immediatly generated and heater current is varied. This will, in turn, gradually reposition the modes and reduce the error signal present at Amplifiers A and B. Thus, by means of this servo-loop, a new temperature/frequency equilibrium is established and a constant output frequency is maintained.

3. PERFORMANCE AND OPERATING SPECIFICIATIONS

OUTPUT POWER	0.7 TO 0.98 mW at 632.8 nm
SPATIAL MODE STRUCTURE	TEM_{00}
TEMPORAL MODE STRUCTURE	Single Frequency
POLARIZATION	Linear
BEAM Ø @ $1/e^2$	0.6 mm
BEAM DIVERGENCE, FULL ANGLE	1.3 mR
AMPLITUDE NOISE (10Hz-10MHz)	$\leq$ 0.1 % RMS
FREQUENCY STABILITY (Short term)	$\leq \pm$ 1 MHz drift per 5 minute interval, .002 ppm.
FREQUENCY STABILITY (Long Term)	Fundamental frequency varies by 5 MHz °C ambient temperature change (.01 PPM). Maximum ambient temperature change after frequency lock = ±5°C.
MAXIMUM AMBIENT TEMPERATURE RANGE	0° TO 40 ° C.
WARMUP TIME REQUIRED TO ACHIEVE RATED SPECS.	40 minutes
WARMUP TIME TO ACHIEVE NOMINAL SINGLE FREQUENCY	25 minutes
INSTANTANEOUS COHERENCE LENGTH	∞
CDRH CLASS	II
CONTROLLER SIZE	8.3" X 11" X 3"
CONTROLLER WEIGHT	8 lbs.
LASERHEAD WEIGHT	2 lbs.
CORD LENGTH	5ft.
OPERATING VOLTAGE @ 50/60 Hz	100/120/220/240V, 50/60 Hz
POWER CONSUMPTION	80W max.

4. OPERATING INSTRUCTIONS

Read through the entire instruction set before attempting to handle any part of the Model 200 HeNe laser. Follow all instructions carefully. Operation of the Model 200 is simple, as there is virtually no operator interaction with the unit after it has been set up and turned on. There are, however, several important precautions to be observed in the operating procedure below.

4.1 MOUNTING AND PLACEMENT

Mount the laser tube by clamping it onto the O-rings provided. It is important that the laser be placed in the most stable thermal environment practical. The laser must not come in contact with objects that might act as heat sinks, and should not be used in drafty areas (but allow plenty of free air space around the tube). Maximum ambient temperature range is 0 to 40 degrees C. If the ambient temperature in the laser's location is variable within this maximum range, it should change at the slowest rate possible for effective operation off the Model 200.

NOTE

The return of the "WAIT" light after the controller has entered "READY" status indicates a thermal environment which will not permit the controller to operate within specifications.

4.2 HOOKUP

Connect cables as sketched in Figure 6, Section 6.6 (pg.11). Insure that all connections are snug. The high-voltage cable between the laser tube and the controller unit (labelled "LASER POWER SUPPLY" on the controller's back panel) must always be connected before AC power is applied. It is preferable to assemble the laser in a permanent location so that it is never necessary to unplug and reconnect cables.

CAUTION

Do not remove cables during operation. Never touch connectors or plugs during operation. Extremely high voltage is present!

4.3 POWER-UP

After hook-up, plug in controller unit and turn its power switch on.

DANGER

Avoid laser exposure. Never stare into beam. Beware of mirror-like reflections of the laser beam—these can be as hazardous as the beam itself. A plastic cap is provided to be placed on the laser tube when its output beam is not in use. The cap may be left over the laser beam indefinitely.

4.4 NORMAL OPERATION

For approximately 25 minutes after power is applied to the Model 200, its red "WAIT" light will glow, indicating the warm-up period. The "READY" light will then go on, indicating that the laser is now ready for use.

However, it is necessary to allow 40 minutes after a cold start to assure that the laser's rated frequency stability has been reached.

Operating lifetime and stability are held to a maximum if the laser is energized continuously.

4.5 SELECTION OF OPERATING VOLTAGE

The Model 200 may be operated at 100, 120, 220, or 240 volts. When shipped, the Model 200 is usually set up in advance to operate on the customer's specified voltage. If it is necessary to select and/or change the unit's operating voltage, perform the following procedure:

a. Turn controller off and unplug it.

b. Unplug the AC power cord from the controller's back panel.

c. Slide the clear-plastic window next to the AC power cord receptable on the controller's back panel to the left, thus covering the receptacle and exposing the fuse, and, PC selector board.

d. Draw the fuse extractor (labelled "FUSE PULL") to the left and remove fuse.

e. Using a small pair of pliers, remove the PC selector board found underneath the fuse mounting.

f. Firmly re-insert the PC selector board with the desired operating voltage facing up on its LEFT side. The new voltage value should be visible after the PC selector board has been re-inserted.

g. Return the fuse extractor to its normal position and insert the proper fuse required to handle the new operating voltage. Fuse rating requirements are found on the controller's back panel.

h. Slide the clear plastic window back to its original position and re-insert the AC power cord.

4.6 PILOT LIGHT

The pilot lamp indicates that the unit is on and that laser radiation is present. If pilot lamp does not glow when the unit is turned on, check the fuse according to the procedure outline above. If fuse is operational, replace the pilot lamp.

4.7 GENERAL PRECAUTIONS

Use of controls, adjustments, or procedures other than those specfied herein may result in hazardous radiation exposure.

Each Model 200 is built with the laser and controller intended to function as a matched pair. Operation in any other manner will not yield the specifications for stability and may shorten the life of the laser.

All labels must stay affixed to this product. Covers must not be removed by the user.

5. GLOSSARY

BEAM DIAMETER @ $1/e^2$

The diameter of that particular irradiance contour in a laser beam at which the irradiance has fallen to approximately 13.5% of the peak or axial irradiance.

CAVITY

An optical resonator formed by two coaxial mirrors positioned so that it is possible for photons to be multiply reflected between them.

COHERENCE LENGTH

The shortest distance between wavefronts in a wave train such that interferenc effects between wavefronts vanish.

DRIFT

Change of an output value with respect to time.

MODE

A three-dimensional configuration of electric and magnetic fields which is exactly reproduced by reflections from the cavity end mirrors.

POWER OUTPUT

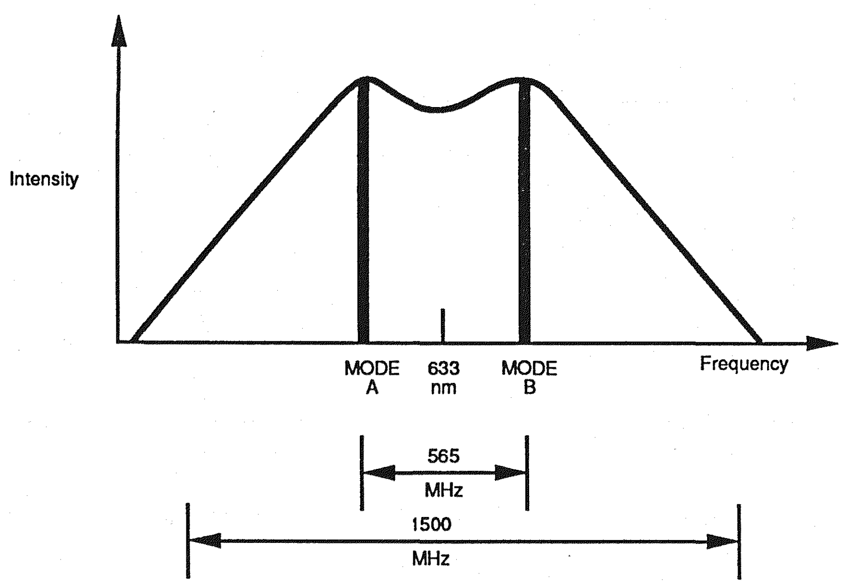
The rate of radiation emission from a laser, normally expressed in watts or milliwatts.

PPM

Parts per million.

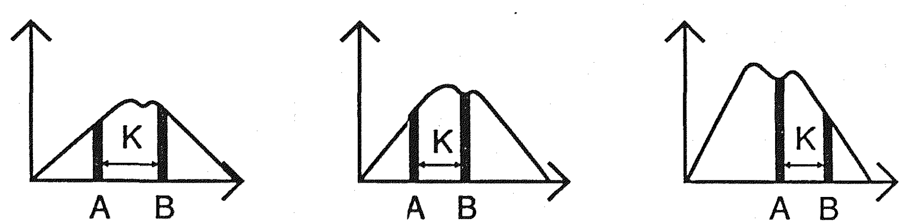
6. DRAWINGS

6.1 FIGURE 1



MODE SLIDING

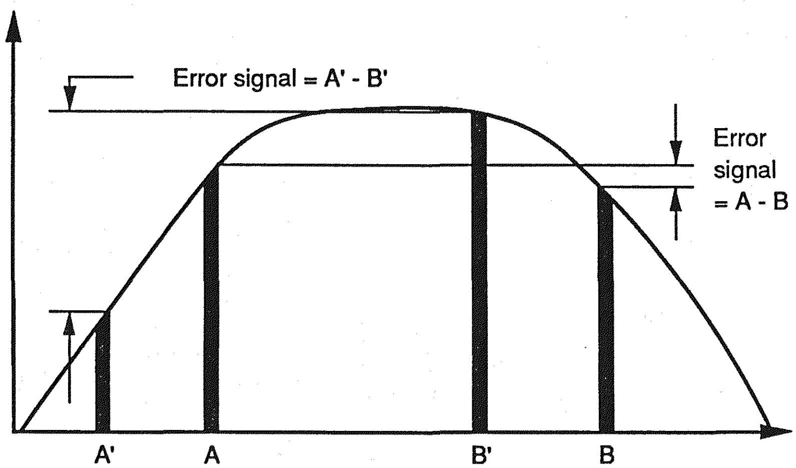
6.2 FIGURE 2



Modes A and B drift left in response to a warming ambient temperature, eventually reappearing at right. Note that modes maintain a constant distance apart (K), which is independent of their instantaneous position on the gain profile.

6.3 FIGURE 3

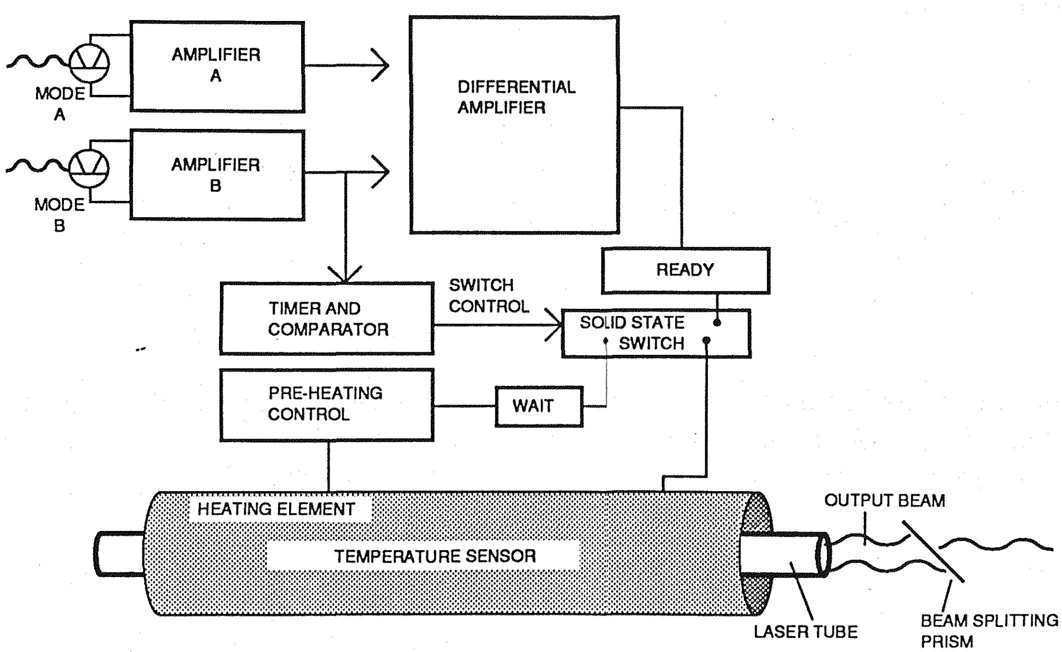
MODE POSITIONS PRODUCE ERROR SIGNAL



Modes drift from proper position (A and B), an error signal is developed (A' and B').

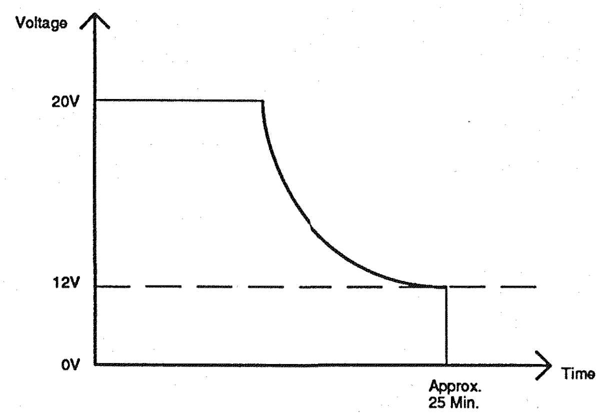
6.4 FIGURE 4

MODEL 200 FUNCTIONAL BLOCK DIAGRAM



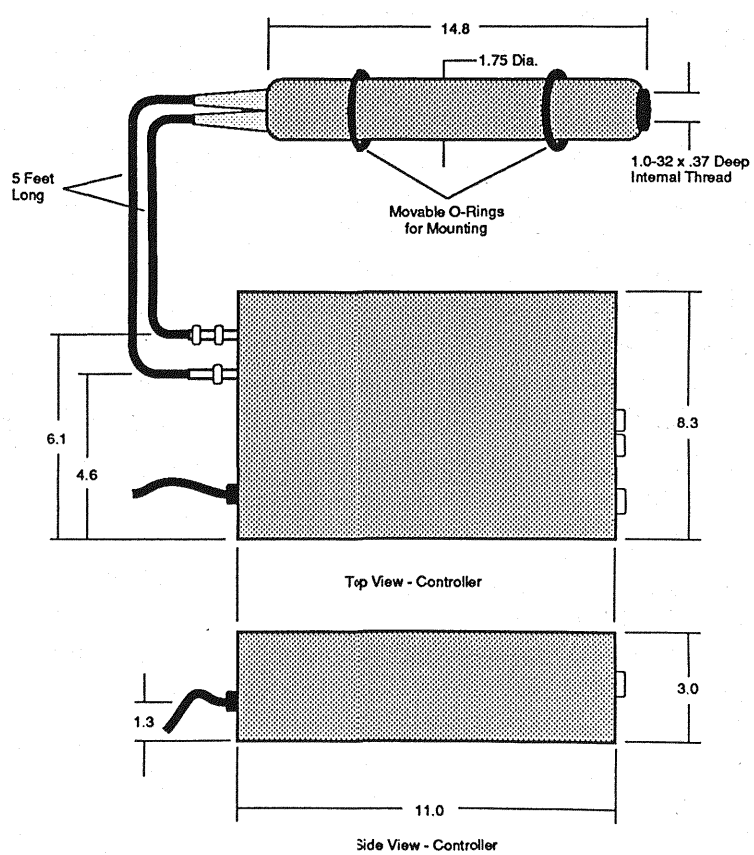
6.5 FIGURE 5

"WAIT" CIRCUIT: HEATER VOLTAGE VS. TIME



6.6 FIGURE 6

BLOCK DIAGRAM



WARRANTY

The seller warrants to the original Buyer each item manufactured by it to be free from defects in material and workmanship for a period of time and under such conditions as specified in the Seller's warranty for the individual product, or for twelve (12) months from delivery if a warranty for the individual product is not specified. Major sub-systems manufactured by other firms but integrated into the Seller's systems are covered by the original Manufacturer's warranty. The Seller's liability under valid warranty claims is limited to repair or replacement at the Seller's plant or the Buyer's location, all at the option of the Seller.

THE FOREGOING WARRANTY IS EXCLUSIVE AND IN LIEU OF ALL OTHER WARRANTIES, WHETHER WRITTEN, ORAL OR IMPLIED AND SHALL BE THE BUYER'S SOLE REMEDY AND THE SELLER'S SOLE LIABILITY ON CONTRACT OR WARRANTY OR OTHERWISE FOR THE PRODUCT. THE SELLER DISCLAIMS ANY IMPLIED WARRANTY OR MERCHANTABILITY OR FITNESS FOR PURPOSE.

All claims under warranty must be made promptly after occurence of circumstances giving rise thereto, must be received within the applicable warranty period by the Seller, and shall be subject to the terms and conditions stated herein. Such claims should include the product serial number, the date of shipment, and a full description of the circumstances giving rise to the claim. Before any products are returned for repair and/or adjustment, authorization for the Seller for the return and instructions as to how and where these Products should be shipped must be obtained. Any product returned to the Seller for examination and/or warranty repair shall be sent prepaid via the means of transportation indicated as acceptable by the Seller. The Seller reserves the right to reject any warranty claim on any item that has been shipped by non-acceptable means of transportation. When any product is returned for examination and inspection, or for any other reason, the Buyer and its shipping agency shall be responsible for all damage resulting from improper packing or handling, and for loss in transit, notwithstanding any defect of non-conformity in the Product. In all cases, the Seller has sole responsibility for determining the cause and nature of failure, and the Seller's determination with regard thereto shall be final.

If it is found the Seller's Product has been returned without cause and is still servicable, the Buyer will be notified and the Product returned at the Buyer's expense, in addition, a charge for testing and examination may, in the Seller's sole discretion, be made on products so returned.

ORDERING INFORMATION

Coherent LABMASTER is available with a variety of detector heads for CW and pulsed applications (see head specifications). Also available is a pole mount to raise the LABMASTER above the optical bench clutter, soft protective case for the LABMASTER console, and hard carrying case for transporting LABMASTER console and up to two detector heads.

COHERENT COMPONENTS GROUP manufactures a full line of laser instrumentation, including power meters, spectrum analyzers, single frequency HeNe's and Laser Interferometers, as well as standard and custom optical components and assemblies.

You may contact your local representative or Coherent Components Group for further information regarding these items. Call **(916) 888-5107** and ask for one of our customer care specialists. Purchase orders may be placed by phone, FAX, telex or mail. Where fast delivery is desired, simply contact us at the number above.

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COHERENT®
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TROUBLESHOOTING TIPS

FOR THE MODEL 200 SINGLE FREQUENCY HeNe LASER

AVOID	REASON
DIRECT EXPOSURE TO HEATING OR AIR CONDITIONING DRAFTS.	CAUSES FREQUENCY DRIFT AND/OR INSTABILITY.
SUBJECTING THE LASER HEAD TO VIBRATION.	CAUSES FREQUENCY DRIFT AND/OR INSTABILITY.
OBJECTS CONTACTING THE LASER HEAD THAT MAY ACT AS A HEAT SINK.	SYSTEM USES HEAT TO ADJUST CAVITY LENGTH, AND MAY NOT BE ABLE TO COMPENSATE FOR EXCESSIVE COOLING.
REFLECTIONS FROM ENTERING THE LASER CAVITY.	SYSTEM WILL BE UNABLE TO STABILIZE FREQUENCY DUE TO LIGHT FROM ABNORMAL SOURCES.
OPERATING THE LASER IN A CLOSED ENVIRONMENT THAT DOES NOT ALLOW ADEQUATE CONVECTION COOLING.	SYSTEM USES HEAT TO ADJUST CAVITY LENGTH, AND MAY NOT BE ABLE TO COMPENSATE FOR EXCESSIVE HEATING.
INTERMITTENT OPERATION.	FOR HIGHEST STABILITY, OPERATE CONTINUOUSLY.

Lasers for Science, Medicine and Industry.

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