Spectra-Physics

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Model 155
Helium-Neon Laser

Instruction Manual

Issue E/155 1/77

LASER SAFETY

Please read this section of the manual carefully before installing or operating your laser.

The protective housing of this laser product is not intended to be removed by the user. It is recommended that any maintenance or service requiring access to the interior of the laser be performed only by a Spectra-Physics representative.

Follow intructions contained in this manual for proper installation and operation of your laser.

Use of protective eyewear or other protective procedures in the use of this product depends on the conditions of use, visual function required, and type of user product. In the United States, consult user standards of the American National Standards Institute (ANSI), the American Conference of Governmental Industrial Hygienists (ACGIH), or the Occupational Safety and Health Act (OSHA) for guidance.

> **WARNING—HIGH VOLTAGES:** This laser product contains electrical circuits operating at HIGH VOLTAGES. THESE HIGH VOLTAGES ARE LETHAL.

> **WARNING:** At all times during installation or operation of your laser, avoid possible exposure to laser or collateral radiation* in excess of the accessible emission limits listed in the Federal Register, Volume 40, No. 148, July 31, 1975: Tables I-A, I-B, I-C, and III.

> **CAUTION:** Use of controls or adjustments or performance of procedures other than those specified herein may result in hazardous radiation exposure.

* Collateral radiation, as defined by BRH Laser Products Performance Standard, is "any electronic product radiation, except laser radiation, emitted by a laser product as a result of or necessary for the operation of a laser incorporated into that product."

Spectra-Physics manufactures many different lasers. Their output powers vary from a few microwatts to tens of watts. Obviously, lasers which produce higher output powers will normally have the potential for greater safety hazard. Laser users should be especially careful with lasers which produce pulsed or invisible output. The following general laser safety precautions are especially important.

SAFETY RECOMMENDATIONS FOR LASER USE

1. Never look directly into the laser beam.
2. Set up experiments so the laser beam is NOT at eye level.

SCHEDULE OF MAINTENANCE NECESSARY TO KEEP THIS LASER PRODUCT IN COMPLIANCE WITH 21 CFR CHAPTER I, SUBCHAPTER J, PARTS 1040.10 AND 1040.11

This laser product complies with Title 21 of the United States Code of Federal Regulations, Chapter I, Subchapter J, Parts 1040.10 and 1040.11, as applicable. To maintain compliance with these regulations, once a year, or whenever the product has been subjected to adverse environmental conditions such as fire, flood, mechanical abrasion, solvent spillage, etc:

1. Check to see that all features of the product listed on the radiation control drawing in this section (emission indicators, beam attenuators, etc.) are functioning properly and all required labels are firmly in place.
2. Verify that, when the laser product is operated, a visible or audible signal is provided during emission of accessible laser radiation in excess of the accessible emission limits of Class 1.†
3. Verify that the beam attenuator is capable of prohibiting access to laser radiation in excess of the accessible emission limits of Class 1.†

† 0.39 microwatts for CW operation where output is limited to the range 400 to 1400 nm.

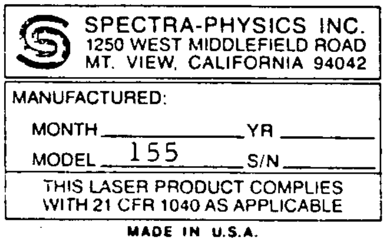
UNITS

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

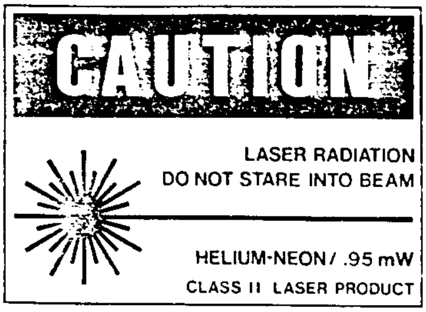
Prefixes	
tera (10^{12})	T
giga (10^{9})	G
mega (10^{6})	M
kilo (10^{3})	k
deci (10^{-1})	d
centi (10^{-2})	c
milli (10^{-3})	m
micro (10^{-6})	μ
nano (10^{-9})	n
pico (10^{-12})	p
femto (10^{-15})	f
atto (10^{-18})	a

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

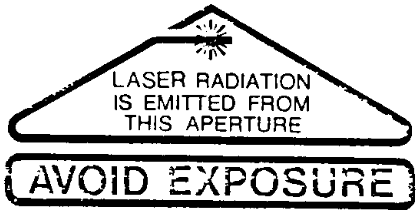
LABELS REQUIRED FOR MODEL 155



Model 155 Certification Label

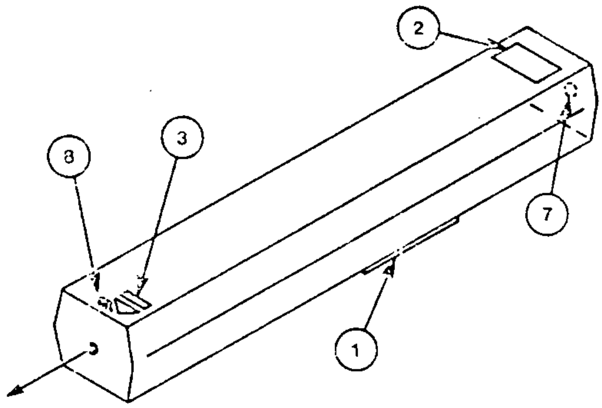


Model 155 Warning Logotype



Model 155 Aperture Label

LASER RADIATION CONTROL



Model 155 Laser Radiation Control Drawing

DRAWING KEY

Laser Safety Feature	Location
Certification and Identification Label	1
Warning Logotype Label	2
Aperture Label	3
Laser Radiation Emission Indicator	7
Beam Attenuator	8

UNPACKING

The Model 155 laser was carefully packed for shipment. IF THE PACKING CONTAINER IS DAMAGED, HAVE THE SHIPPER'S AGENT PRESENT FOR UNPACKING. Unpack the unit carefully and save the padding and container in case the unit must be returned for maintenance or service.

INSPECTION

The Model 155 laser should be inspected as soon as possible after it is received. Look for dents, scratches, or other evidence of damage. If you observe any damage, immediately file a claim against the carrier and notify your nearest Spectra-Physics representative. Spectra-Physics will arrange for repair without waiting for claim settlement.

SPECIFICATIONS

Output power	0.5 mW
Wavelength	632.8 nm, visible red
Spatial mode	TEM_{00}
Beam diameter, at $1/e^2$ points	0.88 mm
Beam divergence	1.0 mrad
Longitudinal mode spacing (c/2L)	550 MHz
Amplitude noise (1 kHz to 100 kHz)	0.3% rms
Amplitude ripple, at 120 Hz	0.5% rms
Polarization	random
Plasma tube lifetime	Typically greater than 10,000 operating hours
Long-term stability	<5% output power drift with constant line voltage
Input power	115/220 ± 10% V AC, 50/60 Hz, 22 W
Warmup	70% of full power at turn-on 90% power within 3 minutes Full power within 15 minutes
Operating temperature	10°C to 40°C
Storage temperature	-20°C to 60°C
Storage humidity	>6 months, at 90%RH, 25°C >18 months at 30%RH, 25°C
Vibration, operating	0.1 g max. at 10–500 Hz for output power modulation <10% at mechanical resonance
Vibration, survival	10 g, 0–500 Hz
Shock, survival	25 g, 10 ms

INTRODUCTION

The basic principles of laser operation were predicted by Schawlow and Townes in 1958, and in 1960 the first operating laser was developed. Shortly after that, Spectra-Physics was organized to produce lasers for commercial use. In 1962, our first laser was offered to the public.

Since that time, thousands of Spectra-Physics lasers have been sold for applications ranging from aligning storm and sanitary drain pipes to teaching optics in science classes. Light from our lasers has been bounced off the moon, used for eye surgery, and used to measure the height of ocean waves. Your laser, although of low power, exhibits the same properties that made these applications possible.

There have been many stories in the popular press regarding spectacular applications of laser light—about how it can drill holes in diamonds and vaporize metals. Although very powerful ruby and carbon dioxide lasers can be used for these purposes, this helium-neon laser is quite different. It produces one half of one-thousandth of one watt (0.0005 watt). You can work with it with absolute safety to your skin and clothes.

Nevertheless, the laser, like the sun, is an intense light source; common sense dictates that you never stare directly into the laser beam or position it such that others may look directly into it.

However, you can view the laser beam striking an object such as a wall or screen with complete safety. You need only avoid the direct beam and its reflection in a mirror or other highly polished surface.

Laser light differs from ordinary light in several important and useful respects.

The laser beam is highly *collimated*. That is, the beam spreads very little after being emitted from the laser tube; its *divergence* is low. A conventional light bulb emits light in all directions, and its energy is quickly dissipated. However, laser light can be directed in a narrow beam for great distances. As the beam leaves the laser it is about 1/16 inch in diameter; 20 feet away, it will have spread to only about 1/4 inch.

Laser light is also very *intense*. Because of the low divergence and small spot size, the direct beam from your 0.5 milliwatt (0.0005 watt) laser is more intense than the light from a 100 watt light bulb; you can see the spot from the laser beam even with the lights on. Light intensity is measured in terms of power per unit area. Your laser produces 0.5 mW of radiant power over an area of about 2 square millimeters; this is an intensity of 0.025 watts/cm^2. For comparison, the intensity of the sun is about 0.135 watts/cm^2.

While the light from the sun is more intense, it is made up of many different colors. The primary light from your laser, however, is *monochromatic*, or made up of one single color—bright red. Its wavelength is 632.8 nanometers (0.0000006328 meters). Because of this, you will still see the red spot produced by the laser beam even in bright sunlight. The monochromatic nature of laser light can be likened to the single frequency of a tuning fork or an electronic sine-wave generator. Although the primary light output of your laser is at 632.8 nm, there is also noticeable discharge light in the blue and green wavelengths, a characteristic of He-Ne lasers.

Besides being monochromatic, laser light is *coherent*. This means that, in addition to having only a single wavelength, all the light at a particular point in the beam at a particular instant in time also has the same phase, amplitude, and direction. The low divergence of the laser beam is largely a result of its coherence and the construction of the laser tube itself.

MODEL 155 COMPONENTS

The Model 155 laser consists of the following major components:

1. Plasma tube (see Figure 1)
2. Power supply printed circuit board
3. Power supply transformer
4. Protective housing
5. On/Off Switch
6. Beam attenuator
7. Laser radiation emission indicator
8. Power cord

THEORY OF OPERATION

The name **LASER** is actually an acronym which stands for Light Amplification by Stimulated Emission of Radiation. Although this describes the production of laser light to the scientist, most people desire a more thorough explanation. In order to understand the operation of the laser, it is first necessary to understand how light is produced from electrons.

In all atoms, electrons usually occupy well-defined orbits around the nucleus. Although these electrons can be excited to higher energy states, they will eventually fall back into their normal or ground state; when they do, they emit radiation. If the difference between the excited state and the ground state is within certain limits, the radiation is visible as light. This change in state is called an energy transition, and the radiation from a single transition is called a photon.

In a conventional light bulb, tungsten atoms are excited by an electric current. The transition back to the ground state is random, and photons are emitted in all directions, each with a different frequency, phase, and energy.

We get laser action when many electrons make the same energy transition at the same time. This can occur when many of the same kind of atoms are excited in a small area. Then when one transition occurs, and a photon is emitted, the photon is likely to collide with another excited atom. This collision produces two photons which are like twins;

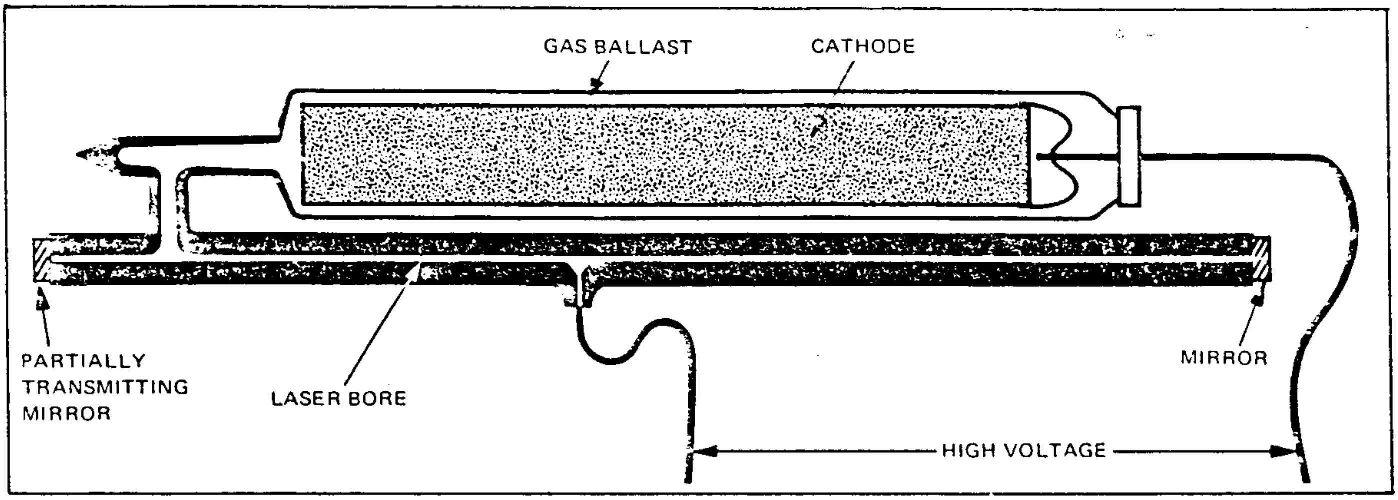


Figure 1. The 155 laser tube.

they are identical in frequency, phase, energy, and direction. When this happens on a large scale, laser light is produced.

In a helium-neon (He-Ne) laser, the desired transition occurs in the neon atoms. The helium helps to excite the neon. An electric current passed through the laser tube easily excites the helium atoms; when these collide with the neon atoms, energy is transferred, and the neon atoms are left excited.

By enclosing the gas in a sealed tube with mirrors on both ends, the photons released in neon energy transitions are reflected back and forth. These photons collide with other excited neon atoms and more photons are released. These collisions build up until there is a continuous flow of photons producing a very intense beam of coherent light along the axis of the tube.

To get the beam out of the laser tube, one of the mirrors is partially transmitting; while it reflects most of the light back, it lets a small portion through. This is the beam you see (Figure 1).

CIRCUIT DESCRIPTION

> **WARNING—HIGH VOLTAGES:** This laser product contains electrical circuits operating at HIGH VOLTAGES. THESE HIGH VOLTAGES ARE LETHAL.

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Input power is transmitted through the line cord, fuse F100, and On/Off switch S100 to high voltage transformer T100, also lighting the incandescent emission indicator. High voltage transformer T100 primaries are connected in series for 220 V operation or in parallel as shown for 115 V operation. Taps 2 and 2, rather than 3 and 6, are used for 100 V operation.

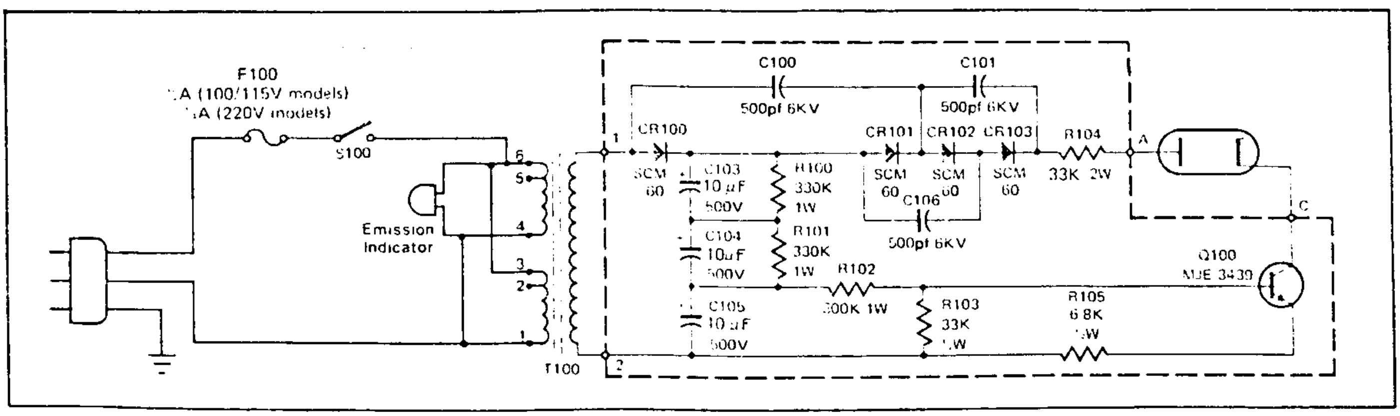

Figure 2. Model 155 Schematic

The secondary of T100 provides 1245 V AC across terminals 1 and 2. This is rectified by half-wave diode rectifier CR100 producing a peak (no load) voltage of 1700 V DC, filtered by R-C filter network capacitors C103, C104, C105, and resistors R100, R101, R102, and R103.

When the Model 155 is initially turned on, the plasma tube, whose anode is connected to point A and cathode to point C, is not ionized and therefore not conducting. An initial high voltage is required to ionize the gas in the plasma tube. This high voltage is provided by the start boost circuit consisting of capacitors C100, C101, C106 and diodes CR101, CR102, and CR103. The start boost circuit provides a voltage at its output about 1000 volts higher per stage than the input voltage. Since there are three stages, the output of this circuit at point A (the anode of the plasma tube) is about 3000 + 1700 volts = 4700 volts. This voltage appears as a short pulse and voltage decreases as the tube conducts. Voltage across the plasma tube under normal operating conditions is about 1000 V DC. Additional components of the circuit are ballast resistor R104, current-regulating transistor Q100, and current-sampling resistor R105.

OPERATION

Operation of the Model 155 laser is simple and straightforward.

1. Point the laser toward a dull surface in a direction that will not intercept anyone's line of vision.
2. Remove the tape covering the output aperture. When the laser is not in use, it is advisable to replace the tape to avoid contamination of the outside surface of the neutral density filter by dust.
3. Leave the beam attenuator in the Off position.
4. Connect the power cord to a 115 V 50/60 Hz receptacle (220 V for European models; 100 V for Japanese models).

> NOTE: The input power cord has a three-pronged plug. To avoid a possible shock hazard, the ground prong must be connected to a ground point at the electric outlet.

Line variations of up to ±10% are tolerable, but they may cause some variation of output power.

5. Turn On/Off switch to On.
6. The emission indicator should light, indicating that power has been applied to the laser.
7. Move the beam attenuator to the On position.
8. A thin red beam of light should be coming from the output aperture of the laser. If the red output beam does not appear within a few seconds, see the section on troubleshooting.

MAINTENANCE

The Model 155 laser is not normally expected to require maintenance. The laser mirror surfaces are inside the glass plasma tube and so are not subject to contamination and cannot be cleaned. It is possible that the outer surface of the neutral density filter could eventually become contaminated by dust, surface film, or other foreign matter. It is unlikely that contamination would make its way to the outer surface of the output mirror. It is recommended that the beam attenuator be closed when the laser is not in use. This will prevent most contamination.

Contamination of the outer surface of the neutral density filter will not affect actual operation of the laser, but film, if severe enough, could cause output power to drop, and dust causes diffraction effects which show up as distortions of the far-field pattern of the output beam.

The outer surface of the neutral density filter, accessible through the output aperture, should be cleaned carefully if necessary. First, use low-velocity dry air to remove any loose particles. If this fails to correct the problem, put a small amount of alcohol on a cotton swab, shake it to remove excess alcohol, and sweep it *lightly* in one direction across the surface. The entire surface need not be clean, since the output beam passes only through the center of the filter.

TROUBLESHOOTING

No Emission Indicator Light. If the laser power cord is connected to the proper source of power and the On/Off switch is in the On position, but the emission indicator light does not turn on, check the fuse located at the rear of the laser. If the laser still does not operate, contact your nearest Spectra-Physics service center.

Emission Indicator Lights, No Output Beam. If the beam attenuator is in the open position and the emission indicator lights, but the red output beam does not appear within a few seconds, look at the output aperture (DO NOT LOOK DIRECTLY INTO THE LASER). Look for an indication of plasma excitation. If the plasma is lit, there will be a blue light reflecting inside the case. If the plasma is lit but there is no laser output, the tube is defective. If there is no indication of plasma excitation, check the fuse which is located at the rear of the laser. If your laser is still not operating to published specifications, contact your nearest Spectra-Physics service center.

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 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.

Complete U.S. service facilities are located in Mountain View, California and in Piscataway, New Jersey. U.S. customers east of the Mississippi are serviced from the Piscataway office. Spectra-Physics also maintains several European service centers.

Replacement parts should be ordered directly from your nearest Spectra-Physics service center. For ordering or shipping instructions or for assistance of any kind, contact your nearest service center and give the instrument model and serial numbers. Service data or shipping instructions will be promptly supplied.

WARRANTY

The Model 155 laser is warranted to be free from defects in workmanship and materials for 18 months from date of shipment. Spectra-Physics will repair or replace instruments which prove to be defective during the warranty period without charge. The obligation of Spectra-Physics is limited to such repair and does not extend to consequential damages.

A frequent cause of failure is simple contamination of optical surfaces. The warranty does not cover the cleaning or return of the instrument if this is the cause of failure. A charge will be made in the event that a returned unit requires cleaning only.

RETURN OF THE INSTRUMENT FOR REPAIR

Contact your nearest Spectra-Physics service center or service representative for shipping instructions, and forward the instrument prepaid to the destination indicated. Spectra-Physics recommends that the shipment be insured. The box in which the instrument was originally supplied was designed to hold it securely during shipment. If this box has been lost or destroyed, the instrument should be protected by at least 5 cm of foam packing material and enclosed in a sturdy shipping container. Within the United States (except Alaska and Hawaii), the return shipment to you by Spectra-Physics will normally be by U.P.S.

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Spectra-Physics

PRODUCT/INSTRUCTION MANUAL – PROBLEMS AND SOLUTIONS

Date ____________ FROM: Name ____________

Organization ____________

Address ____________

____________ Zip ____________

Please mail original copy to:

Customer Service Department
Spectra-Physics, Inc.
1250 West Middlefield Road
Mountain View, CA 94042

This form is provided to encourage you to tell us about any difficulties you have experienced in using your Spectra-Physics product or instruction manual—problems or errors which did not require a call or formal letter to our Customer Service Department, but which you feel could be remedied by action on our part. We are always interested in improving our products and manuals, and we appreciate any information you can give us. Thank you.

PRODUCT NAME or MODEL NUMBER ____________

SERIAL NUMBER ____________

PROBLEM ____________

SUGGESTED SOLUTION(S) ____________

SERVICE CENTERS

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