

Operation Manual

CB Erbium/2.94TM
Er:YAG Laser System

Continuum Biomedical
A Medical Division of Continuum Electro-Optics, Inc.
6533 Sierra Lane
Dublin, CA 94568
(800) 532-1064 or (510) 828-3210

Important!

Read this section before operating the Laser.

1. Laser safety eyewear supplied with the CB Erbium/2.94 must be worn by **all** persons present during the operation of the laser. The eyewear has an OD of 4+ at 2.94 μ and meets the ANSI standards Z136.1 and Z136.3.
2. **Do not** remove the protective eyewear until the laser is returned to the "Standby" mode. This is accomplished by releasing the foot switch; pressing the "STANDBY" keypad; and securing the articulated arm in its clasp. The Standby Indicator will light indicating "Standby" mode.
3. Never look directly into the laser beam or its reflection. Permanent damage to the eye can occur.
4. During laser operation, do not allow any non-essential personnel in the treatment room.
5. Remove all shiny reflective objects such as rings, watch bands and metallic pencils from the patient and the operating physician.
6. Never depress the foot switch without first verifying the safe orientation of the articulated arm and the attached hand pieces.
7. Never leave the laser in a READY or EMISSION mode unattended. Turn laser off and remove the KEY when not in use.
8. Never allow untrained personnel to operate the laser system unless directly supervised by a trained, experienced physician. Refer to section 1.C. for information on training requirements.
9. Never attempt to remove the protective covers from the laser cabinet. Only allow a factory authorized service technician or representative to remove any of the protective covers.
10. Review the safety labels used on or in the CB Erbium/2.94 Laser System. Refer to Section 3.H. for their location.

If you have any questions or concerns regarding the CB Erbium/2.94 Laser System call Continuum Biomedical at 510-828-3210.

Continuum Biomedical considers itself responsible for the effects on safety, reliability, and performance of the CB Erbium/2.94 only if:

- assembly operations, readjustment, modifications or repairs are carried out by persons authorized by the company.
- the electrical installation of the relevant room complies with the appropriate requirements.
- the CB Erbium/2.94 is used in accordance with the instructions for use outlined in this manual.

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1. Physician Information Statement

A. Description

The CB Erbium/2.94 Er:YAG Laser System is an Erbium laser producing laser emission at 2.94 μ . Refer to Section 3 for a more detailed description of the CB Erbium/2.94 Laser System.

B. Indications

The CB Erbium/2.94 Laser System indicated for use in dermatology for the incision, excision, ablation, vaporization and hemostasis of soft tissue as well as for skin resurfacing in the treatment of wrinkles

C. Intended Use

The following treatment parameters are recommended (see Precautions below):

Indication	Number of Passes	Fluence Level
Skin Resurfacing	4 - 6	500 - 1500 mj
Wrinkles	8 - 10	500 - 1500 mj
General Dermatology	4 - 8	500 - 1500 mj

D. Contraindications

There are no known contra-indications for the CB Erbium/2.94 Laser System in the treatment of wrinkles, skin resurfacing or general derm. applications. However, patients who have had prior problems with laser therapy should be carefully screened as potential candidates for treatment.

E. Warnings

Laser safety eyewear with an OD of 4+ or higher at 2.94 μ , must be worn by all persons present during the operation of the CB Erbium/2.94 Laser.

Do not remove the protective eyewear until the laser is returned to the "Standby" mode. This is accomplished by releasing the foot switch; pressing the "STANDBY" keypad; and securing the articulated arm in its clasp. The Standby Indicator will light indicating "Standby" mode.

Observe all safety precautions described in the Section 2 - Safety.

F. Precautions

Begin treatment with the lowest energy possible. If more tissue reaction is desired, increase the energy level in small increments until the desired tissue effect is observed.

G. Complications/Adverse Effects

Potential complications include:

- Scarring, keloid formation and indentation of the tissue may develop following laser therapy.
- Postoperative erythema, edema, and pain may be experienced after laser treatment.
- Hypopigmentation or hyperpigmentation may occur.

H. Required Maintenance/Service

- The laser calibration checked and, if necessary, recalibrated every 3 months by a Continuum Biomedical trained service representative.
- Articulated arm mirrors inspected and, if necessary, replaced every 3 months by a Continuum Biomedical trained service representative.

I. Training Requirements

The CB Erbium/2.94 Laser System is intended for use only by physicians trained in the safe handling and use of the laser. Continuum Biomedical suggests that in addition to laser safety training of all operating room or clinic personnel, the user/institution adopt a training and safety program as outlined in the latest revision of the ANSI standard Z136.3, the American National Standard for the Safe Use of Lasers in Health Care Facilities.

It is further suggested that each physician desiring privilege for laser use be approved by the appropriate credentialing body within their respective institutions.

Physicians should consider the following training avenues:

1. An accredited training course within the physician's specialty.
2. "Hands-on" training under the preceptorship of a qualified user.
3. Attendance at specialty specific courses presented during academy or college meetings.

Nurses and other allied health professionals handling lasers may also complete a training program which may include subjects such as basic laser physics, laser safety, tissue interaction, laser operating procedures, laser set-up procedures, potential hazards, and hands-on experience.

In-Service training in the use of the CB Erbium/2.94 Laser System will be provided by Continuum Biomedical during the system's installation. Clinical techniques

described here are presented only as a reference based on clinical experience with the device and other laser devices reported in the public literature.

Continuum Biomedical maintains a current listing of recommended training courses which are available to the user and allied health professionals. Contact Continuum Biomedical for further information at (510) 828-3210.

2. Safety

WARNING!

Improper use of the CB Erbium/2.94 controls or performance of procedures other than those specified in the Physician's Information Statement (Section 1) may result in hazardous radiation exposure.

Laser Safety Precautions

Continuum Biomedical's user information is in compliance with section 1040.10 of 21CFR Chapter 1, Subchapter J concerning Radiological Health published by the US Department of Health & Human Services, Center for Devices & Radiological Health, 1988.

The following safety precautions should be read and observed by anyone using the laser.

1. Always wear laser protective eyewear of an optical density of at least 4+ at 2.94 μ to protect the eyes from the maximum energy produced. Eyewear must meet the ANSI Z136.3 standard.
2. Never look directly into the laser beam or its reflection. Permanent damage to the eye can occur.
3. During laser operation, do not allow any non-essential personnel in the treatment room.
4. Remove all shiny reflective objects such as rings, watch bands and metallic pencils from the patient and the operating physician.

5. Never depress the foot switch without first verifying the safe orientation of the articulated arm and the attached hand pieces.

6. Never leave the laser in a READY or EMISSION mode unattended. Turn laser off and remove the KEY when not in use.

7. Never allow untrained personnel to operate the laser system unless directly supervised by a trained, experienced physician.

8. Never attempt to remove the protective covers from the laser cabinet. Only allow a factory authorized service technician or representative to remove any of the protective covers.

9. Call Continuum Biomedical at 510-828-3210 for further information on any safety features of the CB Erbium/2.94 Laser System.

Review the safety labels used on or in the CB Erbium/2.94 Laser System. Refer to Section 3.H. for their location:

3. Erbium/2.94 Laser Description

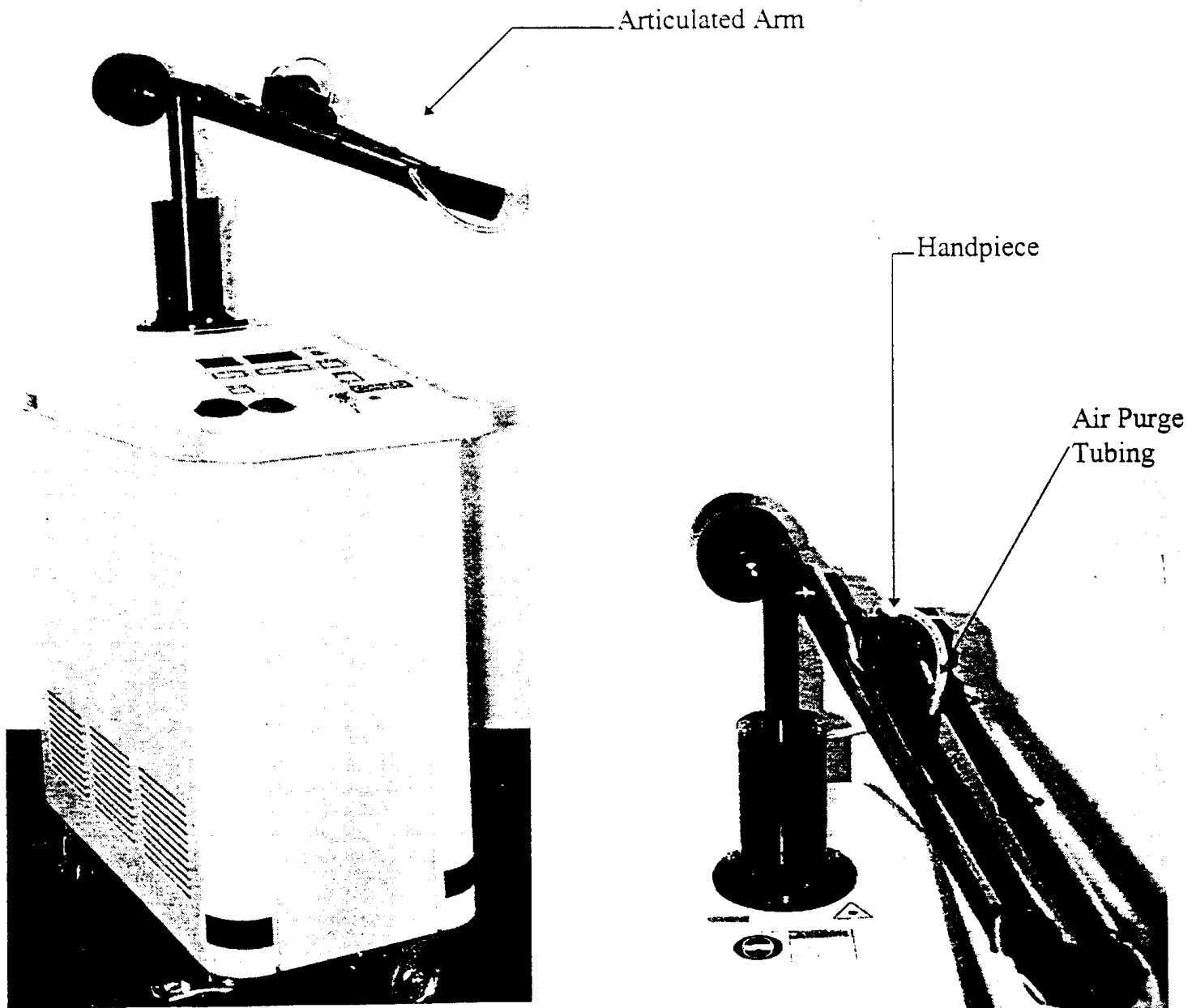


Figure 1 - CB Erbium/2.94 Front View

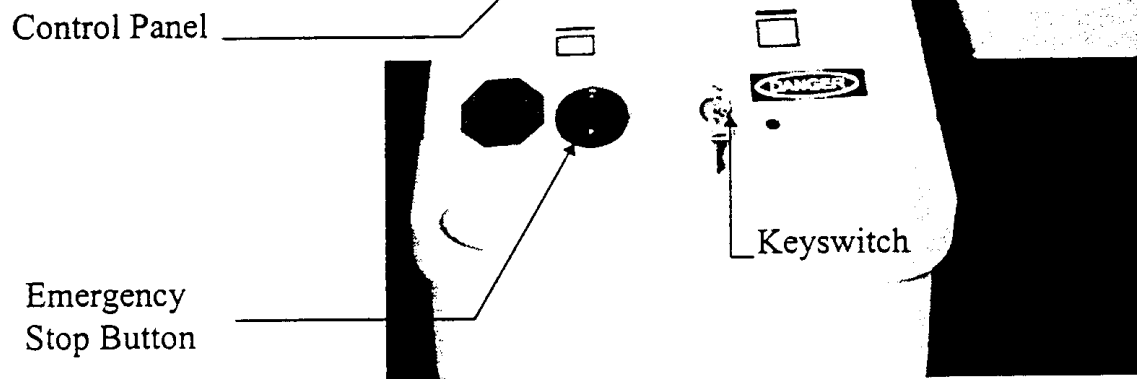


Figure 2 - Top View

A. Front Panel Functions

The Control Panel of the CB Erbium/2.94 is used primarily to display the parameters and status of the system while treating. In addition, various error codes may be displayed on the front panel indicating a fault has occurred somewhere in the system. For an explanation of these error codes, see Section 7.

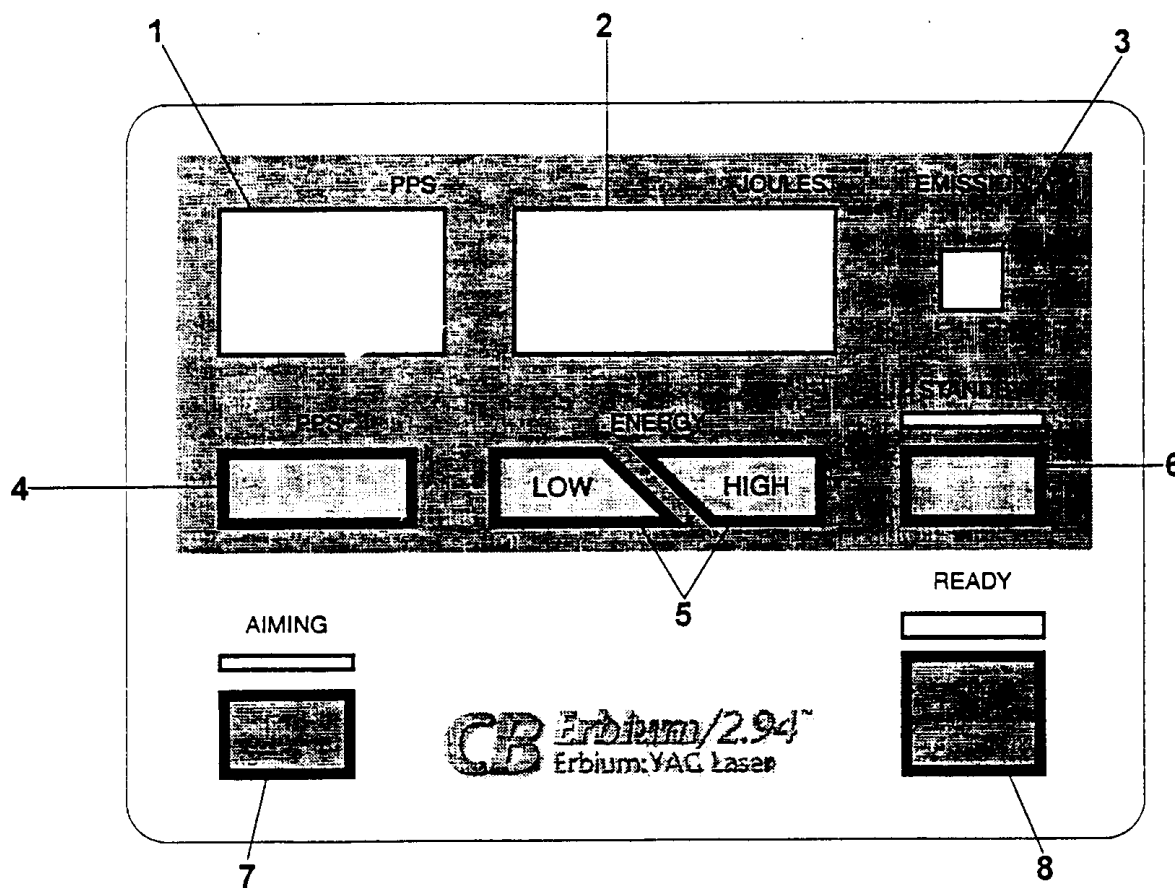


Figure 3 - Control Panel

Below is a description of the various indicators and keypads on the Control Panel. Figure 3 shows the location of indicators and keypads.

1. Repetition Rate Display This LED display indicates the current pulse repetition rate in pulses per second (PPS). It is also used to display system status messages.

- | | |
|-------------------------|---|
| 2. Pulse Energy Display | This set of 3 LEDs displays the current energy per pulse in Joules. It is also used to display system status messages. |
| 3. Emission Indicator | This indicator is lit when the footswitch is depressed and laser emission from the arm. |
| 4. PPS Keypad | Pressing this keypad changes the pulse repetition rate. |
| 5. ENERGY Keypads | Pressing the keypad labeled "LOW" reduces the pulse energy. Pressing the keypad labeled "HIGH" increases the pulse energy. |
| 6. STANDBY Keypad | Pressing this keypad changes the system into Standby mode. Press to reset for error code |
| 7. AIMING Keypad | Press this keypad to turn the aiming beam on and off. |
| 8. READY Keypad | Press this keypad to change the system into the READY Mode. When in the READY mode, laser light is available when the foot switch is depressed. |

B. Power Measurement System

The CB Erbium/2.94 utilizes a calibrated pyro detector for monitoring the energy during treatment.

Note: Continuum Biomedical recommends the system's calibration be checked every 90 days by a qualified service person. For more information on calibration, consult Section 5.B.

1. When the CB Erbium/2.94 is changed from the STANDBY mode to the READY mode, the system performs a warming procedure. During this 30-second period, the laser is operating internally at 8 Hertz. No laser emission is available from the articulated arm. When the warming is complete, the energy level and rep rate are displayed on the panel display indicators.
2. While in the READY mode, if an operating parameter such as output power or rep rate are changed, the CB Erbium/2.94 will perform a calibration and ensure the output power matches the displayed value.
3. When the foot switch is pressed, laser pulses are emitted from the articulated arm. The pyro detector is monitoring the power and sending signals to the microprocessor maintaining a voltage that will provide and maintain the energy level displayed on the Front Panel. The energy will be maintained within $\pm 20\%$. If for some reason the

energy cannot be maintained the laser will shut down with an error code, see Section 7 for error code description.

C. Articulated Arm

1. Using the articulated arm.

Before setting up the laser for a treatment procedure, the articulated arm must be unfolded. First release the arm from the clasp holding the arm to the laser cabinet. The clasp is released by pulling upward and rotating the top portion approximately one quarter turn. Carefully lift the arm from the clasp. The weight should be used to balance the arm with the handpiece attached. Hold the handpiece and rotate the weight until little or no force is felt while holding or moving the handpiece.

Caution: Damage may occur to the arm bearings if the weight is adjusted so that when the handpiece is released the arm points up and keeps the handpiece from hitting the floor.

Now the arm must be released from its clamp. The clamp is located on the arm and allows it fold up upon itself. The two supports on the clamp are labeled "Tube down" and "Tube Up". Gently remove the arm from the clamp. The arm is now ready for use.

The various handpieces are easily screwed into the output end of the articulated arm. See Section 3.G. for the use and care of these accessories.

2. Mirror Inspection.

The articulated arm is used to transmit the laser pulses from the laser cabinet to the patient. It consists of a series of seven mirrors located at the various knuckles.

Note: The mirrors should be inspected by a qualified service technician every three months. Contact Continuum Biomedical for information on replacement mirrors.

3. Mirror Removal.

A 5/64" Allen key is needed to remove the two screws holding the mirrors to the arm. Using your thumb, press firmly on the back of the mirror holder. Release both retaining screws before releasing your thumb. Carefully pull the mirrors back from the arm and inspect the reflecting surface. Replace the mirror avoiding any touching of the reflective surface. There is no preferential orientation of the mirrors on the three outermost knuckles. The four mirrors on the inner knuckles have a required orientation. Note the orientation prior to removing the mirror, and replace the mirrors using the same orientation.

D. Foot Switch

The foot switch plugs into the rear of the CB Erbium/2.94 system.

1. To operate the footswitch, the laser must be in the "Ready" mode.
2. The foot switch is fully depressed downward and held to emit continuous pulse at the selected rep rate. Switch laser PPS to 1Hz for single pulse operation.
3. If the foot switch is depressed and the laser is switched from "Standby" mode to "Ready" mode, a fault is detected. The laser will emit a tone for five seconds. If the foot switch is not released during the tone, the laser will turn itself off and the appropriate error code will appear on the front panel. See Section 7 for additional information on error codes.

E. External Interlock

The external interlock is located on the rear control panel. It is provided to enable the operator to connect an interlock on an entranceway to the treatment room. When opened, this interlock will turn off the power to the CB Erbium/2.94.

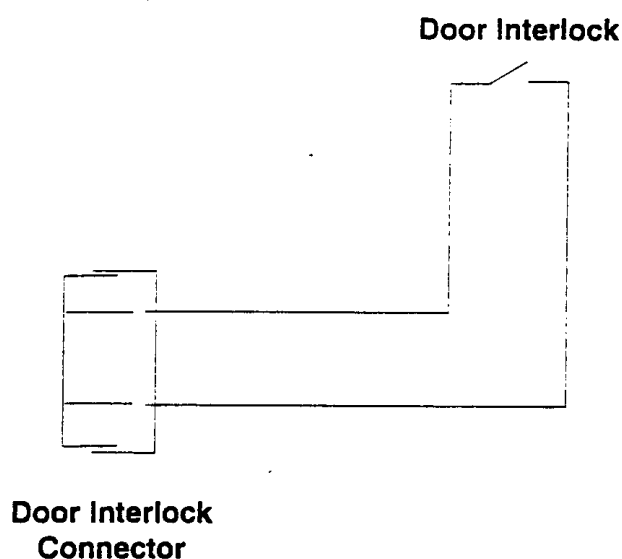


Figure 4 - External Interlock

The external interlock on the CB Erbium/2.94 consists of a two wire male pin connector. The pins are energized to 12 Volts DC. The two pins on the female mating connector which is installed on the laser are connected together by a short wire. The operator can either disconnect this short wire and use the provided female connector or Continuum Biomedical will provide an unwired female plug for this interlock upon request. Figure 4 shows the recommended connection procedure for this external interlock.

F. Water Cooling System

The cooling system must be filled with de-ionized water (Distilled water from the super market works well). Failure to use de-ionized water may result in equipment failure and **INVALIDATE THE WARRANTY**. The system **may not** be filled with any concentration of ethylene glycol.

Caution: The cooling system must be drained if the CB Erbium/2.94 is subjected to temperatures below the freezing point of water. If the system is subjected to temperatures below the freezing the point of water, and the water has not been thoroughly drained from the system, the **WARRANTY IS INVALIDATED**.

Only a qualified service technician should either fill or drain the water cooling system.

G. Accessories

The manufacturer reserves the right to substitute or eliminate accessories as necessary. Any substitutions will be made with comparable equipment.

1. Laser Safety EyeWear

The CB Erbium/2.94 is supplied with four pairs of laser safety eyewear. They are have a optical density of 4+ at 2.94 μ . The eyewear meets ANSI standards Z136.1.

Caution: Use only laser safety eyewear provided by Continuum Biomedical or eyewear with an OD of 4+ at 2.94 μ . The eyewear should remain with the laser at all times, and should be worn by everyone present during laser treatment.

2. Handpieces

A 2.0 mm, 3.5mm 5.0mm and a 7.0mm handpiece are provided as part of the CB Erbium/2.94. The size is engraved into each handpiece. One end of the handpiece screws into the articulated arm. The cone screws into the other end.

The handpieces shown in Figure 5 are used to deliver the laser light onto the treatment area at the indicated spot size. The distance to the tissue should be no less than 1 inch and no greater that 3 inches. These handpieces produce a collimated beam of the indicated spot size up to 3 inches from the cone end. After 3 inches, the spot will increase in size.

An air hose is attached to the side of the tapered cone. An air pump, located in side the CB Erbium/2.94 supplies a small purge of air through this tip. The air purge is intended to help reduce particulate matter from scattering up inside the handpiece and coating the protective window.

Ablated tissue from a treatment procedure may collect on the protective window of the handpiece. Consequently, the handpiece should be cleaned after each patient. The protective window can be cleaned using a cotton swab and normal lens cleaning solution. Removing the cone facilitates easy cleaning. Refer to Section 5.A. for the recommended cleaning procedure.

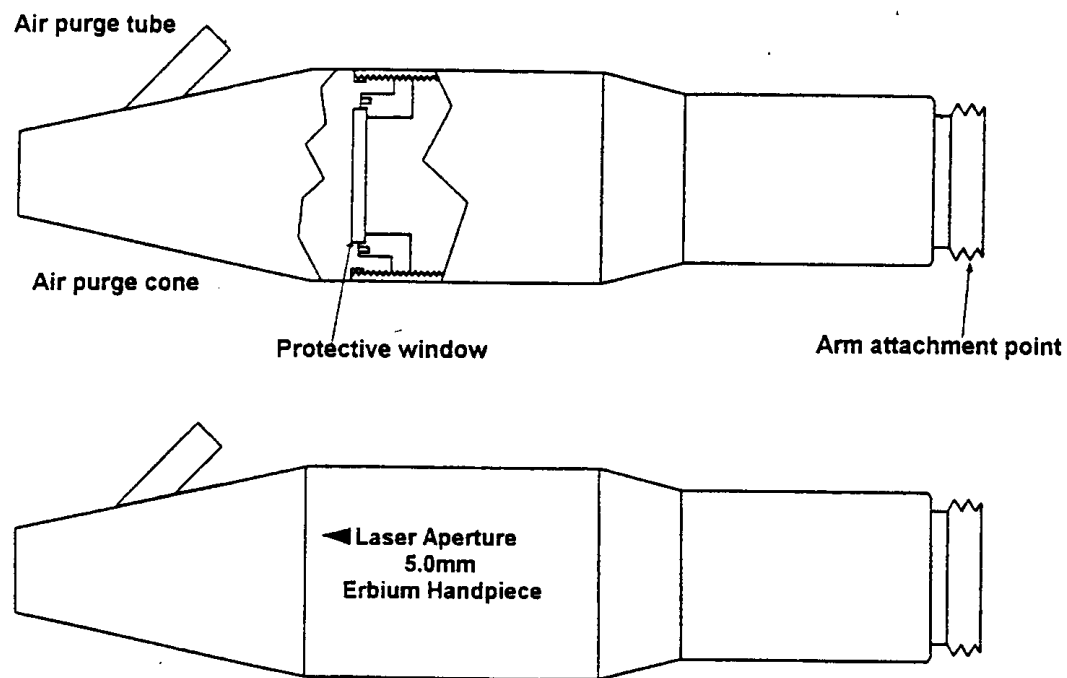
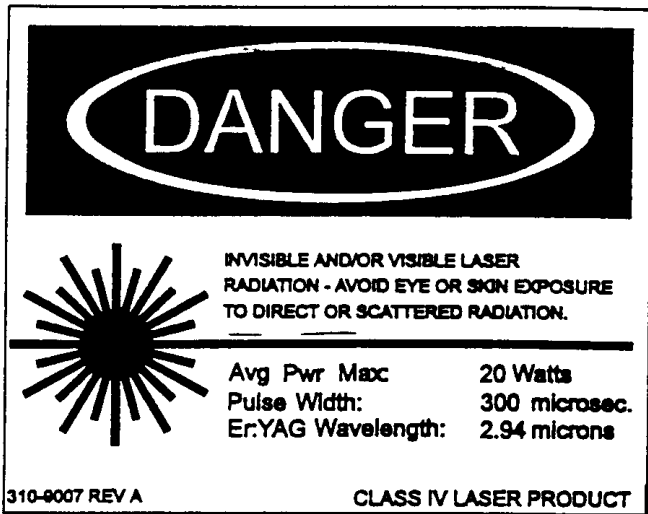


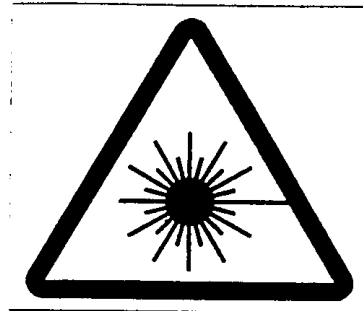
Figure 5 - Collimated Handpiece

H. Warning/Safety Labels

- Label 1. This is the Laser Warning Label indicating the Product is a Class IV device. The label also lists the various laser parameters
- Label 2. This is the label warning of laser output from an adjacent aperture. It is located on the handpiece and on the top surface next to the entrance to the articulated arm.
- Label 3. This is the Laser Aperture label located on the handpiece.
- Label 4. This is the Manufacturer's Certification label. It indicates the manufacturer in the United States, the date of manufacturing and the serial number of the unit
- Label 5. This is a label indicating the product can only be sold to a medical facility, a physician or a physician's representative.
- Label 6. This is the label warning of visible and invisible radiation when the doors are opened and the cover removed and the interlock defeated. It is located on the side panels.
- Label 7. This is the label warning of visible and invisible radiation when the top cover is removed and the doors are closed. It is located on the top cover.
- Label 8. This is a warning concerning electrical power. It is located on the rear panel of the laser.
- Label 9. This is a warning concerning electrical power. It is located on the inside of the laser. Only authorized service individuals should have access to these areas.
- Label 10. This is the Explosive Hazard Warning Label required by UL.
- Label 11. This is the Laser Eyewear Safety Label. It is located on the top surface of the laser.



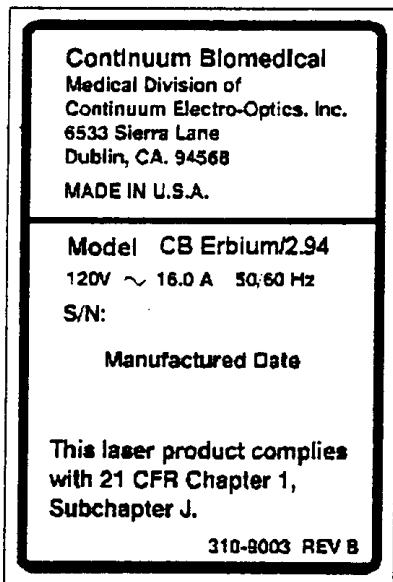
Label 1



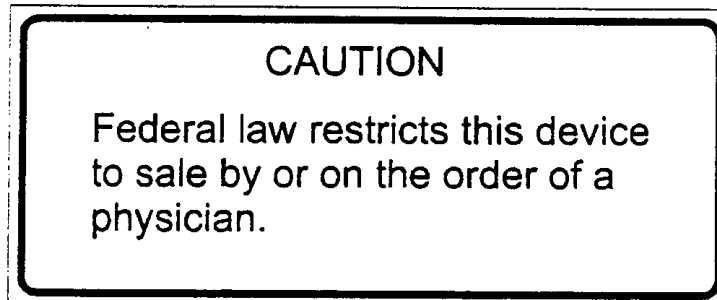
Label 2



Label 3



Label 4



Label 5

DANGER

Visible and invisible laser radiation when open, and interlock defeated. AVOID EYE OR SKIN EXPOSURE TO DIRECT OR SCATTERED RADIATION.

Label 6

DANGER Visible and/or invisible laser radiation when open. AVOID EYE OR SKIN EXPOSURE TO DIRECT OR SCATTERED RADIATION.

Label 7

CAUTION HIGH-VOLTAGE
BEFORE WORKING ON THIS UNIT
-SWITCH OFF POWER SUPPLY
-DISCONNECT ALL PLUGS

Label 8

CAUTION

HIGH VOLTAGE/HIGH CAPACITANCE
UNIT CONTAINS POTENTIALLY LETHAL ELECTRICAL CHARGE

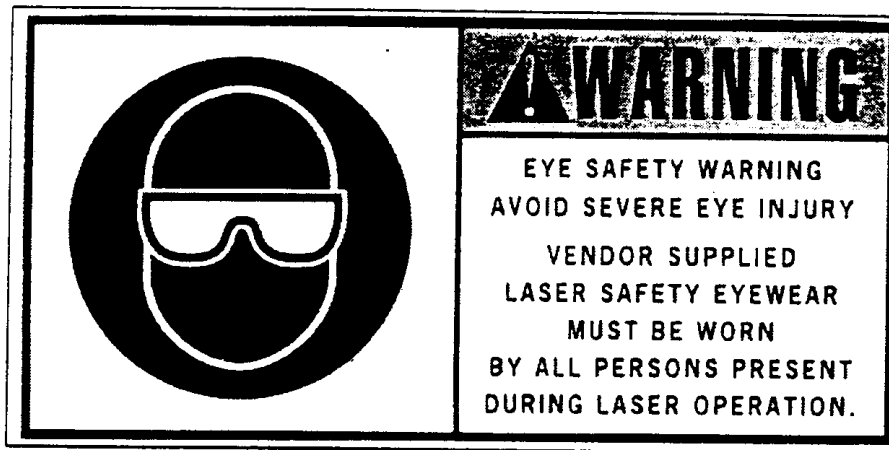
BEFORE WORKING ON UNIT:
-Disconnect All Cables Including Laserhead Plug
-Wear Insulated Gloves
-Short Capacitors to Ground (see Operating Manual)

Label 9

DANGER
EXPLOSION HAZARD

DO NOT USE IN PRESENCE OF FLAMMABLE ANESTHETICS

Label 10



Label 11

4. Operation

A. Set Up

1. Plug power cord into socket at rear of laser. Plug power cord into wall power outlet. Verify the External Interlock is connected properly.
2. Release the Emergency Button located on top of laser by depressing until button pops up.
3. This completes the application of electrical power to the system.

B. Start Up and Operation

WARNING!

Make sure all individuals in the vicinity of the CB Erbium/2.94 have the proper laser protection eyewear. See Section 3.G. for description of this eyewear.

1. Insert key and turn key switch one quarter turn clockwise. An initial delay of approximately 30 seconds follows to enable the microprocessor to complete a check of the various safety features and interlocks of the CB Erbium/2.94. During this period, the installed software version flashes in the indicators for Pulse Energy and Repetition Rate.
2. When all the checks are complete the Control Panel will display "OFF".
3. Press the "STANDBY" keypad. The air pump, water pump and cooling fans start.
4. Turn on aiming beam by pressing the "AIMING" keypad.
5. Make sure the foot switch is connected to the laser and locate it in a comfortable place for the intended treatment.
6. Press the "READY" keypad.
 - a. The letters WM ING appear in the displays, indicating the laser is warming.
 - b. The READY light flashes for approximately 45 seconds.
 - c. When the READY light stops flashing laser is ready for treatment.

Note: While in the Standby mode or when READY light is flashing, laser light is not available from the articulated arm. Pressing the foot switch will not produce emission from the articulated arm.

7. Using the "HIGH" or "LOW" keypads, set the desired treatment pulse energy. Use the chart on the following page to determine energy density for a given spot size.
8. Set the desired repetition rate by pressing the "PPS" keypad under the PPS display on the front panel. (see Figure 3)

Note: The laser will not fire while pulse energy and repetition rate are being set. The footswitch is disarmed.

9. Release the articulated arm by gently lifting the top portion of the clasp and rotating it counterclockwise. Also, release the arm from the fold down clamp located on the long tube of the articulated arm. (For more information on the articulated arm, refer to Section 3.C.)
10. Grasp the handpiece firmly, keep the end of the collimated handpiece within 1 to 3 inches from the tissue, and depress the foot switch to begin treatment.

Note: Do not touch the tissue with end of cone. This will cause excessive contamination of protective window.

11. When treatment is completed, release the foot switch, secure the articulated arm by placing it in its folded position and reinstall it in its clasp.
12. Press the "STANDBY" keypad. The system will return to Standby mode.

WARNING!

Do not remove the laser protection eyewear until the laser system is in Standby mode.

C. Shut Down Procedure

1. From Ready mode press the "STANDBY" keypad. If system is already in Standby mode go to step 2.
2. When "ON STB" appears in the display rotate the key counterclockwise.
3. Remove the key and store in a safe and secured location.

**CB Erbium/2.94 Er:YAG Laser
Energy Density Conversion Chart
(J/cm²)**

	Spotsize			
	2mm	3.5mm	5mm	7mm
100	3.18	1.04	0.51	0.26
200	6.37	2.08	1.02	0.52
300	9.55	3.12	1.53	0.78
400	12.73	4.16	2.04	1.04
500	15.92	5.20	2.55	1.30
600	19.10	6.24	3.06	1.56
700	22.28	7.28	3.57	1.82
800	25.46	8.32	4.07	2.08
900	28.65	9.35	4.58	2.34
1,000	31.83	10.39	5.09	2.60
1,100	35.01	11.43	5.60	2.86
1,200	38.20	12.47	6.11	3.12
1,300	41.38	13.51	6.62	3.38
1,400	44.56	14.55	7.13	3.64
1,500	47.75	15.59	7.64	3.90
1,600	50.93	16.63	8.15	4.16
1,700	54.11	17.67	8.66	4.42
1,800	57.30	18.71	9.17	4.68
1,900	60.48	19.75	9.68	4.94
2,000	63.66	20.79	10.19	5.20

**Energy
Per Pulse
(mJ)**

Table 1

5. Cleaning and Maintenance

A. Laser Cleaning

1. Cleaning of the Handpieces

The handpiece should be cleaned after each patient treatment. This procedure is outlined below:

- While wearing surgical gloves, remove the handpiece from the articulating arm by unthreading it. Unscrew the air purge cone from the handpiece.
- Clean the debris from the cone with a mild detergent and water. Then soak the cone in Cidex cleaner (Glutaraldehyde 2.4%) for 45 minutes. Rinse with water for a minimum of 3 minutes. Dry with a clean cloth. This recommendation follows the AAMI Guidelines, which provides a SAL of at least 10^{-6} .
- Clean any debris from handpiece's protective window with a cotton swab and a lens cleaning solution.

2. Surface Cleaning of the Laser Cabinet

The cabinet may be cleaned using a general purpose cleaner. Wipe dry using a standard paper towel.

B. Calibration Check

The CB Erbium/2.94 utilizes a calibrated photo diode for determining the pulse energy of the system. It is important that the calibration is correct and that it be checked on a periodic basis. *Continuum Biomedical recommends testing the calibration of the CB Erbium/2.94 every three months by a company trained service representative.*

1. Pulse Energy

The pulse energy measured in Joules is the average power divided by the repetition rate. For example, a 10 watt average power laser operating at 10 pulses per second produces 1 Joule per pulse.

2. Calibration

To check the calibration of the CB Erbium/2.94, a properly calibrated laser power meter is required. Continuum Biomedical is prepared to recommend several makes and models of power meters. To check the calibration, follow this procedure.

WARNING!

Make sure all individuals in the vicinity of the CB Erbium/2.94 have the proper laser protection eyewear. See Section 3.G. for description of this eyewear.

Caution: The handpiece **must** be removed from the output end of the articulated arm.

- a. The CB Erbium/2.94 should be in the Ready mode.
- b. Position the articulated arm and properly calibrated power meter such that the laser output from the arm impacts the absorbing surface of the power meter. The average power is measured by depressing the foot switch and operating the CB Erbium/2.94 into the power meter for several seconds, allowing the power meter to stabilize. Record the average power in watts from the power meter and the energy as displayed on the front panel. Divide the average power from the power meter by the rep rate. The displayed and measured values should be within $\pm 20\%$.
- c. Adjust the power using the "LOW" button on the Control Panel and repeat step c for a variety of output energies.
- d. If the CB Erbium/2.94 is not properly calibrated, either call you local service representative or perform the re-calibration procedure described in Service Manual. Continuum Biomedical will supply a copy of the Service Manual upon request.

C. Mirror Inspection and Replacement

The articulated arm mirrors should be inspected by a qualified service technician every three months and replaced when indicated. See Section 3.C. for more information.

6. Technical Description

Continuum Biomedical will make available on request circuit diagrams, component part lists, descriptions, calibration instructions, or any other information which will assist the user's appropriately qualified technical personnel to repair those parts of the CB Erbium/2.94 which are designated by Continuum Biomedical as repairable.

A. Specifications

Laser Parameters

Laser Material:	Erbium Rod; 6mm diameter; 4.5" long
Wavelength:	2.94 μ
Pulse Energy	2.0 Joules \pm 10% from the arm @ 1, 2, 4 and 8Hz
Pulse Energy Density:	Refer to Table 1 for Energy Density at 2.0 Joules for each handpiece (spotsize). Measurements recorded at output end of articulated arm.
Repetition Rate:	1, 2, 4 and 8Hz
Spot Size (nominal):	2.0mm, 3.5mm, 5.0mm, 7.0mm (collimated)
Pulse Duration	Approx. 300 μ sec.
Beam Delivery	Articulated Arm
Output Mode	Flattop Distribution
Safety Goggles:	OD 4+ @ 2.94 μ

Physical Parameters

Dimensions:	Height: 34" (Not including Articulated Arm) Width: 16" Depth: 34" (Includes Handle)
Handpiece Material	Anodized Aluminum
Articulated Arm:	0.75" and 1.0" Diameter Mirrors. Total 7 Mirrors.
Articulated Arm:	Length fully extended >4 feet.
Wheels:	4" diameter; hard rubber; all wheels swivel 360°.
Weight (approximate):	250 pounds
Operating Voltage:	120 Volts +/- 10% or 220* Volts +/- 10%
Operating Current:	20 Amps Max. @120V, 10 Amps Max. @ 220V
Operating Frequency:	50 or 60Hz.
Leakage current:	<200 micro amperes
Operating Temperature:	32°F to 90°F
Operating Humidity:	30% to 85%

* Not all units have a transformer compatible for this voltage.

B. Physics of the Erbium Laser

The operation of the CB Erbium/2.94 Laser System has been designed for the maximum of safety and convenience for both the physician and the patient. This section is provided to assist the operator in better understanding the internal operations of the CB Erbium/2.94 system.

The first part of this section explains the nature of laser pulses, discusses energy and power definitions and serves as a general physics lesson. The second part discusses the fundamentals of an Erbium laser. The third section discusses the microprocessor and its software used to operate the CB Erbium/2.94 Laser system and control its output parameters.

1. Fundamentals of Laser Light

Lasers are categorized by the wavelength of their output and whether they are pulsed or continuous wave (cw). The wavelength of the light is the distance, measured in nanometers (nm), between the intensity peaks of the light as shown in Figure 6. A nanometer is 0.000,000,001 or 1×10^{-9} meters. The frequency of the light is the number of intensity peaks in one second. For green light the wavelength is approximately 500nm and the frequency is 60,000,000,000,000 or 6×10^{14} .

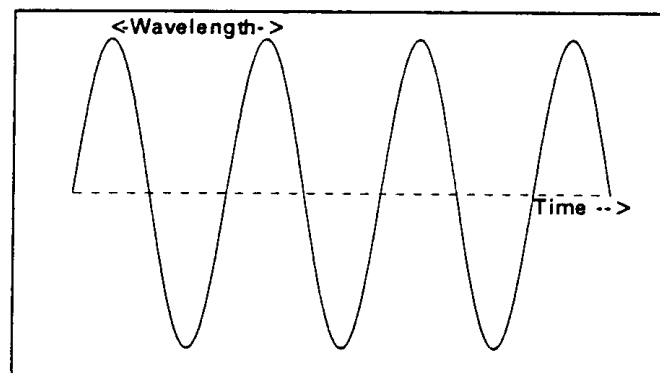


Figure 6 - Wavelength of Light

Figure 7 shows the relative wavelengths of various light colors. The wavelength of ultraviolet light is shorter than visible light while infrared light is longer. On a similar drawing showing frequency rather than wavelength, ultraviolet has a high frequency while infrared has a lower frequency.

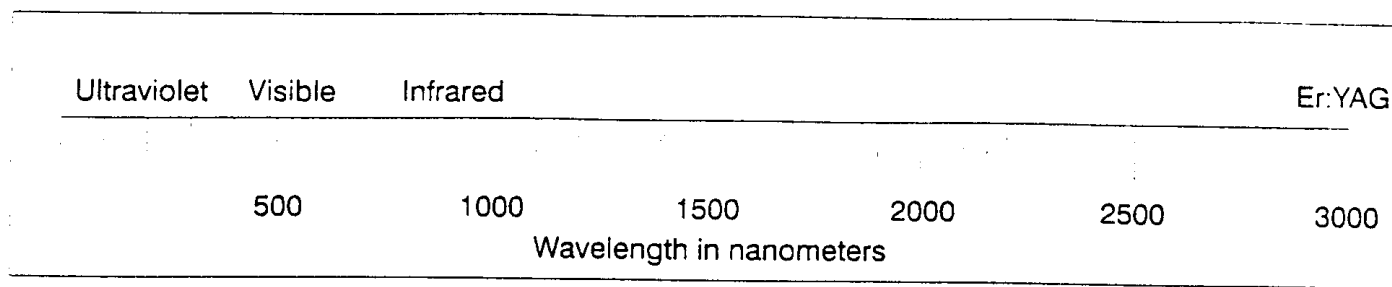


Figure 7 - Wavelength Spectrum

The frequency of light multiplied by its wavelength is the speed of light, a constant number (3×10^8 meters per second.)

In addition to wavelength, lasers are referred to as cw or pulsed. A cw laser produces a steady stream of light measured as average power in watts or kilowatts. A pulsed laser produces a burst of light followed by a period of no light. If repetitively pulsed, the burst repeats itself on a regular basis. The time between pulses is referred to as the interpulse period and the length of each pulse is called the pulse duration. The number of pulses per second is called the repetition rate.

The pulse duration is one for the main variables in pulsed laser. Long pulses generally last for a few milliseconds (10^{-3} seconds). Short pulses are measured in nanoseconds (10^{-9} seconds.) In between is the range of microsecond (10^{-6} seconds) pulses.

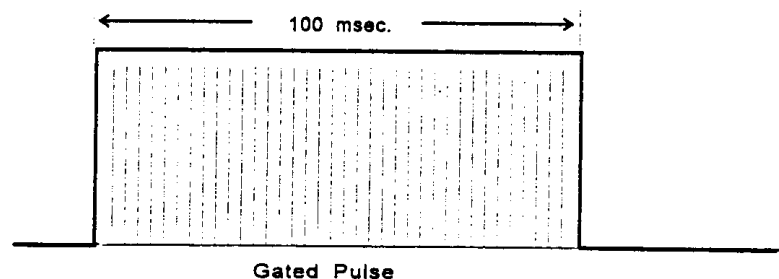


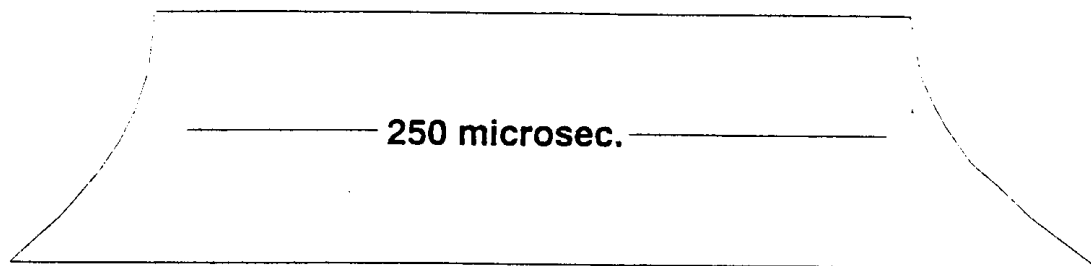
Figure 8 - Laser Burst Mode Operation

Sometimes lasers produce a burst of pulses. For example, a laser operating at 10kHz produces 10,000 pulses per second. If the laser is activated for 0.1 second, it will produce a burst of 1,000 pulses. This is referred to as operating the laser in a burst mode. Figure 8 is an example of a laser operating in burst mode. The total gated pulse duration is 100 msec. Within this gated pulse, there are many smaller pulses.

CW lasers are measured in terms of watts of output power. A watt is a measure of the "flow of energy" or power. The sum of this power over a period of time is the total energy measured in Joules. One Joule is one watt for one second. Since light can be represented as a stream of particles called photons. Each photon, depending upon the wavelength of the light, has a specific energy. Photons with short wavelengths have more energy than photons of longer wavelength.

A watt is a measure of the number of photons multiplied by their energy striking a target at any one instant of time. A Joule is a measure of the total number of these photons striking the target over a period of time.

Figure 9 is a drawing of a laser pulse. The height of the pulse at any time is a measure of the instantaneous power measured in watts. For the Er:YAG laser, the total of the area is 0.1 to 2.0 Joules. The instantaneous power at the peak may be 8 Kilowatts.



*Figure 9 - Typical Laser Pulse
(with fast rise at 250 microseconds full width half max)*

The CB Erbium/2.94 measures energy in a single pulse rather than the average power. At 10 pulses per second and a pulse energy of 1 Joules, the average power from the laser is 10 watts, the product of the pulse energy times the repetition rate.

When the energy from a single pulse is focused to a circular spot, the energy density is often used to measure the output. This is the energy in a single pulse divided by the cross sectional area of the spot generated by the focusing lens. The unit of measure is the Joules/cm².

B. Erbium Laser Fundamentals

An Erbium laser consists of three interconnected sections.. One is the power supply used to provide the proper voltage and current to the laser system. The second is the water cooling system used to remove heat from the power supply and the Erbium rod located in the laser head, the third section, the optical bench. Figure 10 is a diagram of the optical bench consisting of the Erbium laser head, various mirrors, lenses and the photo diode (energy detector).

A high voltage electrical pulse from the power supply excites the flash lamp, which emits a broad spectrum of light in the ultraviolet and visible. The Erbium rod absorbs most of this light and releases the energy as laser light at 2.94 μ . In the CB Erbium/2.94 Laser System, the flash lamp is always operating at the selected pulses per seconds or Hertz. This ensures the temperature of the Erbium rod and the cavity remains constant. A shutter inside the laser cavity prevents lasing during STANDBY mode.

The beam diameter is approximately 5mm corresponding to the diameter of the Erbium rod. It is very collimated and should be directed through the articulated arm without blockage. The optics in the arm are coated for high reflectivity and low loss at 2.94μ . Because of the high pulse intensity of the laser emission, any contamination on these optics will destroy the coatings reducing significantly the laser power. It is important to avoid getting dirt, lint or any other particles on these optics.

At the end of the arm, a lens in the handpiece collimates the beam to the desired spot size. Four handpieces are provided.

The cooling system in the Erbium laser is used to remove heat from the power supply and the laser head. A heat sensor on the laser head protects the system in the event the cooling system fails.

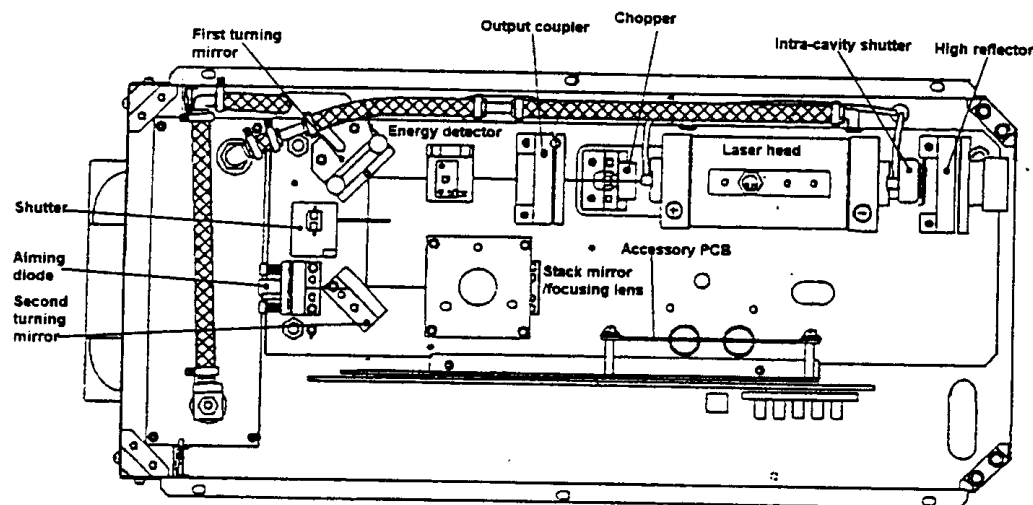


Figure 10 - Laser Bench

7. Error Codes

Errors can be cleared most of the time by pushing the "Standby" keypad when one of the error codes below is flashing on the display. If this does not clear the error, note the error code number and call for service.

This section describes the various error messages that may appear on the Front Panel in the event of a system fault. These messages appear as the letters "ER" in the Energy Density Indicator and a number of the repetition rate indicator. The numbers assist the service personnel in diagnosing the problem.

Code	Error Message	Indication
Er 11	Laser head temp sensor or cover interlock failure.	The laser head has exceeded the maximum temperature or the cover interlock has been opened.
Er 12	Arm shutter not moved.	The arm shutter feedback sensor has not detected a change in shutter position after the controller has told it to move.
Er 13	Interlock not connected.	The external interlock is not connected on the back of the unit. If the external interlock is used, check the interlock entryway.
Er 14	Chopper wheel sync.	The chopper wheel has lost synchronization.
Er 16	Serial port communications error.	The CB Erbium/2.94 controller has detected a bad data stream in the RS-232 serial communications port.
Er 20	Energy error.	The laser cannot achieve the displayed energy level.
Er 21	Simmer supply not working correctly.	Simmer supply has failed to keep the flash lamp simmered.
Er 22	End of charge not detected.	While firing the flash lamp the power supply has failed to recharge the flash lamp capacitors.
Er 24	Defective pyro detector or system is out of calibration.	
Er 31	Coolant over temp.	The temperature of the coolant has exceeded the maximum limit.
Er 32	Coolant flow interrupted.	Coolant flow switch detected lack of flow while the coolant pump was running.
Er 33	Flow switch error during boot.	

Code	Error Message	Indication
Er 61	Key board switch or foot switch error.	A key is stuck on the keypad or the foot switch is held on in an illegal state.
Er 98	Power low by 20% or more.	
Er 99	Power high by 20% or more.	