OPERATION AND MAINTENANCE MANUAL

UNIVERSAL LASER SYSTEMS
Model ULS1750C

Universal Laser Systems, Inc.
7707 East Acoma Drive
Scottsdale, AZ 85260
602/483-1214

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NOTICE

INTRODUCTION

The ULS series of Laser Processing Systems are designed to provide the user with the flexibility of computer control combined with a wide variety of functions.

The main features of the ULS 1750C system are:

- Water cooled, RF driven 50 watt $C0_2$ laser based on the latest technology in sealed carbon dioxide devices.
- Digital laser controller providing a wide range of parameters for material processing.
- Class I safety enclosure.
- Fast X-Y laser beam positioning system for quality laser processing at high speed.
- Large material processing area.
- Extended vertical adjustment with one thousandth increment vertical indicator.
- Two types of computer interface -- parallel (Centronics) and serial (RC-232C).

  Note: Serial interface is not available if the High Speed Raster Engraving Option is installed.
- A variety of controls for quick setting of parameters.
- Complete emulation of HP7475 and Roland DXY 1300 B size plotter.
- Compact design.

SECTION 1 - SAFETY

Please read this section before operating the equipment.

1.1 SAFETY SUMMARY

1. Exposure to laser radiation may produce damage and/or physical burns.

2. Exposure to the beam may cause ignition of combustible materials.

3. When operator or maintenance personnel are working with the laser beam "ON" and any of the safety interlocks defeated, or covers removed, laser safety glasses must be worn and care must be exercised not to place one's self or reflective objects in the path of the beam. Never view laser beam radiation directly or by specular reflection.

4. Operation and maintenance must be accomplished in accordance with this manual.

5. The laser in this system emits radiation at wavelength of 10.6 microns in the far infrared invisible spectrum.

6. A solenoid operated shutter is located between output of the laser and top compartment of the system. In the OFF position the shutter completely blocks the laser beam before it enters the work area. Shutter control is located on the lower right corner of the system control panel. When the shutter switch is open, the LED is on. If any interlocked doors are open, the shutter blocks the beam regardless of the position of shutter control switch.

   NOTE: The LED indicates only whether the shutter switch has been set to open or closed. It does not indicate the physical position of the shutter itself.

7. Under regulations established by the Center for Devices and Radiological Health of the Food and Drug Administration, the laser contained in this system is a Class IV instrument. ULS systems are Class I instruments as long as none of the interlocks are defeated and cover panels are not removed.

8. Improper use of controls and adjustments or performance of procedures other than those specified in this manual may result in hazardous laser radiation exposure.

9. ULS systems are specifically designed to comply with CDRH performance requirements under 21CFR 1040.10 and 1040.11. No guarantees for suitability or safety for any other use are provided by Universal Laser Systems, Inc.

1.2 SAFETY LABELS

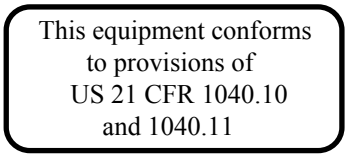
According to CDRH standards, all interlocked and non-interlocked covers that allow access to a Class IV laser beam **must** have appropriate laser safety labels attached to them. These labels must be visible to personnel prior to the removal of the covers. Additional labels must be installed inside the machine and be visible if the covers are removed from the machine.

Labels that provide manufacturer's name, date of manufacture, description of product, model number, serial number and compliance statement must also be visible on the outside of the machine. All CDRH required labels are properly affixed to the machine in the appropriate locations at the time of manufacture. These labels are not to be removed. If they become damaged or removed for any reason, please request additional labels from the manufacturer.

1.2.1 EXAMPLES OF SAFETY LABELS

Label Positions

Lower left corner of rear panel, on the outside of the machine



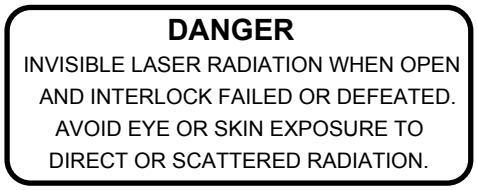
Lower left corner of rear panel below manufacturing label (see above label information).

Below the beam window in top compartment.

Label Positions

Centered on outside of front door (visible when door is closed).

Centered on bottom panel (visible when front door is open).



Inside top door (visible when door is open or closed).

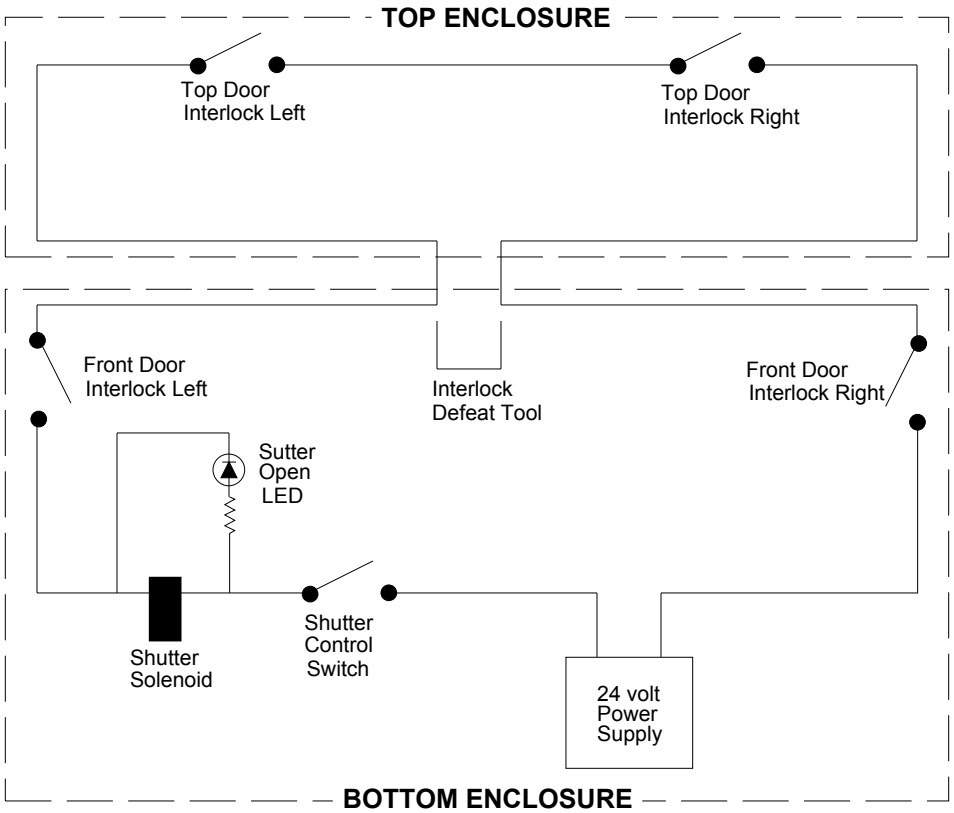
Two on frame inside the top compartment (visible when top cover is removed).

One on each side of interlock defeat tool (visible when interlock tool is installed).

1.3 SAFETY INTERLOCK

The laser system incorporates a safety interlock having an electrical potential of 24V DC between terminals. When the top enclosure of the chassis is removed, the terminals of the interlock connector at the front of the enclosure are no longer in contact and the laser beam will be blocked by the shutter. A shorting plug, called an interlock defeat tool, is provided to over-ride the safety interlock for testing and alignment procedures only. The diagram below is an electrical schematic detailing the interlock system and the interlock defeat tool.

Caution: The interlock defeat tool is utilized only when the top enclosure must be removed for test purposes and beam alignments. Goggles must always be worn when the defeat tools is in use.



Electrical Schematic of Interlock System

SECTION 2 - INSTALLATION

2.1 CAUTIONS

- Install the system on a flat stable base 18-24" high, only in the upright position. Ideally, the top of the system should be mid thigh to waist high.

- Avoid places where the system may be exposed to high temperatures, dust, or high humidity (humidity exceeding 60% or where the temperature is near the dewpoint).

- Avoid places where the system may be exposed to high levels of vibration or electrical noise. We recommend using a high quality surge protector (20 Amp capability) to protect the laser system's electronics.

- The power supply cord and input/output cables for the computer should be connected firmly to avoid disconnection or malfunctioning during operation. Use grounded (3 prong) outlets only. Do not defeat the ground connection under any circumstances.

- When the power is turned on, the automatic origin setting operates and the arm and focusing optics carriage move. Keep hands or objects out of the path of the arm\optics holder.

- When not using the system, unplug the power cord.

- NEVER lubricate any of the mechanical parts!

- Do not apply any pressure or shock to the arm or optical carriage.

- When the X-Y rails get dirty, wipe them off with a soft dry cloth. If the dirt is severe, wipe it off lightly with alcohol. Do not use water. **Do not use silicone-impregnated cloth, neutral detergents or organic solvents.** See the maintenance manual for details on cleaning of the system.

- Do not move arm or optical carriage manually if the power to the system is on!

2.2 SET UP PROCEDURE

The Following is a description of the basic set up procedure.

To connect a ULS series system to a computer for the first time:

1. Install the system on a flat, stable stand. A stand from 18 to 24 inches in height will provide the most comfortable working height. Custom designed, ergometric stands are available from ULS.

2. Connect the fume exhaust tube on the machine to an external exhaust unit.

3. Connect the water cooling tubes from the water chiller.

4. Connect the interface to the computer: both serial and parallel connections are available. (The system is set for parallel connection at the factory.) Most software is set to run in parallel mode, so switching interfacing to serial mode is not normally required.

   Note: Serial Interface is not available if the High Speed Raster Engraving Option is installed.

At this point, the system and chiller are normally ready for power up, therefore, go to Step 9. If your software requires serial interfacing, continue with Steps 5-8.

5. a. To remove the top cover, unclasp the four latches that hold the top cover down. Two latches can be found on the right side of the machine and two can be found on the left side of the machine.

   b. Ensure that the power cord is removed and gently lift the cover up and off of the machine. This will require two people to accomplish. Watch out for the one inch mirror in the front left corner of the machine and the electronics and water lines in the right side of the machine.

6. Set the type of interface using the Dip Switches. Refer to "DIP Switch Settings, section 2.2.2 and Dip Switch Table Appendix A.

7. Set the communication parameters -- These are only set when using a serial connection. They are set by DIP switch. Refer to "DIP Switch Settings, section 2.2.2 and Dip Switch Table Appendix A. (Also, remember to configure the communication settings for the computer and software.)

8. After the setup for serial communication is completed, replace the top cover.

9. Connect the AC power cord.

10. Turn on water chiller. Water temperature should be set to 72**o**F. Be sure the water lines to the laser are open. Also, check to make sure the water chiller has been filled with distilled water to the proper level (remember, empty hoses and the laser itself will slightly reduce the water level in the chiller).

    NOTE: Always turn on water chiller before operating the laser.

11. Turn on the laser system power switch.

Laser processing (engraving) can normally begin at this point.

See SECTION 3 - OPERATION for procedures for focusing laser beam and setting laser controller parameters.

2.2.1 VENTILATION PROCEDURE

To properly exhaust fumes and smoke from the material surface during lasing, 400 cfm minimum is required at the point of 4 inch connection to the system. Use maximum diameter rigid duct work from the roof or down the wall. Reduce the duct work to four inches just before the point of attachment to the laser system.

Locate laser system where a straight run to the ventilator can be achieved. Duct work should be as short as possible between the ventilator and the laser system. Flexible ducting can be used from the laser system to rigid duct work.

Ventilator should be equipped with an on/off switch and wired in accordance with local electrical codes. We recommend plugging the laser system into a 110V switched outlet, controlled by the on/off switch for the ventilator, to ensure laser system cannot be operated without the ventilator. It is also advisable to power the laser system through a surge protector to prevent damage to the electronics and laser.

Installation of the ventilation system should comply with all applicable local and government regulations. We recommend the use of licensed contractors for installation of the equipment.

2.2.2 DIP SWITCH SETTINGS

There are two dip switch blocks on the main control board for the laser system and the cover must be removed to access them. Each block contains ten switches and the two blocks are referred to as Dip Switch one and two.

1. Dip Switch 1 - Located on the right side of the system (under top enclosure) on the printed circuit board with the parallel and serial interface connections. Dip Switch 1, marked "DSW1", has 10 small switches, and is located next to parallel interface connection.

   This switch is used to select the interface (parallel or serial), set field size, and character font, etc. For details refer to "Dip Switch Setting Table" in Appendix A.

2. Dip Switch 2 - Located on the right side of the system (under top enclosure) on the printed circuit board with the parallel and serial interface connections. Dip Switch 2, marked "DSW2", has 10 small switches, and is located next to Dip Switch 1.

This switch is used to set the data format and baud rate when the serial interface is used. For details refer to the "Dip Switch Setting Table" in Appendix A.

2.2.3 CONNECTION WITH COMPUTERS

There are two methods for establishing a connection with the computer:

- Parallel connection (Centronics)
- Serial connection (RS-232C)

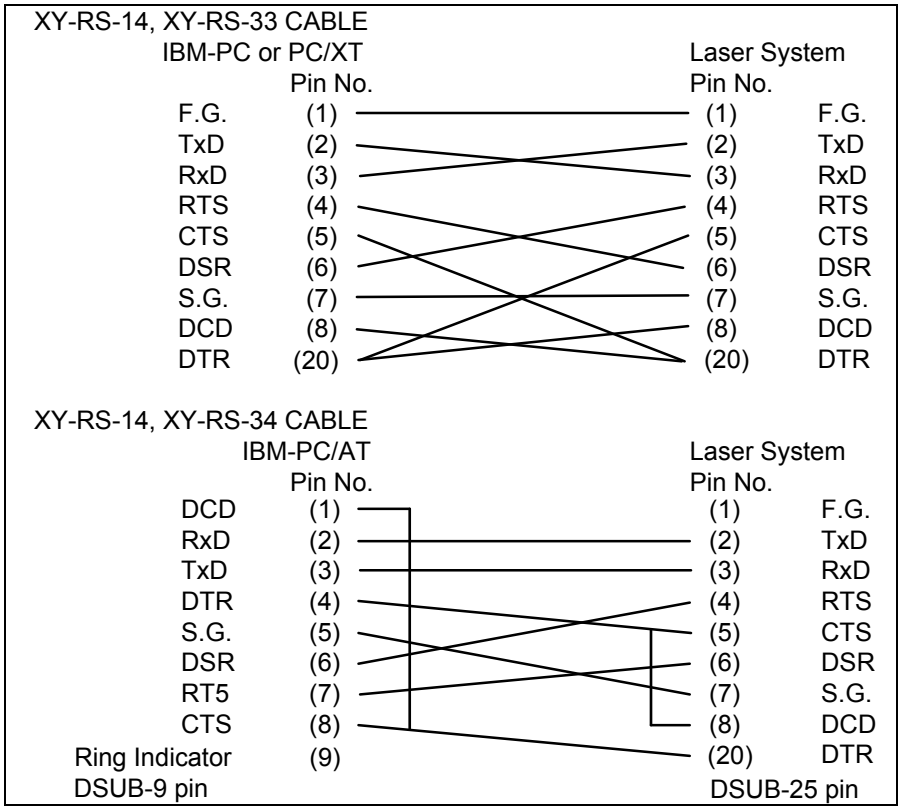
Note: Serial connection is not available if the High Speed Raster Option is installed.

The system is set for a parallel connection at the factory. This will work well with the majority of computers and software packages.

To change to a serial interface connection refer to the "Dip Switch Setting Table" in Appendix A and set the DIP switch settings to match the settings required by the software being used.

2.2.4 RS-232 SERIAL CABLE CONFIGURATION

To use the serial connection on the laser system, the proper serial cable must be used. The diagram below describes the serial cable configuration required.



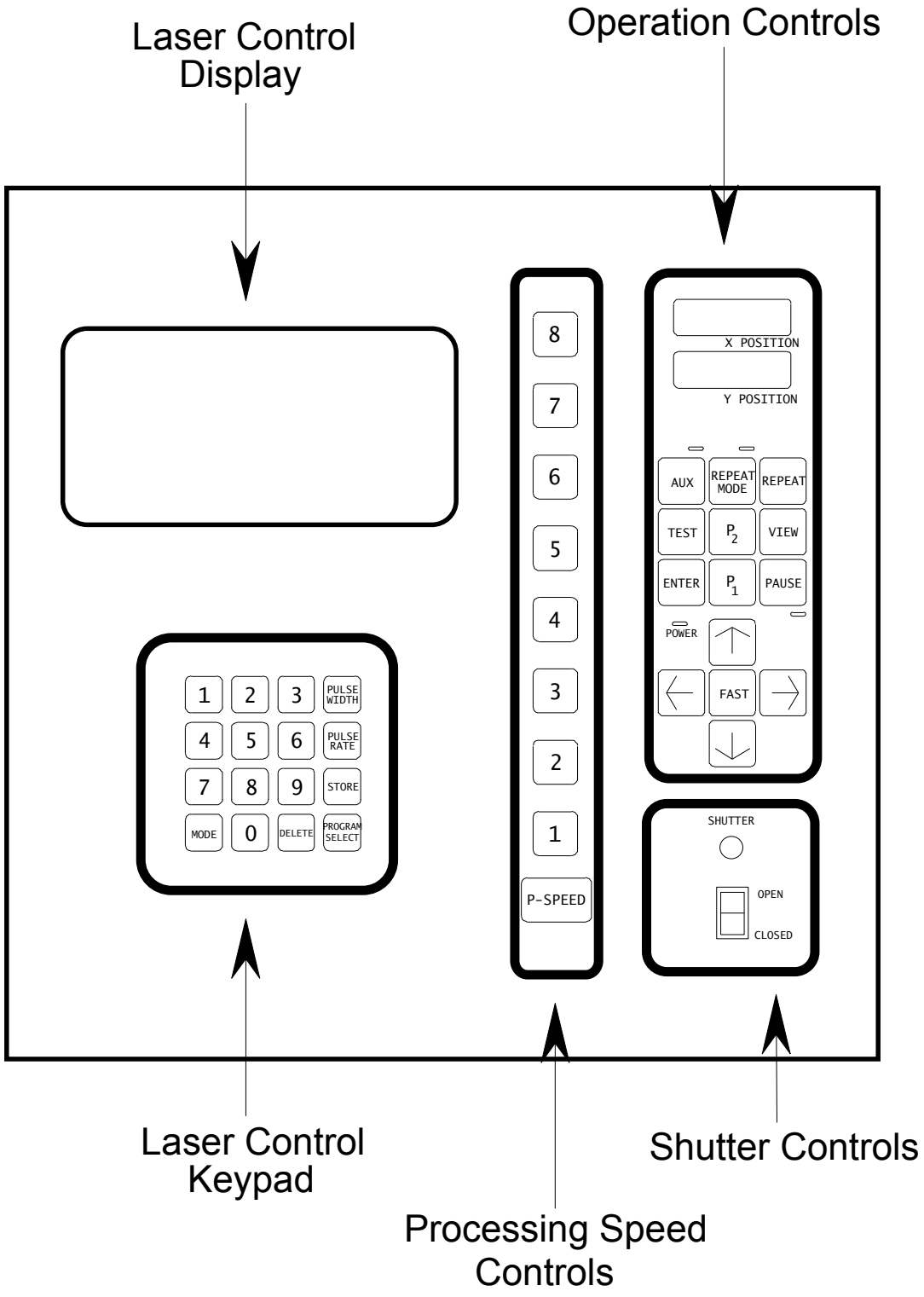
SECTION 3 - OPERATION

3.1 BASIC OPERATING PROCEDURE

1. Turn on water chiller and check that water is flowing to the laser.
2. Turn laser system power ON.
3. Insert the material to be processed.
4. Adjust focus (reference Section 3.8).
5. Close all access doors.
6. Set laser controller parameters (reference Section 3.6).
7. Set the processing speed (reference Section 3.5) (can also be set from software).
8. Be sure shutter switch is in open position.
9. Be sure external exhaust is on.
10. Transmit drawing data from the computer.

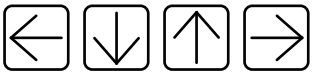
Laser processing of the material should now begin.

3.2 CONTROL PANEL LAYOUT



3.3 OPERATION CONTROLS

POSITIONING KEYS



These keys are used to move the focusing optics manually in any of the arrow directions (four directions) indicated on the keys. Pressing the adjacent two keys together moves it in a diagonal direction.

FAST KEY

Pressing this key together with an arrow POSITIONING key increases the positioning speed at which the focusing optics move.

REFERENCE POINT KEYS - P1 AND P2

Pressing the P1 or P2 keys will move the optics to the lower left or upper right corners, respectively, of the engraving areas. These keys are typically used to position the system for checking power or doing a beam alignment. They can also be used in conjunction with the Test key to manually mark lines on material to indicate the edges of the engraving field or as alignment marks.

VIEW KEY

Pressing this key causes the focusing optics carriage to move to the upper right corner (VIEW position) of the system.

PAUSE KEY AND LED

When this key is pressed once during processing, the PAUSE LED light goes on and motion of the optics is temporarily halted. Pressing this key once more causes the PAUSE LED to go off and the system to resume operation. If the pause is left on for more than one minute, the system will move the optics carriage to the view position (extreme upper right). In either case, the system will resume operation at the point the pause was initially activated.

CAUTION: Laser beam might be on during pause. To prevent damage to work piece, always close shutter switch (located on control panel) prior to pressing PAUSE key.

REPEAT MODE KEY AND LED

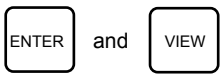
Used to temporarily store drawings that are being sent by the computer. This function allows one to repeat processing many copies of the same drawing and thus free up the computer for other tasks. To use, press the Repeat Mode key and note that the Repeat Mode LED has lit (indicating that all incoming drawings will be stored). Next, send the drawing over to the laser system from the computer. The laser will process the drawing and simultaneously store the drawing in the laser system's memory. The computer can be used for other tasks once the first drawing has been engraved. To repeat the drawing stored in the laser system memory, press the Repeat key (next to the Repeat Mode key). To turn off the Repeat Mode and erase all drawings, press the Repeat Mode key again and note the Repeat Mode LED has gone out (indicating that all drawings have been erased).

CAUTION: Turning off the laser system power will erase all drawings in the repeat mode memory.

NOTE: The repeat mode will continue to store drawings until it is full (the capacity is 1 megabyte). If two drawings are sent to the memory, the first drawing will be processed followed by the second drawing. This is a feature that allows the user to send different parts of a drawing at different times so power settings can be changed on different parts of a drawing, etc. If the 1 megabyte limit on drawing is exceeded, the laser system automatically turns off repeat mode (REPEAT MODE LED goes out) and erases all the drawings.

NOTE: Repeat mode is not functional if the high speed raster engraving option is used to engrave bitmapped or filled images. The repeat mode and high speed raster engraving option can only be used together to engrave vector or outline images.

RESET FUNCTION



If the ENTER KEY is pressed and held down, then the VIEW KEY is pressed, the system will reset to the same conditions as when the machine was first turned on.

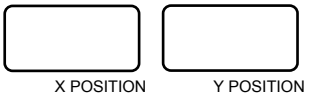
REPEAT KEY

Pressing this key will repeat the drawings stored in the laser's repeat mode memory, starting with the first drawing stored after the REPEAT MODE key was pressed.

POWER/ERROR LED

If an error occurs, the indicator will blink. It displays errors both in commands and in communication protocol with the host computer. Normally this indicator is on and not blinking when power to the laser is on.

X-Y COORDINATE DISPLAY



This displays the position of the focusing optics carriage in millimeters from the extreme lower left of the current engraving field.

AUX. KEY AND LED

Not used - Aux. Key may light when PAUSE or REPEAT MODE are used.

TEST KEY

Used to manually turn the laser power on and off. This key is used to perform beam alignments, power tests, tickle setting and to manually mark origins (with arrow keys), etc. A dot will appear to the right of the pulse mode character in the laser control display when the laser is on (See section 3.6 for details).

3.4 SHUTTER CONTROLS

The shutter controls are used to open and close the mechanical solenoid driven shutter which blocks the beam and stops it from entering the engraving area. The switch will provide power to open and close the shutter and the LED will glow when the shutter switch is in the open position. If any interlocked doors are open, the shutter will close to block the beam regardless of the position of shutter control switch.

NOTE: The LED indicates only whether the shutter switch has been set to open or closed. It does not indicate the physical position of the shutter itself.

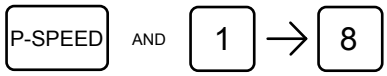
3.5 PROCESSING SPEED CONTROLS

ULS Laser Systems are capable of beam positioning at a maximum speed of 420 mm/sec and this is the default speed selected when the laser systems is powered on . However, for optimum laser processing performance processing speed can be adjusted. The proper processing speed will be dependent on the material being used, the type of engraving or cutting being performed, and the depth of material removal required.

There are two methods for adjusting the processing speed:

1. Control Panel Processing Speed Adjustment:

SPEED SELECT KEYS



Press and hold the P-speed key on the control panel then press one of the processing Speed keys (1 to 8) to change the processing speed. The processing speed set by each speed key is as follows:

P-Speed Key No.	Processing Speed (mm/sec)	Processing Speed (inch/sec)
1	30	1.2
2	40	1.6
3	60	2.4
4	90	3.5
5	120	4.7
6	160	6.3
7	220	8.7
8	420	16.5

Also the above operation can change the processing speed during engraving, therefore, one can use this method to slow the processing speed when high definition images are required. But, if processing speed is being controlled by software, changing speeds manually during engraving may cause unexpected results and is not recommended.

2. Computer Software Package Processing Speed Adjustment

Since the ULS 1750C Laser System emulates an HP-GL plotter device, drawings sent to the laser system from many software packages can include a processing speed which is analogous to the plotter pen speed for a plotting device. See your software manuals for information on how to select "Plotter Pen Speeds".

Example:

> Using Design CAD, from within the plot command one can type in the HP-GL command for pen velocity "VS" with an appropriate speed number 1- 42 cm/sec (this is an HP-GL velocity number in cm/sec and should not be confused with the P-Speed number from the control panel) before sending the drawing to the laser system.

If software resident in Windows is to being used, the processing speed can be set through the ULS Windows printer driver. The procedure for setting speed is explained in the

documentation included with the driver. (This driver is required if Windows is being used and can be purchased from ULS.)

NOTE: A manually set speed will override a software speed command.

3.6 LASER CONTROLS

For optimum engraving performance, the ULS Laser Systems have been designed so that the laser's power output is directed by a digital control board. This control board produces a square wave type signal which is essentially a sequence of on and off commands which cycle the laser at high speeds. The Laser Control keypad is used to enter the parameters for the TTL (square wave) signal which drives the power output of the laser, and an LED display window is provided to visually display the settings for the laser control signal:

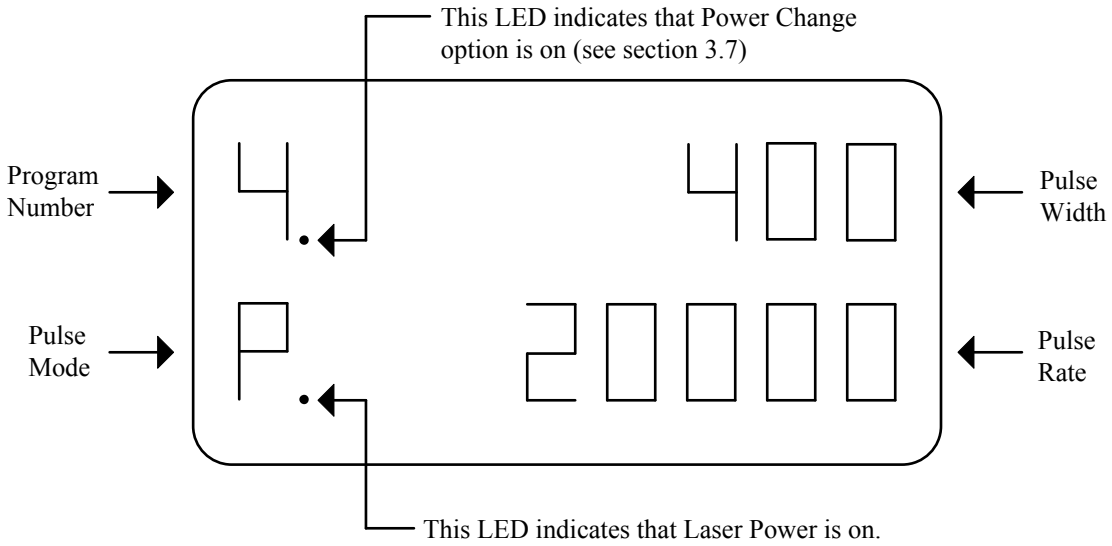


Figure Showing Typical Laser Display

There are three parameters which must be entered to define the characteristics of the signal sent to the laser, these are pulse width, pulse rate, and pulse mode. Pulse width is entered in microseconds and defines the length of time the laser remains on during a pulse cycle. The Pulse rate is a relative number and its meaning is dependent on the pulse mode being used.

There are two pulse modes to choose from:

- Proportional Pulse Mode (PPM)

  Proportional Pulse Mode will be used for most cutting and engraving operations. PPM will provide an even exposure of laser radiation to the material and eliminate variations in depth and line thickness due to acceleration and deceleration of the optical arm. This

even exposure is obtained by linking the laser control pulses with the movement of the motion system. In this way the number of pulses per unit of travel can be made constant and even exposure of the material to laser radiation can be obtained. In proportional mode the pulse rate of the laser control signal is defined in pulses per unit of travel. The lower left corner of the display will indicate "P" if proportional pulse mode is active.

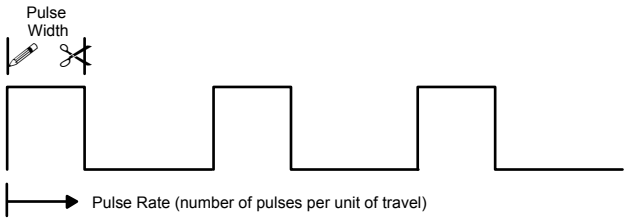


Figure showing laser control signal in proportional pulse mode

- Continuous Pulse Mode (CPM)

  In continuous pulse mode, pulse width and pulse rate are both measured in microseconds and the pulse rate is defined as the time that elapses between the start of one pulse and the start of the next pulse. Continuous Pulse Mode may be used when engraving or marking materials such as coated metals where a higher degree of removal is required; or when cutting materials such as acrylic. CPM mode can be used only on materials that are not sensitive to laser beam overexposure which can occur during acceleration and deceleration of the optical carriage in continuous pulse mode. The lower left corner of the display will indicate "C" if continuous pulse mode is active.

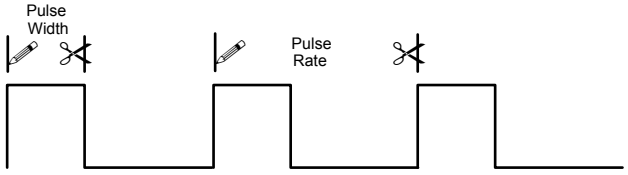


Figure showing laser control signal in continuous pulse mode

To Set Laser Control Parameters:

The ULS Laser Systems have the ability to store 10 different combinations of the three laser control parameters. Each set of laser control parameters is called a program and is identified by a number 0 through 9.

1. Press the PROGRAM SELECT key to enter laser control program mode (the laser control program number in upper left corner of display will blink) and select a program number 0 through 9 on the keypad. The program number selected will appear blinking in the upper left corner of the display panel and the laser control parameters are then entered as follows:

To change Mode:

a. Press Mode key to select the desired mode (P = PPM; C = CPM, ☰ =OFF)

To select Pulse Width (0 - 1400):

a. Press PULSE WIDTH key (pulse width data in upper right corner of the display will blink)

b. Enter new data with number key, or edit with DELETE key then enter data

c. Press PULSE WIDTH key to exit Pulse Width

To select Pulse Rate (10 - 39999):

a. Press PULSE RATE key (pulse rate data in the lower right corner of the display will blink)

b. Enter new data with number keys, or edit with DELETE key then enter data

c. Press PULSE RATE key to exit pulse rate

2. Press the STORE key to exit laser control program mode.

3. Repeat steps 1 and 2 until all desired combinations of laser control parameters are stored in programs.

4. After all of the desired pulse settings have been entered into programs, to permanently save the programmed settings so that they will not be lost when the laser system is turned off, press in rapid sequence the zero key, the store key, and the mode key. The entire display will blink once to indicate that the programs are permanently stored.

NOTE: A Programs laser control parameters can be changed during engraving with out problems but do not attempt to permanently store the settings as described in step 4 above while the system is engraving or the machine will lock up and have to be reset.

To Recall Stored Laser Control Parameters:

During normal operation the laser system uses the laser control parameters which appear on the display screen. To recalled a different set of stored laser control parameters for use, press in sequence the program select key, the program number which contains the desired laser control parameters and the store key.

See Appendix C for suggested laser control parameters for several common materials.

CAUTION: The laser control parameters and speed of processing all effect the final results. It is recommended that experimentation be done on a trial piece of material until desirable results are obtained.

3.7 SOFTWARE CONTROLLED POWER CHANGE (optional)

The ULS Laser Engraving Systems have the optional ability to accept software commands to change power settings before and during engraving, which comes from the fact that the laser systems emulate an HP-GL plotting device. This ability is best understood by an analogy to a plotting device. The program numbers mentioned in section 3.6 can be thought of as pen numbers and when a color in a software package is assigned a pen number that color will be engraved using the Pulse settings stored in the corresponding program number. Once the power settings have been stored in programs as described in section 3.6, accessing a power setting using software is only a matter of assigning the appropriate color to a particular portion of a drawing.

The color/pen number combinations vary from software package to software package and it is best to consult your software manual to find out which colors correspond to which pen numbers in a particular piece of software. Many software packages also give the user the ability to assign a color or several colors to a pen. If Microsoft Windows is being used, the color pen/number combinations are found in the ULS Windows Printer Driver. Use of the driver is explained in the documentation which accompanied it. (This driver is required if Windows is being used and can be purchased from ULS.)

The power change option can be turned on and off by pressing a sequence of keys. If the option is turned of the machine will operate in manual mode as described in section 3.6. To turn the option on, press in sequence the 0 and 8 keys and to turn the option off, press in sequence the 0 and 9 keys. A dot will appear on the display to the right of the program number to indicate that the option is turned on.

3.8 FOCUSING PROCEDURE

Laser Processing should be done with the laser beam focused on the top surface of the work piece. The focal length of standard optics, provided with the system, is 2.5 inches. To find the proper focus position for the work piece, measure the thickness of the work piece with a micrometer and dial the Z axis crank knob to this same thickness. The numbers near the dial indicate X axis movements in one thousandths (0.001 inch) increments.

NOTE: The focal length of high resolution optics is 1.5 inches. You must subtract an additional one inch (01000) from the measured work piece thickness to obtain proper focus.

For example:

a. Work piece is 1/2" or 500 thousandths (.500) inch thick. Dial the Z axis to 00500 to focus the system to the top of the work piece.

b. Work piece is 1.126" thick. Dial the Z axis to 01126 for proper focus.

c. With high resolution lens installed, you measure a work piece of 1.126 inches. Dial the Z axis to 00126 for proper focus.

An alternate method of focusing the system is to use a focus tool. This is an optional part available from ULS.

To use the focusing tool with the system:

a. Set the focus tool base on the surface to be processed.

b. Position the flat side of the focus tool along side and touching the square lens holder on the Y axis arm (this is the square tube that holds the final focus lens).

c. Move the Z axis stage down by turning the crank knob at the top of the system counterclockwise until the flat of the focus tool can be placed flat against the square lens holder.

d. Observe the top of the focus tool. Now raise the Z axis stage (by cranking the knob clockwise) until the focus tool just starts to tilt away from the square lens holder. Back the Z stage down again slightly so the focus tool again sets flat against the side of the square lens holder. This is the proper focus distance for the lens.

CAUTION: Do not apply force on the optics, housing or arm. Severe damage may result! Don't position the focus tool under the lens - lens damage may occur.

NOTE: The 2.5 (standard resolution) and 1.5 (high resolution) lenses require different focus tools.

3.9 COMMAND SYSTEM

The ULS laser systems emulate an HP-GL plotting device and therefore are controlled by a built in library of HP-GL Commands. The HP-GL command set used is actually RD-GL-I and is a superset of HP-GL commands written by Roland Digital Corporation. Some of the characteristics of this command language are listed below.

1. There are 56 types of command.

2. Several commands must be combined to execute one action.

3. The commands can be used to write custom software applications.

4. They permit high definition. (Enlargement, reduction, origin movement, window clipping and terminator definition among others.)

When using commercial software, the user does not need to understand RD-GL-I, since the software will perform the conversions to RD-GL-I invisibly before outputting to the laser system. However, if the user desires to write custom software applications, a reference manually detailing the RD-GL-I command language is available from ULS.

3.10 LASER PROCESSING AREA

The range and maximum processing area of the ULS engraving systems will vary according to the field size selected by the dip switches.

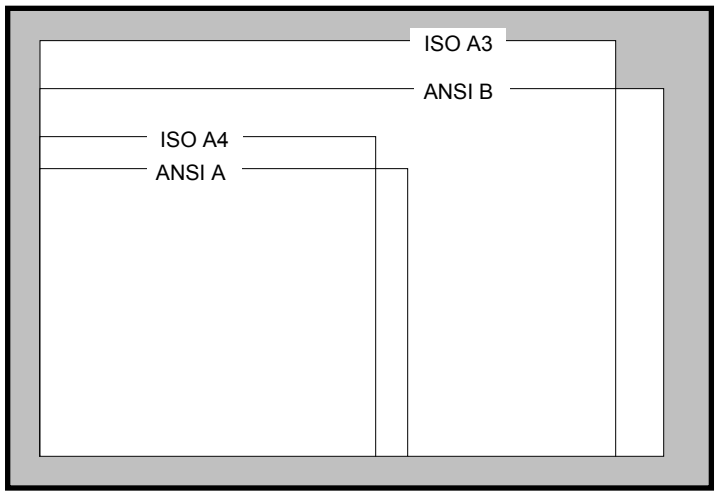


Figure showing Field sizes on the engraving plate

The origin of each field will lie at the bottom left corner of the field. The following table shows the areas for each standard field size. The Dip switches are set to the expanded field size at the factory providing the maximum processing area (11.7 x 17"). This is the most useful size for the majority of users since it allows the full engraving area to be accessed at all times and it is recommended that the machine be operated in this configuration.

Field Size	Maximum Processing Area	Dip Switch Settings SW1-6	SW1-7	SW1-8
420 x 297 mm	403.95 x 276 mm	OFF	OFF	OFF

297 x 210 mm	276 x 193.025 mm	OFF	ON	OFF
431.8 x 279.4 mm 17 x 11 in	416 x 259.125 mm 16.37 x 10.20 in	OFF	OFF	ON
279.4 x 215.9 mm 11 x 8.5 in	259.125 x 199.05 mm 10.20 x 7.83 in	OFF	ON	ON
Expanded	431.8 x 297 mm 17 x 11.69 in	ON	--	--

NOTE: Setting the field size for the Laser System will not guarantee access to the entire field unless the software being used is configured with the same page size dimensions. For the procedure required to configuring software page size please consult the software manuals for the program being used.

SECTION 4 - MAINTENANCE

4.1 SAFETY

Please read the entire manual before operation of equipment.

1. **CAUTION:** The laser beam emitted in this machine is invisible. Exposure to laser radiation may produce damage and/or physical burns.

2. Exposure to the beam may cause ignition of combustible materials.

3. When operator or maintenance personnel are working with the laser beam "ON" and any of the safety interlocks defeated, or covers remove, laser safety goggles must be worn and care must be exercised to not place one's self or reflective objects in the path of the beam. Never view laser beam radiation directly or by specular reflection.

4. Operation, maintenance and service must be accomplished in accordance with this manual.

5. All personnel except the person working on the system during maintenance or service should be cleared from the laser room.

6. The laser in this system emits radiation at a wavelength of 10.6 microns in the far infrared spectrum (beam is invisible).

7. A solenoid operated shutter is located between output of the laser and top compartment of the system. In the OFF position the shutter completely blocks the laser beam before it enters the work area. Shutter control is located on the top right corner of the system on the control panel. When shutter is open, the LED is on. If any interlocked doors are open, the shutter blocks the beam regardless of the position of the shutter control switch.

8. Under regulations established by the Center for Devices and Radiological Health of the Food and Drug Administration, the laser contained in this system is a Class IV instrument. ULS systems are Class I instruments as long as none of the interlocks are defeated and cover panels are not removed.

9. Following procedures or making adjustments, other than those specified in this manual, may result in hazardous laser radiation exposure.

10. ULS systems are specifically designed to comply with CDRH performance requirements under 21CFR 1040.10 and 1040.11. No guarantees for suitability or safety for any other use are provided by Universal Laser Systems, Inc.

4.2 GENERAL CLEANING

1. Ensure system power is off.

2. Clean the bottom of the Y rail, right and left sides, and the Y rail groove on both sides using a cotton swab and alcohol.

   NOTE: Keep swabs used in mirror cleaning for general cleaning.

3. After the Y rail is clean, use a clean swab wetted with alcohol to clean the three Y bearings. Put a swab against the rail and bearing and manually move the focus lens carriage back and forth several times to clean each bearing.

4. Clean front X rail and groove using a cotton swab and alcohol. The front X rail, with its four white bearings, must be cleaned on both front and rear sides.

5. Clean the four X rail bearings using a swab wetted with alcohol as in Step 3. Manually move the Y rail left and right several times for each bearing.

6. Clean rear X rail on the top and bottom with a tissue and alcohol.

7. With Z axis up, clean the material holding plate with glass cleaner and a paper towel. For stubborn stains either alcohol or acetone may be used to remove residue.

8. Move Z stage down to bottom and clean the Z stage guide way with glass cleaner and a paper towel.

9. Remove exhaust hose and clean exhaust tube with glass cleaner and a paper towel, then replace exhaust hose.

10. Check air filters and clean when dirty. The filters can be washed with soap and water if necessary. To remove the filter, unscrew the four 8-32 screws and slide the filter out through the hole in the side panel.

11. Spray inside the front door with glass cleaner and wipe very gently with tissue. Close the front door and clean the outside with glass cleaner. Be careful when cleaning because any excess pressure will permanently scratch the Lexan.

12. Open top door completely and spray inside of door with glass cleaner and wipe gently.

13. Close top door and spray entire top with glass cleaner. Wipe the door and control panel with tissues and the painted top enclosure with paper towels. Clean the door handle top, side and bottom. If flakes of dirt get in corners of control panel, use Aero Duster or any other duster used for cameras and optics to remove the debris.

CAUTION: All Lexan surfaces should be cleaned with tissue, NOT paper towels. Use of paper towels or brushes will scratch the Lexan.

NOTE: Dirt in any parts of motion system will cause uneven engraving or loss of position. A clean machine is the best performing machine.

4.3 OPTICS CLEANING

INTRODUCTION

Optics cleaning on the 50 Watt CO_2 system is especially important. First, clean optics provide the most power at the focal point, making the engraving/cutting process efficient. Secondly, due to the high energy level of the beam, any dirt left on the lens or a mirror will cause that optical element to heat and, eventually, fail.

NOTE: Failure of optics due to improper or inadequate cleaning will void the 90 day warranty on these optics.

NOTE: Wash hands with soap and water prior to handling optics.

4.3.1 TOP ENCLOSURE REMOVAL AND REPLACEMENT

1. Disconnect the power cord to the machine.

2. To remove the top cover, unclasp the four latches that hold the top cover down. Two latches can be found on the right side of the machine and two can be found on the left side of the machine.

3. Ensure power cord is removed then gently lift the cover up and off of the machine. This will require two people to accomplish. Watch out for the one inch mirror in the front left corner of the machine and the electronics and water lines on the right side of the machine.

4.3.2 FINAL FOCUS LENS

1. Remove four 2-56 socket head cap screws from bottom of lens holder located on movable arm. Hold on to sides of the lens holder while removing screws so holder and lens do not drop (reference Figure 12).

2. Remove lens holder. The lens holder, one thick lens spacer, one thin lens spacer, and the yellow lens will come out as a unit. Hold the lens holder level so spacers and lens do not fall out.

3. Remove thick lens spacer (always placed on top of the lens).

4. Hold lens holder in left hand and a clean sheet of lens tissue flat in right hand. Carefully turn the lens holder in your left hand upside down onto tissue and lens will drop out onto lens tissue. When removing lens from holder, stand over a table and keep hands within 3 inches above the table. This will prevent lens damage should the lens fall.

5. Place lens and tissue in a safe place. Inspect thin lens spacer and clean it with a swab and lens cleaner. Inspect and clean lens holder.

6. Put thin lens spacer back into lens holder.

7. Clean oil off of your fingers using acetone.

8. Hold lens by edges using lens tissue and thoroughly dust off the lens using a source of oil free compressed air. A small, hand held, compressed freon duster sold to photographers is satisfactory. Take caution to hold can upright so liquid propellant does not get on the optical equipment.

9. Fold clean lens tissue in fourths, then place lens in between the doubled tissue. Apply lens cleaning solution #1 to the double thick lens tissue covering the lens using the small plastic wash bottle. Make sure both top and bottom surfaces of the lens are covered by wetted tissue. Let it sit for one minute.

10. Final cleaning is done by gently wiping the lens, using several sheets of clean photographic lens tissue soaked with lens cleaning solution #1. Clean the lens by wiping across the top of lens, moving in one direction only. After one wipe, use a clean section of tissue and wipe again. Clean both sides of the lens.

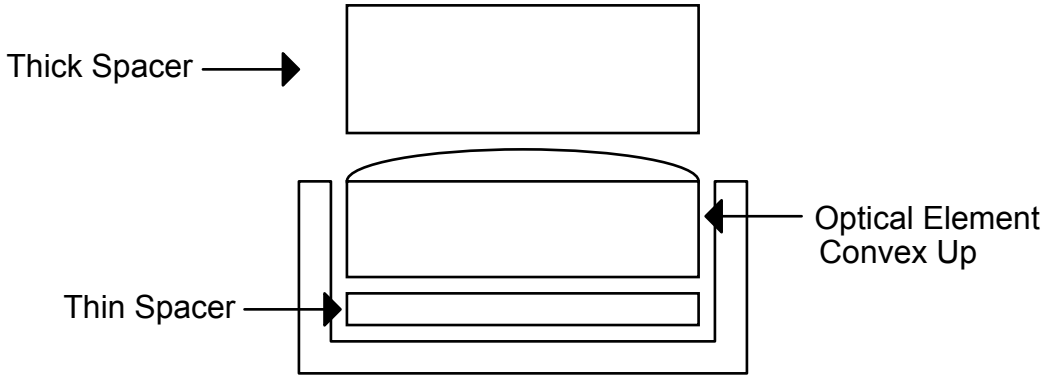
11. Dry optical surface with lens tissue.

    NOTE: Never use the same tissue twice. Dust build-up on the previous tissue may scratch the surface of the lens. Always wipe in one direction when cleaning and use a clean section of lens tissue with each pass to prevent scratching.

12. Replace focus lens into lens holder ensuring convex(curved) side of lens is facing up away from thins spacer. See diagram below.

    To tell which side is the curved side, fold a clean piece of lens tissue over the lens. Gently rub the lens between your fore finger and thumb. One can feel the difference in curvature if the thumb and forefinger are switched back and forth between the sides of the lens.

Diagram:



13. Place the thick spacer on top of the final focus lens element.

14. Carefully slide the lens holder assembly back into the holder on the rail.

15. Replace the four 2-56 screws and tighten gently, just enough to snug the lens in place. Tighten one corner screw, then move to the corner diagonal to it and so on to evenly set the lens.

    NOTE: Over-tightening these screws can cause the lens to break.

The mirrors are provided with a durable, multilayer coating and will withstand repeated cleanings if care is taken and they are cleaned properly following these instructions:

4.3.3 FIRST MIRROR CLEANING

1. Top Enclosure Removal:

    a. To remove the top cover, unclasp the four latches that hold the top cover down. Two latches can be found on the left side of the machine and two can be found on the right side of the machine.

    b. Ensure power cord is removed then gently lift the cover up and off of the machine. This will require two people to accomplish. Watch out for the one inch mirror in the front left corner of the machine and the electronics and water lines on the right side of the machine.

2. This mirror shouldn't require cleaning because it is protected by an output window installed on the shutter block. Removal of this mirror should only be done at the request of ULS and should be performed by a qualified service technician.

3. The first mirror is located inside the shutter block which is at the output end of the laser. To access this mirror, one must remove the top cover and then remove the mirror.

   NOTE: If this mirror is removed, a beam alignment is required after the mirror is replaced.

4. Loosen set screws on the rear and side of the shutter support block and remove the #1 mirror holder from the shutter support block (reference Figure 12).

5. Remove the two 4-4- x 1/8" nylon tip set screws and replace with new ones.

6. Thoroughly dust off the mirror using the oil free compressed air or the freon duster described in Section 1, Paragraph h.

7. Apply lens cleaning solution #1 to the mirror using the small plastic wash bottle. Let sit for one minute.

8. Final cleaning is done by gently wiping using several 100% cotton swabs. Soak the lens with lens cleaning solution #1 and then gently roll the swab and wipe the mirror surface. Clean only once with each swab, while wiping, and make sure that the wiping is done in one direction only.

9. Use a new swab and repeat rolling across the mirror once with each new swab until the mirror is clean and dry.

   NOTE: Never use a swab twice as dust build-up on the swab may scratch the mirror's surface.

10. Reinstall mirror holder into shutter support with mirror surface at a 45^{o} angle towards the front of machine. Tighten set screws until the mirror holder rotates with some friction.

11. Realign optics per the beam alignment procedure (reference Section 4.6 - qualified maintenance technicians only).

4.3.4 OUTPUT WINDOW CLEANING

1. The output window is located in the left rear portion of the processing area, and is accessible only with the top cover removed.

2. To clean the outside surface of the window, first blow off the window with a photographic air duster, as described in Section 1, Paragraph h.

3. Apply lens cleaning solution #1 to the window using the sprayer bottle. Let sit for one minute.

4. Use a clean, 100% cotton, swab to wipe off any remaining surface accumulation on the window. Wipe one section of the window, then using a clean swab, wipe the next section. Continue in this manner until the entire window surface is clean and dry. Do not use excessive pressure or it may scratch the window. If the window becomes scratched, laser radiation can be reflected inside the machine, reducing power and possibly ruining the window.

4.3.5 SECOND MIRROR CLEANING

1. The second mirror is located in the front left corner of the machine and may be reached only if the top enclosure of the machine is off (reference Figure 12). To remove the top enclosure, see section on "Top Enclosure Removal".

2. Thoroughly dust off the #2 mirror using the oil free compressed air or the freon duster as described in Section 1, Paragraph h.

3. Double a piece of lens tissue (lengthwise) and place against the #2 mirror.

4. Apply lens cleaning solution #1 to the tissue and mirror using the small plastic bottle. The lens tissue should stick to the mirror and completely wet the surface. Let sit for one minute.

5. Final cleaning is done by gently pulling the wet tissue across the mirror surface in one direction only, using doubled sheets of photographic lens tissue soaked onto the lens as in Step 4.

6. Dry mirror surface with a clean dry tissue.

NOTE: Never use the same tissue twice as dust build-up on the tissue may scratch the surface of the mirror. Move the tissue across the mirror in one direction only.

4.3.6 THIRD MIRROR CLEANING

1. The third mirror is at the front of the movable (Y axis) arm. The top of the machine will have to be removed to get to this mirror (reference Figure 12).

2. Remove the 2-56 socket head cap screw holding the #3 mirror bracket and pull mirror and bracket straight away from mirror holder (reference Figure 12). Clean the #3 mirror per instructions for the #4 mirror (see Step 5). Replace mirror per instructions in Step 5.

4.3.7 FOURTH MIRROR CLEANING

1. The fourth mirror is located just above the final focus lens and is held in place by a single 2-56 socket head cap screw and 2-56 washer (reference Figure 12).

2. Hold on to the #4 mirror bracket, then remove the 2-56 screw. Lift the mirror and holder straight off the angled portion of the optics holder.

3. Thoroughly dust off the mirror using the oil free compressed air or the freon duster as described in Section 1, Paragraph h.

4. Apply lens cleaning solution #1 to the mirror using the small plastic bottle. Let sit for one minute.

5. Using a clean, 100% cotton, swab, gently roll across mirror once.

6. Use a new swab and repeat rolling across mirror once with each new swab until the mirror is clean and dry. **NOTE:** Never use a swab twice as dust build-up on the swab may scratch the mirror's surface.

7. Replace mirror on the optics by setting mirror and bracket straight down onto the angled portion of the optics holder and screw in the 2-56 screw and washer.

NOTE: Sliding mirror on optics holder will cause scratching of mirror (reference Figure 12).

4.4 LASER REPLACEMENT

Tools required: 1/4" Flat screwdriver, Crimper, Wire Cutters, 9/64" Allen (Hex) Wrenches (for 8-32 and 10-32 screws).

The ULS system has been designed with a field replaceable laser.

Follow the procedure below to replace the laser:

1. Confirm through your distributor or ULS that laser replacement is necessary.

2. Turn off power to the system and disconnect the power cord.

3. Shut off water supply to/from water chiller and disconnect water lines at the laser. Place hose ends in a bucket to catch water.

4. Remove the top enclosure.

    a. To remove the top cover, unclasp the four latches that hold the top cover down. Two latches can be found on the left side of the machine and two can be found on the right side of the machine.

b. Carefully lift enclosure straight up approximately one foot to remove and then set aside.

5. Looking at the laser from the front of the system, remove the three center 10-32 x 1" screws and washers from the laser support brackets. Next, remove the lower left screw and washer. Place your left hand under the left end of the laser and remove the upper left screw. Carefully set the left end of the laser down on the lower enclosure. Hold the right side of the laser with your right hand and remove the final (6th) 10-32 screw from the right most bracket and set the right end of the laser down on the bottom enclosure.

CAUTION: The laser weighs 45 pounds. Use care when handling to prevent personal injury or damage to the laser.

6. Disconnect the red and black 8 gauge cables leading from the power supply to the laser. The 28V power supply is located under the power panel in the right rear corner of the bottom enclosure. Cut the ring connectors off the wire and pull the wires out through the rubber grommets in the bottom enclosure.

7. Remove the output end plate/shutter block combination from the output end of the laser. Remove the protective aluminum cover from the output end of the replacement laser and install on the defective laser.

8. Box the defective laser in the packing box that previously held the replacement laser.

4.5 LASER INSTALLATION

1. Set the laser on the bottom enclosure with the cable end to the right (as you face the front of the machine).

2. Pull the red and black cables through the grommets on the lower enclosure. Route cables to the large power supply and install ring connectors using crimpers. Screw the red cable to the +28V side and the black cable to the -28V side.

3. Install the output end plate/shutter block combination on the output end of the laser.

4. Slide the laser up to the laser support brackets. As you look at the laser from the front of the machine, lift the right side (power cable end) up with your right hand about half an inch and install the far right screw into the laser and use Locktite 242. This screw goes through the middle hole of the far right hand bracket. Tighten the screw so it is snug, but not tight. Next, lift the left hand side of the laser, install the screw in the upper left corner and snug it down. The screw in the lower left corner is next, followed by the screw in the middle of the bracket that is second from the right. Finally, install the two screws in the top and bottom of the laser bracket second from left. Tighten all screws down tight.

5. Check to make sure the laser end plate (which contains the solenoid) is on tight.

6. Now perform a beam alignment on the system. After the beam alignment is finished, the top cover can be reinstalled.

4.6 BEAM ALIGNMENT

Tools required: Thermal Paper (available from ULS), Masking Tape, 1/16, .050" Allen Wrenches.

1. Top Enclosure Removal:

   a. To remove the top cover, unclasp the four latches that hold the top cover down. Two latches can be found on the right side of the machine and two can be found on the left side of the machine.

   b. Ensure power cord is removed then gently lift the cover up and off of the machine. This will require two people to accomplish. Watch out for the one inch mirror in the front left corner of the machine and the electronics and water lines on the right side of the machine.

2. The defeat tool must be inserted into its receptacle in the center of the machine, behind the front frame of the machine (reference Figure 13).

3. Remove the #3 and #4 mirrors and the final focus lens.

❖CAUTION DANGER❖

Invisible laser radiation is radiated from this machine when the top cover is removed and the interlock is defeated, no protection from injury is in place. Avoid eye or skin exposure to direct or scattered radiation. An approved laser safety goggle MUST be worn during alignment. Keep hands, arms, and eyes out of beam path as clothing and skin can be burned.

4. Plug in the machine after removing the top enclosure.

5. Close shutter switch and turn on machine.

6. Set laser power:

   a. Depress and release "Program Select" on the keypad.

   b. Depress and release "Pulse Width" on the keypad.

NOTE: Upper right display should be flashing.

c. Using keypad, enter "30".

d. Depress and release "Pulse Width" on the keypad (the "30"will stop blinking).

e. Depress and release "Pulse Rate" on the keypad.

NOTE: Lower right display should be flashing.

f. Using keypad, enter "1200".

g. Depress and release "Pulse Rate" on the keypad (the "1200" will stop blinking).

h. Depress and release "Mode" on the keypad until lower left of display is "C".

i. Depress and release "Store" on the keypad (all numbers will stop blinking).

NOTE: While setting alignment it may be necessary to lower or raise the pulse width slightly to get a beam trace on the thermal paper without starting a fire.

7. Take a small piece of thermal paper (approximately 4 inches) and put in front of beam window (reference Figure 13). Set shutter switch to open. Depress the "Test" button.

NOTE: Depressing test button turns on laser, depressing again turns off laser.

DANGER: When the laser is on, injuries can occur if a body part is placed in front of the beam. Remember, the beam is invisible.

8. If mirror #1 was previously cleaned, move to Step 9. Otherwise, remove, clean and install the #1 mirror per the section on "First Mirror Cleaning".

9. Adjust mirror #1, on the shutter support block, by turning it slightly left and right (reference Figure 13) until a blue dot appears on the thermal paper approximately centered through the center of the window. The blue dot will appear in a few seconds if the beam is on and exiting the window. If you are unable to get a dot, increase pulse width by five or ten using Steps a, b. c, d and i above. If there is still no beam, loosen the other two set screws on the bottom and side of the shutter block and slightly rotate the shutter support clockwise or counterclockwise while slightly rotating mirror #1 until a blue dot appears.

10. Move paper next to mirror #2 (reference Figure 13). Set the mirror #1 and shutter support to get blue dot approximately centered on mirror #1.

11. Depress "P1" on keypad:

    a. X axis should move to left.

    b. Y axis should move forward.

    c. Focus lens carriage is now in the lower left corner of the system.

12. Place masking tape in front of the opening of mirror mount on the front of the Y axis arm and left of mirror #3 (reference Figure 13). Depress the "Test" button and adjust the two screws on the back of mirror #2 until black dot on the tape is centered in the opening. The upper left knob moves the dot left to right, while the lower right knob moves the dot up and down. Place a fresh piece of tape on the opening and burn a dot (press the "Test" key to stop the laser), not a hole, in the tape.

13. Depress "P2" on keypad:

    a. X axis should move to right.

    b. Y axis should move backward.

    c. Focus lens carriage is now on the upper right corner of the system.

14. When the motion system is in the P2 position, depress the "Test" button long enough to burn a round dot on the masking tape, then depress "Test" to turn the laser off. The P2 black dot you have just burned should be centered in the opening going to the #3 mirror, and should completely cover the test dot burned at P1. If you had no luck in getting the P2 dot to hit the tape, then turn the beam on and use the thermal paper to find the beam and "walk" it over onto the tape using the adjusting knobs on mirror #2.

    If the dots are not perfectly lined up in the center of the opening, the #2 mirror must be adjusted further. The procedure is to first get the P1 and P2 dots lined up on top of each other, then to center the dots in the opening leading to the third mirror.

15. If the P2 dot is to the left of the P1 dot, turn the upper left knob on the back of the #2 mirror counterclockwise. Move the knob about 1mm to move the P2 dot 1mm. Adjust until the P2 dot is directly above the P1 dot.

    If the P2 dot is to the right of the P1 dot, turn the upper left control knob on mirror #2 clockwise until it is directly above P1. Replace the masking tape and burn a new P1 dot (P1, "Test" on - dot - "Test" off) on the tape.

16. Burn a P2 dot (P2, "Test" on - dot - "Test" off) on the tape. If the P2 dot is below the P1 dot, turn the lower right knob clockwise until the P2 dot is directly even with the P1 dot. If the P2 dot is above the P1 dot, turn the lower right knob clockwise to adjust.

17. The P2 dot at this point will completely cover the P1 dot (no figure eights or other such patterns), thus appearing as a single dot. If the combined dot is centered side to side, then move on to Step 17. If the combined dot is off center to the left of the opening leading to the #3 mirror, then the #2 mirror mount must be moved towards the front of the machine slightly. First, look down at the #2 mirror (see Figure 12). Loosen the socket head cap screw holding the mirror bracket to the left motion system rail. Slide the mirror bracket toward the front of the machine about half the distance you want the combined dot on the masking tape to move. Tighten down the socket head cap screw, making sure that the lip on the mirror bracket is flat against the left motion system rail. Recheck the P1 and P2 dots using a fresh piece of tape. If the dots are not directly on top of each other, then adjust as in Steps 13 and 14. When the dots have been combined, check the combined (P1 and P2) dot for center. If the dot is centered left and right in the opening, then go on to Step 16. If the dot needs to be moved, adjust per Step 15 until the combined dot is centered left and right.

18. At this point, the P1 dot is covered by the P2 dot. This combined dot (P1 and P2) will be centered left and right in the opening leading to the #3 mirror. If the combined dot is also perfectly centered vertically, go to Step 18.

    In this step, the combined dot will be centered vertically in the #3 mirror opening. If the combined dot is low in the opening, then the shutter block must be turned slightly counterclockwise to raise where the P1 and P2 dots are hitting. To do this, loosen the two nylon tip set screws holding down the shutter block. With the system at P1, turn on the "Test" button. Move the shutter block counterclockwise until the P1 dot is centered in the #3 mirror opening. Tighten down the set screws until snug and turn off the "Test" button. Change the tape and burn a new P1 dot. The P1 dot should be centered. Keep adjusting the shutter block until the P1 dot is centered. When the P1 dot is centered, tighten down both of the shutter block set screws then burn a P2 dot to make sure the #2 mirror is still aligned properly, i.e., P1 and P2 are on top of each other and centered left and right in the #3 mirror opening. Adjust the mirror knobs and mirror bracket as necessary (Steps 13-15) to line up P1 and p2.

19. P1 and P2 dots have now been aligned all the way to the third mirror. At this point, first clean off all tape and residue. Wipe out the #3 mirror holder and tube with swabs and alcohol. Wipe off the $45^{\mathbf{o}}$ face where the #3 mirror is seated, then install a clean #3 mirror (the #3 and #4 mirrors are interchangeable).

    NOTE: Make sure that when installing the #3 mirror, that is sits flat on the $45^{\mathbf{o}}$ surface on the #3 mirror holder.

    Place masking tape over the hole in the focus lens carriage leading to the #4 mirror. Burn P1 and P2 dots in the masking tape to check for alignment. If the P2 dot cannot be located on the tape, first try bumping up the Pulse Width setting 5 to 15 units. It is also possible that the beam is way off, so use a piece of thermal paper (with beam on) to find the beam.

If the P2 dot isn't on top of P1, some slight tweaking of the #2 mirror, and possibly the #3 mirror holder must be done.

If the P2 dot is higher than P1, rotate the lower right knob on the #2 mirror counterclockwise to lower the P2 dot onto P1. If P2 is lower, turn the lower right know clockwise to align P2 onto P1.

To shift P2 left onto P1, turn the upper left knob on #2 mirror clockwise. Conversely, P2 will be shifted right if the upper knob is rotated counterclockwise.

The dots should lie directly on top of each other and should be centered in the hole on the square tube leading to the #4 mirror. If not, the combined dots (P1 and P2 on top of each other) can be moved slightly left and right by adjusting the #2 mirror bracket. To move the combined dots at the #4 mirror to the left, loosen and move the #2 mirror bracket slightly towards the front of the machine. The combined dot at the #4 mirror will shift right if the #2 mirror bracket is shifted back. Remember to tighten the #2 mirror bracket so it fits flush against the side of the left motion system rail.

The combined dots can be shifted up or down only by loosening the two nylon tip set screws holding the #3 mirror. Generally, this setting is set at the factory and shouldn't need to be changed. However, if the combined dot at #4 mirror has to be adjusted (up or down) loosen the two nylon tip set screws on the #3 mirror tube. With a fresh piece of tape on the hole leading to the #4 mirror, burn a P2 dot (leave beam on). Adjust the #3 mirror tube up or down to position the dot correctly. Shut off the beam and tighten the #3 mirror tube set screws. Recheck the P2 dot position by burning another dot, and readjust as necessary. After the beam has been turned off, tighten the #3 mirror tube. Use the #2 mirror (lower right knob) to realign the vertical position of the P1 and P2 dots at #4 mirror.

Reburn a P2 dot and note whether it is perfectly round, or whether it looks like two footballs placed side by side. If the P2 dot isn't perfectly round, the beam is probably hitting the edge of the entrance to the #3 mirror tube. One can quickly check this by placing thermal paper in front of the #3 mirror tube and burning a dot on the paper. If the dot touches the edge of the tube (or is within 1mm of the edge) the #2 bracket and/or knobs may have to be readjusted to get the beam closer to the center of the #3 mirror tube opening. After moving the dot at #3 mirror towards the center of the opening, try to get the P2 dot at #4 mirror centered and round.

Recheck the P1 and P2 dot alignment and adjust for best possible alignment while maintaining a solid, round P2 dot. When finished, clean off the #3 mirror and reinstall it on the mirror holder.

20. Make sure to clean the tape off of the #4 mirror holder, and clean all surfaces and inside the square tube with alcohol. Clean the #4 mirror and install. To check the beam position at the final focus lens, place the thick spacer inside the small square final focus lens holder (wrap the focus lens in lens tissue and store in a safe place). Tape the spacer and holder up

into the bottom of the square tube that is under the fourth mirror. The tape should run completely across the opening through the final focus lens holder, simulating the position of the lens. At P1 and P2, burn dots on the tape that is stretched across the opening in the square lens holder.

You can observe the burning by looking just over the top of the front frame rail into the #4 mirror.

CAUTION: Be very careful not to get too close to the machine when you bend down to observe the dots as they burn. Also, make sure your safety goggles are on.

The P1 and P2 dots should be on top of each other and centered in the round opening of the lens holder. One can tweak the #2 mirror knobs to achieve dot alignment. To move P2 down, as seen by looking at the dot on the tape through the #4 mirror, move the lower right knob on #2 mirror clockwise and vice versa to move the P2 dot up.

NOTE: Moving the P2 dot down, as seen through #4 mirror, is the same as moving the P2 dot on the tape towards the back of the machine.

To move P2 to the left as seen through the #4 mirror, move the upper left knob on #2 mirror clockwise and vice versa to move P2 to the right.

NOTE: Moving the P2 dot to the left, as seen through the #4 mirror, is the same as moving the P2 dot on the tape towards the left as you face the machine.

Once P1 and P2 are again on top of each other, the combined dots can be centered, if necessary, by moving the #2 mirror block (left and right position as seen in the #4 mirror) or the #3 mirror tube (up and down as seen in the #4 mirror).

To shift the combined dots to the left, as seen in the #4 mirror, move the #2 mirror block towards the front of the machine. To move the combined dots down, as seen in the #4 mirror, rotate the #3 mirror holder down.

Ideally, the dots at both P1 and P2 should now be centered in the opening where the lens normally sits. The dots should both be round. See Step 17 for information on the "Football" beam shapes.

Remove the tape holding the final focus lens holder and thick spacer on the bottom of the square tube. Remove and clean the #4 mirror and the tube. Replace the #4 mirror, clean and install the final focus lens.

21. Close the shutter.

22. Turn the machine off.

23. Remove the defeat tool.

24. Remove the power cord.

25. Replace top enclosure.

4.7 DOOR HINGE ADJUSTMENT

NOTE: Top door hinges should be set just tight enough to hold the door in the vertical position.

1. Hold door in vertical position and tighten hinge screws with Phillips screwdriver so door just stays up. Moving the door one inch to either side should cause the door to drop.

2. Close door and ensure it is flat against top cover. If hinges are too tight, the door will bow by the hinges. Check front and back of door and loosen the hinges, if necessary, so door stays flat.

CAUTION: Excessive bow in door may affect the safety of the system.

3. Set front door hinges loose so door will lay flat against frame when closed. If hinges are too tight, the door sides will bow just above the hinges.

4.8 BELT ADJUSTMENT AND REPLACEMENT

1. Ensure that the power cord is removed.

2. Remove top Enclosure:

    a. To remove the top cover, unclasp the four latches that hold the top cover down. Two latches can be found on the right side of the machine and two can be found on the left side of the machine.

    b. Ensure power cord is removed then gently lift the cover up and off of the machine. This will require two people to accomplish. Watch out for one inch mirror in the front left corner of the machine and the electronics and water lines on the right side of the machine.

4.8.1 X AXIS BELT REPLACEMENT

1. Loosen the two screws on each X axis pulley holder and remove pulley holder (reference Figures 2 and 3).

2. While holding Y rail (reference Figure 2) slowly rotate white nylon bearing by Y axis motor and note friction and torque required to turn both wheels.

3. Remove the two adjusting screws under the front pulley base and remove the two belt keepers (reference Figures 4 and 5). The two adjusting screws serve two purposes: Attaching the belt keepers and tensioning the X axis bearings.

4. Remove the two screws from the rear support and remove the rear belt keeper (reference Figure 6).

5. Loosen the two set screws in the shaft extension that are towards the center of the shaft (reference Figure 7).

6. Slide the shaft into the shaft extension until the opposite end of the shaft is approximately half an inch out of the rear bearing.

7. Remove belt(s).

8. Slide new belts over shaft.

9. Slide shaft back into bearing, put Locktite 242 on set screws, and tighten set screws in shaft extension just so they are snug.

10. Put belt over pulley and put pulley holders back in place. Secure with two socket head cap screws (reference Figures 2 and 3).

11. Ensure front and rear of Y arm is square with calipers (reference Figure 7). The Y arm must be square to within 10 thousandths at this point. Replace rear support belt keeper with two screws and Locktite 242 (reference Figure 6).

12. Replace two front belt keepers with two screws keeping Y arm square front to back. Tighten keepers until friction of white X bearings is the same as before belt removal.

NOTE: Bearings should slip but both should have an equally stiff feel.

13. Move Y arm all the way to the left. Check front and rear gap between Y arm and left front rail with calipers. Loosen the two center shaft extension set screws. Hold the X axis motor pulley (front pulley) with one hand and turn the rear pulley until the Y rail, to the left frame rail, gap is the same. Tighten the shaft extension set screws. The front and rear of the Y arm should be the same distance from the left motion system frame rail, within +4 thousandths.

14. To check the accuracy of the Y rail squareness adjustment, first install interlock then plug in the system. Turn on the machine and hit P1. Adjust the control panel for 150. 15000 P mode and store it. Place a large sheet of paper on the material table. Draw a vertical line

using the arrow keys, moving up about ten inches (254mm). Next, move to the right ten inches, down ten inches and left again ten inches. These measurements will be very precise if you use the millimeter scale LEDs in the upper right corner of the control panel. Now measure the diagonals of the square with an optical measuring instrument (or calipers if the square is drawn smaller). The diagonals should be the same length to within about five thousandths. If the diagonals are not the same, go to step 13 and readjust the position of the Y rail using the X axis motor shaft. Adjust until the readings of the diagonals are correct.

15. Proceed to the X axis tension adjustment.

4.8.2 X AXIS BELT TENSION ADJUSTMENT

1. Turn off power and remove power cord.

2. Remove top enclosure.

   a. To remove the top cover, unclasp the four latches that hold the top cover down. Two latches can be found on the right side of the machine and two can be found on the left side of the machine.

   b. Ensure power cord is removed then gently lift the cover up and off of the machine. This will require two people to accomplish. Watch out for the one inch mirror in the front left corner of the machine and the electronics and water lines on the right side of the machine.

3. Slowly move the Y axis arm all the way to the left.

4. Using the tension scale in the middle of the belt, measure the amount of tension needed to pull the bottom belt into contact with the top belt. Tighten the adjusting screws on the pulley holder until a ready of 200-220 gms is needed to make the top and bottom of belt touch (reference Figures 2, 3, and 8).

NOTE: Try to tighten the two screws evenly as belt should ride near the middle of the pulley.

Do both front and rear belts.

5. Move Y arm all the way to the right. Check tension reading in the middle of the belt. It should still read 200-220 gms.

6. Move arm left and right and adjust screws so belts stay approximately centered on pulleys and tension meter stays as 200-220. Add a drop of Locktite 242 to each adjustment screw.

4.8.3 Y AXIS BELT REPLACEMENT

1. Turn off the power and remove the power cord.

2. Remove the top enclosure.

   a. To remove the top cover, unclasp the four latches that hold the top cover down. Two latches can be found on the right side of the machine and two can be found on the left side of the machine.

   b. Ensure power cord is removed then gently lift the cover up and off of the machine. This will require two people to accomplish. Watch out for the one inch mirror on the front left corner of the machine and the electronics and water lines on the right side of the machine.

3. Remove the two Phillips tension screws from the back side of the Y rail rear support (reference Figure 6).

4. Loosen the two Phillips binding screws on sides of Y rail at the rear support (reference Figure 6).

5. Remove the two black screws located below the front Y axis motor (reference Figure 4).

6. Carefully tilt motor so top of motor (pulley end) tilts towards rear of machine. The Y axis belt should become slack.

7. Carefully remove belt from around sprocket on Y axis motor and rear pulley at the back of the Y rail.

NOTE: Rear pulley may have to be moved towards the middle of the Y rail slightly to loosen belt (do not force).

8. Remove belt from the focus lens carriage by sliding the belt straight down.

9. Install new belt around rear pulley.

10. Install belt around sprocket at motor.

11. Feed belt through belt holder on the focus lens carriage.

12. Slide motor back into place and reinstall black screws in motor. Use Locktite 242 on screws. Snug them only enough to hold the motor in place (reference Figure 4).

13. Reinstall tension screws in rear support but leave them loose.

14. Slide the final focus lens carriage to the front.

15. Proceed to the Y Axis Tension Adjustment.

4.8.4 Y AXIS BELT TENSION ADJUSTMENT

1. Turn power off and remove power cord.

2. Remove top enclosure if not already removed.

    a. To remove the top cover, unclasp the four latches that hold the top cover down. Two latches can be found on the right side of the machine and two can be found on the left side of the machine.

    b. Ensure power cord is removed then gently lift the cover up and off of the machine. This will require two people to accomplish. Watch out for the one inch mirror in the front left corner of the machine and the electronics and water lines on the right side of the machine.

3. Using the tension scale, tighten the Y rail rear support tension screws evenly until a ready of 170-200 gms is needed to pull one belt into contact with the other belt (reference Figures 6 and 8).

4. Move final focus lens carriage to the rear and recheck tension for ready of 170-200 gms (reference Figure 8).

5. Tighten the two binding screws on the sides of the Y arm (next to rear support). These are the lock down screws that hold the tension in the Y belt.

6. Reinstall top enclosure.

4.9 BEARING ADJUSTMENT AND REPLACEMENT

4.9.1 X AXIS BEARING ADJUSTMENT

1. Turn system power off.

2. Remove top enclosure.

    a. To remove the top cover, unclasp the four latches that hold the top cover down. Two latches can be found on the right side of the machine and two can be found on the left side of the machine.

    b. Ensure power cord is removed then gently lift the cover up and off of the machine. This will require two people to accomplish. Watch our for the one inch mirror on

the front left corner of the machine and the electronics and water lines on the right side of the machine.

3. Clean both sides of front X rail where the four white bearings roll.

4. Hold tissue dampened with alcohol against bearings to clean them (reference Figure 5). While they move, gently grasp the Y rail of the motion system (reference Figure 4) and moving it left and right to roll the bearings.

5. Repeat several times for each bearing to ensure they are clean. If the bearings roll smoothly, go to Step 10.

6. There should not be a rough or sticky feel in the bearings when the Y rail is move left and right. However, a slight unevenness of drag from right to left is normal.

7. A sticky feel may mean set screws need adjustment. Refer to the "Set Screw Adjustment" section for procedure.

8. A bumpy feel means either bearings or rail are still dirty or possibly one of the bearings is bad. Recheck and reclean bearings and rail.

9. If after recleaning and adjusting set screws the Y rail still feels bumpy when move left and right, refer to "Bearing Replacement" section to replace the X axis bearings.

10. At this point the Y axis rail moves smoothly left and right (on the X axis). Hold the Y rail gently in place (do not apply pressure up or down as damage may occur to the rail or bearings) and roll the white X bearing with one finger. There should be some friction but the bearing should be movable with one finger.

11. Check both X bearings. Friction should be about equal.

12. If the friction in either X bearing is excessive or bearings can't be moved, use a Phillips screw driver and slightly loosen the screw directly under the tight bearing. These adjusting screws are under the X axis bearing plate and also hold the front X axis belt on the machine (reference Figure 4).

13. If friction in a white, X axis bearing is too light or if the bearings roll with no drag, use a Phillips screw driver and slightly tighten the adjusting screws directly under the loose bearing. These adjusting screws are under the X axis bearing plate and they also hold the front X axis on the machine (reference Figure 4).

CAUTION: Do not tighten the Phillips head screws (under the X axis bearing plate) more then 1/16" turn at a time. If the screws are over tightened, the X bearings will break off of the plate.

4.9.2 Y AXIS BEARING ADJUSTMENT

1. Turn system power off.

2. Remove top enclosure is not already removed.

   a. To remove the top cover, unclasp the four latches that hold the top cover down. Two latches can be found on the right side of the machine and two can be found on the left side of the machine.

   b. Ensure power cord is removed then gently lift cover up and off of the machine. This will require two people to accomplish. Watch out for the one inch mirror in the front left corner of the machine and the electronics and water lines on the right side of the machine.

3. Clean both sides of the Y axis rail in bearing channels with a cotton swab and alcohol (reference Figure 9).

4. Clean the two Y bearings (reference Figure 9) using a tissue and alcohol. Dampen tissue and hold over carriage while moving the final focus lens carriage front to back. Repeat several times to ensure they are clean.

5. Clean Y eccentric bearing (reference Figure 9) using cotton swab and alcohol. Dampen cotton swab and hold against bearing while moving carriage front to rear and rotating cotton swab at the same time.

6. When bearings and the two channels are clean, gently grasp carriage across lens holder and move back and forth. Movement should be smooth and not feel bumpy or sticky. If smooth, go to Step 7. A bumpy movement means either the bearings or channel are still dirty or a bearing may be bad. Recheck and reclean bearings and channel. Some slight unevenness of drag from front to back is normal. A sticky feel means the four nylon tipped set screws on bottom of final focus lens carriage need adjusting. Refer to "Set Screw Adjustment" section.

7. If after cleaning bearings and adjusting the set screws and the final focus lens carriage movement is still bumpy, refer to the "Y Axis Bearing Replacement" section.

8. When Y axis carriage is moving smoothly, hold carriage in middle of Y axis with right hand (do not apply pressure up or down on carriage) and with left hand rotate both Y bearings on the left side of the rail. These should roll smoothly using one finger, but should also have some friction.

9. If friction in the Y axis bearings is excessive or bearing can't be moved:

   a. Place 7mm socket over eccentric bearing (reference Figure 9).

b. Place #1 Phillips screw driver through socket and loosen Phillips screw.

c. Rotate bearing very slightly away from the Y rail, i.e., towards the narrow side of the eccentric, using the socket. Snug the Phillips screw.

d. Remove screw driver and socket and recheck per Step 7. Adjust until friction is correct. Hold the socket still with your fingers then insert the #1 Phillips through the socket and tighten the screw. Do not over tighten the Phillips screw.

CAUTION: Turn the 7mm socket with your fingers, not with a wrench. Over tightening the eccentric bearing will cause permanent damage to the bearings.

10. If friction in the Y axis bearings is too light or non existent:

a. Place 7mm socket over eccentric bearing (reference Figure 9).

b. Place #1 Phillips screw driver through socket and loosen the Phillips screw.

c. Rotate bearing very slightly towards the Y rail, i.e., towards the wide side of the eccentric, using the socket. Hold the socket still with your fingers then insert the #1 Phillips through the socket and tighten the screw.

CAUTION: Turn the 7mm socket with your fingers, not with a wrench. Over tightening the eccentric bearing will cause permanent damage to the bearings.

d. Remove screw driver and socket. Recheck per Step 7. Adjust until friction is correct.

4.9.3 X AXIS BEARING REPLACEMENT

1. Turn off power and remove power cord.

2. Remove top enclosure.

a. To remove the top cover, unclasp the four latches that hold the top cover down. Two latches can be found on the right side of the machine and two can be found on the left side of the machine.

b. Ensure power cord is removed then gently lift the cover up and off of the machine. This will require two people to accomplish. Watch out for the one inch mirror in the front left corner of the machine and the electronics and water lines on the right side of the machine.

3. Before removing and replacing X axis bearings, ensure bearings and X axis rail are completely clean per "Bearing Adjustment" procedure. X bearings rarely need replacement; most problems are due to dirty bearings or rails. Also check that the nylon tipped set screws are not sticking. If set screws stick, refer to "Set Screw Adjustment" section before proceeding.

CAUTION: Uneven or excessive pressure on Y axis rail can damage all bearings and possibly damage the Y axis rail. Proceed slowly and be extremely gentle. Do not drop the Y rail assembly as mirrors and final focus lens may break.

4. Remove four 6-32 socket head cap screws holding the X axis front rail to the left and right side rails.

5. Loosen the two 4-40 socket head cap screws holding the X axis motor under the front X axis rail. Hold the motor, then remove the screws. Slide the drive shaft out of the rear support bearing (see Figure 2) and slide the rear belt off the shaft. Slide the front belt off the motor end of the shaft then pull the motor cable out of the J-Clips on the front of the enclosure. Set the motor and shaft down.

6. Slide the front X axis rail rearward enough (about one inch) to disengage the rear of the Y axis arm from the rear X rail.

7. Slide the Y axis arm off of the front X rail and set the front X rail down. Be careful not to bend or twist the Kapton cable that is still connected to the Y axis arm.

8. Remove the four white X axis bearings. Check the X axis bearing plate for cracks or breakage. If the posts that hold the bearings are cracked or broken, the bearing plate must be replaced.

9. Install new bearings on posts (pure white side up), put a drop of Locktite 242 on screws, then snug down screws.

CAUTION: Do not tighten bearing screws too tight. Turn the screw to the point where you can feel it getting snug. Over tightening will break the X axis bearing plate.

10. Slide the Y arm back onto the front X axis rail and hook the rear of the Y arm over the back X axis rail. Set the front X axis rail on the left and right side rails.

11. Hook front and rear X axis belts on the pulleys of the X motor and shaft. Slide the rear pulley of the drive shaft into the rear X axis bearing. Locktite the two X axis motor screws and rehang the X axis motor on the front X rail (do not tighten motor screws yet).

12. Put Locktite 242 on the four 6-32 socket head cap screws and reinstall front X rail. Tighten the four screws tight.

13. Check the front and rear X axis belt to make sure they are tight on both sides of the Y rail. Remove the X motor, if necessary, to shift the belts a tooth or two in either direction to get the belts tight. Tighten motor hold down screws. Also, check that the Y rail is square to the rest of the motion system. To do this, follow Steps 10-14 in the "X Axis Belt Replacement" section. You must adjust the X axis motor shaft to move the front back of the Y rail square. If this step (X Axis Belt Replacement section) is not done correctly, the lased lines on the work piece will be out of square.

14. Reinstall top enclosure.

15. Hook up power.

16. Turn on system.

17. Check the solenoid shutter switch. Flip switch and listen for shutter click.

4.9.4 Y AXIS BEARING REPLACEMENT

1. Be sure bearings and Y axis rail are completely clean per "Bearing Adjustment" section and that the nylon tipped set screws are not sticking. If they are sticking, refer to the "Set Screw Adjustment" section before proceeding.

CAUTION: Uneven pressure or excessive pressure on the carriage can damage all bearings and possibly damage the Y rail. Proceed slowly and be extremely gentle. Do not drop the carriage as mirror and final focus lens may break.

NOTE: The eccentric bearing must be removed to replace any of the three bearings.

2. Hold carriage in right hand and place Phillips head screw driver in eccentric bearing screw (reference figure 9).

3. Slowly loosen eccentric screw ensuring that eccentric bearing does not start to rotate. If the bearing starts to rotate, use a 7mm socket to hold it in place.

NOTE: If bearing turns and jams, damage to bearing or rail may occur.

4. Remove eccentric screw.

5. Turn eccentric bearing so final focus lens carriage becomes loose i.e., turn bearing away from the Y axis rail.

6. The eccentric bearings and wheel should be able to be lifted away from carriage by slightly tipping the final focus lens carriage.

7. Remove the Y axis belt from the carriage.

8. Ease carriage away from rail and lower slightly.

9. Remove Phillips head screws from the other two Y bearings and remove from carriage.

10. Put a drop of Locktite 242 on screws, place a screw through the new bearing and screw the bearing back into carriage. Just snug down the bearing screws. Over tightening may damage the final focus carriage.

11. Repeat for second bearing.

12. Put carriage back into place on rail and ensure the two bearings are in the bearing channel.

13. Set black eccentric bearing wheel on top of carriage.

14. Put brass eccentric bearing into bearing.

15. Put a drop of Locktite 242 on screw and put through the brass bearing.

16. Install screw just snug, then back it off about 1/8" of a turn.

17. Turn eccentric the 7mm socket by hand. Turn the nut just enough to remove all side to side play in the final focus lens carriage. Snug screw slightly but do not allow eccentric to turn.

18. Slide carriage back and forth. It should move smoothly and with minimum effort.

19. Reinstall the Y axis belt.

20. Reset Y rail friction per "Bearing Adjustment" section.

21. Reset the Y rail set screws per "Set Screw Adjustment" section.

4.10 SET SCREW ADJUSTMENT

Set screw adjustment is necessary when:

1. Motion system loses position or sticks due to cold weather.

2. Corners of objects drawn on system do not connect or overshoot.

3. Wiggly lines occur in either X, Y or diagonal movement.

4. Y rail bearings are adjusted or replaced.

4.10.1 X AXIS

1. Turn off system power.

2. Unplug system.

3. Remove top enclosure if not already removed.

    a. To remove the top cover, unclasp the four latches that hold the top cover down. Two latches can be found on the right side of the machine and two can be found on the left side of the machine.

    b. Ensure power cord is removed then gently lift the cover up and off of the machine. This will require two people to accomplish. Watch out for the one inch mirror in the front left corner of the machine and the electronics and water lines on the right side of the machine.

4. Set Z stage to lowest position.

5. Move X axis to the center of the processing area.

6. Gently grasp across the Y rail and gently move entire Y rail up and down to check for excessive play. Excessive play is any movement greater than approximately 1/64 to 1/32 of an inch (reference Figures 11a and 11c).

7. Gently rotate entire Y rail left and right and check for excessive play. Excessive play is any movement greater than approximately 1/64 to 1/32 of an inch.

8. If it is determined that there is excessive play, X axis set screws will have to be tightened.

9. Open front door of system.

10. While looking over the front rail of the machine, move Y rail until you can see if there is a gap between either of the nylon tip set screws and the rear X rail (reference Figure 11b). A sheet of white paper placed between the rear X rail and the rear frame will make this gap easier to detect.

11. If there is a gap between either set screw, tighten set screw as snug as possible without causing any drag while moving X axis left and right.

NOTE: If the set screws are adjusted unequally, there will be more drag moving in one direction than the other. If this occurs, loosen one set screw slightly and tighten the other set screw slightly until movement is smooth and of equal drag in both directions.

4.10.2 Y AXIS

1. Turn off system power.

2. Unplug system.

3. Remove the top enclosure if not already removed.

    a. To remove the top cover, unclasp the four latches that hold the top cover down. Two latches can be found on the right side of the machine and two can be found on the left side of the machine.

    b. Ensure power cord is removed then gently lift cover up and off of the machine. This will require two people to accomplish. Watch out for the one inch mirror in the front left corner of the machine and the electronics and water lines on the right side of the machine.

4. Set Z stage axis in its lowest position.

5. Move Y rail manually to the center of the processing area.

6. Gently grasp final focus lens holder from front to back with right hand (reference Figure 10a).

7. Gently grasp across Y rail with left hand (reference Figure 10A).

8. Gently move final focus lens carriage base in right hand up and down and check for excessive play. Excessive play is any movement up and down greater than approximately 1/64 of an inch.

9. Gently rotate carriage base back to front and check for excessive play. Excessive play is any movement greater than approximately 1/64 of an inch.

10. If it is determined there is excessive play, Y axis set screws will have to be tightened.

11. Open front door of machine.

12. While looking through front of machine, move the focus lens carriage (on the Y rail) until you can see if there is a gap between any of the four nylon tip set screws and the Y rail (reference Figure 10b). Place a sheet of white paper between the rear Y rail and the rear frame rail to make the set screw gaps easier to detect.

13. If there is a gap at any set screw, carefully tighten the set screw until the gap between the set screw and the bottom of the Y rail disappears. Do not turn the set screw more than 1/64" of a turn at a time.

14. Move the focus lens carriage back and forth and check for drag.

15. Again, observe set screw gaps (Step 1) and adjust (Step 13).

16. Check for excessive play (Steps 8 and 9). Ideally, one should not feel any movement in the final focus lens carriage. A slight movement (less than 1/64 of an inch) will be suitable for applications such as engraving wood. For marking or engraving metals or other high precision tasks, all excessive play must be eliminated.

N**OTE:** Do not bind up the motion system when tightening set screws. When the work environment gets colder, the motion system tightens up. Therefore, warm the room and machine up to the normal work temperature before adjusting the set screws.

4.11 TICKLE ADJUSTMENT

Tickle is laser control signal of small Pulse Width and Pulse Rate applied to the laser whenever power to the system is turned on. The function of tickle is to keep the gas plasma in the laser warmed up at all times to help the laser respond more quickly. Normally, the tickle won't need changing. However, as the laser tube ages, the output stability may change. To compensate for this, the tickle should be optimized. The best setting is maximum pulse width and minimum pulse rate without unwanted leakage. This setting should provide even dot marking at low power settings and not "leak" or burn material while the system is at rest.

1. Turn on the system.

2. Set Mode to Proportional Pulsing:

    a. Depress and release keypad "Mode" until lower left display is "P".

    b. Depress and release keypad "Store".

3. Set Pulse Width to 200:

    a. Depress and release keypad "Program Select".

    b. Depress and release keypad "Pulse Width".

    c. Enter "200" on keypad.

    d. Depress and release keypad "Pulse Width".

4. Set Pulse Rate to 2000:

a. Depress and release keypad "Pulse Rate".

b. Enter "2000" on keypad.

c. Depress and release keypad "Pulse Rate".

5. Place a sheet of paper on the support table.

6. Set focus at 2.5 inches for standard lens; 1.5 inches for high resolution lens.

7. Depress and release "P1" on the keypad, motion system should move to left side and final focus lens carriage to the front side of the machine.

8. Set shutter switch to open. Check to see if any beam leak is burning paper. Beam leak will cause a dot about half the size of the period at the end of this sentence.

9. Tickle Pulse Width setting:

If beam is leaking and burning paper:

a. Depress keypad "0".

b. Depress keypad "Store".

c. Depress keypad "1".

NOTE: Make sure that the 0, Store, 1 keys are pressed rapidly or the machine will not enter the tickle setting mode.

The display changes from Pulse Width 200 and Pulse Rate 2000 to a Pulse Width of one and Pulse Rate of less than 200. The mode in the lower left corner of the display changes from a P to three stacked minus signs (🗐).

10. a. Depress keypad "Pulse Width", upper display should begin to flash.

b. Increase the Pulse Width by one (if display reads one, depress keypad "2").

c. Depress and release keypad "Pulse Width".

d. Depress and release keypad "Store" and the display should go back into the program mode and show a Pulse Width of 200 and Pulse Rate of 2000.

11. Open the top door and move paper slightly so laser burn spot will be in a different place.

12. Close top door and check if laser is leaking and burning a hole in the paper.

13. If there is no burn then repeat Steps 10-12 until the paper has a faint burn spot. When a burn spot is visible, go to Step 15.

14. When a hole is burned in the paper, lower Pulse Width one number using Steps 9 and 10 until the beam stops burning through the paper.

15. Turn system off and wait approximately 15 seconds.

16. Turn on system. Verify Pulse Width is 200 and Pulse Rate is 2000 and in Proportional Mode.

NOTE: The motion system moves to the right and carriage to the rear of the system when power is turned on.

17. Using DesignCAD or other software packages, draw a two inch square box.

18. Transmit drawing data from the computer. Engraving will begin. Note that marking will be visible as individual dots. As marking continues, all dots should be visible and burning the paper with the same intensity. If all the dots appear even and visible, tickle is properly set. If, when starting a line of marking, some dots are missing, the Pulse Rate will have to be changed. Tickle Pulse Rate Setting:

    a. Depress and release keypad "0".

    b. Depress and release keypad "Store".

    c. Depress and release keypad "1".

NOTE: Display will change from Pulse Width of 200 and Pulse Rate of 2000 to Pulse Width of one or whatever was previously set and Pulse Rate of 200. The mode (lower left corner of display) changes from a P to three stacked minus signs ( ).

19. a. Depress and release keypad "Pulse Rate", lower display will begin to flash.

    b. Decrease the Pulse Rate by 25 (if display is flashing 200, depress on the keypad "1" then "7" then "5").

    c. Depress and release keypad "Pulse Rate".

    d. Depress and release keypad "Store" and the display should go back into the program mode and show a Pulse Width of 200 and Pulse Rate of 2000.

20. Open top door and move paper so that the next marking is done on a clean section of paper.

21. Close top door and transmit data from computer. Engraving will begin. If dots are still missing or not even, repeat steps 17a through 20 until dots are even and none are missing. Note that Pulse Rate will not go below 100. When all dots are marking of the same intensity and are evenly spacer, proceed to Step 23.

22. If Pulse Rate has been set to 100 and dots are still not even or are missing, go back to original Pulse Rate and increase by 25. Repeat Steps 18a through 20 but continue to increase Pulse Rate by 25 each time until all dots are even and none are missing. If you reach 300 or more and still can't get stable markings, stop and call Universal Laser Systems, Inc.

23. When dots are even and there are none missing, repeat steps 18a through 20 but increase Pulse Rate by five until dots start to become uneven or missing, then lower Pulse Rate by five.

    If you had to increase Pulse Rate to stabilize, repeat steps 18a through 20, reducing Pulse Rate by five each time until dots started to become uneven or missing. Then raise Pulse Rate by five.

24. When dots are even and none are missing, open top door and move paper to engrave a clean area.

25. Close top door.

26. Depress and release keypad "P1". The motion system should move to the left and final focus lens carriage should move to the front of the machine.

27. Verify that the laser does not leak and burn the paper. If it does, repeat Steps 10 through 13 to lower Pulse Width by one.

NOTE: Do not set Pulse Width to 0 of laser is leaking. Call Universal Laser Systems for recommendations if the Pulse Width is 1 and the system leaks and burns the paper.

SECTION 5 - WARRANTY

5.1 IN-WARRANTY SERVICE

A defective laser system may be shipped to Universal Laser Systems, Inc. F.O.B. Scottsdale, Arizona after you call for an R.M.A. number. Defective units will be repaired or replaced at manufacturer's option depending upon the severity of the defect. Charges, if any, will be assessed pursuant to the provisions of the Universal Laser Systems, Inc. warranty policy. The equipment must be packed for shipment per Section 5.3. A description of the complaint along with the owner's name, address, telephone number, and equipment serial number should be included.

The equipment will be repaired, tested for proper performance, and burned-in for 24 hours. It will then be shipped prepaid to the owner. A brief description of the work performed and materials used will be included with the equipment.

5.2 OUT-OF-WARRANTY SERVICE

The procedure for out-of-warranty service is the same as that for in-warranty service except that a minimum charge is used. This minimum charge guarantees a repair estimate and is used as credit against actual material and labor costs. A purchase order must be received by Universal Laser Systems, Inc. before repair work may be started.

5.3 REPACKAGING FOR SHIPMENT

A tag must be attached to returned equipment listing the owner's name, address, and phone number. The complete equipment serial number and a description of the service requested must also be included.

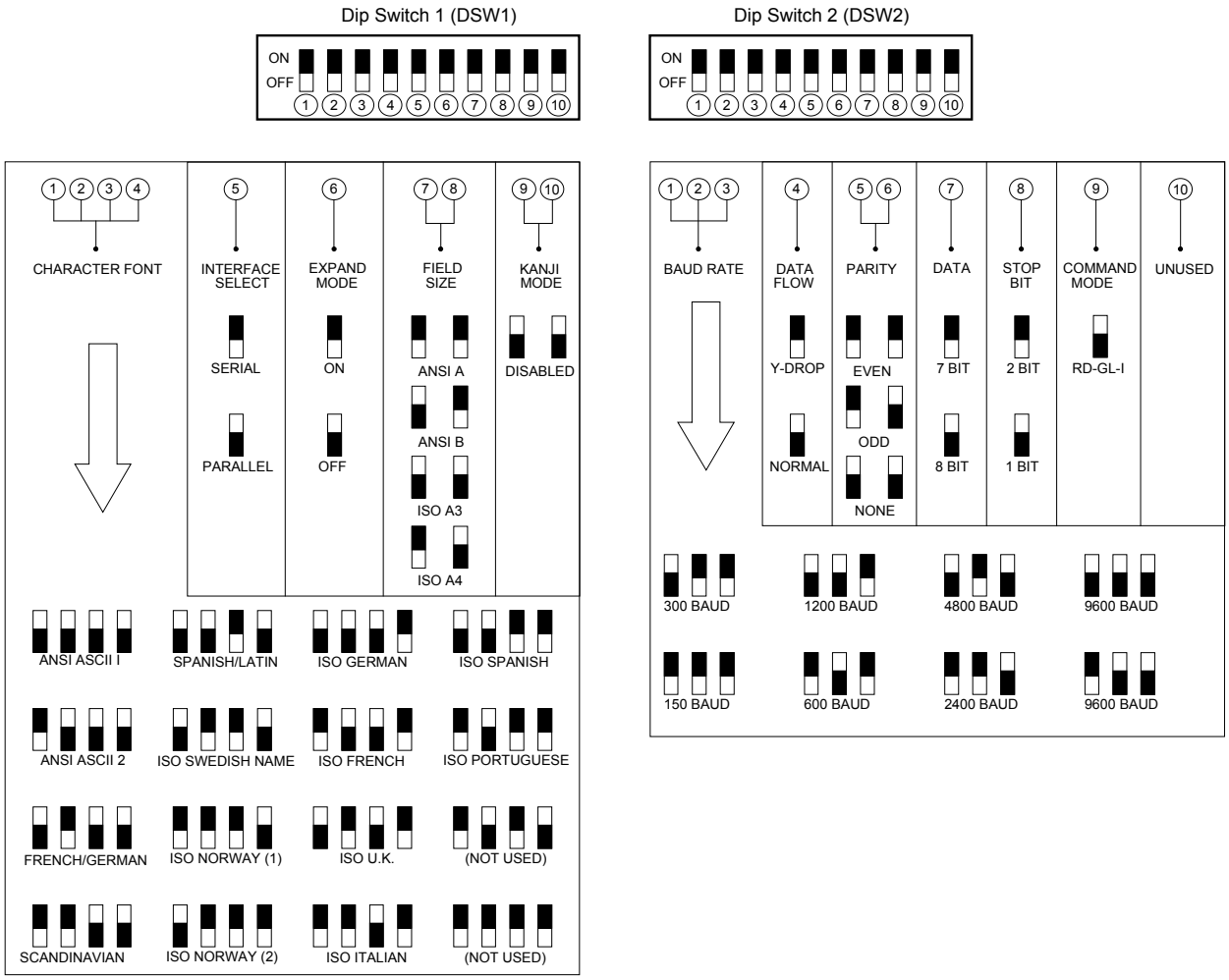
The original shipping container should be used if possible. In any case, the equipment must be packaged so as not to be damaged in transit.

5.4 FIELD SERVICE

For current information regarding field service call Universal Laser Systems, Inc., Scottsdale, Arizona, (602)483-1214.

APPENDIX

APPENDIX A - DIP SWITCH SETTINGS TABLE



NOTE: BLACK SQUARE INDICATES POSITION OF SWITCH

Functions (Locate DSW-1 & DSW-2 on edge of printed circuit board.)

DSW1 1-4: Select character sets out of the 19 sets according to country (factory set to ANSI ASCII (I)).

DSW1 5: Select serial (RS232) or parallel (Centronics) interfacing.

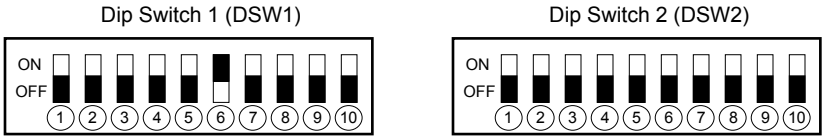
DSW1 6: Sets field size to maximum available. This switch overrides the field size switches.

DSW2 7-8: Sets the field size as long as expand mode is turned off (see DSW1 Switch 6).

DSW2 1-8: Used to setup the serial interface communication parameters.

DSW2 9: OFF sets the command mode to RD-GL I. This switch should always be in the OFF position.

The default switch positions set at the factory are as shown in the diagram below:



APPENDIX B - LASER SYSTEM SPECIFICATIONS

Model Number	ULS 1750C
Maximum Engraving Area	17" x 11.5"
Maximum Engraving Speed	16.5"/second
Laser Source	50 Watt $C0_2$
Laser Beam Diameter - Standard Optics - High Resolution Optics (Optional)	 0.007" 0.003"
Repeatability	+/- 0.002"
Interfaces	Parallel = Centronics Serial = RS-232C
Manual Speed Selection	8 Stage
Commands	HP-GL, RD-GL1
Buffer Memory Size	1MB
System Dimensions	45" x38" x21"
System Weight	208 lbs.
Safety Classification	Class I
Support Table Dimensions:	19" x 14"
Focal Plane (Z axis) Adjustment	6.25"
Focal Plane Adjustment Indicator	0.001" increments

Facility Requirements

Electrical Power:	Single phase, 120 VAC, 60 Hz, 20 Amp
Exhaust:	400 CFM minimum required at point of 4 inch connection to system
Cooling:	Water cooled, 1.5 gal/min at less than 70 °F

Specifications are subject to change without notice.

APPENDIX C - LASER CONTROL -- SUGGESTED PARAMETERS

Following are suggested starting parameters for several materials. Parameters can be adjusted to achieve different results.

V = Velocity
O = Pulse Width
P = Pulse Rate

Anodized Aluminum

V = 1		V = 1
O = 150	or	O = 300
P = 19999		C = 1000 (this is continuous mode)

Wood
V = 5
O = 300
P = 10000 to 19999

Note: Parameters must be adjusted according to density of engraving and style of font/image.

Enamel Coated Brass

V = 1		V = 1
O = 300	or	O = 300
P = 19999		C = 1000 (this is continuous mode)

Clear Acrylic
V = full speed
O = 300
P = 10000 for fine lettering, up to 19999 for images only

Leather
V = 5
O = 120
P = 10000

Glass
V = 5
O = 250
P =10000

Note: Glass was covered with masking tape before engraving.

Engraving Plastic (micro surface)
V = 5
O = 75
P = 19999

Engraving Plastic (medium)
V = 5
O = 400
P = 15000 to 19999

Engraving Plastic (reverse)
V = 5
O = 250
P = 10000

Note: Focus should be at 2.8".