Ref: OP.1

OPERATOR'S MANUAL

HOLOGRAPHIC LASER SYSTEM

Model : HLS2

Serial No: 5 1051 0

Customer: A Stephens

Operating Voltage/Frequency: 208V / 60Hz

MANUFACTURED BY:

LUMONICS LTD
Cosford Lane
Swift Valley
Rugby
Warwickshire
CV21 1QN
England

Telephone : (0788) 70321
Telex : 311540
Fax : (0788) 79824

WARNING

CERTAIN PRECAUTIONS ARE ESSENTIAL TO THE SAFE OPERATION AND MAINTENANCE OF HIGH POWER LASERS. PRECAUTIONS APPLICABLE TO PULSED RUBY HOLOGRAPHIC LASERS ARE OUTLINED HEREIN AND SHOULD BE FULLY UNDERSTOOD BEFORE APPLYING MAINS ELECTRICAL POWER TO THE LASER.

CDRH WARNING

USE OF CONTROLS OR ADJUSTMENTS, OR PERFORMANCE OF PROCEDURES OTHER THAN THOSE SPECIFIED HEREIN, MAY RESULT IN HAZARDOUS LASER RADIATION EXPOSURE.

HOLOGRAPHIC LASERS

TABLE OF CONTENTS

1. INTRODUCTION

The holographic oscillator (HLS1) manufactured by JK Lasers Ltd, is the basis of a family of lasers, formed by the addition of one or two amplifiers to produce output energies up to 10 J, and the necessary reference beam delay line, beamsplitter, etc. to produce a complete, self-contained holocamera.

The following sections constitute a user's handbook for the whole family of lasers and not every section, therefore, may be appropriate for your particular holographic system, but each section has been made self-contained so that you can just ignore those that do not apply.

Section 3 is a brief description of this type of laser, and the component layout for your particular system is given in Figure 1. Section 4 then details the operating procedure for the various parts of the system, to enable you to achieve the optimum performance simply and quickly.

The laser will be set up and aligned for you by a JK Lasers engineer (or an appointed agent) at the time of installation and therefore full alignment procedure is not given in this handbook. However, the last section does deal with the basic routine maintenance that will occasionally be needed - namely, on the flashtube replacement and on the cooler.

Finally, appendices are included listing the system specifications, the factory settings which gave the specified performance and also special features of this system.

COMPONENT LAYOUT FOR HLS-2

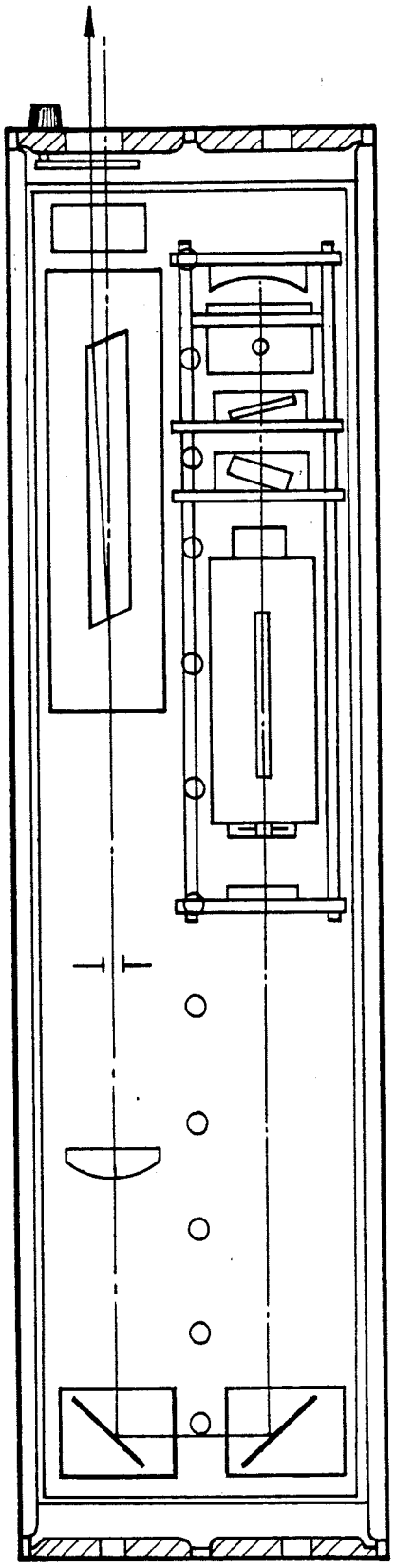


FIG. 1

2. SAFETY PRECAUTIONS

This equipment can be extremely dangerous.

2.1 High voltages

The power supply output is potentially LETHAL and operation with any covers removed should only be carried out by competent technical personnel. Never rely on the automatic discharging system. Always follow the instructions for manual discharge of the capacitors given on the warning labels attached to the laser head and to the inside of the PSU cabinets and switch off the mains supply before working on the equipment. If the system has more than one capacitor shorting probe, make sure they are all firmly in their sockets before proceeding.

2.2 Laser radiation

The laser output is of high intensity and would cause IRREPARABLE DAMAGE TO THE EYES if viewed directly; EYE DAMAGE could also result from diffuse reflections from any surface in the path of the beam. When laser radiation at invisible wavelengths is generated, even more care needs to be taken. SAFETY GOGGLES SHOULD BE WORN AT ALL TIMES by personnel within sight of laser radiation. Ensure that the goggles are suitable for the wavelength(s) being emitted and that they fit snugly.

Extreme care should be taken to ensure a clear path between the laser and the intended target, and safe containment of the beam should it not be absorbed by the target.

An energy dump placed close behind the target is recommended.

Guard against CARELESSNESS, UNTIDINESS AND IMPATIENCE.

Ensure adequate precautions are taken to prevent unauthorised personnel from entering the equipment area when the laser is operating. This can be achieved by interlocking the work area entry door into the laser power supply interlock circuit and/or providing warning notices.

Ensure that the laser controls are always set within the operating specifications for the equipment, and that the laser head cover is always fitted during routine operation. Whilst the cover has to be removed for some adjustments, the laser has been designed so that the need for such removal is minimised and the practice of not replacing the cover is very bad since not only does it increase the danger from stray radiation, but it allows ingress of room dust and dirt to the various optical surfaces.

For further guidance on the safe use of laser equipment, the following is a list of suggested reading material.

1) RADIATION SAFETY OF LASER PRODUCTS AND SYTEMS (A GUIDE FOR PROTECTION OF PERSONNEL AGAINST HAZARDS FROM LASER RADIATION).

Part 1 - General

Part 3 - Guidance for users

BS4803; 1982 British Standards Institution (and subsequent draft revision)

2) LASER SAFETY HANDBOOK

A Mallow & L Chabot

Van Mostrand Reinhold Co (PUB) 1978

3) SAFETY IN UNIVERSITIES: NOTES ON GUIDANCE PART 2:1 LASERS

(Association of Commonwealth Universities for the Committee of Vice-Chancellors & Principals, 29 Tavistock Square, London WC1)

4) In the U.S.A. additional information can be obtained from:-

CENTER FOR DEVICES AND RADIOLOGICAL HEALTH (C.D.R.H.)

Regulations for the Administration and Enforcement of the Radiation Control for Health and Safety Act of 1968 Chapter 21 sub-chapter J.

available from:-

U.S. Dept. of Health and Human Services
Public Health Service
Food and Drug Administration Section
Rockville, Maryland 20857

2.3 Solvents

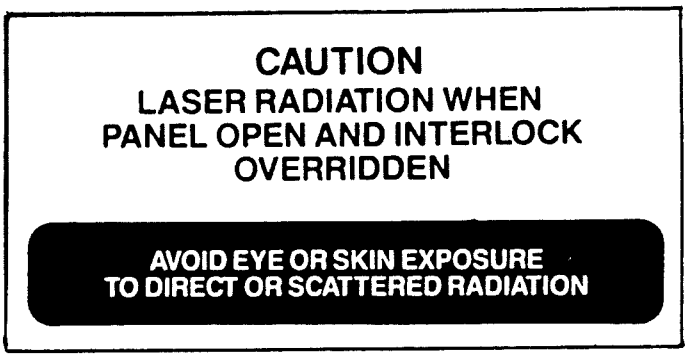
The following solvents recommended for use when maintaining the equipment can be injurious to health unless adequate precautions are taken. TRICHLOROETHANE : Degreasing solvent for optics. Irritating, harmful vapour. Avoid breathing vapour and contact with skin, eyes and clothing. PROPAN-2-OL (ISOPROPANOL, IPA): Degreasing solvent for optics. Highly flammable. Avoid breathing vapour and contact with eyes.

WARNING: DO NOT SMOKE FOR AT LEAST 30 MINUTES AFTER USING TRICHLOROETHANE. THIS SOLVENT IS TOXIC AND MUST BE USED IN THE OPEN AIR OR A WELL VENTILATED PLACE (e.g. CHEMICAL FUME CUPBOARD)

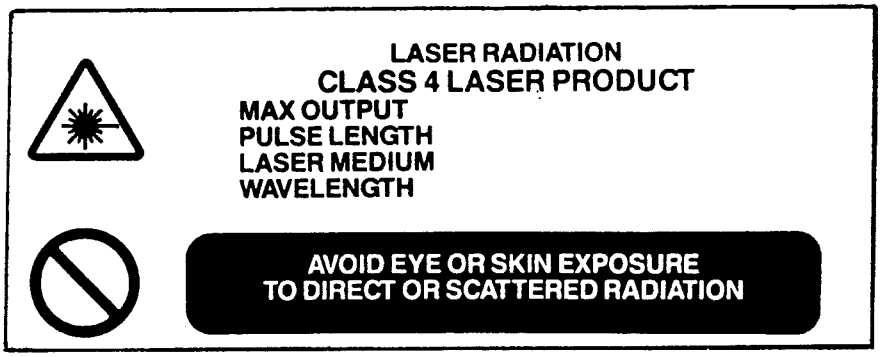
2.4 Safety labelling: European regulations

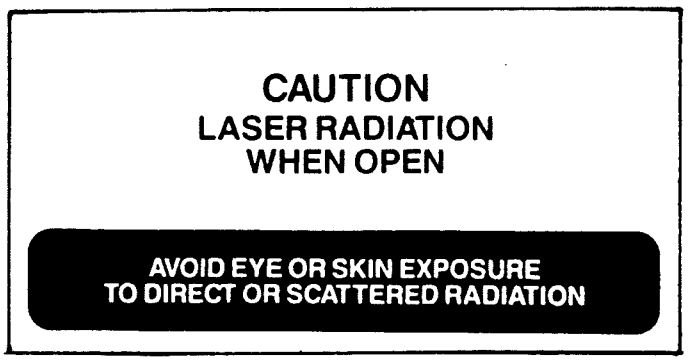
All JK Lasers holographics lasers are categorised 'Class 4' and safety standards require the prominent display of warning labels as illustrated below:

1) On the inside of the laser head base and on the sides of the laser base.

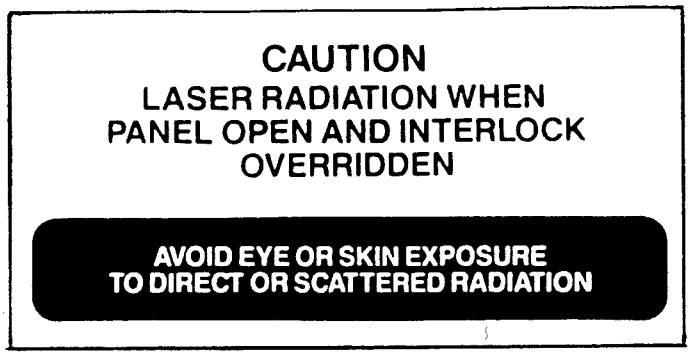


2) On the ends of the laser base.

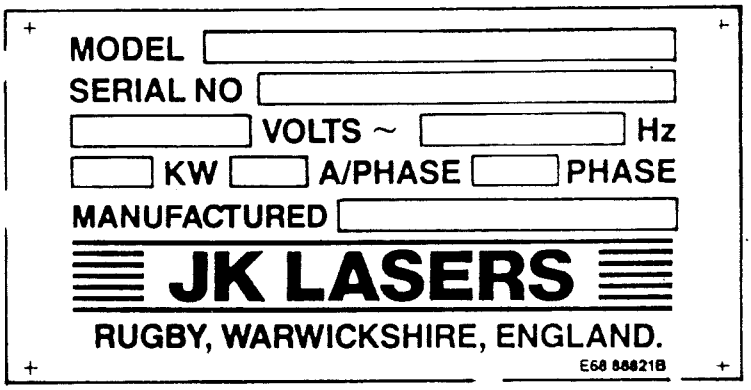




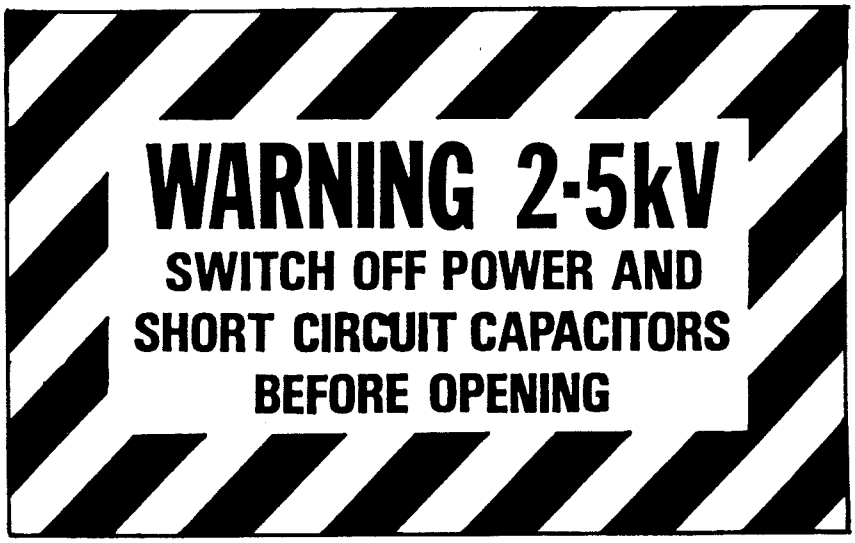
3) On the laser head cover Safety Interlock override flag (one on either side of flag)



4) On the rear of the power supply.



5) On the cover of each pumping chamber.



USA REGULATIONS

2.5 Safety labelling: USA regulations

All JK Lasers holographics lasers are categorised "Class 4" and safety standards require the prominent display of warning labels as illustrated below:

1) On the inside of the laser head base.

DANGER
VISIBLE LASER RADIATION WHEN
OPEN AND INTERLOCK DEFEATED
AVOID EYE OR SKIN EXPOSURE TO
DIRECT OR SCATTERED RADIATION

2) On the sides of the laser base.

DANGER

LASER RADIATION
AVOID EYE OR SKIN EXPOSURE TO
DIRECT OR SCATTERED RADIATION

MAX OUTPUT
PULSE DURATION
WAVELENGTH

CLASS 4 LASER PRODUCT

DANGER
VISIBLE LASER RADIATION WHEN
OPEN AND INTERLOCK DEFEATED
AVOID EYE OR SKIN EXPOSURE TO
DIRECT OR SCATTERED RADIATION

CERTIFICATION
J K LASERS CERTIFIES THAT THIS LASER CONFORMS
TO THE PROVISIONS OF THE UNITED STATES DEPT.
OF HEALTH AND HUMAN SERVICES, CDRH,
REGULATIONS 21CFR 1040, 10 & 1040,11
RELATING TO ENFORCEMENT OF THE RADIATION CONTROL
HEALTH & SAFETY ACT OF 1968

3) On the ends of the laser base.

DANGER
VISIBLE LASER RADIATION WHEN OPEN
AVOID EYE OR SKIN EXPOSURE TO
DIRECT OR SCATTERED RADIATION

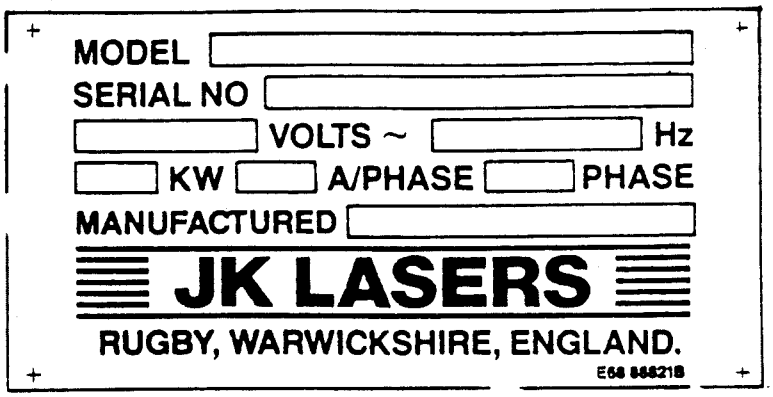
AVOID EXPOSURE
VISIBLE LASER RADIATION IS
EMITTED FROM THIS APERTURE

EMISSION
INDICATOR

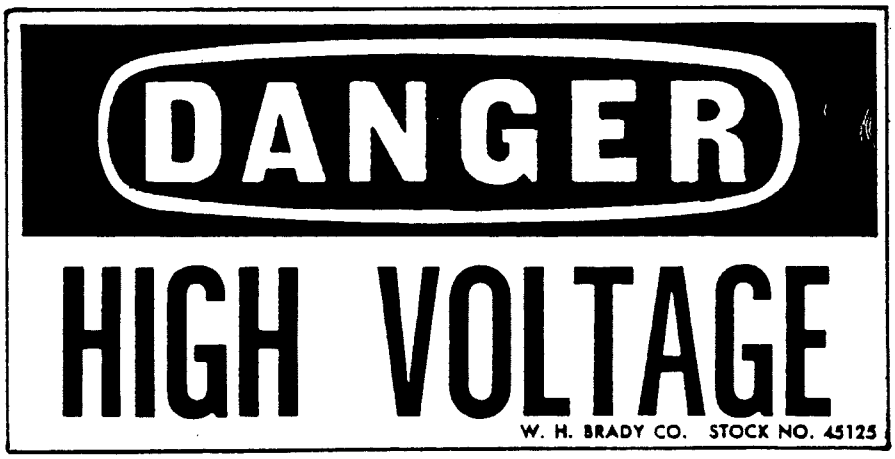
4) On the laser head cover safety interlock override flag (one on either side of flag).

DANGER
VISIBLE LASER RADIATION WHEN
OPEN AND INTERLOCK DEFEATED
AVOID EYE OR SKIN EXPOSURE TO
DIRECT OR SCATTERED RADIATION

5) On the rear of the power supply



6) On the cover of each pumping chamber.



3. GENERAL DESCRIPTION OF THE LASER

3.1 Optical head

A holographic oscillator is a special type of laser in which the necessary coherence length is obtained by the use of bandwidth limiting etalons in the resonator and its satisfactory performance depends very largely on the care with which the oscillator components are set up by the JK Lasers test engineer. The layout of the optical components comprising this laser is given in Figure 1.

A selected quality ruby laser rod is used, 4" long and 1/4" diameter. This is held in a close coupled type pumping chamber featuring a glazed ceramic reflector to provide diffuse coupling of the pump light into the laser rod. A flow of distilled water at an accurately controlled temperature provides optimum water cooling for the laser rod and the flashlamps.

The basic optical resonator is provided by a plane partially reflecting, wedged output mirror and a 5m curvature concave, fully reflecting rear mirror. Operation in single transverse mode is assured by the inclusion of a small aperture, mounted in the end plate of the pumping chamber. A mechanical safety shutter is incorporated in the laser front plate.

The oscillator is pumped by a Xenon-filled flashtube driven by a high stability power supply. Q-switching is achieved by a Pockels cell and a polariser and the drive circuit is designed so that either one or two Q-switched pulses are emitted, as required (in this latter case the pulse separation is adjustable between wide limits - see Appendix A - to allow use of the laser in a wide range of engineering applications). The Pockels cell features a KD*P crystal set in a sealed cell containing index matching fluid and anti-reflection coated windows to give a very low insertion loss. The Pockels cell windows are set at 5' to the crystal faces to minimise unwanted etalon effects within the cavity. The polariser consists of two plates mounted at the Brewster angle: no alignment is required, and the polariser is secured in the pumping chamber rear end plate.

A Q-switched laser will normally operate in several longitudinal modes at the same time. The number of modes depends on the natural fluorescent linewidth of the laser, the number of transverse modes operating and the degree of excitation of the laser rod prior to Q-switching. In order to reduce the number of modes operating and hence increase the coherence length of the holographic oscillator, additional wavelength selecting elements in the form of etalons are introduced into the laser resonator. The etalons are used in transmission and can therefore be coated with high reflectivity dielectric coatings to increase their finesse and reduce further the bandwidth of the laser. The etalons are thermally linked to the rod by the laser coolant, ensuring that any drift in rod temperature is compensated for by the etalons.

In order to prevent additional etalon effects within the resonator the output mirror and rod ends are wedged. The mirrors and etalons are mounted on an invar bar structure for high stability of the optical alignment. The beam from the oscillator is passed through a spatial filter to remove any unwanted perturbations from the beam profile and to match the beam size to the amplifiers, if fitted.

Amplifier stages are based on an 8" x 3/8" Ruby rod which on its own will produce an output of 1J. Used with a 4 x 1/4" preamplifier an output of 3J is available. With a second amplifier using an 8" x 5/8" Ruby rod the 1J output is increased to 10J. To prevent self lasing within the amplifier the ends of the rods are cut at 3° and anti-reflection coated, and to compensate for the beam offset caused by the rod wedge angles, the pumping chambers are skewed with respect to the optical axis. The amplifier rods are mounted in pumping chambers of similar construction to the oscillator, but each 8" rod is pumped by four lamps, to ensure maximum uniformity of the output beam profile.

All systems incorporate a photodiode energy monitor which is used to monitor the laser output and may also be used to balance the beams of an external holographic system. Output signals are provided for oscilloscope display.

The holocamera is based on the standard 1J or 3J holographic laser, but is built onto a 1m x 0.5m base and incorporates all additional optics and plate holder to enable holograms to be taken wherever required. The system has external controls to vary the reference beam path length and beam ratio without removing the cover. The system is designed to be portable and optically stable so that it can be taken to any factory or industrial location to study problems on the spot instead of having to simulate them in the laboratory.

3.2 Power supply units

The power supplies needed for driving the flashlamps in the laser head are contained in one or two 4ft cabinets, depending on the system complexity. The power supply control unit, which incorporates the pockels cell drive electronics and energy monitor interface unit, is situated either on top of the power supply cabinet in its own housing or built into the power supply cabinet.

The flashlamps are driven by conventional capacitor discharge supplies. The capacitors are charged from the constant current charging unit and the discharge is initiated by the series injection of a high voltage impulse from the trigger transformer. The timing and control circuits are built onto printed circuit cards situated in the control unit.

An overvoltage protection trip circuit board is situated on the power chassis of each charger and is powered directly from the incoming a.c. supply. Should the capacitor voltage exceed a set reference voltage the interlock circuit is broken and the capacitors are discharged. Once the trip level has been exceeded the circuit can only be reset by isolating the equipment from the mains.

The power supply incorporates a 'time out' dump circuit which discharges the capacitors after a pre-set time interval if the laser has not been fired. This delay may be adjusted by the DIL switch on the upper edge of the energy monitor & delay board in the control unit. The switch positions are as follows:

Switch No. 1	2	3	4	Delay (Minutes)
Down	Up	Up	Up	1
Down	Down	Up	Up	2
Down	Down	Down	Up	3
Down	Down	Down	Down	4
Up	-	-	-	Infinite

Operation in the infinite position is not recommended unless absolutely necessary as the life of the discharge capacitors may be adversely affected by long periods of charge at high voltage.

On the 3J system the oscillator and pre-amplifier operate together from the oscillator charger. The total energy of the system is set with the amplifier capacitor voltage control. On the 10J system, the amplifier charger operates both amplifiers at the set voltage.

All lasers are supplied with a closed circuit cooler system which works via a heat exchanger to the external mains supply. A heater is incorporated in the cooler unit to maintain the coolant temperature when the laser is not operating and the ambient temperature is below the recommended operating temperature for the coolant. Where mains water supplies of a suitable temperature are unavailable a refrigerator unit may be supplied.

3.3 The control unit

The control unit has four sections labelled POWER, POCKELS CELL, OSCILLATOR and AMPLIFIER, and all connections are via connectors on the rear of the chassis. The unit can be operated from the remote control box supplied. The controls are as follows:-

1) Keyswitch (ENABLE)

This forms a link in the interlock circuit and prevents unauthorised use of the laser.

2) ON

Once power has been applied depression of this button will cause the capacitors to be charged and the laser to operate in the set mode. Illumination of this button serves as an emission indicator. A delay is incorporated into the circuit to ensure that it is illuminated at least five seconds prior to the possible emission of laser radiation.

3) OFF

Depression of this button will stop the operating cycle of the laser and will dump the energy stored in the discharge capacitor bank. The laser is ready for re-use without further operation of the enable keyswitch.

4) INTERLOCK

This lamp lights when the ON button is pressed if any interlock switch remains open.

The interlock circuit comprises microswitches on the power supply cabinet doors and on the end plates of the laser pumping chambers, a pressure switch in the laser coolant circuit, a key-controlled switch, an external access point at the rear of the power supply cabinet and a plug on the laser head cover.

Other conditions which will cause the interlock warning lamp to light are actuation of the overvoltage trip and of the main thermal overload trip.

5) INT/EXT

This switch determines the triggering source for firing the flashtubes. In the INT position triggering occurs at a steady repetition rate preset at the factory. In the EXT position the laser may be fired by feeding a signal into the EXT. TRIG socket on the rear of the control unit or from the FIRE button on the remote control box.

6) SINGLE/AUTO

The position of this switch determines whether the discharge capacitor bank will automatically recharge after firing. In the SINGLE position it will be necessary to depress the ON button each time it is required to charge the discharge capacitor bank. This is recommended as the SAFE way of operating the laser when only occasional single pulses are required.

Operation in the AUTO position is necessary for repetitive operation, either from the internal or an external pulse generator.

7) Oscillator/amplifier main circuit breakers

This switch is used to apply mains voltage to the system. It does not initiate charging of the discharge capacitor bank. In addition, it protects the circuit under fault conditions.

8) CAPACITOR VOLTAGE

This control sets the voltage to which the discharge capacitor bank will be charged. It should be set prior to charging to obtain reproducible results. It is important to note that once charged the discharge capacitor bank voltage cannot be reduced by reducing the thumbswitch setting; this action will affect the voltage level only on subsequent shots. However, the discharge capacitor bank voltage level will always respond immediately to any increase in thumbswitch settings.

9) READY

This indicator is lit when the capacitor banks are charged and the laser is ready to fire.

10) DELAY

This control sets the delay between firing the oscillator flashlamps and the amplifier flashlamps.

11) Meter

The meter displays the voltage applied to the Pockels cell

12) BIAS

This potentiometer sets the voltage applied to the Pockels cell.

13) BALANCE

This potentiometer controls the size of the signal sent to the Pockels cell to reduce the first pulse energy and hence balance the pulses.

14) DELAY 1

This control sets the delay between firing the laser flashtubes and triggering the oscillator Q-switch.

15) DELAY 2

This delay sets the pulse separation between the two laser pulses in microseconds.

3.4 Remote control box

1) LASER OFF

Switches off the laser and dumps the capacitors.

2) LASER ON

Depression of this button will cause the capacitors to be charged and the laser to operate in the set mode.

3) FIRE

With the INT/EXT switch in the EXT position, depression of this button will fire the laser.

4) READY

This indicator is lit when the capacitor banks are charged and the laser is ready to fire.

5) EMISSION INDICATOR

This neon lights when the LASER ON button is pressed.

Note: Except when re-charging the capacitors in the single shot mode, a delay is incorporated into the LASER ON circuit. This ensures that the emission indicators are actuated at least five seconds prior to the possible emission of laser radiation.

4. OPERATING PROCEDURES

4.1 Holographic oscillator

Step-by-step instructions for switching on and operating a holographic oscillator to its specified performance are listed below. (Refer to 4.3 for double pulsing details).

1) Ensure that the tap water suppy to the cooler is turned on or that the chiller unit (if used) is switched on.

2) Turn the ENABLE keyswitch clockwise to the horizontal position and lift the oscillator power breaker. Lift the amplifier power breaker, if fitted.

3) Switch on the cooler, wait for a few minutes for the coolant to reach correct operating temperature.

4) Ensure that the INT/EXT and SINGLE/AUTO switches are set to give the mode of operation required.

5) Check that the following controls are set as per data in Appendix B - System Control Settings.

   CAPACITOR VOLTAGE

   DELAY 1

   DELAY 2

   BALANCE

6) Switch on the Pockels cell.

7) Press the ON button. The emission indicators will now light and after a short delay the capacitors will charge and the laser will operate in the set mode.

8) Press the OFF button to stop the laser operating and dump the energy stored in the capacitors.

4.2 Amplifiers

In this section the controls available for the range of holographic amplifiers is briefly described and then the operating procedures are listed.

HLS2 The amplifier is controlled from the amplifier section of the control unit.

HLS3 The pre-amplifier is controlled by the oscillator control section of the control unit. The main amplifier is controlled by the amplifier section.

HLS4 Both amplifiers are controlled by the amplifier control section of the control unit. The operating procedure is as follows:

1) Switch on the holographic oscillator as outlined in Section 4.1, but do not press the ON button.

2) Set the amplifier delay as indicated in Appendix B.

3) Set the CAPACITOR VOLTAGE control to give the required laser output (Do not exceed the factory setting of this control as detailed in Appendix B). When using lower drive levels than indicated, a different amplifier delay may be necessary to maintain equal double pulses.

4) Press the ON button. The capacitors will now charge and the laser will operate in the set mode.

4.3 Double pulse operation

Switch on as detailed in Sections 4.1 and 4.2 and monitor the laser output on an oscilloscope by means of the integrating photodiode energy monitor supplied with the system. Adjust the BALANCE and DELAY 1 controls until a signal similar to that shown in Figure 4.1 is obtained.

In general for pulse separations longer than 300uS the BALANCE control is set at maximum and the two pulses are equalised by adjusting DELAY 1.

For short pulse separations, DELAY 1 is set to the optimum value and the two pulses are equalised by using the BALANCE control.

For short separations, where there is insufficient time for re-pumping the laser rod between pulses, and for long separations, where the laser is operating in the 'wings' of the flashlamps pulse, it may be found necessary to increase the input energy to the laser. Care must be taken to ensure that this level is reduced, however, before returning to a more efficient mode of operation. It is important to note that, once the flashlamp capacitor bank is fully charged, resetting the input voltage to a lower value before the lamps fire will have no effect. Therefore, it is important to switch the laser off and reset the input voltage before changing other operating conditions.

4.4 1Hz operation

When operating at repetition rates faster than 6 pulses per minute, the equilibrium temperature of the rod is higher than the normal value. This requires a different setting of the micrometers of the intra-cavity etalons. Full details of the settings are given in Appendix B. After adjustment of the etalons, the resonator may require re-optimisation to restore the output energy or improve beam quality. The following alignment procedure should be carried out.

1) Switch off the laser and dump the capacitor.

2) Remove the aperture assembly from the oscillator pumping chamber end plate by loosening the grub screw situated under the cover fixing screw.

3) Operate the laser at the required repetition rate and capacitor voltage but with the Pockels cell switched off.

4) Monitor the oscillator output using the integrating photodiode supplied with the system and display the output on an oscilloscope.

5) Adjust the rear mirror only to obtain maximum output consistent with a smooth oscilloscope trace.

6) Check with burn patterns at the output of the oscillator that the output beam profile is symmetrical. NOTE: a small side beam may be seen at this point. (This is generated by the intracavity etalon and is quite normal).

7) Switch off the laser and replace the aperture assembly.

8) Adjust the X-Y position of the aperture only to obtain maximum output consistent with a smooth oscilloscope trace.

9) Check with burn patterns that the output beam profile is truly circular and even. some ring structure is normal in the beam profile at this stage.

10) Switch on the Pockels cell and check for satisfactory Q-switched performance.

11) Carefully remove any burn paper debris.

4.5 4-pulse operation (optional)

The four pulse Pockels cell driver allows operation of HLS series lasers with one to four Q-switched pulses within a total separation of up to 800uS.

The unit is self-contained; the internal Pockels cell section in the HLS control unit is not used. The 4-pulse driver should be positioned alongside the main control unit on top of the power supply and connected to the mains supply via the 4-way connector block on the rear of the cabinet. Unplug the HNC connector, on the end of the Pockels cell cable, from the rear of the laser control unit, and connect this cable to the 4-pulse driver by means of the 1m co-axial cable supplied (fitted with HNC connector at one end and PET connector at the other). Connect a BNC cable from the oscillator SYNC socket on the control unit to the TRIG socket on the 4-pulse driver.

The BIAS control sets the high voltage bias applied to the Pockels cell and this is displayed on the meter. It should be set to the value given in Appendix B. The output waveform applied to the Pockels cell is of the form shown in Figure 4.3., and the voltage to which the bias falls in the various pulses is set by the appropriate balance control. The overshoot voltage is adjusted by the pre-set control below the bias meter and is factory set to ensure that the Q-switched output of the laser is constant over a wide range of bias settings. A 15V SYNC output pulse is available at the rear of the unit for each of the four pulses.

1) Single pulse operation

Operation in single pulse mode is the same as for the standard control unit as described in Section 4.1/4.2. Set Pulse 1 balance to maximum and switch off Pulses 2-4.

2) Double pulse operation

i) Switch off Pulse 3 and 4.

ii) Set Pulse 2 balance to maximum.

iii) Set the required pulse separation on the Channel 2 delay control and associated multiplier rotary switch.

iv) Ensure that the flashlamp voltage setting is not in excess of that required to give the specified laser output.

v) Switch on the laser and monitor output on an oscilloscope by means of the integrating photodiode Energy Monitor supplied with the laser. Adjust Pulse 1 balance and delay controls until a signal similar to that shown in Figure 4.1. is obtained, giving optimum overall output and approximately equal energy in both pulses.

In general, for pulse separations greater than 300 uS the Pulse 1 balance control is set at maximum and the two pulses are equalised by reducing Pulse 1 delay.

For pulse separations less than 300uS the Pulse 1 delay is set at the optimum value for single pulse operation and the two pulses are equalised by reducing the Pulse 1 balance control setting.

For short separations, where there is insufficient time for re-pumping the laser rod between pulses and for long separations where the laser is operating in the 'wings' of the flashlamp pulse, it may be found necessary to increase the input energy to the laser. Care must be taken to ensure that this level is reduced, however, before returning to a more efficient mode of operation. It is important to note that, once the flashlamp capacitor bank is fully charged, resetting the input voltage to a lower value before the lamps fire will have no effect. Therefore, it is important to switch the laser off and reset the input voltage before changing other operating conditions.

3) Three pulse operation

i) Switch off Pulse 4.

ii) Set Pulse 3 Balance to maximum.

iii) Set the required pulse separations on Pulse 2 and Pulse 3 delay controls and associated multiplier rotary switches.

iv) Ensure that the flashlamp voltage setting is not in excess of that required to give the specified laser output.

v) Set Pulse 1 delay to the optimum value for single pulse operation less the average of the required pulse separations.

vi) Switch on the laser and monitor the output on an oscilloscope. Adjust Pulse 1 and 2 balance controls to obtain approximately equal energy in all three pulses, and adjust the flashlamp voltage to obtain the required overall output.

4) Four pulse operation

i) Set the required pulse separations on Pulse 2-4 delay controls and associated multiplier rotary switches.

ii) Ensure that the flashlamp voltage setting is not in excess of that required to give the specified laser output.

iii) Set Pulse 1 delay to the optimum value for single pulse operation less 1½ times the average of the required pulse separations.

iv) Switch on the laser and monitor the output on an oscilloscope. Adjust Pulse 1-3 balance controls to obtain approximately equal energy in all four pulses (Figure 4.2.), and adjust the flashlamp voltage to obtain the required overall output.

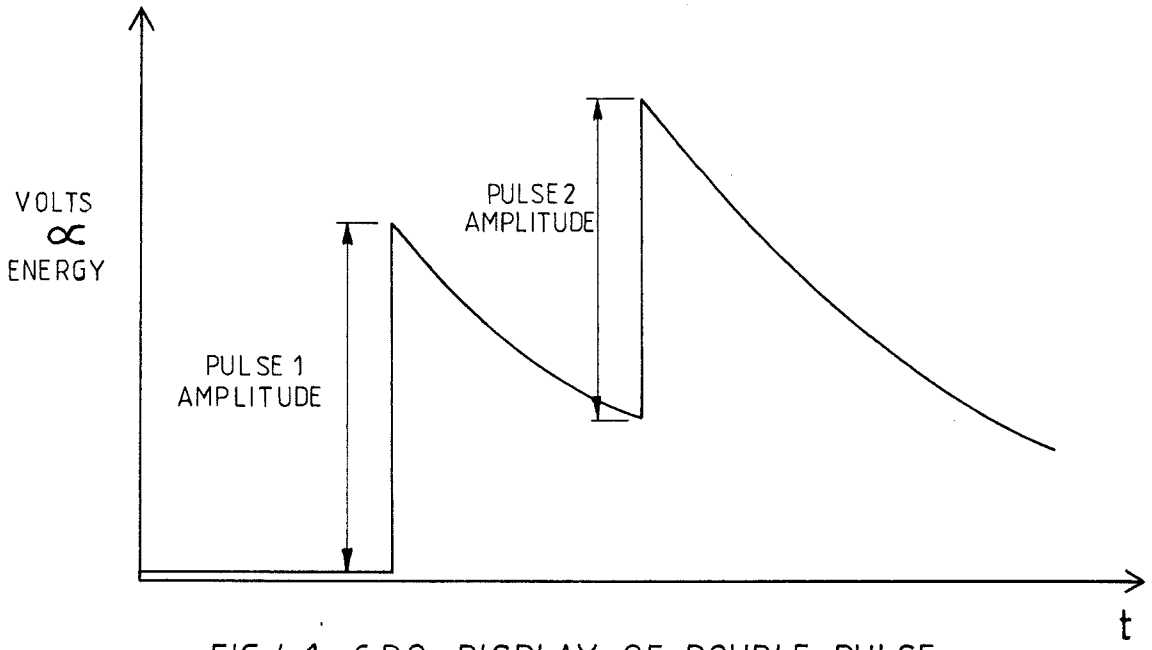


FIG 4.1 C.R.O. DISPLAY OF DOUBLE PULSE LASER OUTPUT

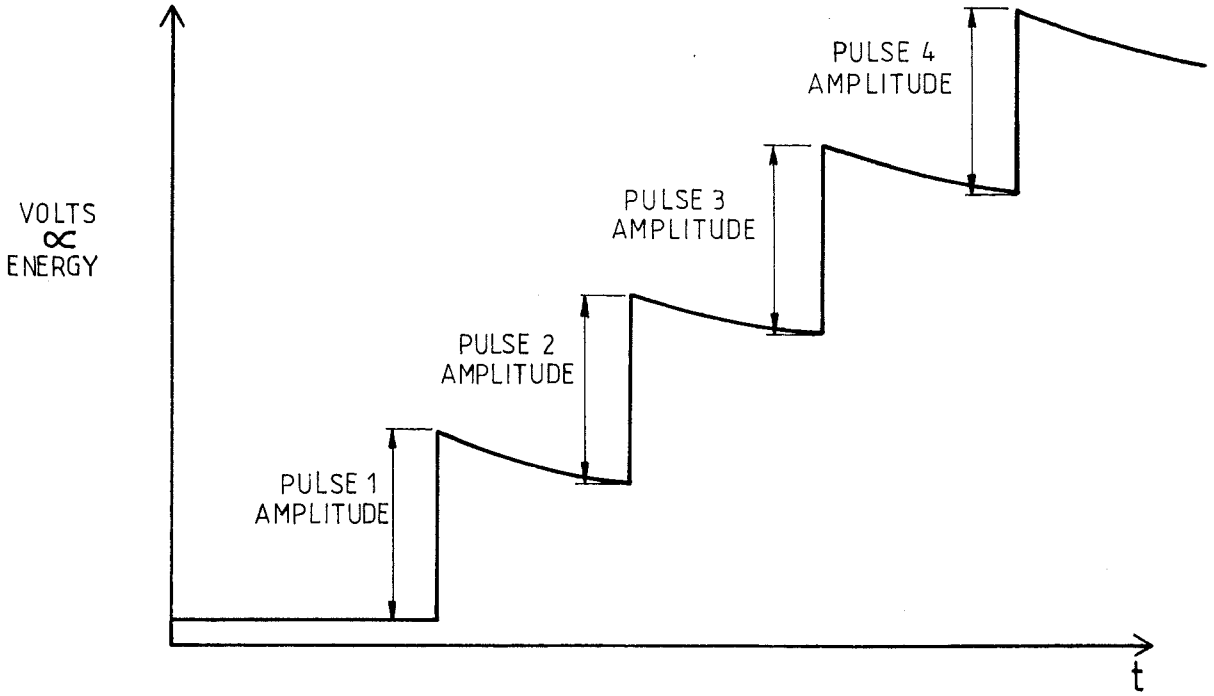


FIG 4.2 C.R.O. DISPLAY OF FOUR PULSE LASER OUTPUT

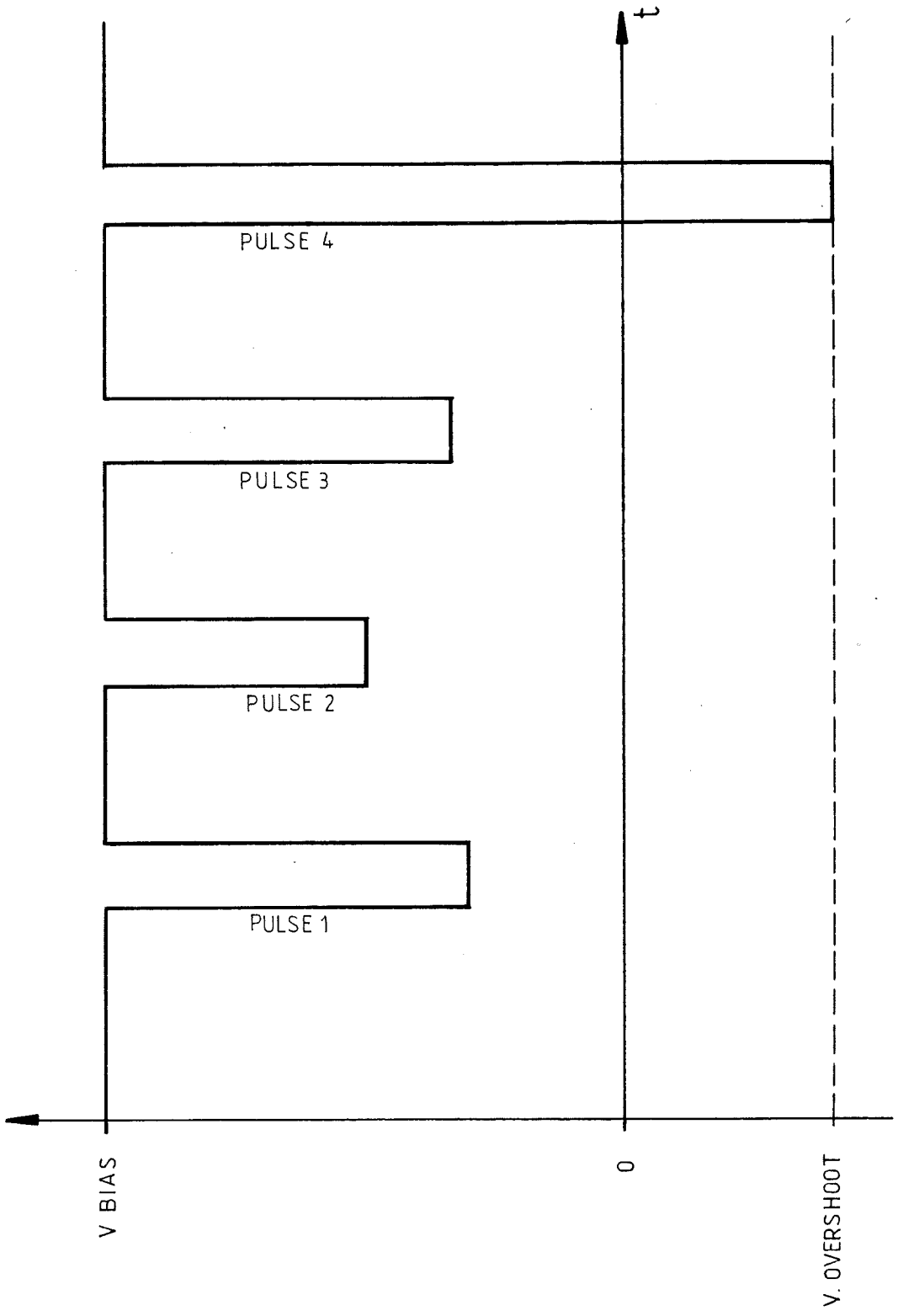


FIG 4.3 TYPICAL OUTPUT WAVEFORM FROM FOUR PULSE POCKELS CELL DRIVER

5. MAINTENANCE

5.1 Lamp changing

Changing of flashlamps will be necessary when they have aged to the extent that the required laser energy cannot be achieved with the available input energy, or if they become dirty on the outside due to contamination of the coolant, resulting in the loss of laser output. In this second case they can be cleaned, as detailed later, and re-used. Occasionally, a flashlamp may fail explosively and shatter inside the pumping chamber. In such cases, ensure that all fragments have been removed from the pumping chamber, to guard against any possibility of blockage.

The presence of other optical modules close to the pumping chambers means that these latter have to be removed bodily before the lamps are changed, but the mounting of the pumping chamber assemblies has been designed to make this operation very simple and to ensure that the chamber - and hence the ruby rod - fits back accurately so that the beam path is not disturbed.

1) Flashlamp removal

i) Ensure that the cooler is switched off and that the power supply is disconnected from the mains electricity supply.

ii) Ensure that the lamps are safe to work on. The safety probe(s) - to be found behind the cabinet doors - must be fitted into the discharge socket(s) according to the instruction label.

iii) Remove the laser cover and then the two screws which secure the pumping chamber cover and remove this cover.

iv) Slacken off the bleed screw on the end block. (See Fig. 5.) At this point a hissing sound will be heard as air enters the coolant circuit causing the level of the coolant to fall below the baseplate.

v) Carefully slide the lamp clips off the flashlamp ferrules.

vi) Carefully slide the PTFE gaitering tubes (if fitted) away from the pumping chamber end blocks.

vii) Remove the four screws which secure the baseplate to the mounting plate.

viii) Carefully lift away the complete pumping chamber assembly.

ix) Remove the two retaining screws and the clamp plate from the 'O' ring seal at each end of the lamp.

x) Gently move the lamp to and fro to unseat the 'O' rings. When the 'O' rings are free on the lamp, carefully withdraw it out of the pumping chamber.

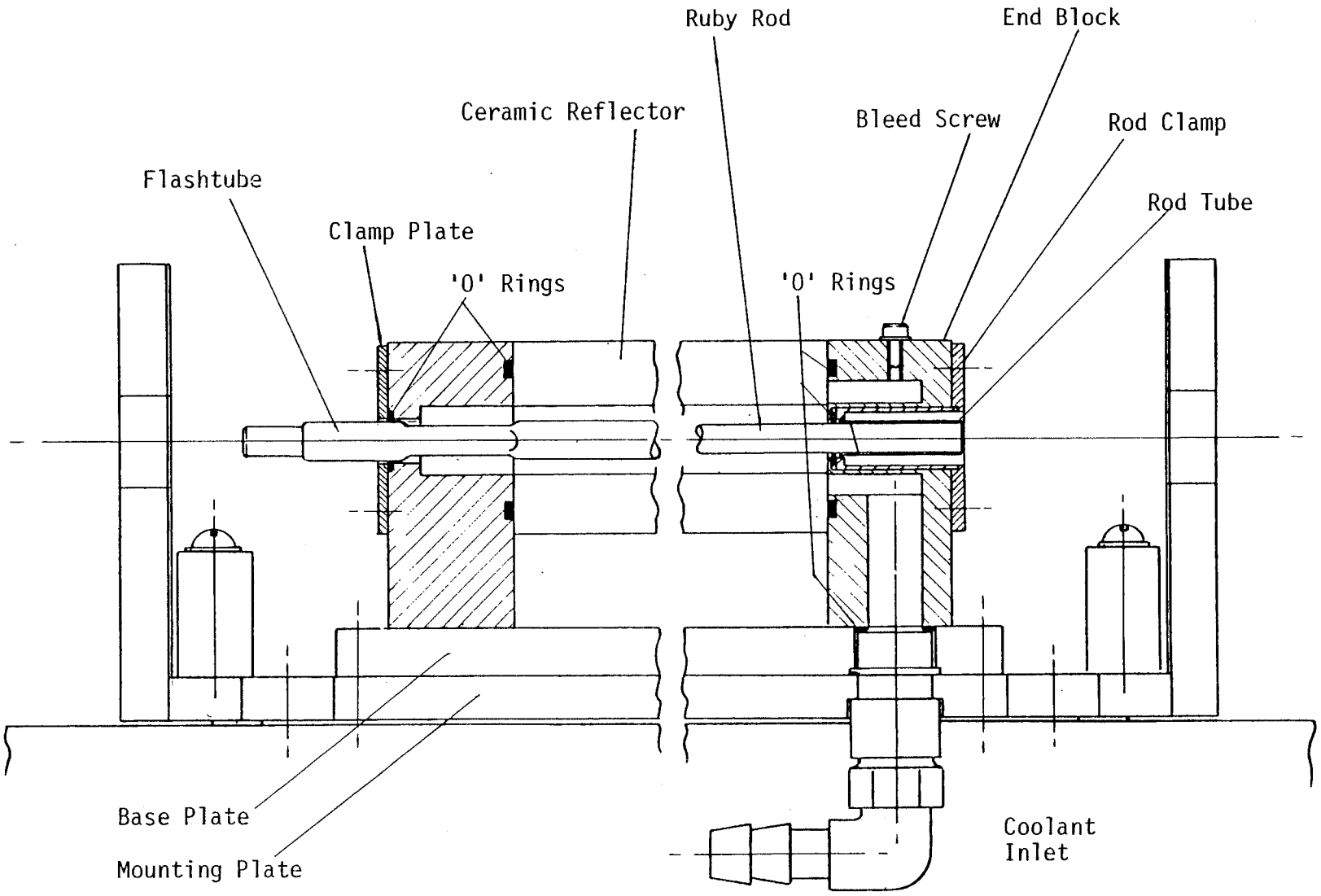


FIG. 5: CROSS-SECTIONS OF LASER HEAD ASSEMBLY SHOWING FLASHTUBE (LEFT) AND ROD (RIGHT)

2) Flashlamp replacement

i) Ensure that the flashlamps are clean; any traces of adhering 'O' ring should be carefully removed, taking care not to scratch the envelope.

ii) Slide the lamps into position in the pumping chamber, ensuring the polarity is correct (+ lead to red terminal). Unless the original 'O' rings are perfect, use new ones, rolling them into position from each end.

iii) Replace the pumping chamber by a reversal of the procedure for removing it, using new 'O' rings unless the old ones are perfect. (Take particular care when replacing the gaitering tubes and when sliding the clips back onto the lamp ferrules.)

iv) Switch on the coolant pump and look carefully for any leaks.

NOTE:Flashlamps in quad. pumping chambers are held in place by castellated clamping nuts. These are removed and replaced using the special tool supplied in the laser tool kit.

3) Flashlamp cleaning

Discolouration of the flashtubes can either be external or internal. First clean the lamp envelope in isopropyl alcohol. If discolouration persists, and is definitely on the outer surface, clean again with dilute nitric acid, keeping it away from the electrodes. If colouration is internal and extends far beyond the electrodes, the flashtubes probably need replacing. Generally, removal of external discolouration from the flashtubes should be accompanied by flushing of the cooling system and refilling with fresh coolant.

5.2 Cooler maintenance

The materials and components of the cooling system have been carefully chosen to minimise the possibility of contamination of the de-ionised water, and the primary maintenance task is thus just to check the level of the water. This can be done with the cooler in situ by unscrewing the large cap on the top of the stainless steel reservoir: the level, when the tubing and pumping chambers are full of water, should be just above the top of the heat exchanger coil. Do not overfill, or the water may spill over the top when the laser head is drained to change a lamp.

Depending on the frequency and conditions of operation, it may be necessary occasionally to change the coolant and possibly clean the system. If a marked drop in output occurs, check the flashtubes first. If these are contaminated on the inside through electrode sputter, but are clean externally,then it is probably not a coolant problem, and lamp replacement is indicated if the desired laser output

cannot be achieved with the available input pumping energy. The transparency of the coolant should be checked, however, and, if in doubt, replaced first. If examination of the external surface of the lamps or the interior of the reservior shows contamination, then the coolant will certainly have to be changed.

4) Changing the coolant

i) Drain the laser head by removing the bleed screws in the pumping chamber(s).

ii) Remove the screws holding the cooler chassis to the cabinet.

iii) Un-plug the electrical connector.

iv) Undo the quick-release coolant connectors, and slide the cooler unit out clear of the cabinet.

v) Remove the lid of the reservoir and empty out the coolant.

vi) Thoroughly clean every surface inside the reservoir, paying special attention to the corners and the coil: a paper towel is ideal for the purpose.

vii) Replace the bleed screw in the pumping chamber.

viii) Refill the reservoir with clean water, temporarily replace the lid, fit the cooler in the cabinet and remake the electrical and coolant connections.

ix) Switch the coolant pump on and flush for a few minutes.

x) Repeat steps i), iii), iv) and v).

xi) Replace the bleed screws and refill the reservoir with de-ionised water.

xii) Refit the cooler in the cabinet.

5.3 CDRH compliance checks

Safety features required by CDRH include:

- labels
- keyswitch master control
- emission indicators
- emission indicator delay
- beam attenuator (on HLS Series Lasers, this is the manual shutter)
- interlock switches in the protective housing
- external (customer) interlock
- reset after 5 seconds mains power interruption

1) Schedule A maintenance

Every week, check the correct operation of the following, taking immediate steps to remedy any defects:

i) The laser emission indicator on front-plate of laser head is illuminated when the POWER ON button is pressed.

ii) When the POWER ON button is pressed, it immediately lights up.

iii) When the POWER ON button is pressed the emission indicator on the remote control box is immediately illuminated.

Check buttons on the power supply control panel and the remote control box.

If any of these operations is obvserved to be defective during or between weekly checks, the fault should be corrected IMMEDIATELY.

2) Schedule B maintenance

Every three months confirm the correct operation of the following, taking steps to remedy any defects.

i) Labels are present on the laser system as specified in section 2.5 of this manual.

ii) If an attempt is made to remove the key from the keyswitch (ENABLE) whilst the POWER ON button is illuminated, then that button immediately ceases to be illuminated and laser operation is prevented.

iii) When the POWER ON button is pressed, there is a nominal 5 second delay before the READY lamp lights up.

iv) With the POWER ON button illuminated, when the laser head cover is removed, the button ceases to be illuminated, and the interlock lamp lights up if an attempt is made to re-start the system. (Wear protective eyewear).

v) With the laser head cover removed and the laser head interlock overriden (interlock override plug, with flag plugged into interlock socket) and the POWER ON button illuminated, then partial removal of the pumping chamber lid cover extinguishes the POWER ON lamp. Test each interlock switch in turn by partially unscrewing each end of the pumping chamber lid in turn (Wear goggles and note the presence of potentially lethal high-voltage beneath the lid.)

vi) When the POWER ON button is pressed the interlock lamp should light when the external (customer) interlock goes open-circuit. This check is only necessary if this interlock provision is being utilised.

vii) With the laser head cover removed, ensure that manual rotation of the shutter knob causes the shutter arm to move between the fully open and the fully closed position.

Note: Although not part of the CDRH - compliance procedure, it would be sensible during such shutter tests, to inspect the shutter ceramic surface for signs of contamination or damage and take appropriate action.

viii) With CAPACITOR VOLTAGE set to minimum value, press the POWER ON button. Then switch off mains power at the isolator, and switch on again after 5 seconds. The POWER ON button should no longer be illuminated.

APPENDIX A - SYSTEM PERFORMANCE

(For Laser Serial No. 5 1051 0)

In this Appendix the Basic specifications are given for this particular system. The system control settings to achieve this performance are given in Appendix B.

Wavelength	694 nanometres
Ouput Energy	1J
Max. Rep. Rate	4 ppm
Coherence Length	Greater than 1 m
Pulse Duration	30 nS nominal
Polarisation	Vertical

CONTROL UNIT SOCKETS

SYNC (output)	Voltage	15 V
	Duration	150 uS
	Impedence	50 ohms
TRIG (input)	Voltage	8 - 15 V
	Duration	100 - 150 uS

APPENDIX B - SYSTEM CONTROL SETTINGS

(For Laser Serial No. 5 1051 0)

In this Appendix the final system control settings from factory testing are recorded. They provide a useful reference for both initial user operation of the system and subsequent changes to operating conditions as the components age or are replaced due to damage.

Pockels Cell Bias	2.9	kV
Energy Monitor Calibration		
Oscillator	-	mJ/Volt
Filter	-	
Shoulder to Block	-	mm
Amplifier	200	mJ/Volt
Filter(s)	No. 6	
Shoulder to Block	8	mm
Coolant	Distilled Water	
Coolant Temperature	20°C	
Micrometer settings (mm)	Top	Side
Thin Etalon (rear), when normal to beam	0.00	Locked
Thick Etalon (front), when normal to beam	Locked	0.00
Thin Etalon - Final Settings	-0.84	Locked
Thick Etalon - Final Settings	Locked	-0.4
Thin Etalon -HLS1, 1 Hz, Final Settings	-	-
Thick Etalon -1 HLS1, 1 Hz, Final Settings	-	-
Pockels Cell Settings	Locked	Locked
Spatial Filter Lens Settings	Locked	Locked
Spatial Filter Aperture Settings	Locked	Locked

CONTROL UNIT SETTINGS

Pulse Interval uS	DELAY 1	DELAY 2	OSC CAPACITOR VOLTAGE	DELAY	AMP CAPACITOR VOLTAGE	BALANCE
Single Pulse	125	000	165	250	230	Max
1	108	001	173	250	245	2.1*
10	108	010	173	250	245	2.4*
100	105	100	168	250	235	4.6*
200	104	200	167	250	225	5.8*
400	099*	400	164	230	230	Max
600	095*	600	167	240	245	Max
800	091*	800	172	290	260	Max

* Adjust these settings to maintain equal double pulses

Ref:RJS68

DRAWINGS SUPPLIED WITH LASER SYSTEM

TYPE: HLS2

Customer: A. Stephens

Serial No: 5 1051 0

Date: 11 December 1986

BOM NO.	REV	DRAWING NO.	REV	DRAWING TITLE
–	–	E810357FB	D	2000L Energy Control Card Circ. Diag.
–	–	E810358FC	C	2000(L & H) Pulse Generator Circ. Diag.
–	–	E830427FB	C	Pockels Cell Driver Power Card Circ. Diag.
–	–	E810428FB	B	System 2000L and H Power Card Circ. Diag.
–	–	E820500FB	B	MK2 Trigger Card Circ. Diag.
–	–	E810520FB	A	TSA 2000 SCR Card Circ. Diag.
–	–	E811041FB	B	L System PD2000 Card Circ. Diag.
–	–	E811204FB	B	2000L System O/V Card Circ. Diag.
–	–	E836985FB	G	Remote Controller Circ. Diag.
–	–	E818017FC	F	Energy Monitor/Delay Card Circ. Diag.
–	–	E818039FB	A	Circ. for Delay Thumbwheel Switch Assy
–	–	E818113FC	C	P.C. Delay and Divider Card Circ. Diag.
–	–	E818209FB	A	3-Digit Thumbswitch V-Demand Circ. Diag.
–	–	E818777LC	B	Cabinet 1 HLS4 (2ppm) Cabinet Component Layout
–	–	E82C405FC	1	HLS2, & 4 Amplifier Circ. Diag. for Trigger Panel and Discharge Capacitors for Parallel Lamps
–	–	E81C419FD	1	HLS1, 2, 3 & 4 Power Supply Circ. Diag.
–	–	E81C421FC	1	Interlock Circuit
–	–	E81C424FD	1	Power Chassis Circ. Diag.
–	–	E82C428FC	1	HLS1, 2 & 4 Oscillator Circ. Diag. for Trigger Panel and Discharge Capacitors for Single or Series Lamps
–	–	E81C531FC	1	Holographic Control Unit Circ. Diag.
E8105670B	A	E810567AB	A	TSA 2000 SCR Card Assy
E8208590B	C	E820859AB	B	MK2 Trigger Card Assy
E8111070X	B	E811107AB	A	2000L and H Power Unit Card Assy
E8111080X	E	E811108AB	C	CU 2000L Card Assy
E8111480B	C	E811148AB	A	2000L System O/V Card Assy
E8344900B	D	E834490AB	C	Pockels Cell Driver Card Assy

Issue 1