Ref. F.4

SERVICING MANUAL

FOR

HOLOGRAPHIC LASERS

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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

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PREFACE

The purpose of this servicing manual is to detail all the procedures that may need to be carried out to keep an HLS laser in good working order - thus it gives the information to enable a technically-minded owner to carry out repairs, adjustments, etc., without having to call in a JK Lasers service engineer.

The manual is intended to be read in conjunction with the operator's handbook supplied with every HLS laser. Accordingly, the section numbering starts at 6, to follow on from the operator's manual sections, and frequent cross references are made.

A large part of this manual is concerned with the alignment procedures which will have to be made if the laser is dismantled for cleaning or replacement of any of the optics. A Helium-Neon alignmment laser is absolutely essential for this, and the text assumes that one fixed in the JK Lasers adjusting mount is available. It must be stressed that the HLS lasers are quite complex and successful operation is critically dependent on very precise alignment and adjustment.

6. LASER RODS: REMOVAL, CLEANING & REPLACEMENT

The oscillator rod is fitted with stainless steel end tubes, whereas the (pre)amplifier rods are not. Further, the oscillator and pre-amplifier rods are $\frac{1}{4}$" diameter and use the same design of pumping chamber with (series connected) twin lamps for pumping, whereas the main amplifier rods have four lamp pumping. Because of this, the methods of removal, cleaning and replacement are different for oscillator, pre-amplifier and main amplifier rods, and are detailed in separate subsections below.

In each case, the pumping chamber has to be moved bodily from the laser head and this should be done using the following procedure:

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

2) 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.

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

4) Slacken off the bleed screw on the end block. 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.

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

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

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

8) Carefully lift away the complete pumping chamber assembly.

9) Remove the two retaining screws and the clamp plate from the 'O' ring seal at each end of the lamp (oscillator and pre-amplifier) or use the special key in the toolkit to remove the 'O' ring clamp nuts (amplifiers).

10) 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.

11) Place the pumping chamber on a suitable table surface and arrange a HeNe laser so that its beam passes along the axis of the rod.

6.1 Removal of the Oscillator Rod

1) Note the deflection imposed on the gas laser beam after passing down the rod axis. Note also the positions of the back reflections from the two surfaces of the rod. This will greatly facilitate reinstallation of the rod.

2) Slacken the M3 screws securing the rod clamps and withdraw both clamps.

3) Very carefully push and pull the exposed thin wall end tubes with a gentle screwing motion to unseat the 'O' rings and then withdraw the laser rod from one end of the pumping chamber.

4) Check the ends of the rod for damage or contamination. Carefully wrap the rod in tissue and put it in a safe place until required.

6.2 Oscillator Rod Cleaning

1) If the rod faces are dirty and the contamination cannot be blown off with a stream of clean, dry air, the protective end tubes will have to be removed. NEVER poke tissues, etc down the tube in an attempt to clean the rod; the only way to satisfactorily clean the whole face of the rod is to remove the tube.

2) The tubes are glued in place. The ends of the rod should be completely immersed in nitromethane for about an hour, by which time the tubes should slide off easily.

3) Gently, but thoroughly, clean the exposed rod end and the cylindrical surface with nitromethane, followed by trichloroethane and then isopropanol. The anti-reflection coatings should be treated most carefully, since they are easily scratched and damaged.

6.3 Fitting End Tubes on the Oscillator Rod

It is important that the laser rod end tubes are fitted the correct distance apart. The 'O' ring seal at each end is made on the actual rod just clear of the tubes. Thus, there is no requirement for the glued joint to be waterproof, the purpose of the tubes is simply to facilitate handling and to protect the rod faces. If the tubes have too little separation, the 'O' rings will seat on them rather than on the rod and coolant may leak onto the rod faces. If the tubes are too far apart, their security on the rod will be adversely affected.

1) Make a pencil mark at the exact centre of the cylindrical surface of the rod.

2) Squeeze a drop of cyanoacrylate adhesive, such as Loctite 496, onto a microscope slide.

3) Preferably using a purpose-made jig (a length of aluminium angle supported between vee-blocks will serve), lay the rod down with the protective tubes pushed over each end. The tubes should fit snugly, otherwise adhesive may creep along the gap and reach the end face of the ruby.

4) Adjust the tubes until they are 98 to 98.5 mm apart and exactly centred on the rod.

5) Pick up a small quantity of adhesive with the tip of a scalpel blade.

6) Taking care not to disturb the position of the tubes, lightly run the tip of the scalpel blade in the angle between the rod tube and the rod until there is a continuous light fillet of adhesive.

7) Ensure the tubes are not tilted with respect to the rod and leave for a few minutes for the adhesive to enter the joint by capillary action and set.

8) Apply a second run of adhesive over the first once it has set, and then leave the rod on the jig for 2 hours for the adhesive to fully harden.

9) Gently remove surplus adhesive with the scalpel blade to leave a fine chamfer on the surface.

10) Check that both surfaces of the rod are perfectly clean. The anti-reflection coatings should look blue when viewed in reflected light. Any hint of yellow indicates that a haze of adhesive has spread onto the surface and the tubes will have to be removed and fitted again after cleaning the haze off the end of the rod.

6.4 Replacement of Oscillator Rod

1) Check that both ends of the rod are perfectly clean and that there is no water lying in the bore of the pumping chamber end blocks.

2) Fit an 'O' ring in position on the rod close to one end tube. Use new 'O' rings unless the original ones are perfect.

3) Insert the other end into the end block of the pumping chamber, taking care to keep clear of any coolant in the pumping chamber.

4) Feed the rod assembly right through the pumping chamber and roll an 'O' ring onto the other end tube. Push the 'O' ring into position on the rod by means of the rod clamp. If the tubes are the correct distance apart, you should be aware of the 'O' ring sliding off the rod tube onto the rod itself as the clamp is pushed home. Now remove the clamp and the rod should have a small amount of longitudinal play - a considerably greater pressure should be required to push the 'O' ring up the chamfer onto the rod tube.

5) The rotational position of the rod can now be set. Align the gas laser beam to the axis of the rod. Rotate the rod until the deflection imposed on the gas laser beam after passing down the rod axis is again in the same direction (upwards) as it was before removal of the rod and that the two back reflections from the ends of the rod are disposed vertically above and below the gas laser aperture.

6) Without disturbing the rod orientation, refit the rod clamps and loosely fit the M3 screws.

7) Place a gelatine polariser each side of the pumping chamber and arrange for the gas laser beam to pass through onto a viewing screen. Ensure the polarisers are crossed and then finely rotate the laser rod to give the best extinction of the gas laser beam.

8) Carefully tighten the rod clamp screws.

9) Refit the flashlamps and refit the pumping chamber, as detailed in Section 5.1.

CAUTION: Do not forget to vent the air from the pumping chamber whenever the coolant has been drained from the laser head. This is done by slackening the bleed screw, with the pump running, until water starts to ooze out.

6.5 Removal of the Pre-Amplifier Laser Rod (HLS3)

1) Slacken the two M3 screws securing the input end rod clamp and withdraw the clamp.

2) Carefully clean the thin walled stainless steel loading tube supplied in the toolkit with isopropanol both inside and outside. The loading tube is fragile and should be treated with care: if it is deformed in any way it will be rendered useless.

3) Very carefully slide the loading tube over the exposed end of the ruby rod. It is important at this stage not to touch the end of the rod with the loading tube as damage to the anti-reflection coatings may result. Gently push the loading tube under the 'O' ring seals with a screwing motion and then into the pumping chamber as far as it will go.

4) Remove the screws from the rod clamp at the other end and withdraw the clamp.

5) Push the loading tube right through the pumping chamber until it is possible to remove the rod from the end of the loading tube.

6) Check the ends of the rod for damage or contamination. Carefully wrap the rod in tissue and put it in a safe place until required.

6.6 Replacement of Pre-amplifier Rod (HLS3)

1) Gently, but thoroughly clean the rod ends and cylindrical surface with trichloroethane followed by isopropanol. The anti-reflection coatings should be treated carefully, since they are easily scratched and damaged. Check that there is no water lying in the bore of the pumping chamber end blocks. Ensure that the loading tube is perfectly clean and dry.

2) Fit an 'O' ring over one end of the rod. This is best done using the loading tube to avoid contamination of the rod end. Use new 'O' rings unless the old ones are perfect. Roll the 'O' ring along the rod until there is about 2 mm gap between it and the end of the rod.

3) Insert the rod into the loading tube until the 'O' ring is resting against the end of the loading tube.

4) Insert the loading tube and rod into the output end of the pumping chamber and push it right through until the end of the rod is almost flush with the end block.

5) The rotational position of the rod can now be set. Align the 'C' axis of the rod by rotating the loading tube until the cylindrical surface of the rod showing the darkest colouration is horizontal.

6) Fit an 'O' ring over the other end of the loading tube and push it into position with the rod clamp. Loosely fit the M3 clamp screws.

7) Place a gelatine polariser each side of the pumping chamber and arrange for the gas laser beam to pass through onto a viewing screen. Ensure the polarisers are crossed and then finely rotate the laser rod to give the best extinction of the gas laser beam.

8) Without disturbing the rod orientation, place the second rod clamp over the exposed end of the rod against the 'O' ring. Simultaneously push the rod clamp and draw the loading tube through the pumping chamber until the clamp is in position against the end block. Fit and carefully tighten the M3 screws.

9) Slowly withdraw the loading tube completely and secure the remaining clamp screws.

10) Check that both 'O' rings are securely seated on the laser rod and that the rod ends are still clean.

11) Refit the flashlamps, and refit the pumping chamber, as detailed in Section 5.1.

CAUTION: Do not forget to vent the air from the pumping chamber whenever the coolant has been drained from the laser head. This is done by slackening the bleed screw, with the pump running, until water starts to ooze out.

6.7 Removal of Amplifier Rod

1) Note the deflection imposed on the gas laser beam after passing down the rod axis. Note also the positions of the back reflections from the two surfaces of the rod. This will greatly facilitate reinstallation of the rod.

2) Slacken the four M3 screws round the periphery of the input end rod clamp a little at a time until the clamp is loose. Withdraw the clamp.

3) Carefully clean the thin walled stainless steel loading tube supplied in the toolkit with isopropanol both inside and outside. The loading tube is fragile and should be treated with care: if it is deformed in any way it will be rendered useless.

4) Very carefully slide the loading tube over the exposed end of the ruby rod. It is important at this stage not to touch the end of the rod with the loading tube, as damage to the anti-reflection coatings may result. Gently push the loading tube under the 'O' ring seals with a screwing motion and then into the pumping chamber as far as it will go.

5) Remove the screws from the rod clamp at the other end and withdraw the clamp.

6) Push the loading tube right through the pumping chamber until it is possible to remove the rod from the end of the loading tube.

7) Check the ends of the rod for damage or contamination. Carefully wrap the rod in tissue and put it in a safe place until required.

6.8 Replacement of Amplifier Rods

1) Gently, but thoroughly, clean the rod ends and cylindrical surface with trichloroethane, followed by isopropanol. The anti-reflection coatings should be treated most carefully since they are easily scratched and damaged. Check that there is no water lying in the bore of the pumping chamber end blocks. Ensure that the loading tube is perfectly clean and dry.

2) Fit an 'O' ring over one end of the rod. This is best done using the loading tube to avoid contamination of the rod end. Use new 'O' rings unless the old ones are perfect. Roll the 'O' ring along the rod until there is about 2 mm gap between it and the end of the rod.

3) Insert the rod into the loading tube until the 'O' ring is resting against the end of the loading tube.

4) Insert the loading tube and rod into the output end of the pumping chamber and push it right through until the output end of the rod is almost flush with the end block.

5) The rotational position of the rod can now be set. Align the gas laser beam to the axis of the rod. Rotate the rod until the deflection imposed on the gas laser beam after passing down the rod axis is in the same direction as it was before removing the rod.

6) Refit the flashlamps, as detailed in Section 5.1. Do not fit the clamp plates.

7) Slacken the flashlamp clamping rings in both clamp plates by about one turn. Fit an 'O' ring over the other end of the loading tube and push it into position with the rod clamp. Loosely fit the M3 clamp screws.

8) Place a gelatine polariser each side of the pumping chamber and arrange for the gas laser beam to pass through onto a viewing screen. Ensure the polarisers are crossed and then finely rotate the laser rod to give the best extinction of the gas laser beam.

9) Without disturbing the rod orientation, place the second rod clamp over the exposed end of the rod against the 'O' ring. Simultaneously push the rod clamp and draw the loading tube through the pumping chamber until the clamp is in position against the end block. Fit and carefully tighten the M3 screws.

10) Slowly withdraw the loading tube completely and secure the remaining clamp screws. Tighten the clamp rings securing the flashlamps.

11) Check that both 'O' rings are securely seated on the laser rod and that the rod ends are still clean.

12) Refit the pumping chamber to the laser rail as detailed in Section 5.1.

<u>CAUTION</u>: Do not forget to vent the air from the pumping chamber whenever the coolant has been drained from the laser head. This is done by slackening the bleed screw, with the pump running, until water starts to ooze out.

7. OSCILLATOR ALIGNMENT

The purpose of this chapter is to detail every step in the full alignment and optimisation of the holographic laser oscillator. Some steps will not be necessary for a minor or partial realignment and these should be disregarded: it is stressed that complete system realignment is certainly not considered routine and should only be necessary after major component replacement.

If major adjustments have to be made and difficulties are encountered, do not hesitate to contact JK Lasers for advice.

7.1 Minor Reoptimisation

Reoptimisation on a routine basis is not recommended and should only be carried out when a fall off in output energy or beam quality occurs or it becomes difficult to obtain stable double pulse performance. Follow the procedure outlined in Section 4.4. under 1 Hz operation.

CONTOURING: The oscillator is normally completely free from contouring (which is caused by incorrect etalon tuning). Should contours be observed on holograms taken with the laser, first check the temperature of the coolant before attempting to retune the etalons. Check also for pre-lasing as this can cause the oscillator to contour - see Section 9. If all seems well, then the etalons can be optimised as follows:

1) Arrange to monitor the oscillator output by placing the energy monitor after the oscillator. (Note that the beam must not be allowed to reach the spatial filter pinhole, since the energy monitor skews the beam somewhat and it will thus not pass centrally through the pinhole, with consequent risk of damage.)

2) Switch off the Pockels cell and display the normal mode output on the oscilloscope.

3) Adjust the top micrometer only of the thin (rear) intracavity etalon to obtain the maximum energy as indicated by the height of the oscilloscope trace.

7.2 Complete Alignment Procedure

The procedure detailed in this section (and in Sections 8, 10 and 11) is essentially the same as that used in the initial factory build of the laser and therefore assumes that no optics are mounted. Do not allow the oscillator beam to reach the spatial filter or amplifiers until proper alignment into these is carried out.

1) Mount a HeNe gas laser to the port in the laser end plate such that the gas laser beam enters the oscillator through the rear mirror.

2) Fit the output mirror and rear mirror, in their holders, to the angular adjusting mounts at front and rear end of the invar stabilised resonator structure. The mirrors should be fitted with their wedge-planes oriented to compensate for the rod wedge - ie with the thinnest edge of each mirror at the top. This orientation can be found by noting the skew of the HeNe beam as it traverses the mirror.

3) Using the alignment card supplied with the laser, adjust the gas laser beam to be exactly on the optical axis at two points equal distances either side of the laser rod, but between the laser mirrors.

4) Slacken the NOMAR screws which lock the output mirror adjustment and adjust the output mirror until the brightest spot it reflects is concentric with the gas laser aperture: this is best done by placing the alignment card just in front of the rear mirror, and arranging it so that the HeNe beam passes through the hole, since reflections from the rear mirror complicate things on the HeNe aperture disc. Retighten the locking screws.

5) Adjust the rear mirror in a similar fashion until the spot it reflects is also concentric with the gas laser aperture, placing the alignment card just before the output mirror to check for concentricity. Ignore the faint return from the second surface of the mirror.

6) The oscillator should now be operated at the specified repetition rate with up to 1 Joule output. Adjust the rear mirror only to obtain maximum output and a smooth oscilloscope trace. Check with burn patterns that the output beam profile is even and symmetrical.

7) Switch off the laser and fit the polariser in the pumping chamber end plate, correctly orientated for vertical polarisation. The polariser is held in position by a NOMAR screw situated beneath the pumping chamber cover fixing bolt, and the plates should be hanging below the Brewster angled support.

8) Fit the Pockels cell in its holder next to the rear mirror and align it , as detailed in Section 9.1. The Pockels cell windows are set at 5 minutes to the crystal faces and therefore will impose a small deviation on the laser beam. Repeat step 6.

9) Insert the mode selecting aperture assembly. Operate the laser (still fixed-Q) and adjust the x-y position of the aperture to give maximum energy output consistent with a smooth oscilloscope trace. All adjustments from now on will be with the aperture in place.

10) Set the Pockels cell delays to zero and note the bias voltage extremes at which breakthrough occurs, increasing the pump level if necessary to give a resonable 'window' width. Set the bias to the mid-point between these extremes. Increase the pump level to obtain breakthrough again and adjust the Pockels cell tilt to minimise this. Note the readings for future reference.

11) The etalons must now be fitted. If either of them is new, it must be angle tuned according to the detailed procedure given in the next section, and this requires the use of additional optical components, care and patience. However, if the original etalons are used again, tuning should not be necessary: the critical adjustment is the offset of the etalons (by the top micrometer for the thin - rear - etalon and the side micrometer for the thick - front - one) from the settings which put them normal to the beam. Adjustment of the etalons to be normal to the beam is given in Steps 7, 8 and 11 of Section 8, and the correct offsets can be found from the original sets of micrometer readings given in Appendix B of the Operator's Manual, supplied with the laser.

8. ETALON TUNING

The purpose of the etalons is to increase the coherence length of the laser by restricting the bandwidth in which lasing occurs, and for satisfactory operation of the oscillator there must be coincidence between a transmission peak of each etalon and the peak in the fluorescence curve for the ruby - see Figure 8.1.

The thin etalon is first fitted and angle-tuned, and then the thick one. This latter is more critical to adjust, since its thickness and high reflectivity mean that beam 'walk-off' can be a problem if the tuning tilt is too great (resulting in a poor beam shape and a degraded finesse value), whereas if the tilt is too small fringing is obtained on the oscillator output beam because of interference effects.

To tune the etalons it is necessary to examine the spectrum of the laser output using a Fabry-Perot analysing etalon of suitable spectral range. A 1 mm, 65%R etalon is used, in conjunction with a concave lens of focal length -20 mm to diverge the beam. The detailed procedure is:

1) Set up the negative lens outside the laser cavity to provide a beam of divergent light and to avoid damage to the analysing etalon.

2) Set up the analysing etalon beyond the lens in a plane where the diverging beam is 10 to 20 mm in diameter.

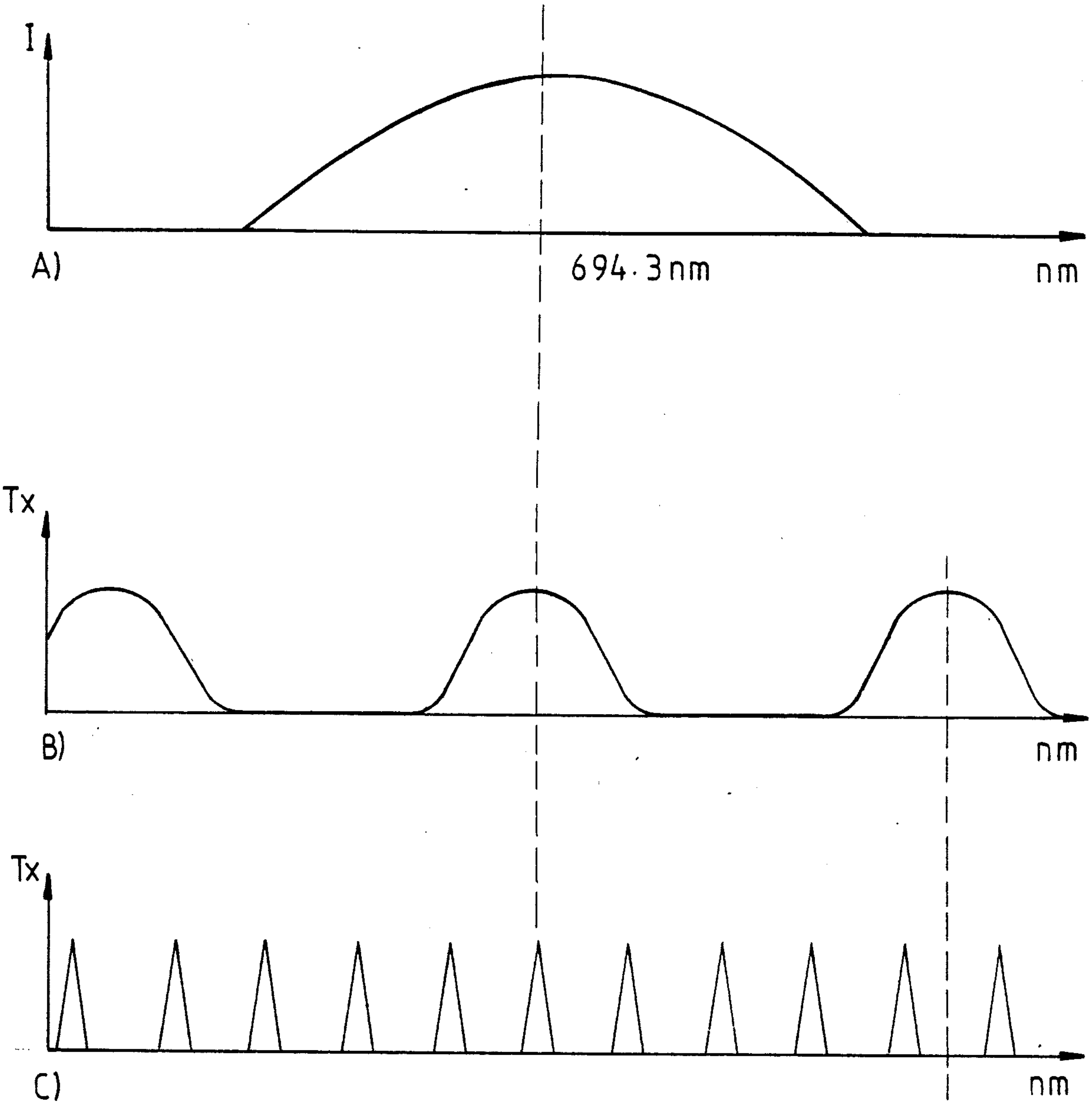
3) Set up a suitable screen a metre or so beyond the etalon.

4) Operate the laser at 40 mJ and with the Pockels cell switched off (since the wavelength varies too much from shot to shot when the oscillator is Q-switched). Note that, for the 1 Hz version of the HLS1, the etalon tuning varies with the repetition rate, and the complete tuning process should be carried out both at 1 Hz and at 10 ppm.

5) With the room darkened, examine the ring structure projected onto the screen when the laser is fired. A series of concentric circles will be seen, well spaced at the centre, but closer together further out and of gradually decreasing intensity. Adjust the x-y position of the lens to centre the beam on the ring structure.

6) Adjust the screen until the first or second ring from the centre is approximately 200 mm diameter. Clearly mark the position of this ring on the screen, taking the mean position of the ring over several shots.

7) Place the thin etalon, in its temperature stabilised holder, in the angular adjusting mount next to the Pockels cell. Align its surfaces with the resonator mirrors by means of the HeNe, having re-aligned this so that its beam travels through the aperture and normal to the output mirror reflecting surface.



A) Spectral output of Ruby Laser without Mode Selection.

B) Transmission Characteristics of thin Etalon.

C) Transmission Characteristics of thick Etalon

FIG. 8.1 ETALON TUNING

8) Place a card between the intracavity etalon and the Pockels cell and operate the laser. Finely adjust the tilt of the etalon to give maximum laser output, and record the micrometer settings. Decrease the reading of the top micrometer only by 0.3 mm.

9) Remove the card and operate the laser in the Q-switched mode. Inspect the rings produced by the analysing etalon and continue to decrease the reading on the top micrometer of the intracavity etalon until the ring structure is the same as before, as indicated by the marks on the screen.

10) Switch off the Pockels cell and fine tune the etalon, using the top micrometer, for maximum fixed-Q output.

11) Place the thick intracavity etalon, in its temperature stabilised holder, in the angular adjusting mount next to the polariser. Align its surfaces with the resonator mirrors by means of the gas laser. Place a card between the two intracavity etalons and operate the laser. Finely adjust the tilt of the thick intracavity etalon to give maximum laser output, and record the micrometer settings. Decrease the reading of the side micrometer only by the amount detailed in Appendix B. If the mount has no micrometers, rotate the side adjusting screw by ¾ of a turn clockwise.

12) Remove the card and operate the laser in the Q-switched mode. Inspect the rings produced by the analysing etalon and increase or decrease the reading on the top micrometer of the thin intracavity etalon until the ring structure is the same as before, as indicated by the marks on the screen.

13) Switch off the Pockels cell and fine tune the thin etalon on the top micrometer only to obtain maximum fixed-Q output. Switch on the Pockels cell and check the ring pattern is still as before. Record all etalon micrometer readings. The net result of this procedure is to bring the peaks of the two etalons into coincidence but slightly away from the broad maximum of the ruby fluoresence curve.

14) Optimise the rear mirror tilt for best beam shape and output energy, and repeat the output v input measurements up to 35 mJ, both fixed-Q and Q-switched.

9. THE POCKELS CELL Q-SWITCH

The purpose of the Pockels cell Q-switch is to produce laser pulses of short duration, typically 20 to 30 nanoseconds in the case of the ruby holographic oscillator, by storing energy in the laser rod during the first part of the flashtube pulse and then releasing it in a single giant pulse. To do this a high voltage bias is applied axially across the DKDP crystal within the Pockels cell which, in conjunction with the polariser, inhibits lasing by acting as an electro optic shutter. Removal of this bias voltage after a period set to maximise the stored energy allows formation of the Q-switched laser pulse.

Two consecutive laser pulses are obtainable from the standard holographic oscillator,but by the use of a special driver, up to four pulses may be generated.

The Pockels cell is a sealed unit with anti-reflection coated windows at each end. The space between the windows and the crystal is filled with FC104 index-matching fluid to minimise transmission losses through the cell. The windows are set at about 5 minutes of arc to the crystal faces and to each other to minimise unwanted etalon effects within the oscillator cavity, and this means that the rear mirror must be re-optimised when the cell is fitted. For correct operation, the crystal must be set so that its optic axis is aligned to the beam: it is not good enough to align only the crystal faces. In addition, the other axes of the crystal must be set parallel and perpendicular to the laser polarisation plane.

Maladjustment of the Pockels cell parameters can cause prelasing - a condition which must be avoided, as it can result in high local beam intensities which rapidly degrade the crystal faces and can cause damage to other oscillator components. Also, prelasing may cause contours to be produced on the holograms.

9.1 Pockels Cell Alignment

The Pockels cell is set up for best performance at the factory and only if the original alignment has been lost, or a new cell is being fitted, should the procedure outlined below be necessary.

1) Fit the Pockels cell so that the indented mark on the black rim lies exactly above the optical axis of the laser oscillator.

2) Remove the aperture assembly and both intracavity etalons.

3) Set up and align a HeNe gas laser, as detailed in Section 7.2, paragraphs 1 and 3.

4) Place one of the gelatine polarisers (supplied in the toolkit) against the Pockels cell on the pumping chamber side. Place the other gelatine polariser between the Pockels cell and the rear mirror with its pass plane orthogonal to the first one. Place a diffuser (eg a lens tissue) between the Pockels cell and the rear mirror and place a white card after the Pockels cell, against the pumping chamber.

5) Observe the HeNe beam projected onto the card. It will be seen to form a pattern: a central dark cross, or near cross, surrounded by concentric rings. It may be necessary to move the diffuser or screen back and forth to obtain the clearest image. Alignment of the optic axis of the Pockels cell consists of adjusting its tilt until the bright central HeNe spot falls on the point of symmetry of the pattern - Figure 9.1.

(Steps 6 - 8 only need to be carried out if the correct rotational setting of the Pockels cell is in doubt.)

6) Rotate one of the gelatine polarisers through 90 degrees, so that the pass planes of both polarisers are the same. The central pattern on the card will now consist of four dark areas disposed about the centre on axes passing through the centre at 45 degrees to the vertical - Figure 9.2.

7) Set the bias control to minimum and the balance control to maximum. Connect the Pockels cell and switch on. Gradually raise the bias voltage observing the pattern projected onto the card. Rotate the Pockels cell until raising the bias voltage causes two of the dark areas in the projected pattern to move towards each other along the 45 degree axis until they merge to form a diamond shape at the centre - Figure 9.3.

8) The Pockels cell is now correctly set for rotational position and Steps 4 and 5 should be repeated, with the bias switched off.

9.2 Pockels Cell Maintenance

Over a period of time, the fluid level in the cell may fall. The cell should always contain enough fluid to completely cover the crystal, and 'topping up' is carried out as follows:

1) Note the correct rotational position of the Pockels cell and remove it from its mount.

2) Undo the two screws securing the filler plug and remove this.

3) Fill a syringe with FC104 (both are supplied in the toolkit) and carefully insert this into the cell. Do not overfill - leave a small air space for expansion.

4) Refit the filler plug and secure.

5) Inspect the surfaces of the crystal for laser damage and the anti-reflection coatings of the windows for dirt and damage and then replace the cell. If this is done carefully, no adjustment or re-alignment should be necessary.

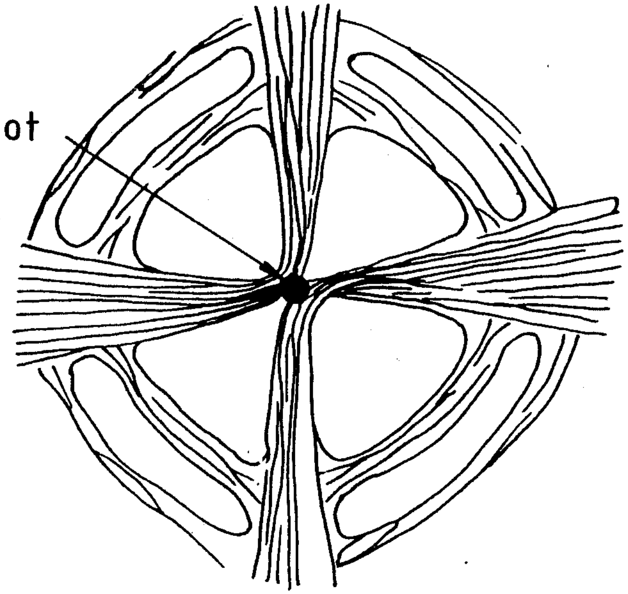
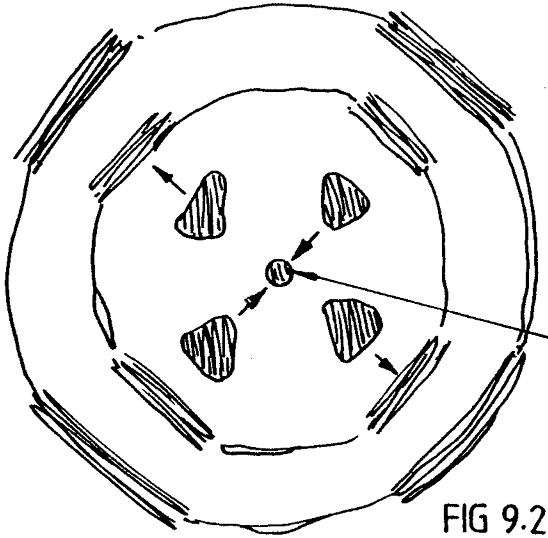
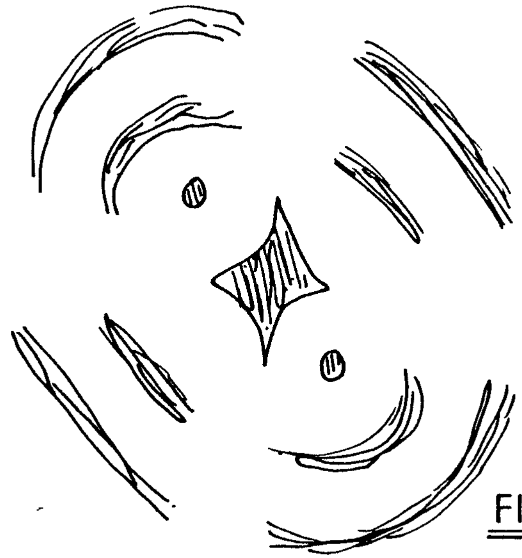


FIG 9.1 PATTERN OBTAINED WITH CORRECTLY ALIGNED POCKELS CELL



1) Volts OFF
(Arrows indicate movement when volts applied)

FIG 9.2



2) Volts ON
(Central diamond only achievable when correctly rotated)

FIG 9.3

PATTERNS OBTAINED WITH CORRECTLY ROTATED POCKELS CELL

10. SPATIAL FILTER ALIGNMENT (NOT HLS2)

All systems are fitted with a spatial filter after the oscillator to remove unwanted perturbations from the beam profile and to produce a gaussian distribution without the need for an extended beam path between the oscillator and amplifier. The focal length of the input lens is chosen to allow the natural beam divergence produced by the spatial filter to fill the following amplifier(s) without the need for subsequent beam expanding optics. For alignment of the spatial filter on the HLS2, refer to Section 11.

1) Inspect the pinhole for cleanliness and circularity, preferably using a microscope.

2) Fix a piece of burn paper about one metre from the laser and make a burn with 30-40 mJ Q-switched operation. Adjust the rear screws on the gas laser to centre its beam on the burn spot, the front screws to centre the beam on the laser aperture, and repeating these adjustments as necessary.

3) Mount the pinhole in its holder to the second fixed plate following the oscillator.

4) Mount the lens in its centering mount to the first fixed plate after the oscillator. Adjust the x-y position of the lens until the gas laser beam is focussed centrally through the diamond pinhole.

5) Adjust the x-y position of the lens to obtain maximum FQ mode output through the spatial filter, as indicated by an energy monitor. Note: up to 20% loss of energy through the spatial filter is not uncommon.

6) Check the output beam quality with burn pattern. Make fine adjustments to the x-y position of the lens to obtain an even and truly circular beam profile.

7) Switch on the Pockels cell and check the output energy and beam profile for Q-switched operation at about 35 mJ at the oscillator output mirror. Because of slight differences in beam geometry for Q-switched instead of fixed-Q operation, it may be necessary to make final slight adjustments to the spatial filter lens, but note that a Q-switched pulse must never be fired at the pinhole until careful adjustments under fixed-Q conditions have been made, for if more than 50% of the Q-switched beam is intercepted, damage to the diamond can result.

8) Record the spatial filter lens centering mount micrometer settings.

11. AMPLIFIER ALIGNMENT

All holographic lasers fitted with amplifiers have two turning mirrors and it is essential that these are clean and damage-free, since even a small imperfection can degrade the quality of the beam into the amplifiers. If there is any doubt about their condition, they should be inspected before starting the amplifier alignment procedure.

To gain access to a turning mirror, undo the four screws at the corners of the top plate, which allows this, complete with the mirror assembly, to be withdrawn from the protective housing. The actual mirror is glued to its immediate mounting bracket and this complete subassembly should be replaced, as necessary.

11.1 HLS2 Amplifier Alignment

1) Fit the two 45 degree incidence beam steering mirrors in their mounts at the rear end of the laser rail.

2) Mount a HeNe gas laser to the port in the endplate behind the second turning mirror.

3) Using the alignment card, adjust the front alignment screws of the gas laser until the beam is on the 50/60 axis near to the second 45° mirror.

4) Adjust the rear alignment screws to centre the gas laser beam in the output end of the amplifier rod. The beam should be 8 mm to the outside of the 50/60 axis.

5) Repeat Steps 3 and 4 until no further improvement is seen.

6) Fire the oscillator and take burn patterns just beyond the second 45 degree mirror. Adjust the first mirror until the burns are exactly coincident with the gas laser beam.

7) Make burn patterns at the input to the amplifier pumping chamber, and adjust the second turning mirror until the burns are coincident with the gas laser.

8) Repeat Steps 6 and 7, until no further improvement is seen.

9) Inspect the spatial filter pinhole for cleanliness and circularity, preferably using a microscope, place it in its mount and adjust its x-y position to centre it on the gas laser beam.

10) Place the spatial filter lens in its holder between the second turning mirror and the pinhole. Adjust the x-y position of the lens until the gas laser beam is again centered on the pinhole.

11) Switch off the Pockels cell and monitor the laser fixed-Q output after the spatial filter. Adjust the spatial filter lens to obtain maximum output.

12) Switch on the Pockels cell and remove the monitor. Make fine adjustments to the x-y position of the spatial filter lens to give completely round and even burn patterns at the input to the amplifier pumping chamber for a Q-switched pulse of about 35 mJ at the oscillator output mirror, but observe the warnings under Instruction 7 of Section 10.

13) The oscillator-amplifier combination may now be fired. Starting with the oscillator operating at 30-35 mJ single pulse, and a low amplifier voltage, progressively increase the amplifier gain. It may be necessary to adjust the spatial filter to centre the beam in the amplifier rod and obtain the most symmetrical and even burn pattern: this should be done with great care. Note that, to a first approximation, the filter will remain correctly set for optimum transmission if the micrometers centering the lens and the pinhole are each adjusted by the same amount.

14) Record the micrometer settings for the centering mounts of both the pinhole and the lens.

11.2 HLS3 Amplifier Alignment

1) Fit the two 45 degree incidence beam steering mirrors in their mounts at the rear end of the laser rail.

2) Mount a HeNe gas laser to the port in the end plate behind the second turning mirror.

3) Using the alignment card, adjust the front alignment screws of the gas laser until the beam is on the 50/60 axis near to the second 45 degree mirror.

4) Adjust the rear alignment screws to centre the gas laser beam in the output end of the main amplifier rod. The beam should be 8 mm to the outside of the 50/60 axis.

5) Repeat Steps 3 and 4 until no further improvement is seen.

6) Fire the oscillator and take burn patterns just beyond the second 45 degree mirror. Adjust the first mirror until the burns are exactly coincident with the gas laser beam.

7) Make burn patterns at the input to the main amplifier pumping chamber. Adjust the second turning mirror until the burns are coincident with the gas laser.

8) Repeat Steps 6 and 7 until no further improvement is seen.

9) The complete laser may now be fired, starting with the oscillator operating at 30-35 mJ single pulse, and a low amplifier voltage.

10) Progressively increase the amplifier gain, adjusting the turning mirrors to centre the beam in both the pre-amplifier and amplifier rods and obtain the most symmetrical and even burn pattern.

11.3 HLS4 Amplifier Alignment

1) Fit the two 45 degree incidence beam steering mirrors in their mounts at the rear end of the laser rail.

2) Mount a HeNe gas laser to the port in the endplate behind the second turning mirror.

3) Using the alignment card, adjust the front alignment screws of the gas laser until the beam is on the 50/60 axis near to the second 45 degree mirror.

4) Adjust the rear alignment screws until the gas laser beam is on the 50/60 axis at the output end of the 2nd amplifier.

5) Repeat Steps 3 and 4 until no further improvement is seen. The gas laser beam should be exactly centered in the output end of both of the amplifier rods. The beam should be 8 mm to the outside of the 50/60 axis between the amplifiers.

6) Fire the oscillator and take burn patterns just in front of the second 45 degree mirror. Adjust the first mirror until the burns are exactly coincident with the gas laser beam.

7) Using the alignment card as a screen, fire the oscillator and observe the position of the beam at the input to the 2nd amplifier pumping chamber. (The 1st amplifier will greatly attenuate the beam.) Adjust the second turning mirror until the beam is coincident with the gas laser, 8 mm to the left of the laser rail axis.

8) Repeat Steps 6 and 7 until no further improvement is seen.

9) The complete laser may now be fired, starting with the oscillator operating at 30-35 mJ single pulse, and a low amplifier voltage.

10) Progressively increase the amplifier gain, adjusting the turning mirrors to centre the beam in both amplifier rods and obtain a symmetrical and even burn pattern.

12. HOLOCAMERA ALIGNMENT

The HLS2 and 3 lasers may be supplied in a modified format as complete holocameras, and whilst the basic lasers are unchanged technically, the new layout and the additional components mean that a new setting up procedure is needed.

1) The oscillator has a standard layout but the beam emerges in the opposite direction along the rail. It may be aligned by the internal HeNe, using mirrors e and f to steer the HeNe beam, or by an external HeNe, as preferred: refer to the layout in the Operator's Manual.

2) Follow the procedure for testing an HLS2 or 3, as appropriate, centering the beam on the spatial filter pinhole, using turning mirror b, and on the optical axis just after mirror b, using mirror a. Note that the mount for mirror b has a tube fitted, to hold the photodiode assembly.

3) Fit the prisms. Note that the fixed prism mounting plate is wedged 3°, and the front edge of this is set perpendicular to the 50/60 axis whilst the prism hypotenuse face is parallel with the rear edge, ie at 87° to the beam.

4) Fit and align turning mirrors e and g such that the HeNe beam is on the 50/60 axis just beyond mirror c and centred on a burn pattern 1-2 metres from the laser output.

5) Fit the beamsplitter into its mount with the uncoated surface facing the amplifier. Rotate the beamsplitter to centre the beam vertically on the filters and clamp the mount in position to centre the beam horizontally on the filters and perpendicular to the rail axis. Note that the broad side of the wedge should be towards the centre of the holocamera base.

6) Fit the reference beam 45° dielectric mirror such that the gas laser beam is positioned centrally on it and is collinear with the rail axis and centred horizontally in the first moving prism. Adjust the first prism such that the return beam is parallel to the incident beam. Ensure that the position of the beam on the fixed prism is constant as the moving prisms are translated along the rail.

7) Adjust the fixed prism to centre the beam vertically at the reference beam exit port and adjust the second moving prism, such that the beam leaving it is parallel to the beam incident on it.

8) To centre the beam horizontally in the reference beam output port, translate the reference beam turning mirror in a direction perpendicular to the rail axis. Note that this is difficult to do without affecting the tilt of the mirror, which must be checked and reset as necessary.

9) Make fine adjustments to all elements to ensure that the HeNe beam is optimally centred in the reference beam output port throughout the entire travel of the moving prisms. Fire the ruby laser and make any further fine adjustments as required.

10) Fit the energy monitor diode and adjust its position so that the beam from the AR (back) surface of the beamsplitter falls centrally on the 19 mm ceramic diffuser.

11) Fit the main beam expanding lens in its holder such that the plano face of the lens is towards the laser. Adjust the x-y position of the lens to be central on the HeNe beam. Fire the ruby laser and make any further small adjustments to centre the beam in the lens.

(NB: This lens is not intended to steer the beam: the centering mount is to centre the lens on the beam.)

12) Fit the plate holder and reference beam outrigger mirror assembly. Adjust the reference beam steering mirror in this assembly to centre the reference beam on the plateholder.

13) The alignment is now complete, and test holograms should be taken at representative pulse separations, to check for satisfactory coherence length and freedom from contouring. The reference beam intensity at the plateholder should be 2-4 times that of the main beam reflection intensity from the chosen object, and this ratio is checked by using the energy monitor photodiode. Firstly, the reference beam is blocked off by closing the tube cover plate and the photodiode is held in front of the plateholder. Then the reference beam outrigger mirror is uncovered again, the photodiode is pointed towards it and the intensity adjusted by selection of the appropriate filters.

13. THE POWER SUPPLY AND CONTROL UNIT

The power supply is housed in a floor standing cabinet with interlocked front doors for ease of access. In section 13.1 following, the control unit is considered as an integral part of the power supply, it also contains the Pockels cell drive circuits, described in section 13.2. HLS1 has one charger and associated control circuits whereas the rest of the range have two units each. All chargers are 500W except for HLS1 (1 Hz) and the amplifier supply on HLS4 (4 ppm) where 2000W units are fitted.

The energy storage capacitors are charged from the constant current charging unit. The flashtube discharge is initiated by the series injection of a high voltage impulse from the trigger transformer. The timing and control circuit for each charger are built onto three circuit cards situated in the control unit (energy control card, pulse generator card and power card), drawing E81C420FC (E81C531FC on earlier units).

13.1 The power supply assembly

1) The constant current charger (Drawing E81C424FD)

The oscillator charger chassis incorporates a 'delay on' contactor RL3 which energises the main contactor RL1, 5 seconds after pressing the POWER ON button.

RL1 provides both the mains voltage for the constant current charger, and an enable contact for RL1 on the amplifier charger chassis (not HLS1 systems). When the POWER ON button is pressed the emission indicators on the laser head and remote control box are immediately illuminated. Circuit breakers CB1 for the oscillator and CB2 for the amplifier are used both as isolating switches and to provide circuit protection. The various interlocks are connected in series with RL3. Any interlock open will prevent RL3 closing and render the unit inoperative. Most of the interlocks are connected between terminals F and G of TB1, on the charger chassis which are convenient checking points.

The charger itself has a constant current network L1, C1, series control thyristor pair SCR 1-2, a step up tranformer T1 and a rectifier B1.

The constant current network maintains the charging current approximately constant during the charge of the capacitors. This has the advantage of minimising current surges from the AC supply and maximising the overall efficiency. Control of the capacitor voltage is achieved by operating the thyristor pair SCR 1-2 as a contactor effectively opening the primary circuit when the capacitors are charged to the required level. A sample of the capacitor voltage is derived by the PD2000 card (R1 and R3) and compared with a stable reference voltage. When the sample exceeds the reference voltage, firing pulses to the control thyristor SCR 1-2 are stopped, causing the device to switch off at the next current zero. "Topping Up" is allowed when the capacitor voltage has decayed by approximately 10 volts.

A refinement fitted to give very precise control of the capcitor voltage is the shunt thyristor pair SCR 3-4.

When the capacitor voltage reaches the required level, the shunt switch is fired, effectively diverting charging current out of the transformer Tl and abruptly stopping the charge. High power versions (Cl = 4 x 40 uF) are fitted with a capacitive clamp circuit to limit the transient voltage across Cl to a safe value. The clamp comprises Diodes Dl-4, electrolytic capacitors C5-6 and shunt resistors R7-8.

The various controlling signals are generated on the energy control card, housed in the control unit.

2) <u>Energy control card</u> (Drawing E810357FB)

This consists essentially of a comparator, a reference input and a gated pulse generator.

A sample of the voltage across the main discharge capacitor is derived by the PD2000 card (Rl and R3) in the main power unit. The front panel mounted voltage setting thumbswitch is supplied with +/- 15V from the control card to generate a reference voltage. The demanded voltage from this control is fed to one input of the comparator ICl, the other being supplied with the capacitor voltage sample. ICl output is negative when the capacitor voltage is less than the reference and positive when it is above. This changing polarity is used to gate the unijunction oscillator TR5, the output of which drives the series control thyristors SCRl-2 via a pulse transformer Tl on the TSA2000 SCR card in the main power unit. The abrupt change in polarity of ICl output when the storage capacitor reaches the demanded voltage is used to trigger the pulse generator formed by one half of IC3; hence to fire the shunt switch (SCR 3-4) TR2 introduces an asymmetry into the turn on/off process of the charger.

The 'turn-off' time constant R17, C7 is very short compared with that of the 'turn-on', R16, C7. This feature is introduced to allow a significant deionisation time for the flashtube before recharging the capacitor. IC2 drives the meter.

There are three pre-set controls. RVl allows adjustment in the 'topping up' point of the energy storage capacitor. RV2 is not used in HLS systems. RV3 situated at the top of the card is used to calibrate the meter.

3) <u>Trigger circuit card</u> (Drawing E820500FB)

This card is situated on the trigger panel. The trigger transformer (T6) and circuit card, generate the high voltage lamp firing impulse. Capacitor (C9) is charged to approximately 600 volts from the 440 volt winding on T2. (Mounted on the power chassis). Thyristor SCRl is triggered by a pulse from the pulse generator housed in the control unit, effectively connecting C9 across the primary of T6, generating an impulse of approximately 18 kV at its secondary.

4) Pulse generator circuit card (Drawing E810358FC or E811071FC)

This card, situated in the control unit, generates the low voltage pulse to initiate the firing of the flashtube. It also houses the relay RL1 that switches on and off the control card, hence controlling the charging of the storage capacitors.

The pulse generator may be operated either internally or externally as selected on the front panel mode switch (INT/EXT).

In the internal mode the system operates at the specified repetition rate, the interpulse period being set by capacitor C1 and two resistors either R43 and R44 mounted on the card on later systems or R1 and R2 on the energy monitor delay card on earlier systems - selected during laser test at the factory.

In the external position the system is operated by manually depressing the FIRE button on the remote control unit or from an external 8-15V 100 uS trigger signal applied to the EXT. TRIG. socket at the rear of the control unit.

A reference voltage set by RV1 is compared with the instantaneous voltage on C1 by the comparator IC1. When the capacitor voltage exceeds the reference, IC1 output changes polarity firing a monostable multivibrator (half of IC3) via the mode gate IC2. The pulse from the multivibrator (TP2) is used both to discharge C1 and to reset the generator as well as providing principal output to trigger the flashtube. The remaining multivibrator (the other half of IC3) is used to facilitate automatic or manual recharge (AUTO/SINGLE).

Relay RL1 is driven by TR3 and switched on by means of TR7 on the energy monitor and delay card 5 seconds after pressing the POWER ON button and feeds the positive 15 volt supply to the charging circuit on the control card.

In the AUTO position TR3 is permanently biased on by R16/17. In the SINGLE position bias for TR3 is supplied via R19 from IC3 so that when a pulse is produced, i.e. the laser fired, IC3 output goes low cutting off TR3 and causing RL1 to drop out. Further operation necessitates pressing the POWER ON button again.

The POWER ON/POWER OFF function is duplicated by the CHARGE/DUMP buttons on the remote control unit. (LASER ON/OFF on earlier systems).

5) Low voltage power supply card (Drawing E810428FB)

This card is used to power the two other associated circuit cards. It provides stabilised output of +/- 15 volts. Test point (1) is the positive output monitor point and (2) the negative. Relay RL1 is used to clamp the pulse generator output to prevent spurious firing pulses at power switch off.

NOTE: The energy monitor and delay card is supplied with +/- 15 volts by the oscillator power card.

6) <u>Energy monitor and delay card</u> (Drawing E818017FC)

The energy monitor and delay card is located in the control unit and contains several circuits with the following functions:

i) Resistors R1 and R2 set the internal repetition rate interpulse period. This function is transferred to the pulse generator card in later versions.

ii) Extra smoothing and decoupling components are incorporated, particularly C15 which ensures ripple free operation of the energy monitor circuit.

iii) The READY signal is generated by the AND gate formed by TR1 and TR5. This requires both oscillator and amplifier capacitor banks to be fully charged before illuminating the READY light. In oscillator only systems R21 switches on TR1 in the absence of amplifier circuitry, enabling the READY signal to operate from the oscillator only. IC3b and d form a gating circuit to prevent the laser from firing before the capacitors are fully charged.

iv) The energy monitor circuit integrates the signal from the system photodiode. The time constant is set by R8 and C4 working into an impedance conversion stage IC1. The inductor L1 removes any h.f. elements from the input signal.

v) The OSC SYNC signal is buffered by TR2 and is available on a socket at the rear of the control unit for triggering oscilloscopes and other ancillary equipment.

vi) Two sections of IC2 are used to generate a delayed AMP SYNC signal to trigger the amplifier flashlamps after the AMPLIFIER DELAY set on the front panel thumbswitch.

vii) The time out delay circuit which uses IC2C and IC4 causes the laser to switch off and the capacitors to dump after a period set by S1-S4 (see operator's manual for switch settings). The delay is refreshed by the SYNC signal, should the laser be fired, via IC3a and also from pin 27 when the capacitors are charged. The main timing capacitor, C17 is charged through the resistor chain formed by R36-R39 as selected by S1-S4. When the voltage on C17 exceeds that on C21 it will cause the comparator IC4 to switch. TR4 then conducts energising relay RLA, opening the contact RLA/1, which is in the main interlock chain, shutting down the system.

viii) The circuit of TR7 is part of the 5 second switch on delay.

7) <u>Overvoltage protection trip circuit</u> (Drawing E811204FB)

This circuit card is situated on the charger chassis and is powered directly from the incoming AC supply, ahead of the main contactor.

The circuit consists of a comparator (IC1) which compares a sample of the discharge capacitor voltage, derived by the PD2000 card (R2 and R4) and R1, R2 with a reference voltage set by RV1. Should the capacitor voltage sample exceed the reference, the output of IC1 changes from near zero to -30 volts, causing the relay RL1 to open. The contact of RL1 is connected in series with the interlock chain. Once the trip level has been exceeded, IC1 latches, by the action of D4 and D5 and can only be reset by isolating the equipment from the AC supply.

8) Lamp matching and trigger circuits

Consist of a trigger circuit card, trigger transformer(s) and lamp matching inductor(s) mounted on an insulated panel.

Oscillator (except HLS3)	Drawing E82C428FC
Oscillator & Pre-amp HLS3	Drawing E82C410FC
All main amplifiers	Drawing E82C405FC

13.2 The Pockels cell drive circuit (Drawing E81C420FC or E81C531FC on earlier units)

The Pockels cell drive circuit is situated in the control unit and comprises:

Two high voltage pulse generators.

A high voltage supply module to provide bias for the Pockels cell.

A delay circuit card, which introduces the necessary delays between the input trigger (flashtube) and the generation of the Q-switched pulses.

A low voltage power supply card.

1) High voltage pulse generator

The generator consists of a krytron switch tube and pulse forming network (R6, C1, L1). In double pulse operation the amplitude of the first pulse is adjusted by the BALANCE control RV2, which sets the voltage on the pulse forming capacitor C1. The range of control is from 40-100% of the Pockels cell bias voltage. The pulse width is approximately 1 uS. The krytron trigger pulse at the primary of T2 is -24 volts, generated by the delay circuit.

2) Pockels cell delay circuit card (Drawing E818113FC)

Two independent delay circuits are contained on the same circuit card. The delays are set by front panel thumbswitches (see section 3.3).

DELAY 1 is produced by IC1. One half of IC1 produces the delay, whilst the other produces a pulse for triggering the high voltage pulse generator and for the synchronisation of external events (P.CELL SYNC). The delay generator IC1 is isolated from the input by a noise filter and threshold amplifier TR1. A-24 volts pulse for triggering the high voltage pulse generator is generated by TR3 and TR4.

DELAY 2 Between the input at R21 and the delay generator proper, there is a noise filter and threshold amplifier TR5, 6. The delay generator consists of an RS flip flop IC2, a discharge switch TR7 and a threshold detector TR8-11. Preset controls RV4 and RV5 are used to calibrate the delays.

CALIBRATION Should recalibration be necessary, the following procedure is recommended:

i) Check on the Pockels cell driver power card that the voltage across C1 is 22V and across C2 is 15V. Monitor the voltage on TP2 whilst varying the BIAS control, it should swing from 5V to 15V.

ii) Set DELAY 1 for 199 and DELAY 2 for 999.

iii) Feed a suitable trigger pulse at 1 Hz into the EXT.TRIG trigger socket. Check both krytrons flash.

iv) Connect a X1000 VAC oscilloscope probe in place of the Pockels cell at the end of the PET cable. Set BIAS control to its normal operating voltage and BALANCE to maximum.

v) Set DELAY 2 first. All adjustments are on the Pockels cell delay card. Adjust RV5 to give 999 uS between the first negative edge of each pulse as seen on the oscilloscope. The pulses should be approx. 1 uS duration.

vi) Set DELAY 2 thumbswitch to 000 and oscilloscope time base to 1uS/div. Adjust RV3 so that both pulses coincide on the left hand side of screen.

vii) Reset DELAY 2 thumbswitch to 999 and check linearity.

viii) Trigger the oscilloscope from the OSC. SYNC socket and adjust RV1 to obtain 1990 uS (2 mS) from the trigger signal to the first pulse.

ix) Set DELAY 1 thumbswitch to 010 (100 uS) and adjust RV2 to obtain 100 uS delay.

x) Reset DELAY 1 thumbswitch to 199 and trim RV1 for 2 mS delay. Repeat para (ix), as necessary to optimise linearity.

The synchronising pulse from channel 1 leads the actual laser pulse by 2 to 3 microseconds. The setting of DELAY 2 gives the delay between the two laser pulses not between the delay pulses. The difference between the laser pulse delays is accounted for by the various filter and propagation delays of the circuits and is of the order of a few microseconds. RV3 is used to equalise the fixed delays of the two channels, ensuring that the DELAY 2 calibration is between laser pulses.

Pockels cell driver power card (Drawing E830427FB)

The low voltage power card comprises two independent stabilised supplies. One is a fixed +15 volt supply for the delay unit and the other adjustable in the range 5-15 volts to supply and control the output of the EHT module.

The output voltages may be checked at test point 1 for the fixed and 2 for the variable supply; the negative side of the large electrolytic capacitor being common.

14. INSTALLATION INSTRUCTIONS

Carefully unpack all the packages and check the components against the parts list supplied. Notify any shortages to the supplier immediately.

1) Cooler

   i) Fill with 7 litres of distilled water.

   ii) Fit the venting washer to the filler cap and replace.

   iii) Install the cooler in the power supply cabinet or slide into its own cabinet, if free standing type.

   iv) Plug the cooler lead into the socket in the centre of the power supply unit or, if the free standing type, plug it into the socket strip on the rear of the power supply cabinet.

   v) Connect the WATER INLET to the mains water supply or chiller unit as appropriate.

   vi) Connect the WATER OUTLET to the drain.

2) Laser head

   i) Remove the packaging and route the conduits to the rear of the power supply unit.

   ii) Remove the protective tape from the optics taking care not to disturb any component.

   iii) Install the interlock override flag.

3) Power supply unit

   i) Position the control unit on top of the power supply and remove the lid. Remove the panels from the rear of the power supply.

   ii) Connect the leads from the control unit conduit, at the rear of the main power supply cabinet, to the relevant sockets in the control unit.

   iii) Install the oscillator conduit to the rear of the power supply.

   iv) Connect the Pockels cell and energy monitor cables from the oscillator conduit to the relevant sockets at the power supply end of the control unit conduit.

   v) Connect the coolant self-seal connectors to the cooler.

vi) Connect the amplifier conduit and inter-cabinet conduits if fitted.

vii) Plug the remote control box into the 'D' socket in the control unit.

viii) Plug the interlock cable into the six-pin Q.M. socket on top of the oscillator conduit box.

ix) Connect the power supply to the mains via the white 3-core cable. The wires are coded as follows:-

LIVE - Brown
NEUTRAL - Blue
EARTH - Green/Yellow

4) <u>Operation</u>

i) Switch on the external cooling water and check for leaks.

ii) Lift the oscillator breaker and switch on the cooler. Vent the air from the pumping chambers by slackening the bleed screws until water starts to ooze out. Check for leaks. Ensure the coolant temperature controls to 20°C +/- 0.3°C.

iii) Refer to Appendix B in the Operator's Manual and set the control unit for single pulse operation.

iv) With the Pockels cell switched off and the amplifier CAPACITOR VOLTAGE set to 000, follow the procedure detailed in section 4.1 in the Operator's Manual and take a burn pattern after the oscillator. If this is truly circular and even take a further burn pattern after the spatial filter.

v) Switch on the Pockels cell and repeat these burn patterns Q-switched. If no burns are seen, or the beam profile is not circular and even, then refer to Section 7 and re-align the oscillator before proceeding.

vi) Gradually increase the drive level to the amplifier(s), if fitted, and make burn patterns 0.5 metres from the laser beam exit port.

vii) If the burn pattern is not circular and even refer to section 11 to centre the beam in the amplifier rod(s) and obtain the specified output energy.

viii) Check the double pulse operation at each setting given in Appendix B, in the Operator's Manual.

ix) Take test holograms at each setting.

x) Replace the laser head lid and all the power supply & control unit panels.