8. ENERGY MONITOR CALIBRATION

8.1. Positioning

The energy monitor is provided with the laser primarily to allow the customer to balance the energy in the two pulses in double-pulse operation, and to provide a check on the absolute output energy levels. Hence, it is positioned at the output end of the laser base. However, it may be moved by the customer and placed after the oscillator output mirror to check on the oscillator performance in any re-alignment operations. Particularly for larger diameter beams, it is important to ensure that the beam path through the energy monitor is well-defined, since this affects the sensitivity somewhat. The monitor baseplate has two pins projecting down, and precise lateral positioning on the laser base is achieved by ensuring that these are hard against the edge of the groove in the extrusion.

The beamsplitter block may be fitted on its baseplate in one of two positions, to allow for the 8 mm offset in the HLS2 and 3 and the on-line beam position for the HLS1 and 4. Note that the block does not need to be refitted when the monitor is moved to the oscillator output, since its aperture can accommodate the TEM_{oo} beam size at an 8 mm offset.

8.2. Calibration Procedure

The sensitivity of the energy monitor is governed bythe neutral density filters used in front of the photodiode on the end of its mounting tube assembly. Because of the noise output produced by the general electrical noise generated by the firing of the laser, this sensitivity should be kept high, to give 3-6 volts output at specified laser performance. Variations in photodiode sensitivity prevents the definition of the filter density needed to achieve this, but the conditions to be aimed at are:

For the HLS1, 10 mJ/V, using 1 filter
For the HLS2, 200 mJ/V, using 1 filter
For the HLS3, 500 mJ/V, using 2 filters
For the HLS4, 2 J/V, using 2 filters

Two filters are used for the HLS3 and 4 so that one can be removed to give a reasonable sensitivity again when the monitor is used to check the oscillator output. Note that the beam should be dumped before the spatial filter aperture when the oscillator output is checked, since the wedge on the beamsplitter will prevent the beam passing centrally through the diamond pinhole and following components.

Note also that the monitor will also respond to flashlamp light and should therefore be mounted as far from the nearest pumping chamber as is practicable.

The actual calibration is carried out against a glass disc calorimeter, but note that the laser input to this should not exceed 1 J, to avoid the possibility of damage to the absorber: refer to Section 1. Fine adjustment of the energy monitor sensitivity, to give the exact calibration required, is made by adjusting the position of the photodiode tube in the beamsplitter block.

8.3. Holocamera Energy Monitors

These differ from those used on the HLS1-4, since the space limitations preclude the use of a beamsplitter block. Rather, the photodiode tube assembly is fixed so that it interrupts the beam reflected from the rear (AR coated) surface of the reference beamsplitter optic. To avoid gross sensitivity variations with the beam position, a ceramic diffuser disc is mounted in front of the neutral density filter.

When used for aligning the oscillator, the photodiode tube assembly is removed from its mount and put in a tubulation attached to the second turning mirror mount after the oscillator (mirror b in Figures 5 and 6). Again, the beam should be dumped before the spatial filter diamond pinhole.

9. DOUBLE-PULSE PERFORMANCE

The prime use of the HLS Series of lasers is for dynamic analysis of structures, etc., which requires double-pulse operation, and it is therefore important to fully characterise the laser operation for various pulse separations.

The total output energy in the double pulse decreases at the short and the long extremes of separation, and the energy balance between pulses can become difficult to achieve. At the short end, the 'DELAY 1' control is set to the optimum value and the energies are equalised by the 'BALANCE' control. For separations beyond about 300 uS, the 'BALANCE' control is set to maximum and the two pulses are equalised by adjusting 'DELAY 1'. Below 10 uS separation it is difficult to see the height of the first pulse on the oscilloscope trace and a way round this problem is to switch the Delay 2 setting between 1 uS and 901 uS between shots: this is easy to do and it means that either the total energy or the first pulse energy is displayed on the oscilloscope, so that the average balance over a few shots is made visible.

Check that the output specifications in Appendix A can be attained, and record the pump voltage settings, etc for specification outputs in the test data sheets.

10. 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.

As Figures 5 and 6 show, there are two more steering mirrors in the laser beampath, to make this more compact. Also, a HeNe is supplied, permanently fixed down and with its psu under the extruded base, and the first thing to do before starting the alignment is to ensure that these are mounted in position, with the aperture assembly on the front of the laser and the psu mains cable held in a strain-relief bush between the two conduits.

1. The oscillator has a standard layout but the beam emerges in the opposite direction along the rail, ie the only difference from standard is the INVAR structure which should be a "mirror image" of the usual one. (It has the same part number, but is assembled differently.) 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.

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 must have a tube fitted, to hold the photodiode assembly, as shown in Figures 5 and 6).

3. Assemble and fit the moving prism assembly. Apply light grease sparingly to all shafts and WD40 to the rail where the prisms slide. Ensure the mechanism operates freely and is approx. zeroed when the prisms are fully forward. Clamp a M4 bolt to the 'T' slot to act as a mechanical stop at the front end. (This mechanical assembly may be carried out before the basic laser alignment, if preferred.)

4. Fit the fixed prism. Note that the mounting plate is wedged 3^o, 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^o to the beam.

5. Fit the filter assembly. Ensure the filters line up properly at beam height and are in the correct sequence of 1, 2, 4 from left to right as the front of the laser is viewed.

6. 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.

7. 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.

8. 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.

9. 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.

10. 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.

11. 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.

12. 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. Calibrate the monitor.

13. 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.)

14. 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.

15. 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.

11. TEST HOLOGRAMS PROCEDURE

After laser test of a holographic laser it is necessary to take a series of holograms to prove the operation of the laser under actual operating conditions and to maintain confidence in the double pulse settings obtained earlier. This test also shows up any misalignment of the intracavity etalons, which would cause contours on the holograms; as would any prelasing caused by Pockels cell misalignment.

The in-house holocamera "rig" can be used for this purpose and is shown in Figure 8.

The beam emerging from the laser is turned through 90° by mirror M1 and steered through the beamsplitter prism onto the object beam expanding lens L1. Mirror M2 steers the beam through the collimating lens L2 onto the object - a 2 metre long aluminium bar.

The beam from the front surface of the prism forms the reference beam. Lens L3 diverges this beam through the neutral density filter F onto mirror M3, which finally reflects it onto the holographic film held in a camera positioned over the beamsplitter assembly.

Alignment

1. Mount a gas laser in the rear endplate of the laser under test and align the beam to the ruby laser beam.

2. Mount the holocamera rig at beam height and position the object as shown in Figure 8.

3. Adjust M1 so the HeNe beam passes through the prism assembly and lens L1 onto the centre of M2.

4. Adjust M2 to best illuminate the object, adjusting the position of L2 to suit.

5. Tilt the prism and adjust L3 to centre the gas laser beam on mirror M3.

6. Use mirror M3 to steer the beam onto the film plane of the camera.

7. Fire the pulsed laser single pulse at a reduced output and check to see that the pulsed beam covers as much of the object as possible and that the reference beam is centred on the camera.

8. Using an integrated photodiode and oscilloscope measure the intensity of the main beam at the film plane.

9. Adjust the reference beam intensity to be about 4 times that of the main beam by varying the filter which screws onto lens L3.

10. When testing an HLS4 an extra filter is placed in the beam before mirror M1 to reduce the laser output to about 1 Joule. (To be representative the tests should always be carried out with the laser running at specified output.)

Taking the Holograms

1. Load approx. 1 metre of Agfa Gaevaert 10E75 film into a 35 mm film cassette and load this into the camera. (The film is relatively insensitive to daylight and strict darkroom standards are thus not necessary.)

2. Mount the camera onto the holocamera rig so that it points in a direction bisecting the centre point of the object and the reference beam.

3. With the main room light off, open the shutter (set to 'B') and fire the laser. Several shots should be done at each of a range of double pulse settings and a few at single pulse.

4. Remove the film from the camera and load into the developing tank.

5. Develop the film in G127 developer for 40-60 seconds (5 mins for HLS1).

6. Wash the film vigorously in fresh water for 30 seconds.

7. Fix the film in Amfix for 3 minutes.

8. Wash in running water for 5 minutes.

9. Soak the film in methanol for 30 seconds: this effectively removes the water from it.

10. Remove the film and quickly remove any excess methanol.

11. To view the holograms pass a HeNe beam through a strong negative lens (-25 mm) and onto the film at the same angle as the reference beam. Look through the film in the direction of the object and a full size image of the object should be seen. Make slight adjustments to the angle of the film to maximise the image intensity.

12. Estimate the coherence length for each shot by noting over what length of the bar the hologram is clear - it should exceed 1 metre. Examine the holograms for contours - dark bands across the image at about 1 cm spacing. They often move on the object as you change viewing angle through the hologram.

13. If any contours are seen then retune the etalons and ensure that no prelasing is occurring. Take another reel of holograms to ensure that the problem has been cured.

12. FINAL CHECKS

It is the responsibility of the laser test engineer to ensure that the laser is shipped correctly, with full technical documentation, labelling, etc. Note particularly that this is most important for lasers sold to the USA because of the stringent CDRH requirements.

1. Initiate the predelivery procedure (itemised on next page) and check that it has been done. Note that for UK deliveries, the laser is shipped without draining the cooler or disconnecting the psu.

2. Ensure that all necessary labels are on the laser head and psu.

3. Obtain the drawings package and the handbook for the laser from the DO. Fill in the customer's name on the front page, the sales brochure specification for the laser type in Appendix A and the test data sheet values of the various parameters in Appendix B, and return the sheets to the DO for typing.

4. Place the test data sheets in the filing cabinet under the internal order number for the laser.

Shipping Check List

PSU
Control Unit
Head
(Autotransformer)
Tool Kit
2 off Interlock Override Keys*
2 off PSU Cabinet Keys*
2 off Control Unit Keys*
Waterpipe
Cooler
User Interlock Loop
Interlock Override Flag*
Manual
Drawing Package

*These items should be put in the tool kit box for safe shipment.

PRE-DELIVERY CHECK OF HLS SERIES LASERS

Power Supply Cabinet

- Remove all panels back and front.
- Remove conduit boxes, disconnect and remove cooler
- General visual inspection, including paintwork.
- Check nuts and bolts for tightness-
- Disconnect harness from control unit, place it inside cabinet.
- Check labels:-

  Zig Zags, HV Signs, Safety/Discharge Labels on Makrolon Covers, 2000L Label on Front, VA/Serial No on Rear, "TESTED" Label and Interlock Labels on Conduit Box.

- Replace panels.

Control Unit

- Remove top cover.
- Check labelling of all PCB's and Sockets.
- Check Card Retainer is in place.
- Check Brackets that secure chassis to case.
- Check "Tested" label on rear of chassis.
- Replace top cover.

Mechanical

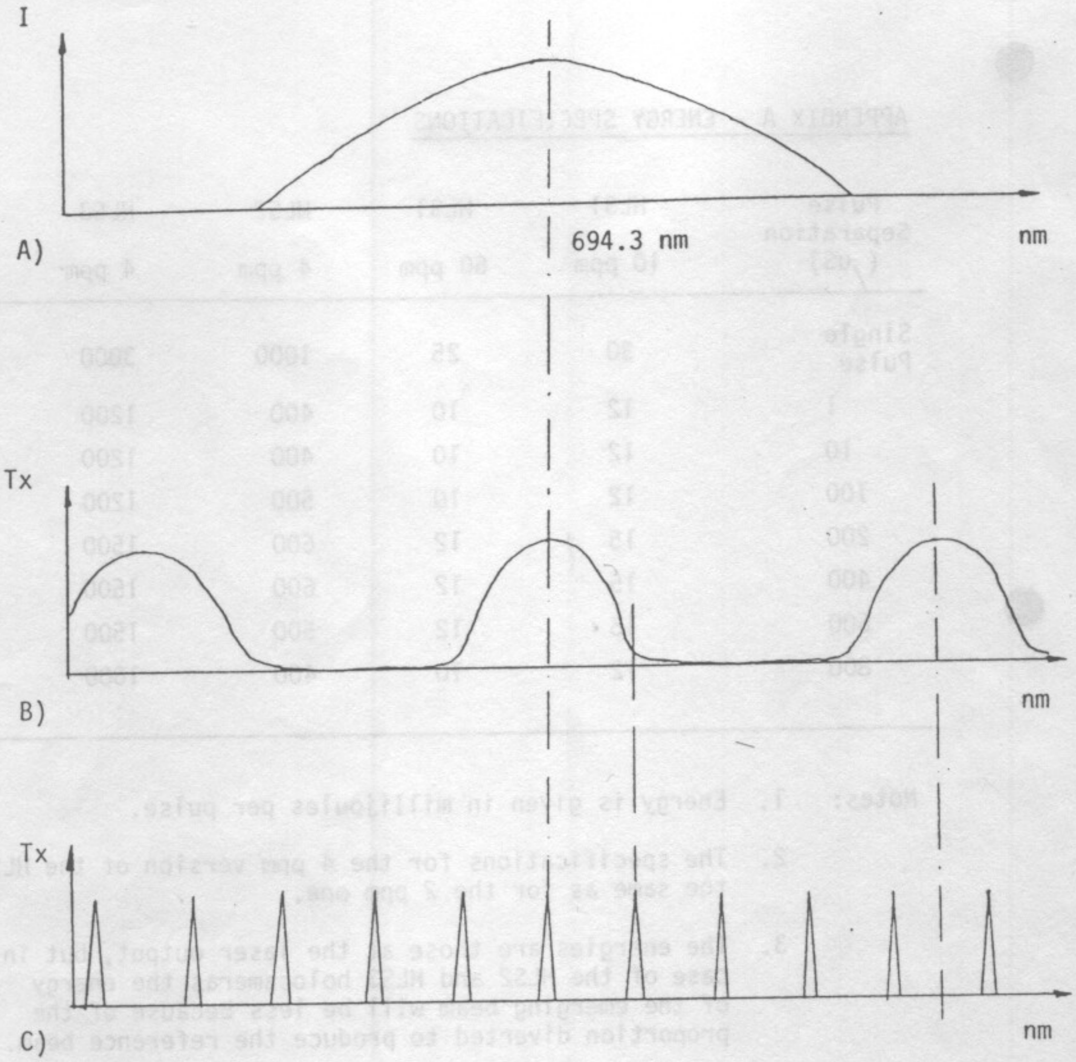
- Drain cooler, tape up fill hole.
- Drain Head.
- General visual inspection, including paintwork.
- Fix bottom panel.
- Check 3 Heycoes are in end plates.
- Put on lid.

APPENDIX A - ENERGY SPECIFICATIONS

Pulse Separation (μS)	HLS1 10 ppm	HLS1 60 ppm	HLS2 4 ppm	HLS3 4 ppm	HLS4 2 ppm
Single Pulse	30	25	1000	3000	10000
1	12	10	400	1200	4000
10	12	10	400	1200	4000
100	12	10	500	1200	4000
200	15	12	600	1500	5000
400	15	12	600	1500	5000
600	15	12	500	1500	5000
800	12	10	400	1000	4000

Notes:

1. Energy is given in millijoules per pulse.
2. The specifications for the 4 ppm version of the HLS4 are the same as for the 2 ppm one.
3. The energies are those at the laser output, but in the case of the HLS2 and HLS3 holocameras the energy of the emerging beam will be less because of the proportion diverted to produce the reference beam.



A) Spectral output of ruby laser without mode selection.

B) Transmission characteristic of 2.25 mm etalon.

C) Transmission characteristic of 10 mm etalon

FIGURE (7): ETALON TUNING

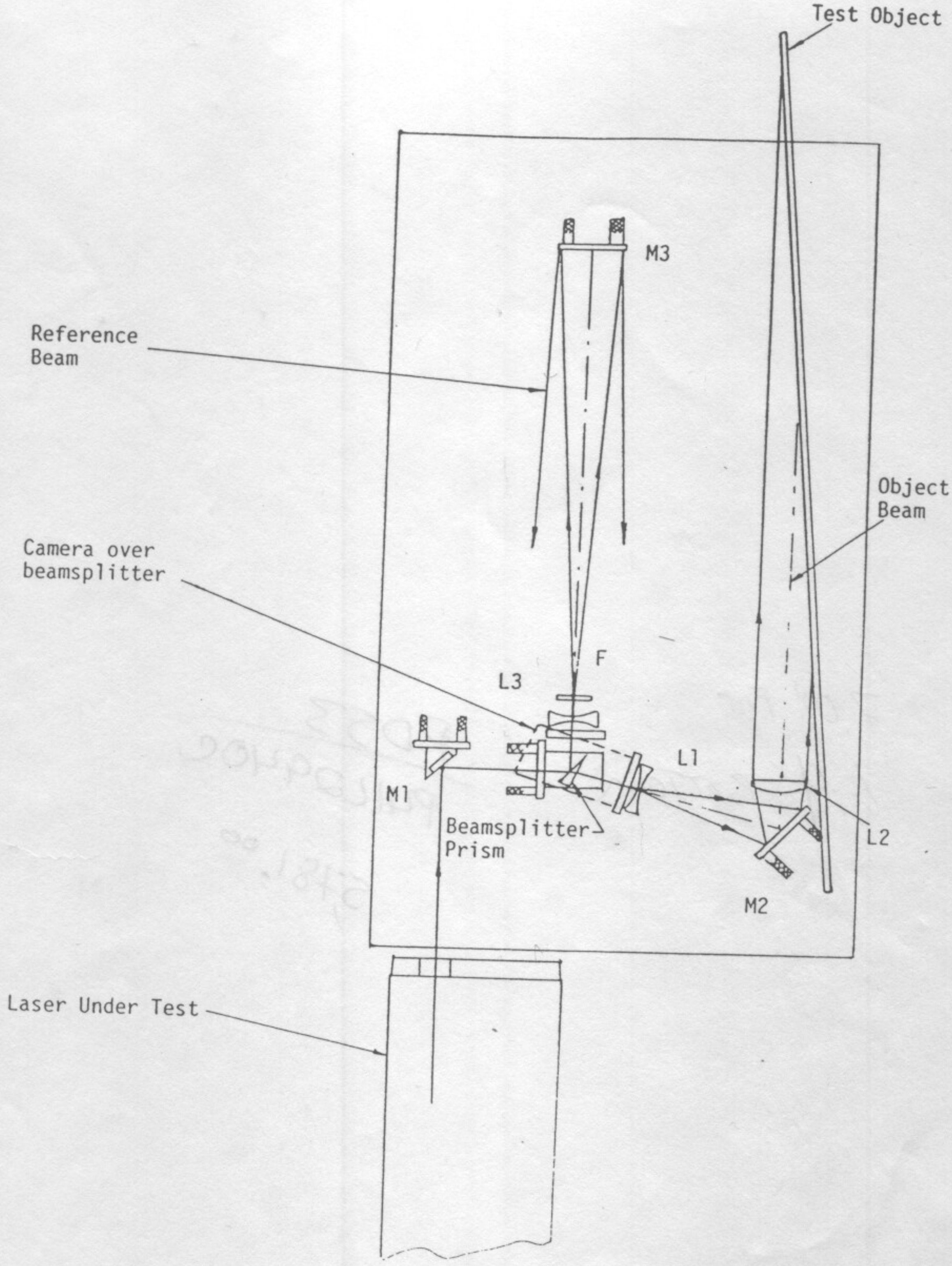
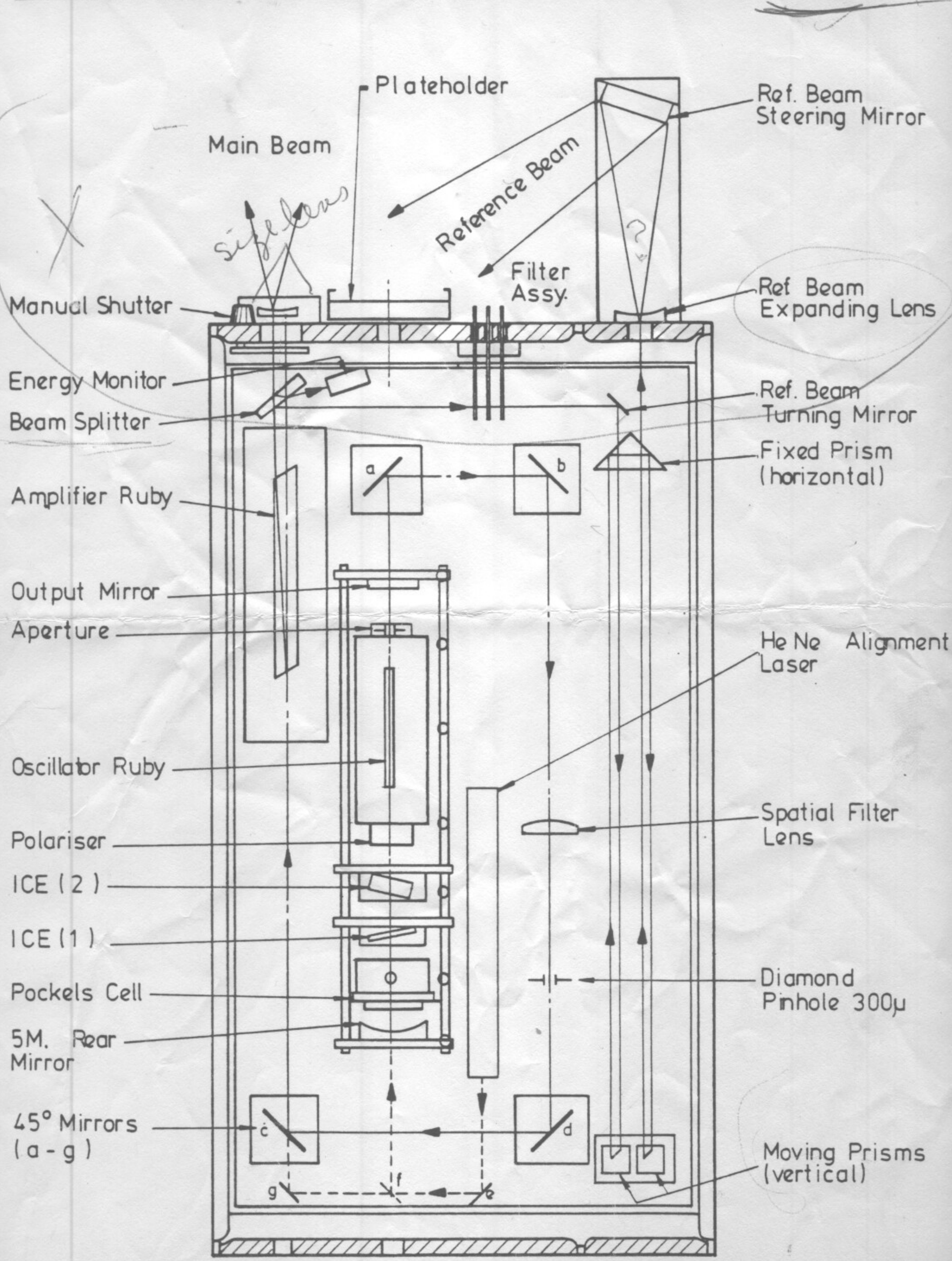


FIGURE (8): HOLOGRAPHIC TEST RIG

COMPONENT LAYOUT FOR HLS-2 HOLOCAMERA



COMPONENT LAYOUT FOR HLS-3 HOLOCAMERA