MAINTENANCE AND BASIC SERVICING

MODEL 257

SPECTROPHOTOMETER

4. MAINTENANCE AND BASIC SERVICING

INTRODUCTION

1. The model 257 Spectrophotometer has been designed to operate over long periods of time with a minimum amount of attention. In order to ensure maximum performance at all times, regular maintenance routines should be carried out and the object of this chapter is to explain the method and frequency of carrying out these routine checks. Sufficient details are also given to enable a competent operator to diagnose and correct most faults that may occur. The ability to do this will depend largely on the operator's past experience and should he not feel confident about tackling a problem the nearest Perkin-Elmer Service Department should be consulted. Unless otherwise stated, all the test procedures should be carried out with the instrument working on the normal slit programme.

GENERAL

Cleanliness and Protection from Moisture

2. The special gasket around the edge of the monochromator prevents dust particles accumulating on the optical surfaces, but even so, the instrument should be installed in as clean and dry an atmosphere as possible. As a general practice the dust cover provided should always be placed over the instrument when it is not in use.

3. WARNING Certain items in the instrument that greatly affect its performance are easily damaged.

Do not touch:

a) Any optical surface
b) The slit jaws
c) The optical attenuator
d) The sample beam comb.

N.B. Keep uncovered hands away from the thermocouple window.

Maintenance and Test Equipment

4. Cathode ray oscilloscope of at least 10mV/cm sensitivity.
Universal Meter (e.g. Avo Model 8)
Air syringe

REMOVAL OF COVERS

5. For many of the maintenance routines it will be necessary to remove one or more of the instrument covers. To remove certain covers, others must first be removed, and these are listed.

a) Removal of Sample Tray

Unscrew the knurled screw and lift the tray upwards and forwards.

REMOVAL OF COVERS

b) Removal of the Looks Cover

1. Remove the mains input plug and the sample tray.
2. Remove the mode indicator finger plate by removal of the screw and the two knurled nuts on the STOP and START buttons.
3. Remove the rear cover over the time drive motor.
4. Gently prise off the front faces of the 3 front panel knobs, slacken the exposed screws and remove the knobs.
5. Undo and remove the two nuts at the left-hand side of the instrument and the one at the right-hand side using the nut driver provided. These nuts are located in the over-lap of the looks cover and the baseplate.
6. Lift the pen bridge and raise the chart magazine cover.
7. Lift the looks cover vertically.

c) Removal of the Photometer Cover

1. Remove the looks cover.
2. Unscrew four 8-32 screws on the top and one on the front edge of the photometer cover. Temporarily secure the mode indicator bracket to the source panel by means of one of the source cover screws.
3. Lift the photometer cover vertically.

d) Removal of the Source Cover

1. Remove the looks cover.
2. Unscrew two 8-32 screws on the top and one on the front edge of the source cover.
3. Lift the source cover vertically.

e) Removal of the Monochromator Cover

1. Remove the looks cover.
2. Unscrew the mode indicator bracket and move it forward one screw position.
3. Unscrew two 10-32 nuts on top of the cover and remove the washers.
4. Manually rotate the quadrant until the pen reads approximately 90% transmission.
5. Lift the monochromator cover vertically.

f) Removal of the Pan Base Cover

1. Remove the mains lead
2. Tip the instrument backwards by lifting its front edge until it supports itself. This may be done with or without the looks cover in place.
3. Remove twelve 5-40 screws.

MONTHLY MAINTENANCE ROUTINE

6. a) Remove the looks, photometer and source covers and blow the dust off the mirrors using an air syringe.
   b) Wipe the pen rod with a lens tissue to remove accumulated dirt.
   c) When the instrument is running, visually examine the source element for cracks or hot spots and when the source is cold check for white spots. These defects, if present, will probably result in a base line that is out of specification. Should this be the case,

the source should be changed as described in the section covering replacement of parts (paragraph 4.30).

d) Occasionally the gain setting of the instrument should be checked at 2500 cm^{-1} and at 1250 cm^{-1}. If the normal gain setting does not give the same pen response in both cases the 20k potentiometer R402 mounted next to the knurled grating changeover drive should adjusted to equate the responses. This will necessitate removal of the pan base cover.

FURTHER MAINTENANCE

7. The following maintenance routines may be carried out when deemed necessary by the operator. The necessity for this type of maintenance will vary from instrument to instrument and will be dependent upon:

a) Location of the instrument.
b) Total number of hours of operation.
c) Level of performance required from the instrument.
d) Operator's ability and availability of test equipment.

OPTICAL MAINTENANCE

Cleaning

8. The surfaces of the mirrors, gratings and filters may require, from time to time, to be blown free from dust using an air syringe; they should NOT be touched by hand or brushed under any circumstances. Mirrors should not be washed except on very rare occasions and then only by a person who is familiar with handling high quality optical components and who is capable of tackling the realignment procedure when the components are replaced.

9. If, in exceptional circumstances, a competent person decides to wash the mirrors, they should be flushed with copious quantities of a weak solution of liquid detergent in distilled water. The mirrors should then be thoroughly rinsed with clean distilled water. If the mirrors are perfectly clean all the distilled water will run off the surfaces leaving them completely dry. If only small droplets of water remain, these should be removed by blowing with an air syringe.

NOTE: THE GRATINGS AND FILTERS MUST NEVER BE WASHED.

I_o (or Base Line) Trimming

10. If the I_o lines need straightening the following procedure should be adopted.

a) Remove the looks, source and photometer covers.

b) With the instrument running, examine the source for cracks or hot spots and with the instrument cold, check the source for white spots. (A white spot source is usually associated with a dip or rise in the I_o line between 4000 and 2500 cm^{-1}). If either of these faults is apparent the source should be changed. (paragraph 4.30)

c) Check that the source images seen on the left hand panel of the sample compartment are as shown in Fig. 4.1. The images should be off-centre by approximately the same amount and of equal height. Should this not be the case then M2 and M3 source toroids must be adjusted until this condition is achieved.

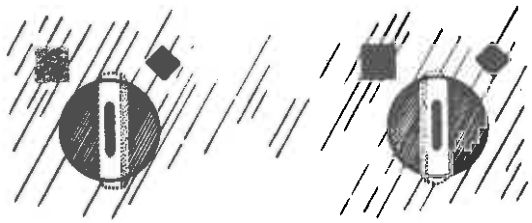

Fig. 4·1 Source Images on Photometer Baffles with Source Optics properly aligned. (Dotted portions indicate location of radiant energy not common to both beams).

Lateral adjustments may be made by slackening the three screws holding the toroid mount to the base and moving the mount by hand. Heights are adjusted by means of a tilt adjustment screw at the top of the toroid mount. Tighten all screws, checking that this causes no displacement of image.

d) Re-run the I_o line and if it is still out of specification make minor lateral or tilt adjustments to mirrors M2 and M3 and check the resulting I_o. If it is improved continue the adjustment, if not, adjust in the opposite direction on a trial and error basis until the base line is within specification.

e) Should the I_o line still be out of specification then M1, M2 and M3 should be removed from their mounts and washed. After drying they should be replaced and adjusted as described in paragraphs c) and d).

f) If the baseline is still outside the specified limits a new source assembly should be fitted irrespective of the apparent condition of the old one.

Reduction of Base Line Shift at Filter Changeover

11. Should there be a change in the height of the baseline when the filters change over then the fault is almost certainly due to the filter not being perpendicular to the light beam. The two securing screws in the base of the filter unit should be slackened, the assembly pivotted slightly and the baseline re-run. The adjustment should be continued until the optimum position is achieved.

NOTE: If at any time a small oscillation appears on the I_o line, check the chopper assembly for freedom of movement. In particular, the chopper belt tension should be checked. This should be such that a deflection of approximately 3/16 in is obtained when a light finger pressure is applied to the belt mid-way between the pulleys.

OVERALL OPTICAL ALIGNMENT

General

12. The optical alignment is carried out in the following sequence; source optics, photometer optics, monochromator and detector optics. The procedure becomes progressively more detailed and only qualified personnel who are thoroughly familiar with this type of optical system should attempt to align the monochromator and detector optics. Fortunately these optics, and also the photometer optics, rarely need attention but the source optics must be realigned whenever the source is changed.

Source Optics

13. The alignment is carried out as explained in the section dealing with the I_0 trimming (paragraph 4.10).

Photometer Optics

14. The photometer should be aligned using light from the source so that the sample and reference beams are focussed coincidently and centrally on the entrance slit. The 100% comb and optical attenuator should both be imaged clearly with little or no displacement between the two images. Coincidence of beams and uniformity of illumination should also be observed at toroid M7 and the pupil baffle. The beam should not overfill any mirror but should overfill the pupil baffle aperture on all sides.

Monochromator

15. The alignment of this section of the instrument requires a mercury lamp positioned in the sample compartment so as to uniformly illuminate the pupil baffle aperture. The slits should be set at or near their narrowest width, this being on the narrowest slit programme and at approximately 1800 cm^{-1} (after the grating changeover).

16. Plane mirrors M8 and M9 should be orientated so that the light falling on the grating clips both edges of the grating simultaneously as it is rotated to steeper angles; at the same time the images on the entrance slit must be maintained in a central position and in focus. The gratings must be corrected for tilt (rotation about a horizontal axis in the plane of the grating) and rock (rotation about an axis normal to the grating surface) using the lowest and highest observable orders of the mercury green line so that the illumination falling on a white card placed close behind the exit slit does not move up or down as the image is scanned across the exit slit.

NOTE: It is to be emphasized that, if the alignment of the monochromator is suspect and the operator is not experienced in such optical alignment, the nearest Perkin-Elmer Service Department should be contacted.

Detector Optics

17. The ellipsoid must be adjusted so that the maximum amount of energy is focussed on the thermocouple. With the SLIT control set to N (normal) and the instrument switched on and set to approx 800 cm^{-1} observe the signal at the signal test point (paragraph 4.22) with an oscilloscope. If the signal waveform shows saturation, i.e. noticeable assymetry reduce the amplifier gain. Normally only rotational adjustments about vertical and horizontal axes in the plane of the mirror will be necessary. If the focus of the ellipsoid is suspect, move the mount (in its slide) by small increments and after each movement retighten the screws and check the two rotation adjustments. Note that the rotational adjustment about a vertical axis is the most critical. Finally, after locking all means of adjustment, confirm that the signal is maximised by applying moderate pressure to the mount. Only a reduction in signal should be observed.

If over a period of time a general deterioration in the signal to noise ratio is observed, the GAIN control being set to give the correct pen response, and this deterioration is not overcome by replacement of the valves, the thermocouple allignment should be checked. If no improvement results, replace the thermocouple.

CALIBRATION

General

18. The instrument is calibrated using a 0.05 mm cell filled with indene and using the 3927·2, 2770·9, 1915·3 and 1361·1 cm absorption bands. (Ref: International Union of Pure and Applied Chemistry – "Tables of Wavenumbers for the Calibration of I.R. Spectrometers", edited by H.W. Thompson and published by Butterworths). Should calibration errors exist they can be corrected by three separate adjustments which can be applied in four ways.

a) The pen holder is normally set to its central position on the pen carriage and should only be moved to correct for small constant errors. To do this, release screw A (Fig 4:11.) securing the holder to its carriage and adjust the holder in the appropriate direction. Retighten the screw and check the calibration.

b) The cosecant carriage can be moved along its axis of motion by slackening screws A and B (Fig. 4.2) and adjusting screw X. This adjustment is used to take up large constant errors.

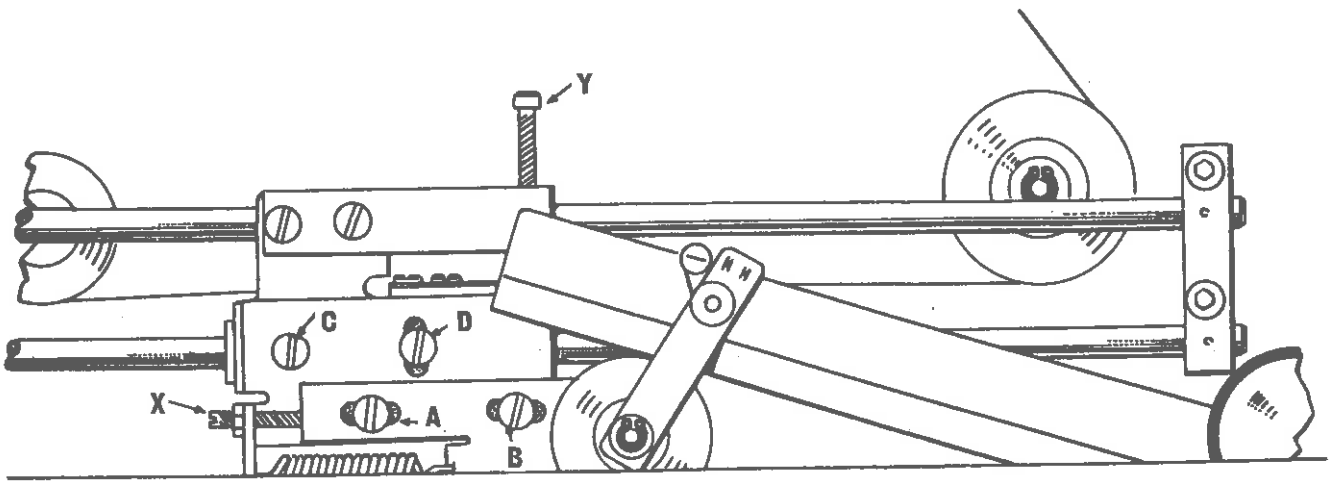

Fig. 4·2 Cosecant Carriage (Showing Adjustment Screws)

c) There are two magnetic stops (one for each grating) (see Fig. 3.5). Prior to their adjustment, the small Allen locking screw must be slackened. The correction is non-linear and if an error $\Delta\nu_1$ is observed at 3927·2 cm^{-1}, then the error at other calibration points in the Range 1 mode will be as follows:

Indene	3927·2 cm^{-1}	2770·9 cm^{-1}	1361·1 cm^{-1}
Correction, $\Delta\nu$	$\Delta\nu_1$	0.47 $\Delta\nu_1$	0.06 $\Delta\nu_1$

d) The line of motion of the rotational axis of the cosecant pulley E should pass through the axis of rotation of the grating. Adjustment of this pulley is accomplished by slackening screws C and D (Fig. 4.2) and adjusting screw Y. The correction is again non-linear and if an error $\Delta\nu_2$ is observed at 3927.2 cm^{-1} then in the Range 1 mode, the following errors occur at the other calibration points:–

Indene	3927·2 cm^{-1}	2770·9 cm^{-1}	1361·1 cm^{-1}
Correction $\Delta\nu$	$\Delta\nu_2$	0.67 $\Delta\nu_2$	0.17 $\Delta\nu_2$

NOTE: A calibration adjustment which, for a fixed position of the wavenumber scale, rotates the grating to higher angles results in recorded absorption bands moving to higher frequencies on the chart and *vice versa*.

Practical Calibration

19. The general procedure is as follows:–

a) Run a spectrum of indene in the Range 1 mode, taking up any error at 1361·1 cm^{-1} with a pen shift (paragraph 4.18a) or carriage shift (paragraph 4.18b).
b) Take up any error at 3927.2 cm^{-1} by adjusting the grating stop in contact with the magnets on the grating table (paragraph 4.18c).
c) Repeat (a)
d) Take up any error at 2770·9 cm^{-1} by adjusting the cosecant arm actuator assembly (paragraph 4.18d).
e) Repeat (a)
f) Continue to repeat the sequence in the Range 1 mode until the instrument calibration is within the specification. Then turn to full range operation.
g) Check the 1915·3 cm^{-1} indene band after the grating changeover and correct any error by adjusting the grating stop in contact with the magnets on the grating table. Theoretically the calibration should now be correct. Check further using the following indene calibration peaks:–

First grating:	3139.5 cm^{-1}	1915·3 cm^{-1}	
Second grating:	1553·32 cm^{-1}	1361·1 cm^{-1} or 1205.1 cm^{-1}	830.5 cm^{-1} or NH_3 951.8 and 984.2 cm^{-1}

Sources of Calibration Errors

20. Calibration errors may be caused for any of the following reasons:–

a) Incorrect or unclamped settings of normal calibration controls.

b) The pen not screwed fully into its holder or not moving parallel to the vertical grid lines on the chart. In the latter case adjust the phasing of the sprocket wheels.

c) Iron filings or dust particles on the grating table magnet stops introducing an error in the angular setting of the gratings.

d) The grating table not returning to its stops after the actuation of the grating changeover.

Check:– 1. The freedom of rotation of the grating table in its oilite bearings.
2. The knurled sector wheel is free from the drive ring.
3. The grating table is not touching the flock spray on the inside of the monochromator cover. If necessary, remove the flock spray and paint the exposed surface optical black.

e) The cosecant arm is not firmly in contact with the cosecant roller. Check that the spring-loaded "keeper" ball bearing is moving freely.

ELECTRONIC MAINTENANCE

General

21. Very little electronic maintenance is necessary except the replacement of valves as required.

Should the operator suspect that the instrument is not functioning correctly he can perform a few simple checks that may help to isolate a fault. The main amplifier has six test points along its top edge, (Fig. 4.3), and the following paragraphs indicate the voltage and waveforms that should be obtained. (All these tests will necessitate removal of the looks cover according to paragraph 4.5b).

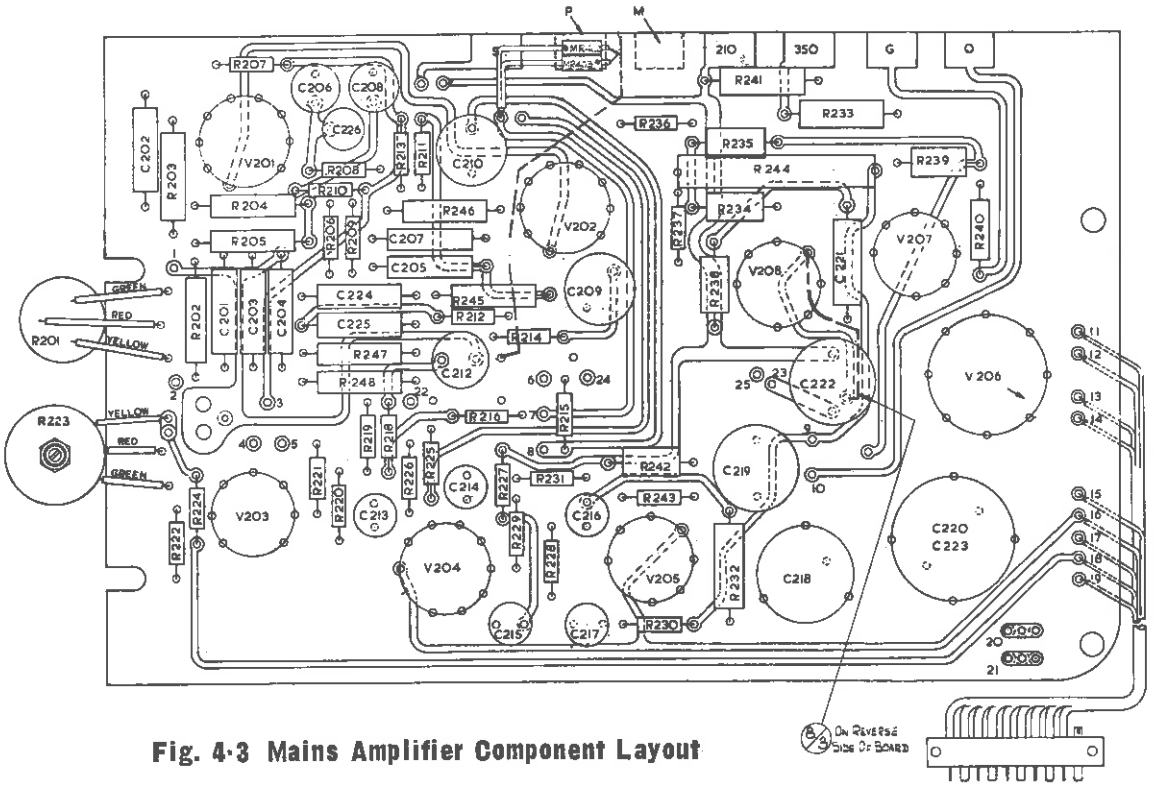

Fig. 4·3 Mains Amplifier Component Layout

Signal Test Point

22. Connect the leads of an oscilloscope across points S (Signal) and G (Ground) on the main amplifier board. Remove the 6AQ5 output valve V205 on the main amplifier board. Block the reference beam by slowly pushing the pen carriage to the bottom of the transmittance scale, maintain the GAIN control at its normal setting and with the instrument on, scan to 2500 cm^{-1}. After a brief warm-up period, an 11 c/s sine wave with a 50 c/s ripple running along it should appear as shown in Fig. 4.4. The signal should be approximately 4V peak-to-peak in amplitude. If, when the 11 c/s signal is synchronized on the oscilloscope, the 50 c/s ripple also remains stationary, then the chopper motor should be checked for freedom of action. Particular attention should be paid to tension of the drive belt. The belt should not slip but must not be over-tightened. The output at 1200 cm^{-1} should be approximately 2V. Note that these voltages are only approximate since they depend on the position of the 100% comb, slit cam setting and the gain of the preamplifier, which will vary slightly between instruments.

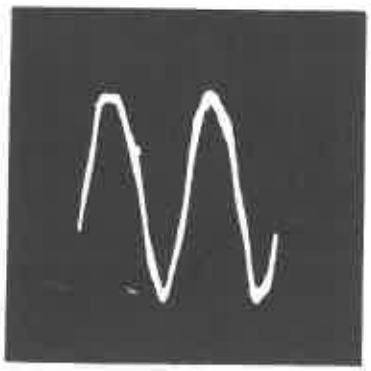

Fig. 4·4 Signal Test Point

NOTE 1. A better indication of the signal level from the preamplifier will be obtained by measuring the percentage of the GAIN potentiometer resistance that is used to obtain normal gain. In the normal gain position the amount of resistance used should be approximately 12%.

NOTE 2. The earth lead of the oscilloscope should always be connected to test point G.

Energy Balance Adjustment

23. With the same conditions as for monitoring the signal test point, check that the signal on the oscilloscope is approximately the same at 3500 and 2000 cm^{-1} in the region covered by the first grating and at 2000 and 900 cm^{-1} with the second grating. If this is not the case difficulty may be experienced in setting the gain potentiometer, and the nearest Perkin-Elmer Service Department should be contacted.

Phase Test Point

24. With the same conditions as for monitoring the signal test point, connect the leads of an oscilloscope across test points P (Phase) and G. The waveform obtained should be typical of full wave rectification and appear as illustrated in Fig. 4.5. Should the pattern not be as shown, the photometer cover should be removed and the shutter rotated on the sector mirror shaft relative to the sector mirror. (See Fig. 4.6). To do this it is necessary to slacken the Allen locking screw and rotate the shutter slightly, taking care not to move it along its axis. Retighten the Allen screw and ensure that the shaft turns freely. Reobserve the signal and repeat the procedure until the correct phasing is obtained.

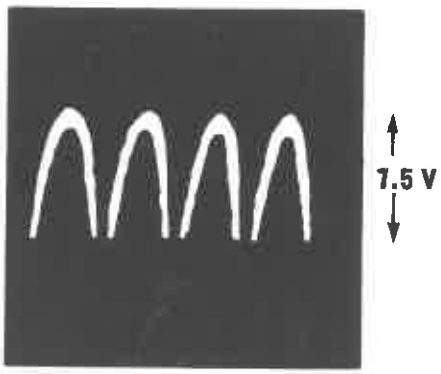

Fig. 4·5 Phase Test Point

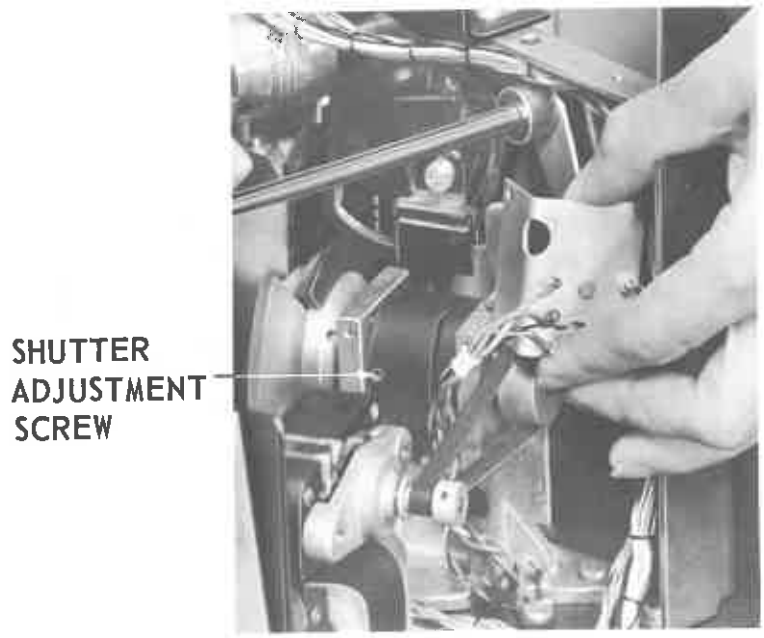

Fig. 4·6 Shutter Adjustment Screw (Lamp Mount detached)

NOTE: When correct phasing has been obtained, the 6AQ5 output valve V205 should be replaced and the pen should drive upwards. If at this stage, the pen drives downwards then the shutter is 180 degrees out of alignment and must be reorientated. If blips are seen on the signal or if only half-wave rectification is seen, then one of the photo-conductive cells may not be working correctly (and should be replaced) or the connections may be at fault.

Modulator Test Point

25. To check the signal at the modulator test point, proceed as follows:–

a) Set the GAIN control to zero and with the oscilloscope leads across M (Modulator) and G, a pattern of alternative sine and square waves should be seen. These sine waves will change their height and reverse their polarity as the BALANCE control is altered. If a balance point cannot be obtained, then the double diode assembly V203 should be changed.

b) With the GAIN control at its normal setting, adjust the BALANCE control for no pen movement when both sample and reference beams are blocked. Unblock the sample beam and with the 6AQ5 (V205) removed, the waveform should be as shown in Fig. 4.7.

210 Volt Test Point

26. The 210 volt (nominal) d.c. line may in fact vary between 205 and 215 V from instrument to instrument, depending on the exact values of certain components. When the voltage is monitored on an oscilloscope, with the oscilloscope gain adjusted to give high amplification, a saw-tooth ripple which does not exceed 30mV peak-to-peak should be seen as shown in Fig. 4.8.

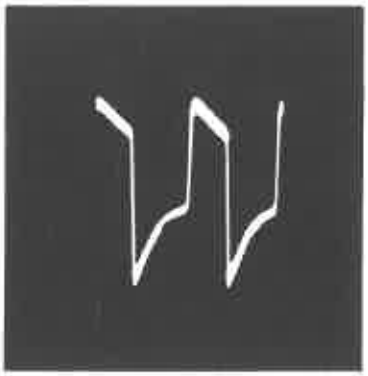

Fig. 4·7 Modulator Test Point

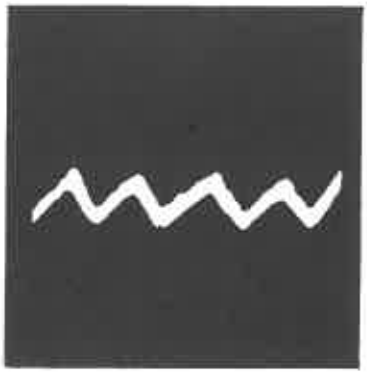

Fig. 4·8 210V Test Point

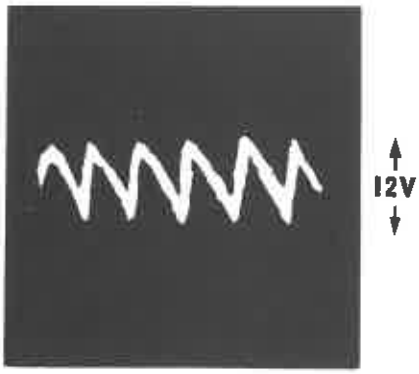

Fig. 4·9 350V Test Point

350 Volt Test Point

27. The 350 d.c. voltage may vary between instruments from 320-370 V and when viewed on an oscilloscope will show a 100 c/s ripple (Fig. 4.9). This voltage should be checked with the output valve in place.

Output Test Point

28. Set the GAIN and BALANCE controls to their normal operating positions and connect the leads of an oscilloscope across test points O (output) and G. At pen balance (pen stationary on scale) a 100 c/s signal will be seen. With the reference beam blocked a 50 c/s signal of at least twice the original amplitude should appear (Fig. 4.10).

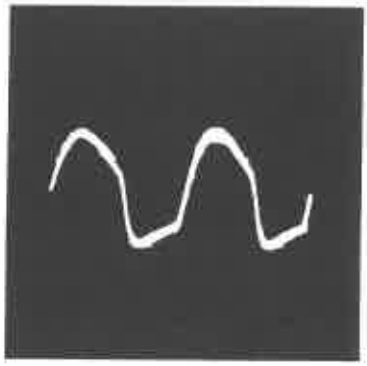

Fig. 4·10a
Beams balanced
(approx. 70v peak-to-peak)

Fig. 4·10b
Out of balance
(approx. 450—500v peak to peak)

Control Circuit Failure

29. Although the control circuits are so designed that the positioning of the micro switches is not critical, should any of these switches become badly out of adjustment, malfunctioning of the instrument could occur. If there is any incorrect functioning in the sequence of operations, the grating change limit switches, S413a, b and c and S414 a, b and c, adjacent to the slit cam should be checked. Both switches in each pair must be operated before the singly mounted switches.

Chopper Assembly

30. Remove the photometer cover to check the chopper assembly. The chopper belt should be reasonably slack and may be adjusted if necessary by moving the motor mount sideways. If the belt is frayed it should be replaced. A defective photoconductive cell will show up on the oscilloscope when performing the phase check. Should a cell fail to operate, the position of the cell holder relative to the rotating shutter slots should first be checked to ensure that the cell is illuminated. (Also see paragraph 4.32)

REPLACEMENT OF PARTS

Source Assembly

31. Remove the looks and source covers and also the toroid mount on the front righthand corner of the instrument. Use the long thin screwdriver to remove the three screws holding the porcelain source base to the mounting bracket. Apply a heavy duty soldering iron to the eyelets and gently ease the assembly away from the connecting leads. Insert the exposed wires in the eyelets of the new assembly and resolder. Fasten the source assembly to the mounting bracket with the three screws and replace the source toroid. Realign the source optics as described in the section covering I_o trimming (paragraph 4.10). Return the old assembly to Perkin-Elmer Limited for a new element to be fitted.

Photoconductive Cells and Lamp

32. In the unlikely event of failure of a photoconductive cell, it can be replaced as follows. Take off the chopper belt. Release the setscrew and remove the pulley from the sector mirror shaft. Remove the lamp bracket retaining screw nearest to the front of the instrument. Slacken the grubscrew inserted in the same tapped hole and carefully withdraw the photoconductive cell holder. Remove the clamp and screw. Disconnect the faulty cell at the soldered joints and discard it. Replace with a new cell resoldering the connections, and reassembling in the reverse order.

NOTE: Do not apply excessive heat to the cell leads when soldering.

33. In the event of failure of the lamp illuminating the photoconductive cells in the synchronous rectifier unit, remove the photometer cover and the two screws securing the terminal bracket to the side of the main casting. Replace the defective bulb and reassemble in the reverse order. Ensure that approximately 1/32 in clearance exists between the terminals of the bulb holder and the main casting when the bracket is reassembled to the unit

Wavenumber Scale Lamps

34. Remove the looks cover. Note the wavenumber scale reading and remove the scale. Replace the defective lamp and reassemble in the reverse order, checking that the scale is correctly located prior to fitting the looks cover.

Mode Indicator Lamps

35. Remove the looks cover and release the mode indicator bracket. Remove the terminal block at the rear of the mode indicator by releasing the two retaining spring clips. The defective

lamp can now be replaced. The lamp numbers on the rear of the terminal block are related to their display on the schematic circuit diagram (Fig. 3.20). Reassemble in the reverse order.

Preamplifier Valve V201

36. Remove the monochromator cover. Extract the old valve and replace with a new one. Deterioration of this valve will cause an increase in the noise level.

NOTE: This is a selected valve. Use only Perkin-Elmer part number VT002.

Replacement of the Pen Chain

37. The following instructions (with reference to Fig. 4.11) detail the correct procedure for the replacement of the pen drive chain.

a) Remove the looks cover.
b) Disconnect the 100% linkage by removing the pivot pin behind the front panel.
c) Disconnect the solid coupling connecting the two halves of the drive shaft of the variable slit assembly.
d) Remove two front panel screws on the righthand foot and one screw on the lefthand foot; then pivot the panel outwards to the left.
e) Remove the wavenumber scale after noting its position.
f) Slacken the Allen screws securing the latch block to the pen shaft, and remove the two screws securing the transmission scale. Slide the latch block along the pen shaft so that the transmission scale can be removed.
g) Lock the quadrant at 100%.
h) Disconnect and remove the old chain from the pen carriage and the quadrant.
i) Loop the pen spring in the end link of the new chain and assemble to the quadrant.

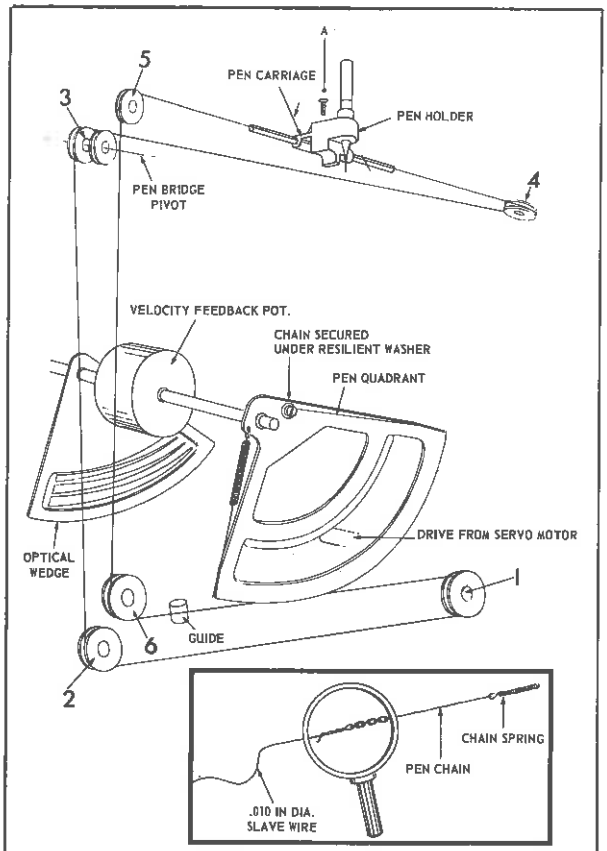

Fig 4-11 Replacement of the Pen Chain

j) Connect a slave wire approximately 0.25 mm x 15 cm long to the other end of the chain. Thread the wire and chain through the pulleys in the following manner: Around the quadrant, over and under idler pulley 1, around pulley 2, over pulley 3 (in the hinge block), under and over pulley 4 (in the latch block), back over and around pulley 5, down through the hole in the casting, around and under pulley 6, past the guide and around the quadrant. Replace the transmittance scale and reposition the latch block taking care not to foul the sprocket teeth. Adjust the tension and secure the chain under the resilient washer on the quadrant. Remove the slave wire.
k) Reassemble in the reverse order (Steps g to a)
l) Secure the pen carriage to the chain and reset the pen zero (paragraph 2.22).

Moving the Instrument

38. When the instrument is to be moved, set the slit control to the N (normal) position, SCAN to the final limit in the full range SCAN mode and switch the instrument OFF five seconds after it has reversed to 4000 cm^{-1}. The grating change operation will then be only half completed and the grating table will be held by the friction drive.

For conversion of Absorbance to Transmittance
and Transmittance to Absorbance (symbols T & A)
For rapid quantitative analysis with
PERKIN - ELMER
Spectrophotometers.

T	A	T	A	T	A	T	A	T	A	T	A
100%	0.000	48.5%	0.314	30.8%	0.511	19.1%	0.719	12.8%	0.893	6.4%	1.194
99.0	0.004	48.0	0.319	30.6	0.514	19.0	0.721	12.7	0.896	6.3	1.201
98.0	0.009	47.5	0.323	30.4	0.517	18.9	0.724	12.6	0.900	6.2	1.208
97.0	0.013	47.0	0.328	30.2	0.520	18.8	0.726	12.5	0.903	6.1	1.215
96.0	0.018	46.5	0.333	30.0	0.523	18.7	0.728	12.4	0.907	6.0	1.222
95.0	0.022	46.0	0.337	29.8	0.526	18.6	0.731	12.3	0.910	5.9	1.229
94.0	0.027	45.5	0.342	29.6	0.529	18.5	0.733	12.2	0.914	5.8	1.237
93.0	0.032	45.0	0.347	29.4	0.532	18.4	0.735	12.1	0.917	5.7	1.244
92.0	0.036	44.5	0.352	29.2	0.535	18.3	0.738	12.0	0.921	5.6	1.252
91.0	0.041	44.0	0.357	29.0	0.538	18.2	0.740	11.9	0.925	5.5	1.260
90.0	0.046	43.5	0.362	28.8	0.541	18.1	0.742	11.8	0.928	5.4	1.268
89.0	0.051	43.0	0.367	28.6	0.544	18.0	0.745	11.7	0.932	5.3	1.276
88.0	0.056	42.5	0.372	28.4	0.547	17.9	0.747	11.6	0.936	5.2	1.284
87.0	0.061	42.0	0.377	28.2	0.550	17.8	0.750	11.5	0.939	5.1	1.292
86.0	0.066	41.5	0.382	28.0	0.552	17.7	0.752	11.4	0.943	5.0	1.301
85.0	0.071	41.0	0.387	27.8	0.556	17.6	0.755	11.3	0.947	4.9	1.310
84.0	0.076	40.5	0.393	27.6	0.559	17.5	0.757	11.2	0.951	4.8	1.319
83.0	0.081	40.0	0.398	27.4	0.562	17.4	0.760	11.1	0.955	4.7	1.328
82.0	0.086	39.8	0.400	27.2	0.565	17.3	0.762	11.0	0.959	4.6	1.337
81.0	0.092	39.6	0.402	27.0	0.569	17.2	0.765	10.9	0.963	4.5	1.347
80.0	0.097	39.4	0.405	26.8	0.572	17.1	0.767	10.8	0.967	4.4	1.357
79.0	0.102	39.2	0.407	26.6	0.575	17.0	0.770	10.7	0.971	4.3	1.367
78.0	0.108	39.0	0.409	26.4	0.578	16.9	0.772	10.6	0.975	4.2	1.377
77.0	0.114	38.8	0.411	26.2	0.582	16.8	0.775	10.5	0.979	4.1	1.387
76.0	0.119	38.6	0.413	26.0	0.585	16.7	0.777	10.4	0.983	4.0	1.398
75.0	0.125	38.4	0.416	25.8	0.588	16.6	0.780	10.3	0.987	3.9	1.409
74.0	0.131	38.2	0.418	25.6	0.592	16.5	0.783	10.2	0.991	3.8	1.420
73.0	0.137	38.0	0.420	25.4	0.595	16.4	0.785	10.1	0.996	3.7	1.432
72.0	0.143	37.8	0.423	25.2	0.599	16.3	0.788	10.0	1.000	3.6	1.444
71.0	0.149	37.6	0.425	25.0	0.602	16.2	0.791	9.9	1.004	3.5	1.456
70.0	0.155	37.4	0.427	24.8	0.606	16.1	0.793	9.8	1.009	3.4	1.469
69.0	0.161	37.2	0.430	24.6	0.609	16.0	0.796	9.7	1.013	3.3	1.482
68.0	0.168	37.0	0.432	24.4	0.613	15.9	0.799	9.6	1.018	3.2	1.495
67.0	0.174	36.8	0.434	24.2	0.616	15.8	0.801	9.5	1.022	3.1	1.509
66.0	0.181	36.6	0.437	24.0	0.620	15.7	0.804	9.4	1.027	3.0	1.523
65.0	0.187	36.4	0.439	23.8	0.623	15.6	0.807	9.3	1.032	2.9	1.538
64.0	0.194	36.2	0.441	23.6	0.627	15.5	0.810	9.2	1.036	2.8	1.552
63.0	0.201	36.0	0.444	23.4	0.631	15.4	0.813	9.1	1.041	2.7	1.569
62.0	0.208	35.8	0.446	23.2	0.635	15.3	0.815	9.0	1.046	2.6	1.585
61.0	0.215	35.6	0.449	23.0	0.638	15.2	0.818	8.9	1.051	2.5	1.602
60.0	0.222	35.4	0.451	22.8	0.642	15.1	0.821	8.8	1.056	2.4	1.620
59.5	0.226	35.2	0.454	22.6	0.646	15.0	0.824	8.7	1.061	2.3	1.638
59.0	0.229	35.0	0.456	22.4	0.650	14.9	0.827	8.6	1.066	2.2	1.658
58.5	0.233	34.8	0.458	22.2	0.654	14.8	0.830	8.5	1.071	2.1	1.678
58.0	0.237	34.6	0.461	22.0	0.658	14.7	0.833	8.4	1.076	2.0	1.699
57.5	0.240	34.4	0.463	21.8	0.662	14.6	0.836	8.3	1.081	1.9	1.722
57.0	0.244	34.2	0.466	21.6	0.666	14.5	0.839	8.2	1.086	1.8	1.745
56.5	0.248	34.0	0.469	21.4	0.670	14.4	0.842	8.1	1.092	1.7	1.770
56.0	0.252	33.8	0.471	21.2	0.674	14.3	0.845	8.0	1.097	1.6	1.796
55.5	0.256	33.6	0.474	21.0	0.678	14.2	0.848	7.9	1.102	1.5	1.824
55.0	0.260	33.4	0.477	20.8	0.682	14.1	0.851	7.8	1.108	1.4	1.854
54.5	0.264	33.2	0.480	20.6	0.686	14.0	0.854	7.7	1.114	1.3	1.886
54.0	0.268	33.0	0.482	20.4	0.690	13.9	0.857	7.6	1.119	1.2	1.921
53.5	0.272	32.8	0.484	20.2	0.695	13.8	0.860	7.5	1.125	1.1	1.959
53.0	0.276	32.6	0.487	20.0	0.699	13.7	0.863	7.4	1.131	1.0	2.00
52.5	0.280	32.4	0.490	19.9	0.701	13.6	0.867	7.3	1.137	.9	2.05
52.0	0.284	32.2	0.492	19.8	0.703	13.5	0.870	7.2	1.143	.8	2.10
51.5	0.288	32.0	0.495	19.7	0.706	13.4	0.873	7.1	1.149	.7	2.15
51.0	0.292	31.8	0.498	19.6	0.708	13.3	0.876	7.0	1.155	.6	2.22
50.5	0.297	31.6	0.500	19.5	0.710	13.2	0.879	6.9	1.161	.5	2.30
50.0	0.301	31.4	0.503	19.4	0.712	13.1	0.883	6.8	1.168	.4	2.40
49.5	0.305	31.2	0.506	19.3	0.714	13.0	0.886	6.7	1.174	.3	2.52
49.0	0.310	31.0	0.509	19.2	0.717	12.9	0.889	6.6	1.181	.2	2.70
								6.5	1.187	.1	3.00