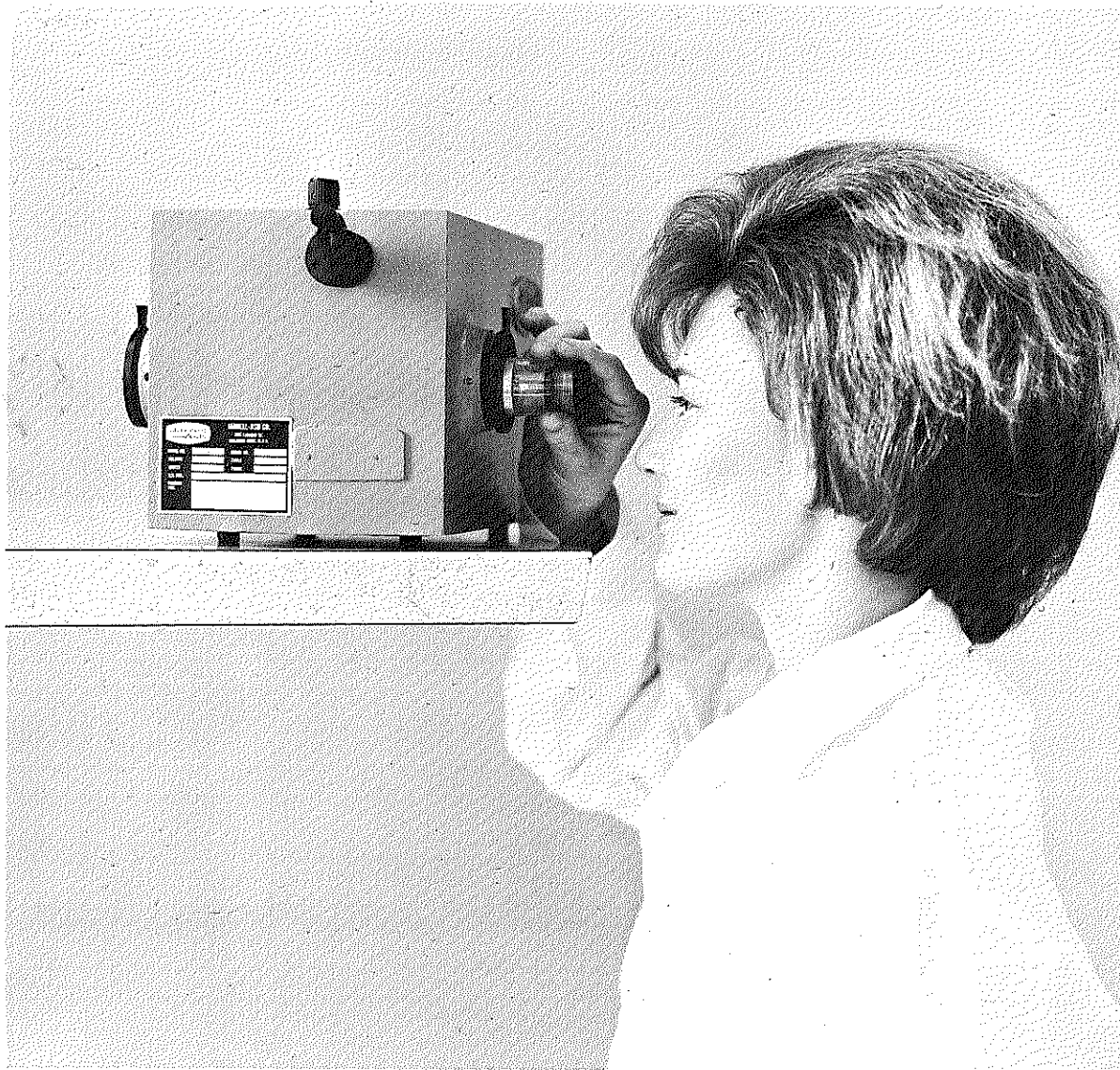


OPERATING AND SERVICE INSTRUCTIONS
FOR THE
0.25 METER EBERT MONOCHROMATOR



IM 100

\$3.00

MAY '67

JARRELL-ASH COMPANY · 590 LINCOLN STREET · WALTHAM, MASS.

TABLE OF CONTENTS

SECTION		PAGE
1	INTRODUCTION	1
	1-1 General Description	1
	1-2 Equipment Specifications	1
	1-3 Component Identification and Description	1
	1-4 Auxiliary and Related Equipment	2-3
2	PRE-OPERATIONAL CHECK	5
	2-1 Unpacking	5
	2-2 Installation	5
	2-3 Optical Alignment	5-6
	2-4 Wavelength Drive Calibration	6-7
	2-5 Use of Gratings other than 1180 g/mm	7
	2-6 Interchanging Grating Holders	7-8
3	OPERATION	9
	3-1 Manual Wavelength Drive	9
	3-2 Electrical Wavelength Drive	9
4	SERVICE INSTRUCTIONS	11
5	SPARE PARTS LIST	13
	APPENDIX A - 82-440 and 82-441 Double Monochromator Mounting Assemblies	17-18
	APPENDIX B - Operating Instructions for the 45-544 Mercury Lamp Assembly	19
	APPENDIX C - Operating Instructions for the 45-543 Xenon Lamp Assembly	21
	APPENDIX D - Operating Instructions for the 45-541-B Combined Tungsten Deuterium Lamp Assembly	23-24
	APPENDIX E - Operating Instructions for the 45-542 Tungsten Quartz Iodine Lamp Assembly	25

LIST OF ILLUSTRATIONS

FIGURE		PAGE
1	Overall View 82-410	1
2	Overall View 82-411	2
3	Optical Layout	2
3	Optical Layout	5
4	Interior View 82-410	5
5	Grating Holder Assembly	6
6	Slit Alignment	6
7	Sine Drive Calibration	7
8	82-410 With Electric Drive Mounted	9
9	Interior View 82-410	11
10	82-440 Double Monochromator	16
11	82-441 Components	17
12	82-440 Double Monochromator	18
13	45-544 Mercury Lamp and Power Supply	19
14	45-543 Xenon Lamp and Power Supply	20
15	Lamp Holder	23
16	45-541-B Power Supply, Rear View	24
17	45-541-B Power Supply, Front View	24
18	Deuterium Lamp and Holder	24
19	45-541 Tungsten Quartz Iodine Lamp	25
20	45-541 - Interior View	25

SECTION 1 INTRODUCTION

1-1 General Description

The 0.25 Meter Ebert Monochromator combines high aperture ratio with good resolution. It comes complete with two gratings and slits and is preadjusted and calibrated. It can be used easily by all laboratory personnel. It may be used as a monochromatic illuminator or as a spectrometer in a wide variety of applications. The unit can be used in measurements of absorption, transmission, emission, reflection, radiation, fluorescence, phosphorescence and low level luminescence of all types. It is useful as a source of monochromatic light for microscopes, photometers, and other spectrometric uses. The versatility of the Model 82-410 Series Monochromator makes it the standard monochromator for general use in physics, chemistry, biology laboratories. The instrument is suitable for use in the ultraviolet, visible and infrared.

This manual should be read and understood thoroughly prior to commencing installation, operation, and/or servicing.

1-2 Equipment Specifications

Over-all dimensions:	17.7 x 22.1 x 21.4 cm 7" x 8-3/4" x 12-1/2"
Weight:	Approximately 12 lbs. 5.44 Kilograms
Focal Length:	0.25 meter
Linear Dispersion:	3.3 m μ /mm with 1180 grooves/mm grating.
Aperture Ratio (Speed): Model 82-410	f/3.6
Gratings (two supplied): Model 82-410	Ruled Area: 64mm x 64mm Replicas, 1180 grooves/mm
Gratings Blazed at:	300.0 m μ and 600.0 m μ
Resolution: (half-band width at 3131 m μ)	.2 m μ with 25 micron slits .3 m μ with 75 micron slits .5 m μ with 100 micron slits
Scattered Light: *	Less than 0.3% at 300.0 m μ
Slits:	Two 100 micron slits, standard interchangeable.
Slit Arrangement:	Focusing slits in line on opposite sides of instrument.

* See Para. 2-3-12, Page 6

Calibrated Readout: Preadjusted and calibrated, three digit wavelength dial reads directly in millimicrons, 0 - 900 equivalent to 0 to 900 m μ , accuracy ± 1 m μ .

Wavelength Drive Coverage: 0 to 900 m μ .

1-3 Component Identification and Description

1-3-1 OVERALL VIEW 82-410 (Figure 1)

1. Interchangeable Slit
100 μ , standard width, others available.
2. Slit Focus
A #6-32 x 3/4" long oval tip set screw is provided in the right hand threaded hole in the slit face plate, and is used to set focus.
3. Two nylon tipped set screws are used to retain the focus tube position.
4. Wavelength Drive Knob
Hand rotated to cover 0 - 900.0 m μ .
5. Mounting holes for electric drive accessories.

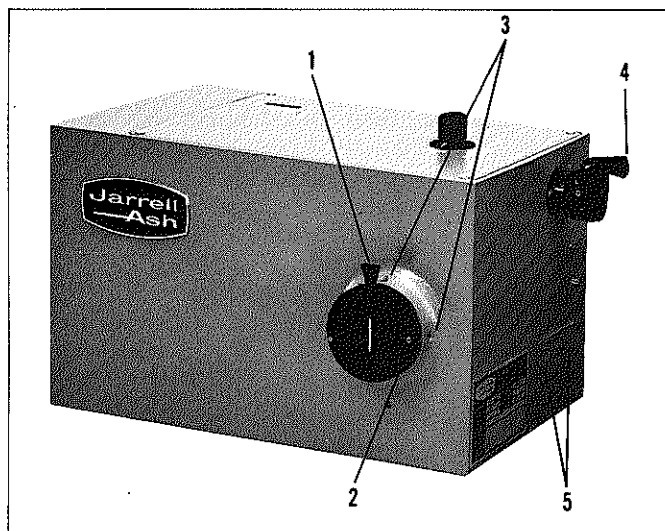


Figure 1

1-3-2 OVERALL VIEW 82-410 (Figure 2)

6. Wavelength Counter
Reads from 0 to 900, equivalent 0 to 900 m μ .
7. Grating Selector Knob
Two gratings are located back-to-back in a single grating holder. The Selector Knob places desired grating in operating position.

8. Main Compartment Cover Plate
Remove for access to the grating holder.
9. Mirror Compartment Cover Plate
Remove for access to the mirror.
10. Locking screw to maintain the 45° mirror position.

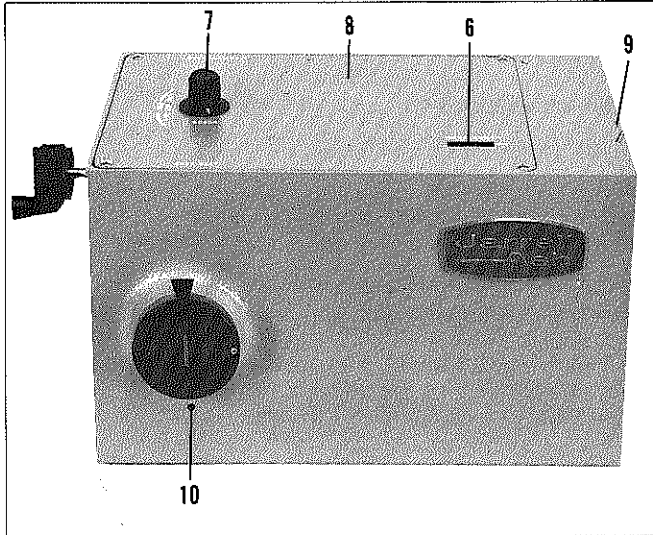


Figure 2

1-3-3 OPTICAL LAYOUT (Figure 3)

The monochromator is an Ebert optical mount. The light passes through the entrance slit (A) striking a 45° mirror (B) and is reflected to a large collimating mirror (C-1). From this mirror it is reflected to the grating (D) and dispersed back to the collimating mirror (C-2). The light beam, returning to focus, is reflected; by 45° mirror (E) out through exit slit (F). The entrance and exit slits (A,F) are in line on opposite sides of the instrument. Two gratings are mounted back-to-back at (D) and either may be selected for use by turning the external knob (7, Fig. 2).

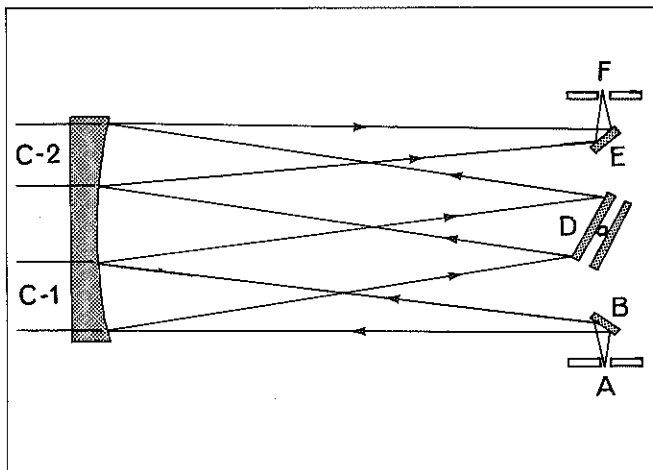


Figure 3

1-4 Auxiliary and Related Equipment

1-4-1 LIGHT SOURCES

Model Number

- | | |
|-------------|--|
| 45-451 | Deuterium Lamp and Tungsten lamp with power supply for deuterium and Tungsten lamps. For 115 volts, 60 cycles, single phase. |
| 45-541D | Deuterium Lamp and Tungsten lamp with power supply for deuterium and Tungsten lamps. For 115 volts, 50 cycles, single phase. |
| 45-542 | Tungsten Quartz Iodine Lamp |
| 45-541-A-01 | Deuterium Lamp. |
| 45-542-A-01 | Tungsten Lamp. |
| 45-543 | Xenon Lamp and power supply. For 115 volts, 60 cycles, single phase. |
| 45-543-A-01 | Xenon Lamp. |
| 45-544 | Mercury Lamp & Power Supply. For 115 volts, 50/60 cycles, single phase. |
| 45-544-A-01 | Mercury Lamp. For 115 volts, 50/60 cycles, single phase. |
| 45-544-A-01 | Mercury Lamp. |

1-4-2 MOUNTING AND SCANNING ACCESSORIES

Model Number

- | | |
|--------|--|
| 82-440 | Same as above, including factory alignment and calibration of two monochromators. Refer to App. A. |
| 82-441 | Double Monochromator Assembly Plate. Refer to App. A. |
| 82-451 | Gear Assembly for wavelength drive. |
| 82-452 | Motor unit for 10 mμ/min. For 115 volts, 60 cycles, single phase. |
| 82-453 | Motor unit for 10 mμ/min. For 115 volts, 50 cycles, single phase. |
| 82-455 | Motor unit for 25 mμ/min. For 115 volts, 60 cycles, single phase. |
| 82-454 | Motor unit for 25 mμ/min. For 115 volts, 50 cycles, single phase. |
| 82-457 | Motor unit for 100 mμ/min. For 115 volts, 60 cycles, single phase. |
| 82-456 | Motor unit for 100 mμ/min. For 115 volts, 50 cycles, single phase. |

Model Number

82-442		Adaptor for Jarrell-Ash Accessory Bars of 10-000 series.
82-443	A	Adaptor for triangular profile optical bar.
10-014		Jarrell-Ash 100 cm bar.
10-024		Jarrell-Ash 125 cm bar.
10-034		Jarrell-Ash 150 cm bar.
10-104		Triangular profile, 50 cm optical bench.
10-114		Triangular profile, 100 cm optical bench.

1-4-3 GRATINGS AND HOLDERS

Model Number

11-043		Holder for two gratings of 69 x 69 x 6 mm blank size.
11-044		Holder for one grating of 69 x 69 x 10 mm blank size.
37-00-60-29		Grating, 1180 grooves/mm, blazed for 3000 A.
37-00-60-36		Grating, 1180 grooves/mm, blazed for 6000 A.
37-00-60-57		Grating, 590 grooves/mm, blazed for 1.2 microns.
37-00-60-72		Grating, 295 grooves/mm, blazed for 2.1 microns.
37-00-60-84		Grating, 148 grooves/mm, blazed for 5.0 microns.

1-4-4 SLITS

12-510		Slit, width 25 microns.
12-515		Slit width 50 microns.
12-525		Slit width 100 microns.
12-535		Slit width 250 microns.
12-540		Slit width 500 microns.
12-560		Slit width 1000 microns.
12-570		Slit width 2000 microns.
12-590		Circular aperture, 3mm dia.
12-591		Circular aperture, 6 mm dia.

1-4-5 POWER SUPPLIES AND AMPLIFIERS

Model Number

82-375C	High Voltage Power Supply and Amplifier. For 115 volts, 50/60 cycles.
26-780	Power Supply Amplifier for DC operation. For 110 volts, 60 cycles.

1-4-6 PHOTOMULTIPLIERS

83-021	Side Window Photomultiplier Tube Housing with wired socket.
--------	---

Photomultiplier Tube, 931 A, spectral response S-4:

17-700A	Grade A
17-700B	Grade B
17-700C	Grade C
17-700D	Grade D
17-700E	Grade E

Photomultiplier, R212, spectral response S-5:

17-724A	Grade A
17-724B	Grade B
17-724C	Grade C
17-724D	Grade D
17-724E	Grade E

Photomultiplier with quartz envelope, R106, spectral response S-19:

17-721A	Grade A
17-721B	Grade B
17-721C	Grade C
17-721D	Grade D
17-721E	Grade E

SECTION 2 PRE-OPERATIONAL CHECK

2-1 Unpacking

The 82-410 should be carefully unpacked and inspected for any visible signs of damage. The customer is responsible for filing any damage claim against the carrier. All items should be checked against the packing list so that no small parts will be discarded with the packing material.

2-2 Installation

The 82-410 is shipped completely assembled, adjusted, and calibrated. However, the grating yoke is locked in place by a red screw, which must be removed before operating the instrument.

2-2-1 Remove the main compartment cover plate.

2-2-2 Remove the Red, grating yoke shipping screw. Follow the directions on the blue card attached to the main compartment cover plate.

2-2-3 Replace the cover plate.

Note The shipping screw should be retained and replaced, whenever the instrument is to be transported to a new location.

2-3 Optical Alignment Procedure

The 82-410 has been completely aligned and calibrated at the factory, and NO further adjustments should be required. However, to insure that no damage has occurred during shipment, or that the alignment has not been disturbed, a visual check of the alignment should be made. The complete alignment procedure is outlined in the following steps, and should be followed closely to insure proper operation.

2-3-1 Remove main compartment cover plate.

2-3-2 Set a bright tungsten source at the entrance slit ($100\ \mu$). The light beam reflected from the 45° mirror (B, Fig. 3) should be centered on the rear collimating mirror (C-1, Fig. 3), which is closest to the entrance slit.

2-3-3 Then move the tungsten source to the exit slit ($100\ \mu$). The light beam reflected from the 45° mirror (E, Fig. 3) should be centered on the rear collimating mirror (C-2, Fig. 3) which is closest to the exit slit.

Note Do not adjust the 45° mirrors before checking the rest of the alignment.

2-3-4 Remove the tungsten source from the exit slit and place a mercury lamp at the entrance slit ($100\ \mu$).

2-3-5 Using the standard $1180\ \text{g/mm}$ gratings, rotate the grating selector lever arm so that the $600.0\ \text{m}\mu$ blaze grating is facing the collimating mirror. The grating

holder adjusting screw (4, Fig. 5) should come in contact with the magnetic stop (2, Fig. 5).

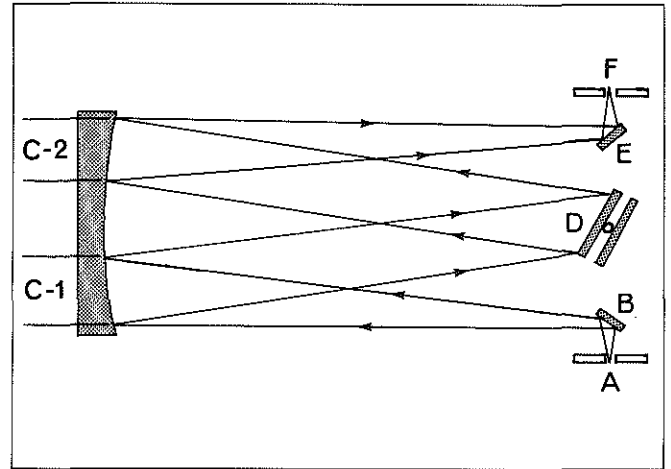


Figure 3

2-3-6 Rotate the wavelength drive until a bright green mercury line is seen visually through the exit slit ($100\ \mu$). Set the counter to $546\ \text{m}\mu$, by loosening the set screw on the small counter gear (2, Fig. 4).

2-3-7 Rotate the Grating Selector Lever Arm until the $300.0\ \text{m}\mu$ blaze grating adjusting screw (3, Fig. 5) contacts the magnetic stop (1, Fig. 5). The green mercury line from the $300.0\ \text{m}\mu$ blaze grating should be seen through the exit slit.

Note Extreme care must be taken to prevent any contact of the grating face, or mirror surfaces - Permanent damage will result.

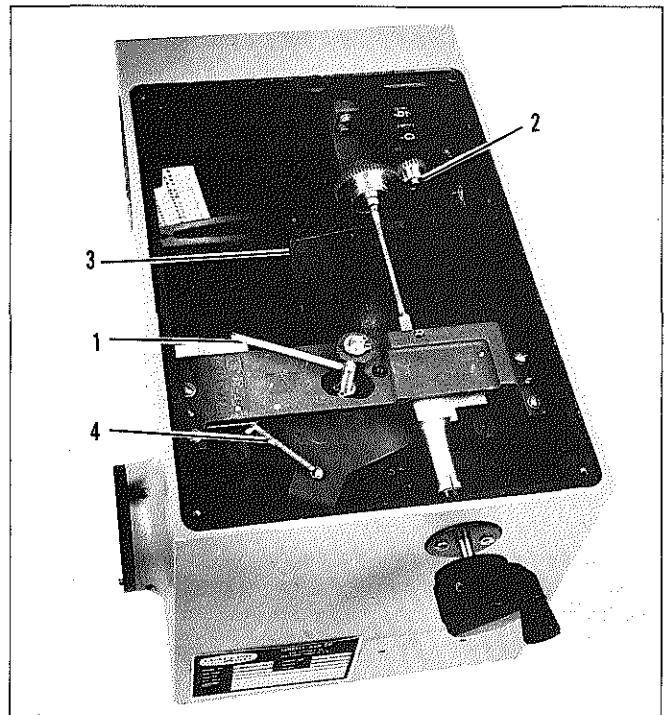


Figure 4

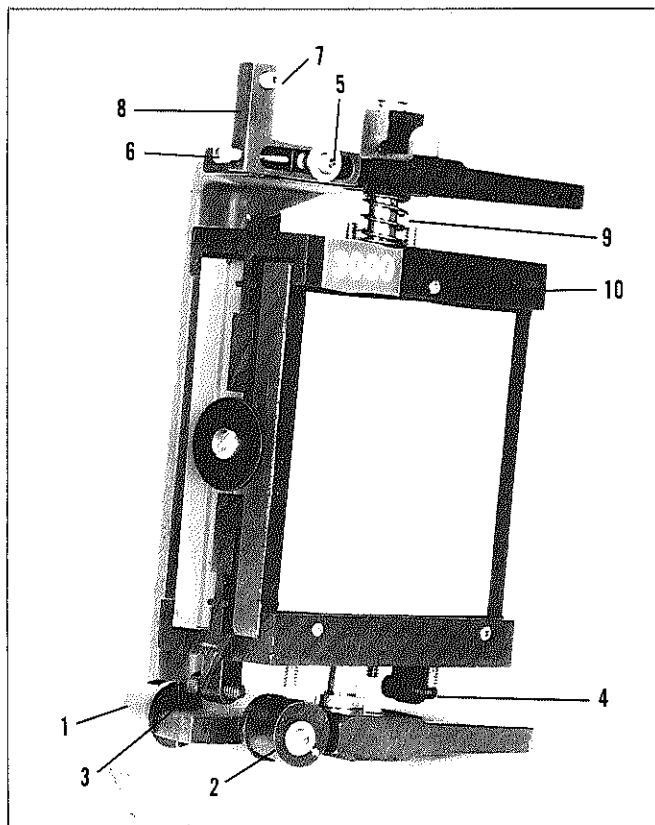


Figure 5

2-3-8 The 300.0 m μ blaze grating holder adjusting screw (3, Fig. 5) should be adjusted either in or out until both gratings can be positioned on the magnetic stops and the green mercury line seen through the exit slit. The counter should read 546.m μ at this point.

2-3-9 Loosen the two set screws (3, Fig. 1). Holding your eye as close as possible to the slit, adjust the focus tube by sliding either in or out until green illumination fills the entire grating surface. With the grating fully illuminated, slowly rotate the wavelength drive and re-adjust the focus tube slightly until proper focus is achieved. Focus is correct when the entire grating surface is illuminated and extinguishes uniformly and quickly as the wavelength drive is rotated.

Note Both the entrance and exit focus tubes should be withdrawn approximately the same distance when focus is achieved. (3mm - 5mm).

2-3-10 Position your eye about 12" from the exit slit, and slowly rotate the wavelength drive toward lower wavelengths until the 546 m μ mercury green line starts to appear in the exit slit. The illumination should come in evenly from the top and bottom of the slit. Rotate the exit slit assembly slightly until the illumination comes in evenly at the top and bottom and appears to close out in the center of the slit (See Fig. 6).

2-3-11 The focus tube should be locked in this position and not moved unless it is necessary to readjust the focus for another set of gratings.

2-3-12 Rotate the wavelength drive to approximately 300.0 m μ , and place a tungsten source at the entrance slit. A re-entry spectrum will appear at the center of the collimating mirror and may be observed at the exit slit. To eliminate the re-entry spectrum, rotate the baffle (3, Fig. 4) located below the wavelength counter, until the re-entry spectrum is visually eliminated from the C-2 collimating mirror. Do not mask out more light than is required to accomplish the above step.

Note Re-entry spectra is inherent to grating monochromators of the type, and masking is necessary to insure the lowest possible light scattering in the monochromatic spectra near 300.0 m μ . Optimum masking depends upon the length of the slit illuminated by the particular source used. The illumination should be centered vertically on the entrance slit so that only the minimum masking is required. For each source used, the mask will have to be adjusted slightly because of the various image sizes or illumination properties. When working in the visible region, the mask is not required to cut out any light.

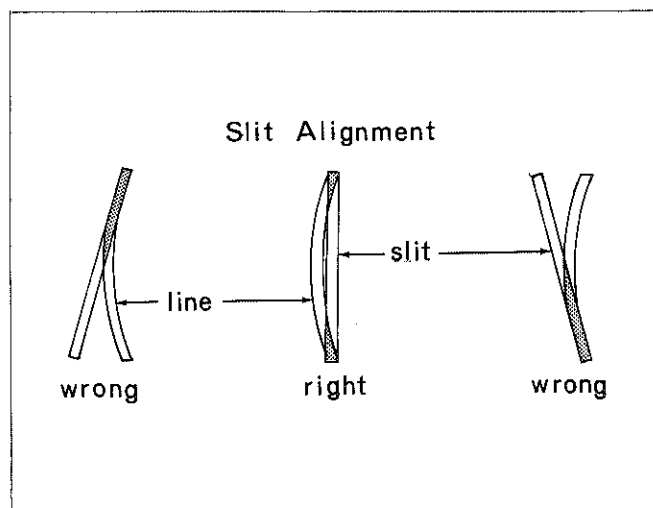


Figure 6

2-4 Wavelength Drive Calibration

The wavelength drive has been calibrated at the factory. A visual check is required to insure that the calibration has not been disturbed during shipment.

2-4-1 Place a mercury lamp at the entrance slit.

2-4-2 Locate the bright green mercury line and set the wavelength counter to 546.0 m μ .

2-4-3 Rotate the wavelength drive toward lower wavelength until the counter reads 0000.

2-4-4 Locate the following mercury lines, and record the counter readings for each line .

Central Image: 0 μ white
 435.8 μ blue
 546.0 μ green
 871.6 μ blue = 2nd order
 435.8 μ

All readings should be taken rotating the wavelength drive in the same direction, to eliminate errors due to backlash.

2-4-5 If the counter readings obtained, for the various mercury lines, exceed the true wavelength values by more than $\pm 1 \mu$, the wavelength drive will require some adjustment.

2-4-6 By plotting the wavelength calibration on a graph as shown in Fig. 7; one is easily able to determine which adjustment is required to properly calibrate the wavelength drive.

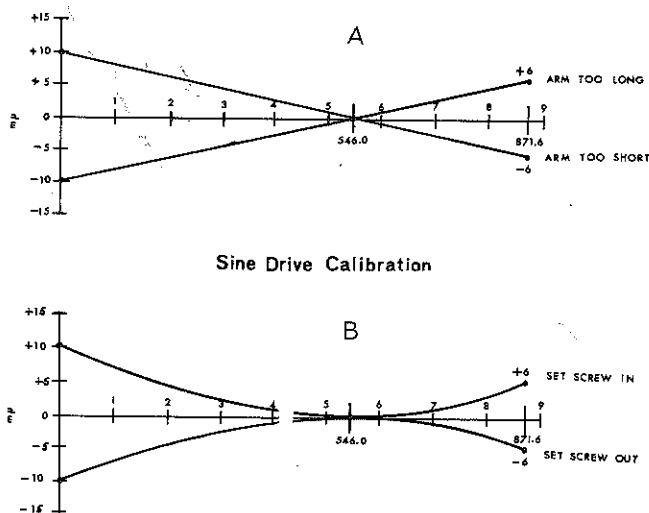


Figure 7

2-4-7 If the plot shows the error to be a curved line bending up, as shown in Fig. 7B; the set screw (7, Fig. 5) should be adjusted (1/2 turn or less) counter clockwise. The set screw (7, Fig. 5) is adjusted clockwise if the curve bends down.

2-4-8 If the plot shows the error to be a straight line going up as shown in Fig. 7A; the length of the arm (8, Fig. 5) must be shortened. Loosen cap screw (5, Fig. 5) and adjust cap screw (6, Fig. 5) counter clockwise (1/2 turn or less). Push the arm toward the pivot and tighten cap screw (5, Fig. 5). The arm (8, Fig. 5) is made longer if the plot shows the error to be a straight line going down.

Note All adjustments should be kept small. Adjustments of 1/2 turn or less on all adjusting screws are adequate.

2-4-9 Repeat Steps 2-4-2 through 2-4-8 until the calibration is complete. Calibration is complete when all readings are within $\pm 1 \mu$.

2-4-10 The second grating requires only to be zeroed out at 546.0 μ . Refer to Para.'s 2-3-5, 2-3-6, 2-3-7, and 2-3-8. All points should then be identical to those of the first grating.

2-5 Use of Gratings Other than 1180 groove/mm

- All Jarrell-Ash Model 82-410 monochromators are provided with wavelength counters calibrated for 1180 groove/mm. To obtain direct wavelength readings for other gratings, use the following table:

Grating Spacing	For Counter Reading Multiply Desired Wavelength by Factor	OR	For Wavelength Multiply Counter Reading by Factor
1180 g/mm	1.0		1.0
590 g/mm	0.5		2.0
295 g/mm	0.25		4.0
2160 g/mm	1.83		0.5468

Note At 546.0 μ when using a 590 g/mm grating a green line will be seen at the exit slit. This line is the 2nd order of 546.0 μ . A 295 g/mm grating will show the 4th order green at a setting of 546.0 μ . The order of the line will be the same as the factor (described above) at any particular setting.

2-6 Interchanging Grating Holders

Additional gratings may be mounted in separate holders (two per holder). Grating holders may easily be interchanged in the 82-410 by following the procedure listed below.

CAUTION

Extreme care must be taken to prevent any contact between the grating face and installer's fingers. This will result in permanent damage.

- Remove the monochromators main compartment cover plate.
- Unscrew the grating selector arm (1, Fig. 4).
- Disconnect spring (4, Fig. 4) from grating yoke.

2-6-4 Lift entire grating yoke assembly (Fig. 5) until the bottom pivot is free of the pivot boss, move the bottom of the grating yoke to the rear of the instrument until free of all obstacles before lifting it out of the monochromator.

2-6-5 To remove the grating and holder from the yoke, grasp the dual holder firmly at the sides and push against the spring loaded pivot (9, Fig. 5) at the top of the yoke. Swing the bottom of the holder out and free of obstructions and remove from yoke. Replace a new grating and holder in the same manner. Care should be taken to ensure that grating holder will rotate freely within the grating yoke.

2-6-6 Carefully replace grating yoke assembly within the monochromator and complete the assembly by replacing the spring (4, Fig. 4) and the selector arm (1, Fig. 4).

2-6-7 Place a mercury lamp at the entrance slit. Adjust wavelength drive until readout is set at 546. Visually check the exit slit to ensure that slits are filled with green light.

2-6-8 If the green light is not visible on exit slit, adjust grating holder adjusting screws (3, 4, Fig. 5) which come in contact with the magnetic stops until green light appears for each grating. Instrument is now ready for use. Do not change counter, since this has been set up previously.

SECTION 3 OPERATION

3-1 Manual Wavelength Drive

1. Turn the wavelength drive knob to the ^{desired} region of interest i.e., $250 \text{ m}\mu = 2500 \text{ \AA}$.
2. Select the most efficient grating for the area of interest by use of the grating selector. Note that the selector knob will turn 180° only. Do not force this selector knob.
3. Illuminate the entrance slit with the desired source.
4. If the instrument is going to be used around $300 \text{ m}\mu$ check the setting of the re-entry spectra mask for the particular source used (Para. 2-3-12).
5. Install the desired phototube or detector at the exit slit.

3-2 Electrical Wavelength Drive

1. By use of an accessory kit, the unit can be converted for electrical scanning with a choice of drive rates: $10 \text{ m}\mu/\text{min.}$ - Catalog No. 82-452; $25 \text{ m}\mu/\text{min.}$ - Catalog No. 82-455; $100 \text{ m}\mu/\text{min.}$ Catalog No. 82-457. Each of these units contains a motor on a mounting plate, complete with drive gear, line cord, switch, and plug.
2. Remove the crank knob on the wavelength drive shaft and attach the drive gear (Cat. No. 82-451) on the shaft.

Replace handle. Insert knurled screws into appropriate threaded holes (3, Fig. 4). Do not screw these all the way home.

3. The keyhole slots of the motor mounting bracket fit over the knurled screw heads. Slide motor vertically upwards for full engagement into driven gear and tighten knurled headed screws.
4. Connect line cord to a 110 V, 60 cycle outlet.
5. The electrical drive is arranged to scan in a direction of increasing wavelength only. When the electrical drive is in operation, the manual drive may not be used.
6. To return to starting wavelength, switch OFF motor, manually rotate wavelength drive to a shorter wavelength region then switch ON the motor drive to scan to higher wavelengths.
7. The motor is provided with a stall clutch mechanism. If the high wavelength limit of travel is reached, the motor will stall but the switch will remain ON. It is important, to switch OFF the motor before returning the wavelength drive to a shorter wavelength setting.
8. For a change of wavelength drive speed, exchange one motor drive unit for another. To do this, remove line cord from the electrical outlet, loosen the knurled headed screws and remove the motor drive unit by use of the keyhole slots. Replace the drive unit of the desired speed and engage the electric drive gear with the shaft gear, then tighten the knurled screws.

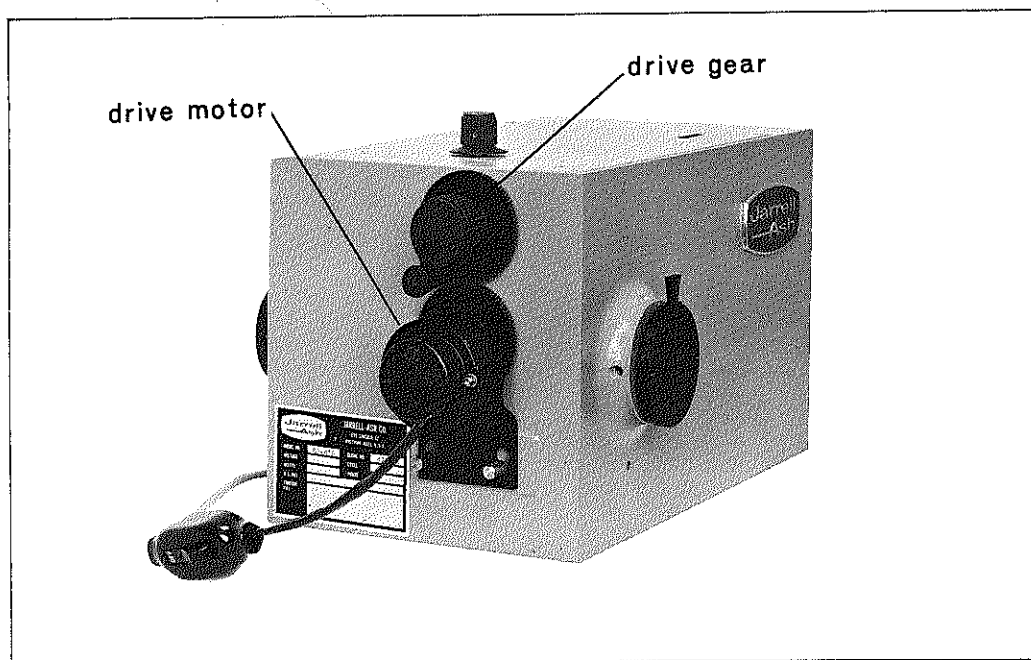


Figure 8

SECTION 4 SERVICE INSTRUCTIONS

4-1 Periodic Inspection

Periodic inspection should be performed in the following manner:

1. Check focus as described in Sec. 2, Para. 2-3-9, 2-3-10, and 2-3-11.
2. Check grating selector knob to ensure gratings are against the stops. (Refer to Sec. 2, Para. 2-3-7, and 2-3-8).
3. Check wavelength calibration either visually or photoelectrically (See Section 2-4).

4. Check wavelength drive mechanism for axial play. Play can be removed by adjusting the small nut (1, Fig. 9) until the play is eliminated and the micrometer operates smoothly. The nut (2, Fig. 9) on the flexible shaft should be jammed against the small nut (1, Fig. 9) to maintain the adjustment.
5. Once a year it is advisable to go through the optical alignment procedures as described in Sec. 2. At this time it is also advisable to check the grating drive for "skipping". With the cover removed and the wavelength readout set on 150, turn wavelength knob clockwise. While turning, notice that the grating yoke is following the micrometer arm in a smooth motion. If any "sticking" occurs, two items must be checked:
 - a. Wavelength drive mechanism as in Item 4 above.
 - b. Excess wear on face of micrometer arm, or the contact screw.

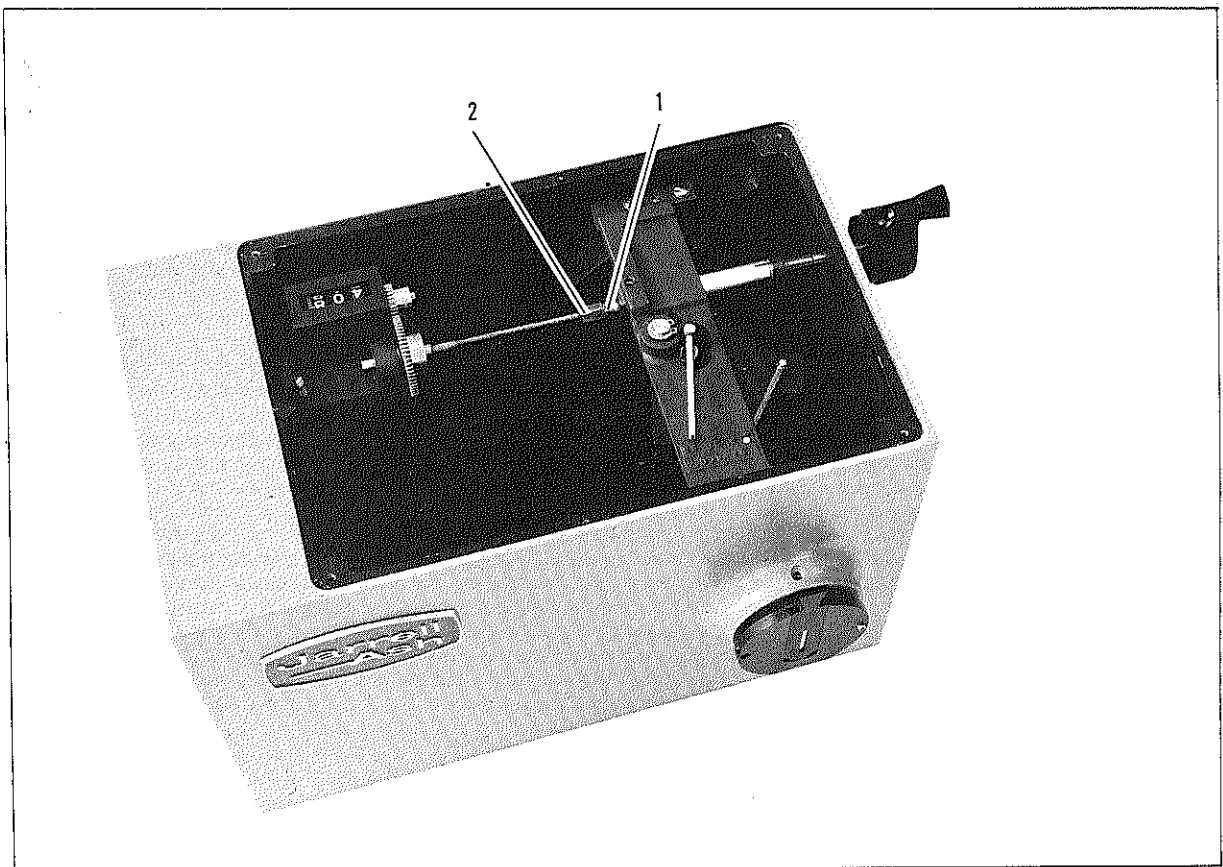


Figure 9

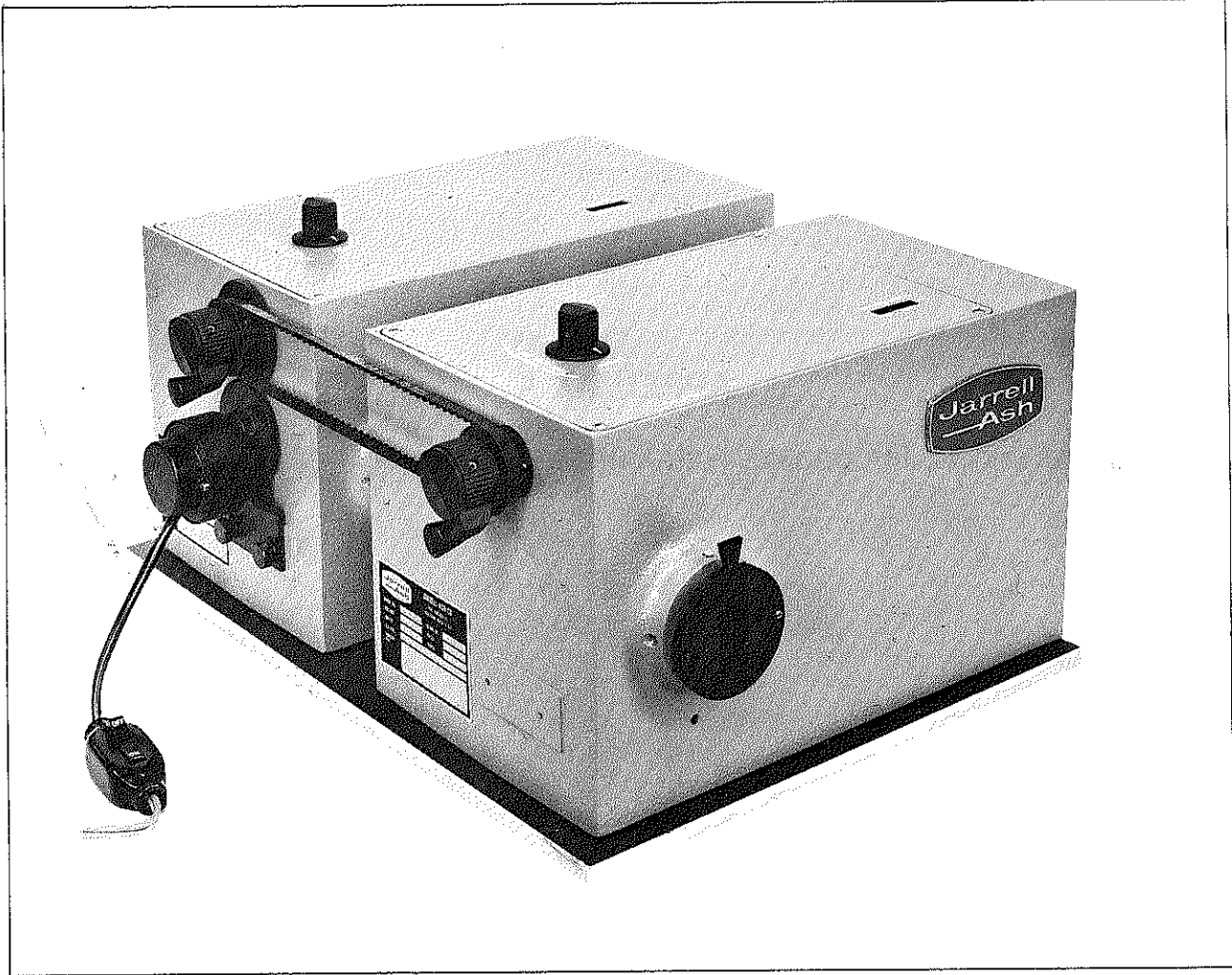
SECTION 5 SPARE PARTS LIST

DESCRIPTION	MFR	JACO STOCK OR PART NO.	RS*
Thumb Screws	PIC #4015	82-451-A-01	
Spur Gear		82-400-A-13 A-00-2857	1
Counter Gear		82-400-A-14 A-00-2858	1
Micrometer		82-400-A-17 B-00-2204	1
Phototube Housing Light Shield Neoprene Rubber 1/16 thick		82-400-A-45	1
Flexible Counter Shaft		82-400-A-37 82-400-A-39 82-400-A-46	1
Counter	Durant #378823-L-CL	82-400-A-014	1
Knob (crank)	Raytheon #125-6-2	82-400-A-016	1
Knob (skirted rd.)	Raytheon #70-3-2	82-400-A-017	1
Stem Bumper	Atlantic India #16	82-400-A-021	4
Grating Yoke Tension Spring SE 11/16 x 3/16 x .016 Loops	Hardware Product	82-400-A-034 12240062	1
Rotation Pin 2-3/16 Long	PIC #A8-11	82-400-C-4 29100089	1
Sine Bar 2024-T4 Alum. Rect. Bar 3/16 thick x 1 x 1-5/16		82-400-C-11	1
Sine Bar Adjusting Screw Slotted Head Set Screw	Long-Lok LP 57 x B40J8	82-400-C-04 12190018	1
Magnet	General Magnet Alinco	82-400-C-014 12430009	2
Front Surface Mirror Glass 1/4 thick x 1-1/8 x 3		82-400-D-1	2
Operational Kit		82-400-E	
Focus Tube Adjusting Screw	PIC #CS-15 (No-Mar)	82-400-H-02	1
Re-Entry Spectrum Baffle		82-400-J	

* Recommended Spare

APPENDIX A

82-440 AND 82-441 DOUBLE MONOCHROMATOR MOUNTING ASSEMBLIES



82-440 DOUBLE MONOCHROMATOR ASSEMBLY

APPENDIX A

82-440 AND 82-441 DOUBLE MONOCHROMATOR MOUNTING ASSEMBLIES

SECTION 1 INTRODUCTION

1-1 General Description

The 82-441 Double Monochromator Mounting Assembly includes a mounting plate and all necessary hardware to align and operate two 82-410's in tandem. The 82-440 is similar to the 82-441 except that it is completely assembled, aligned and calibrated at the factory. Two 82-410's are mounted and aligned on the mounting plate and operate as a single unit. A pair of pulleys and a timing belt operate both wavelength drives simultaneously and accurately. Use of two 82-410's in tandem reduces scattered light to less than one part in ten million (.00001%) thereby producing light of very high spectral purity.

1-2 Component Identification

Refer to Figure 11

1. Mounting Plate 30.5 x 40.6 cm.
2. Timing pulleys (one for each 82-410 wavelength drive)
3. Timing belt couples the wavelength drives of both 82-410's.
4. Dummy exit slit (2) for use on the 2nd 82-410.

5. Light Shield attaches to the exit slit assembly of 1st 82-410.
6. Rubber feet (4) for bottom of the mounting plate.
7. Screws (6) for mounting the 82-410's to the mounting plate. (Binder head 6-32 x 3/4")
8. Screws (2) for mounting the light shield to the slit assembly (Flat Head 6-32 x 1/4")

SECTION 2 ALIGNMENT AND CALIBRATION

2-1 General

The 82-440, Double Monochromator Mounting Assembly has been completely aligned at the factory, only the red shipping screws in the 82-410's should be removed (see Section 2, Para. 2-2). To insure that no damage has occurred during shipment, a visual check of the alignment should be made and is fully described below.

The 82-441, Double Monochromator Mounting Assembly is not factory aligned, the following steps should be carefully followed to properly align two 82-410's on the Assembly.

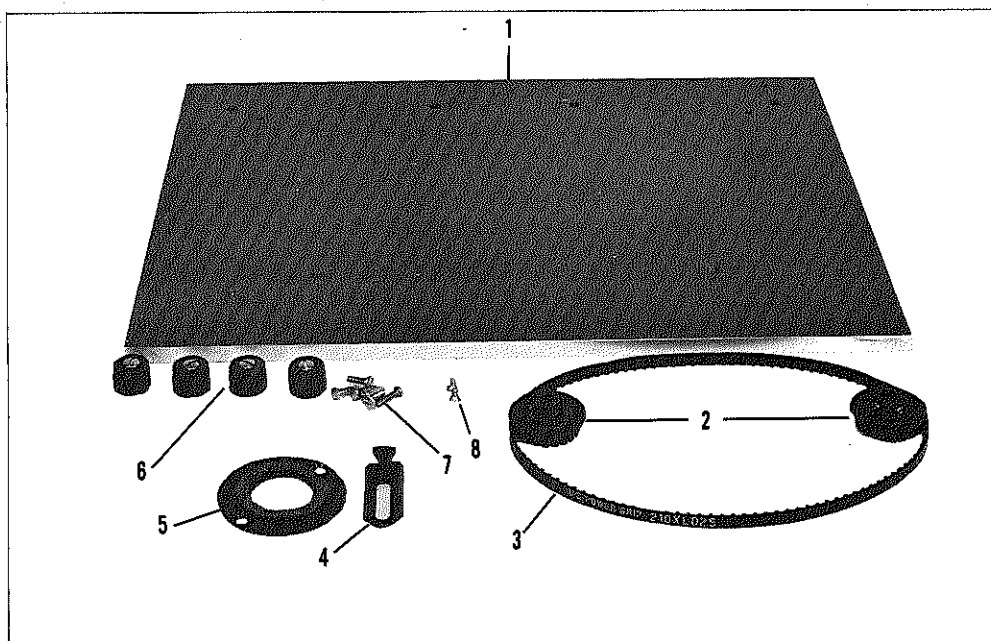


Figure 11

2-2-1 Align and calibrate both 82-410's as described in section 2, Pre-Operational Check.

2-2-2 Mount the light seal (5, Figure 11), on the exit slit of the first monochromator.

2-2-3 Replace the entrance and exit slits of the second monochromator with the dummy slits provided (4, Figure 11).

2-2-4 Remove the rubber feet from the bottom of both 82-410's.

2-2-5 Mount the 1st monochromator (1, Fig. 12) on the mounting plate using the three screws provided (7, Fig. 11).

2-2-6 Mount the 2nd monochromator (2, Fig. 12) on the mounting plate. The exit slit (3, Fig. 12) on the 1st 82-410 and the entrance slit (4, Fig. 12) on the 2nd 82-410 should be moved in as necessary (see Section 2, Para. 2-3-9).

2-2-7 Remove the wavelength crank knob from both 82-410's. Place the 2 timing pulleys on the drive shafts of both 82-410's and lock in place.

2-2-8 Adjust the wavelength drive on each 82-410 to read 546.0 m μ .

2-2-9 Place the timing belt on the pulleys and maintain both counter readings at 546.0 m μ .

2-2-10 Adjust both 82-410's away from each other until the belt is snug between the two pulleys. Tighten the screws holding the 82-410's to the base plate so the 82-410's will maintain their positions.

2-2-11 Replace the crank knobs and rotate the wavelength drives in both directions. If the belt does not run

true, adjust the position of the 82-410's until the belt is snug and does run true. Rotate the wavelength drive back to 546.0 m μ .

2-2-12 Place a mercury lamp at the entrance slit (5, Fig. 2, App. A) of the 1st 82-410.

2-2-13 Uncouple the pulley on the 2nd 82-410 by loosening the 2 set screws. Rotate the wavelength drive on the 1st 82-410 until green illumination can be seen at the exit slit (6, Fig. 12). of the 2nd 82-410.

2-2-14 Holding the 1st 82-410's wavelength drive in place, adjust the 2nd 82-410's wavelength drive until the best illumination is seen visually at the exit of the 2nd 82-410. Lock the pulley in place on the 2nd 82-410.

2-2-15 Adjust the entrance slit focus tube on the 1st 82-410 and the exit slit focus tube on the 2nd 82-410 either in or out until proper focus is achieved (Section 2, Para. 2-3-9, 2-3-10, and 2-3-11).

2-2-16 Looking in the exit slit of the 2nd 82-410, adjust the exit 45° mirror of the 1st 82-410, or the entrance 45° mirror of the 2nd 82-410, or both slightly until the maximum illumination is seen to cover the face of the grating.

2-2-17 With the green illumination peaked to a maximum, set both wavelength counters to 546.0 m μ . The Double Monochromator should now be ready for operation.

2-3 Operation

The Double Monochromator is operated the same as a single unit. The entrance slit is on the 1st 82-410, the exit slit is on the 2nd 82-410 (See Section 3, Operation).

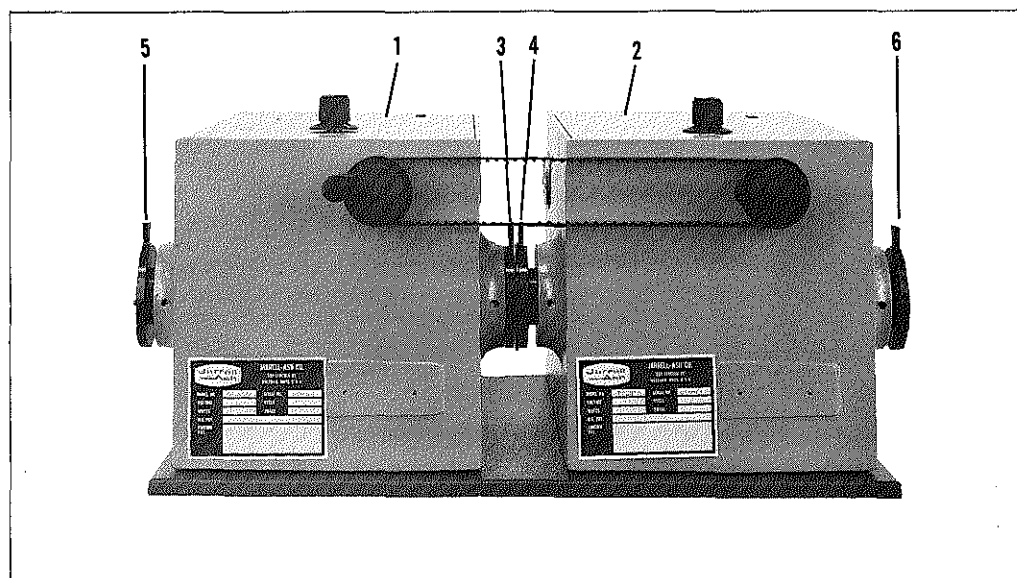


Figure 12

APPENDIX B

OPERATING INSTRUCTIONS FOR THE 45-544 MERCURY LAMP ASSEMBLY

1 General Description

The Model 45-544 Mercury Germicidal Lamp, housing, and power supply form an ideal light source for aligning 82-410 monochromator. Because of the relatively small number of visible lines emitted by the mercury lamp it is an excellent tool for wavelength drive calibration. The lamp operates on 110 V, 50 or 60 cycles.

The 45-544 includes: a mercury lamp power supply, a mercury lamp and housing, and all necessary cables and connectors.

2 Operation

2-1 Mount the lamp housing on the entrance slit assembly of the 82-410 Monochromator. Two #6-32 screws are provided for this purpose.

2-2 Plug the power supply into a 110 V wall outlet.

2-3 Depress the button on the power supply; the pilot lamp will indicate when the mercury lamp is ON.

CAUTION

Do not look at the light emitted from the mercury lamp. It emits strong ultraviolet radiation which is capable of damaging eye tissues.

3 Lamp Replacement

3-1 Turn OFF the lamp and unplug the lamp housing from the connector (2, Fig. 13).

3-2 Remove the two smallest screws (1, Fig. 13) at the base of the lamp housing.

3-3 Withdraw the lamp from the housing and unplug it from its receptacle.

3-4 Insert a new lamp into the receptacle.

Note The lamp will only fit into the receptacle in its proper position, due to the pin arrangement.

3-5 Gently insert the lamp into the housing. Replace the two screws to secure the base to the housing.

3-6 Plug the lamp housing back into the connector (2, Fig. 13).

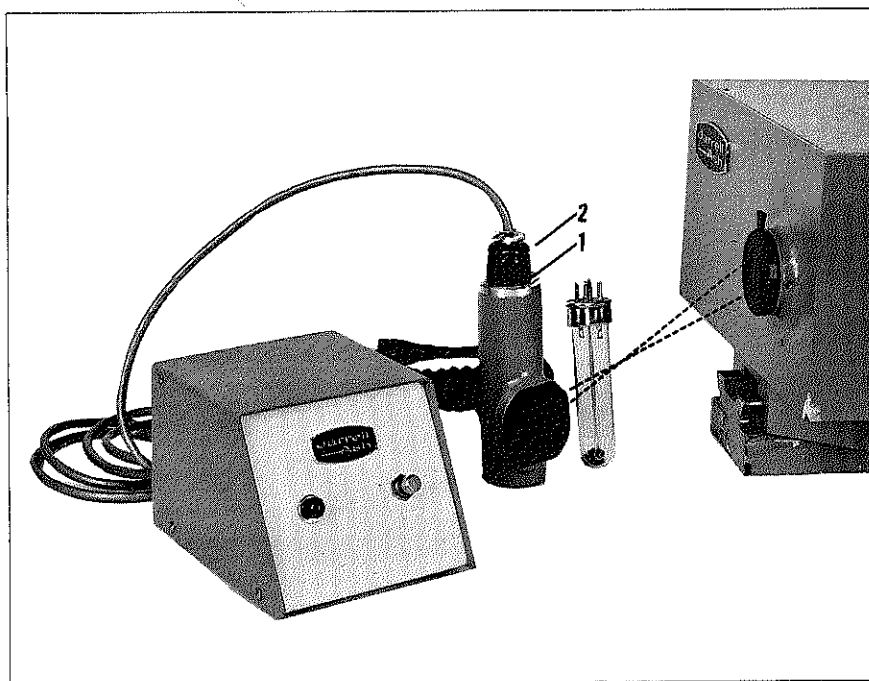


Figure 13

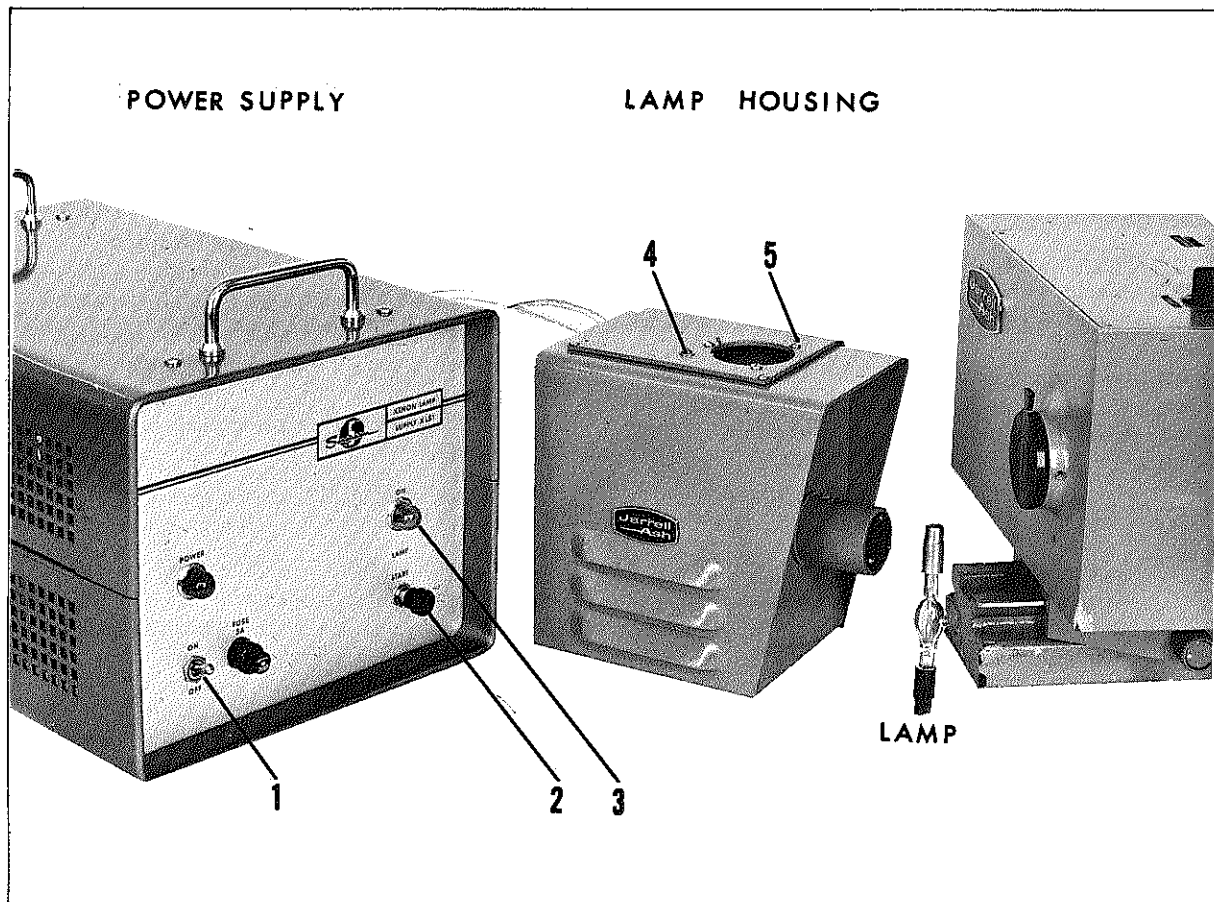


Figure 14

APPENDIX C

OPERATING INSTRUCTIONS FOR THE 45-543 XENON LAMP ASSEMBLY

1 General Description

The Model 45-543 Xenon Lamp, housing, and power supply produces extremely high intensity, illumination in the 2500A-5500A range. It is especially useful as a fluorescence excitation source. The lamp assembly operates on 110 V, 60 cycles. A 50 cycle version is available on special order. The 45-543 includes: a Xenon Lamp power supply, a xenon lamp and housing, a lens, and all necessary cables and connectors.

2 Operation

2-1 Connect the voltage lead from the lamp housing to the output of the power supply. This is the upper lead coming from the housing.

2-2 Connect the ground lead from the lamp housing to the ground terminal on the power supply. This is the lower lead coming from the housing.

CAUTION

Be certain that the lamp housing is grounded properly to the power supply before operating the lamp.

2-3 Plug the power supply into a 110 V, 60 cycle wall outlet with an adequate ground.

CAUTION

A three-wire line cord is provided with the power supply for adequate grounding. If a cord adaptor is used be certain it is connected to a proper ground.

2-5 Depress the ignition "Start" button (2, Fig. 14). The pilot lamp (3, Fig. 14) will indicate when the Xenon Lamp is lit.

2-4 Turn ON the master power switch (1, Fig. 14).

WARNING

Do not operate the Xenon Lamp outside of its housing. A voltage of 20,000-40,000 volts is used to ignite the lamp. During ignition of the lamp keep hands away from the terminals and cables.

Also because of high operating pressure and temperatures the lamp is subject to explosion.

2-6 Focus the Xenon Lamp on the center of the Monochromator entrance slit. Two screws on the side of the lamp housing provide horizontal adjustment. A single screw (4, Fig. 14) on the top of the housing, provides vertical adjustment.

WARNING

Do not look at the light emitted from the Xenon lamp. It emits strong ultraviolet radiation and is capable of damaging eye tissues.

2-7 Illumination from the lamp should completely fill the collimating mirror (C-1), but not spill over onto (C-2). To accomplish this, the lamp housing can be moved either closer to, or further away from the entrance slit.

2-8 To turn OFF the Xenon Lamp; shut off the master power switch.

3 Lamp Replacement

3-1 Turn OFF the master power switch and disconnect the voltage and ground cables from the power supply.

3-2 Remove the 4 screws holding the cover plate (5, Fig. 14) on the lamp housing. The lamp terminals are attached to the cover plate.

3-3 Gently remove the old lamp by snapping the ends out of the snap-terminals.

WARNING

It is advisable to wear gloves and a face protector when handling Xenon lamps as they may explode.

Do not severely jar the Xenon Lamp as it may explode. Avoid touching the quartz surface with your fingers. Fingerprints cause etching which heightens the danger of explosion.

3-4 Caution: Insert the new lamp with the positive (+) terminal UP and the negative (-) terminal DOWN. If their positions are reversed the electrodes will melt.

3-5 Replace the cover plate on the lamp housing and secure it in place.

3-6 Reconnect the voltage and ground cables to the power supply (Para. 2-1, 2-2).

APPENDIX D

OPERATING INSTRUCTIONS FOR THE 45-541 B COMBINED TUNGSTEN AND DEUTERIUM LAMP POWER SUPPLY

1 General Description

The 45-541B Power Supply is used to energize either the Tungsten or Deuterium light sources. The lamps, are mounted in holders, which fit into a housing that may be mounted on the entrance slit of the monochromator. The Deuterium Lamp emits strong radiation from 2000 Å to 3600 Å. Tungsten is useful over a rather wide range of 3500 Å to 8000 Å. The power supply operates on 110 V, 60 cycles. A special model 45-541D is available for 50 cycle operation.

The 45-541 B includes: a combination Tungsten and Deuterium lamp powers supply, a lamp housing which mounts on the monochromator entrance slit, a Tungsten lamp and holder, a Deuterium lamp and holder, a lens, and all necessary cables and connectors.

2 Operation of the Deuterium Lamp Assembly

45-541 A

2-1 Remove the two hex-nuts (1, Fig. 15) from the #6-32 cap screws on the flange of the lamp housing. Leave the two spacers in place.

2-2 Mount the housing on the Monochromator entrance slit using the two #6-32 cap screws. Keep the spacers between the housing flange and the entrance slit.

2-3 Plug the 4-pin, cannon-type plug (2, Fig. 15) into the socket (1, Fig. 16) at the rear of the power supply.

2-4 Place the rotary switch (2, Fig. 17) in either the 30 or 60 watt position.

2-5 Plug in the power supply.

CAUTION

A three-wire line cord is provided with the power supply for adequate grounding. If a cord adaptor is used be certain that it is connected to a proper ground.

2-6 Switch on the master power switch (1, Fig. 17).

2-7 Depress the red "Start" button (3, Fig. 17) for a few seconds until the lamp lights.

WARNING

Do not look at the light emitted from the Deuterium Lamp. It emits strong ultraviolet radiation and is capable of damaging eye tissues.

2-8 With the Deuterium Lamp ON, focus the illumination on the Monochromator entrance slit by loosening the #6-32 binder head screw (3, Fig. 15) and sliding the lens holder in or out to achieve optimum focus. Tighten the lens holder screw to maintain the lens position.

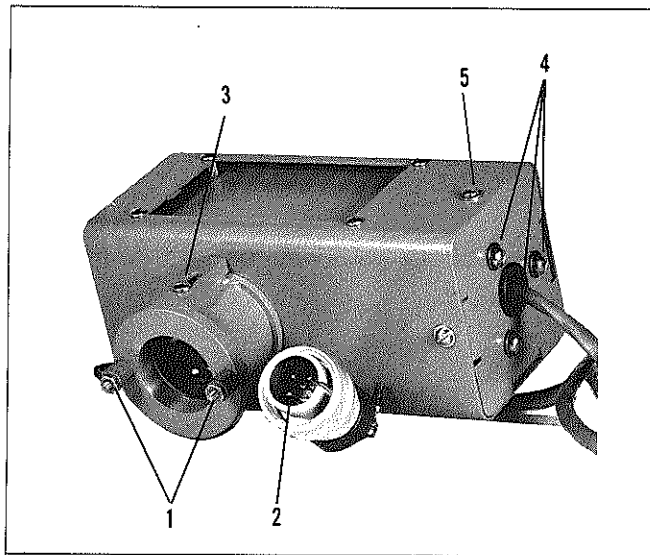


Figure 15

2-9 The focused illumination must be centered on the monochromator's entrance slit. Three adjusting screws (4, Fig. 15) are provided for this purpose.

WARNING

Do not remove the Deuterium Lamp Assembly from the housing unless the power supply is turned OFF and the power cord to the lamp is unplugged from the power supply.

3 Operation of the Tungsten Lamp Assembly 45-542 A

3-1 Mount the Tungsten Lamp housing on the Monochromator entrance slit (Para's 2-1, 2-2).

3-2 Plug the two-prong plug into the socket (2, Fig. 16) at the rear of the power supply.

3-3 Place the rotary switch (2, Fig. 17) in the W position.

3-4 Plug in the power supply (Para. 2-5).

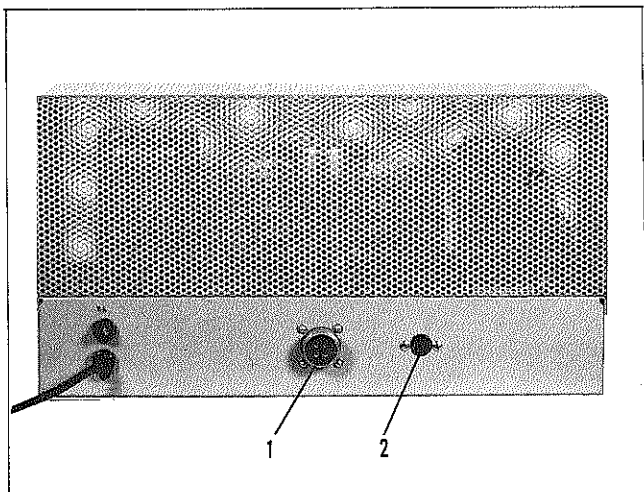


Figure 16

3-5 Switch on the master power switch (1, Fig. 17).

4 Tungsten Lamp Replacement

4-1 Turn OFF the power supply and unplug the Tungsten Lamp power cord.

4-2 Remove the three screws holding the lamp assembly in the housing.

Note Do not remove screw (5, Fig. 15). It is a stop to position the lamp assembly.

4-3 To remove the Tungsten Lamp, push down and turn counter-clockwise.

4-4 Insert a new lamp. Replace the lamp assembly in the housing and tighten the three screws.

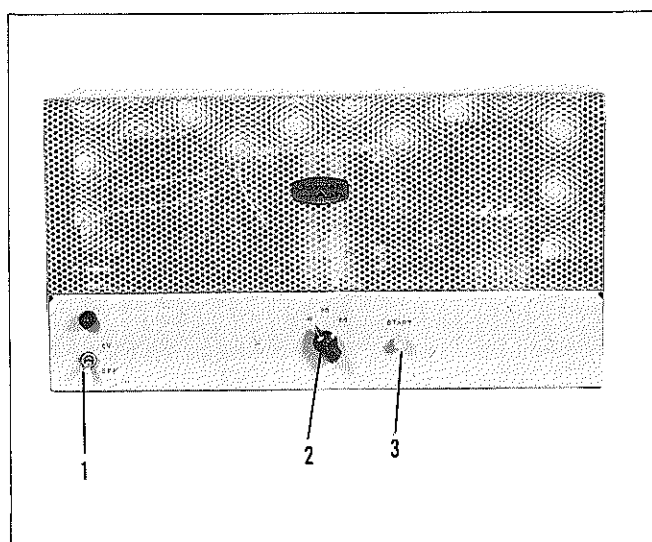


Figure 17

5 Deuterium Lamp Replacement

5-1 Turn OFF the power supply and unplug the power cord from the Deuterium Lamp.

WARNING

Do not attempt to remove the Deuterium Lamp from the housing unless it is unplugged from the power supply. Dangerous electrical shock may occur.

5-2 Remove the lamp holder from the housing. (Para. 4-2).

5-3 Remove the black protective cover (1, Fig. 18).

5-4 Remove the Deuterium Lamps, three leads from their terminals. Note their proper position.

5-5 Gently withdraw the lamp from the two spring clips (2, Fig. 18) holding it in place.

5-6 Install the new Deuterium Lamp in place on the spring clips.

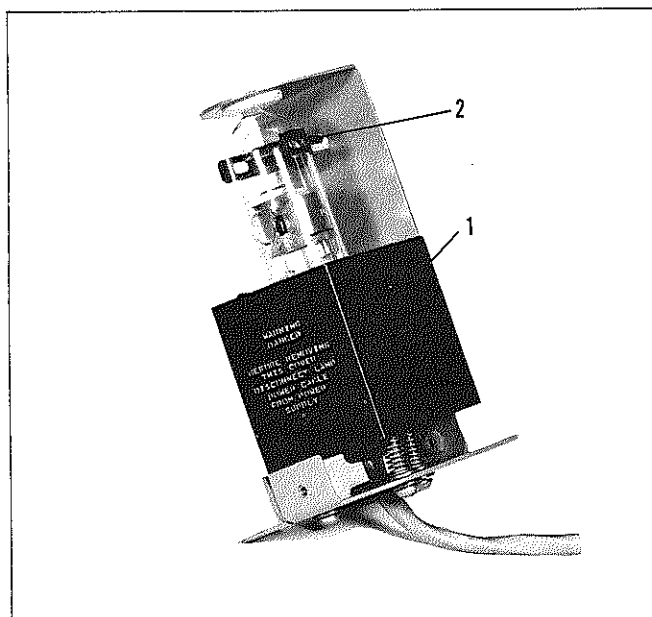


Figure 18

CAUTION

Avoid fingerprinting the quartz surfaces of the Deuterium Lamp. They will cause etching on the quartz surfaces.

5-7 Place the three leads on the proper terminals and secure them in place as on the original lamp. The manufacturer has been known to alter the lead colors.

CAUTION

Be certain to connect the lamp properly to prevent damage to the lamp.

5-8 Replace the black protective cover. Replace the lamp assembly in the housing and replace and tighten the three screws.

APPENDIX E

OPERATING INSTRUCTIONS FOR THE 45-542 TUNGSTEN QUARTZ IODINE LAMP

1 GENERAL DESCRIPTION

The 45-542 Tungsten Quartz Iodine Lamp Assembly is designed for use with the 82-410, 0.25 Meter Ebert Monochromator. It mounts directly on the entrance slit of the 82-410 providing high useful intensity over a range of 3500 Å to 8000 Å.

The 45-542 includes: a ventilated lamp housing, a cooling fan, and a 250 watt Tungsten Quartz Iodine Lamp and socket.

2 OPERATION

2-1 Mount on the 82-410's entrance slit using the two bolts (1, Figure 19) which pass completely through the housing and terminate in thumb screws on the opposite side of the housing.

CAUTION

The two spacers (2, Figure 19) should be kept in place between the housing and the entrance slit to reduce heat transfer between the lamp and the monochromator.

2-2 Plug the line cord into a 115 V. AC. grounded receptacle.

CAUTION

A three-wire line cord is provided with the 45-542 for adequate grounding. If a cord adaptor is used, be certain it is connected to a proper ground.

2-3 Switch ON the master power switch; this will turn ON the cooling fan as well as ignite the lamp.

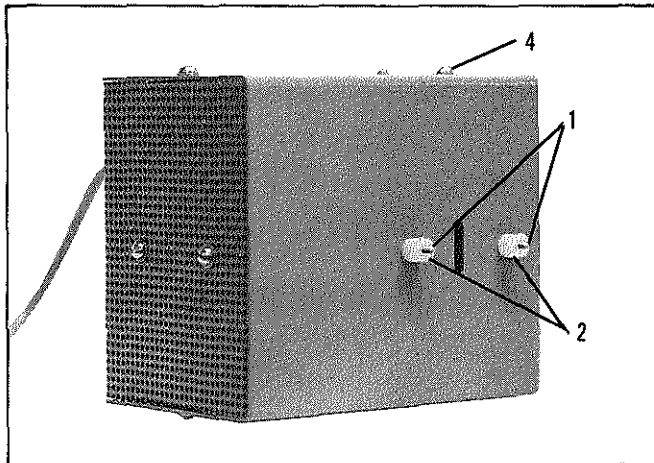


Figure 19

2-4 The re-entry spectra mask in the 82-410 should be adjusted if operating in the vicinity of 300.0 mμ. Refer to para. 2-3-12 of this manual.

2-5 To turn OFF the lamp; shut off the master power switch.

3 LAMP REPLACEMENT

3-1 Turn OFF the master power switch and unplug the line cord.

3-2 Remove the four binding head screws (4, Figure 19) from the lamp housing; the housing will separate into two sections.

CAUTION

Allow the lamp and housing to cool down before attempting to change the lamp.

3-3 Unscrew the lamp (1, Figure 20) from the socket (2, Figure 20) by twisting (counter-clockwise) the ceramic section at the base of the lamp.

3-4 Insert a new lamp in the same manner.

CAUTION

Avoid touching the quartz surfaces of the lamp. Fingerprints will cause etching; thereby, shortening the life of the lamp.

3-5 Place the two sections of the housing together and replace the four screws to secure the housing together. Plug in the line cord and the lamp is now ready for operation.

CAUTION

Do not operate the lamp if the cooling fan fails to operate. Replace the fan before continuing operation.

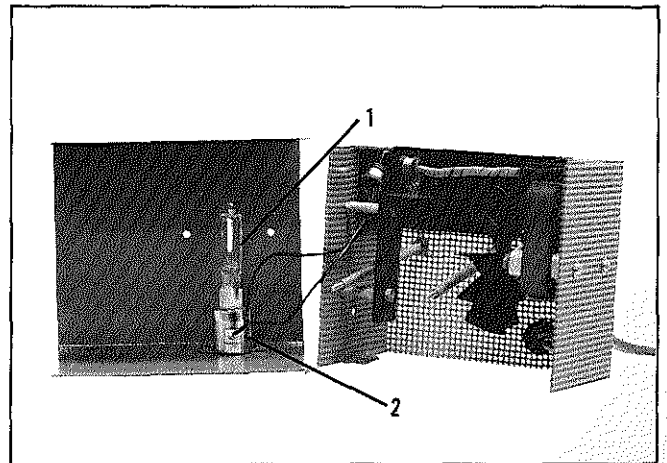
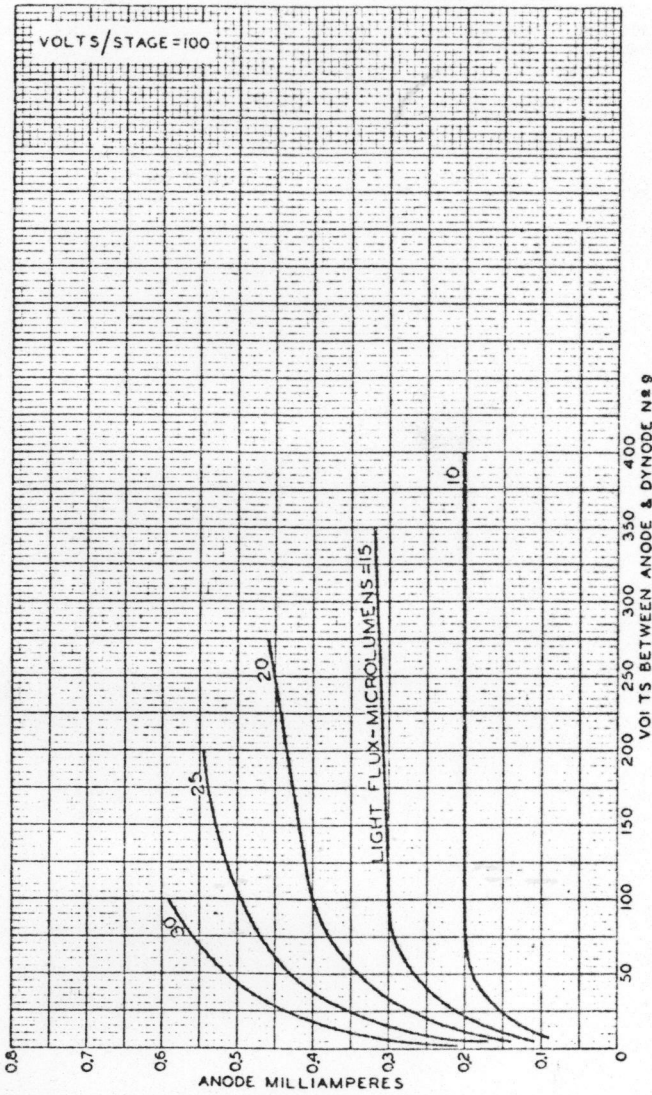


Figure 20

IP28



AVERAGE ANODE CHARACTERISTICS



JUNE 26, 1950 TUBE DEPARTMENT 92CM-6632R2
 RADIO CORPORATION OF AMERICA, HARRISON, NEW JERSEY

IP28



IP28 MULTIPLIER PHOTOTUBE

	Min.	Average	Max.	
Sensitivity:				
At 3400 angstroms.	-	22600	-	$\mu\text{amp}/\mu\text{lumen}$
Luminous:				
Cathode§	-	20	-	$\mu\text{amp}/\mu\text{lumen}$
Anode:†				
At 0 cps	4.5	20	300	amp/amp
At 100 Mc.	-	19	-	amp/amp
Current Amplification [¶]	-	1×10^6	-	
Luminous Equivalent				
Noise Input*	-	7×10^{-12}	-	
Ultraviolet Equivalent				
Noise Input†	-	6×10^{-15}	-	

→ Characteristics: With 75 volts per dynode stage and 50 volts between dynode No. 9 and anode

	Min.	Average	Max.	
Sensitivity:				
At 3400 angstroms.	-	3400	-	$\mu\text{amp}/\mu\text{lumen}$
Luminous:				
Cathode§	-	20	-	$\mu\text{amp}/\mu\text{lumen}$
Anode*, at 0 cps	-	3	-	amp/amp
Current Amplification [¶]	-	150000	-	

§ For conditions the same as shown under Anode Luminous Sensitivity except that the value of light flux is 0.01 lumen and that 100 volts are applied between cathode and all other electrodes connected together as an anode.
 ¶ Measured under conditions specified on sheet "PHOTOTUBE SENSITIVITY MEASUREMENTS" at the front of this section.
 * Ratio of anode sensitivity to cathode sensitivity.
 † Defined as the value where the rms output current is equal to the noise current determined under the following conditions: 100 volt stage, 25°C tube temperature, ac-amplifier bandwidth of 1 cycle per second, tungsten light source at 2870°K interrupted at a low frequency to produce incident radiation pulses alternating between "on" and "off" and the value stated. The "on" period of the pulse is equal to the "off" period. The output current is measured through a filter which passes only the fundamental frequency of the pulses.
 ‡ Defined the same as Luminous Equivalent Noise Input except that it is made of a monochromatic source having radiation at 2537 angstroms.

SPECTRAL-SENSITIVITY CHARACTERISTIC of Phototube having S-5 Response is shown at the front of this Section

OPERATING NOTES

The operating stability of the IP28 is dependent on the magnitude of the anode current and its duration. When the IP28 is operated at high values of anode current, a drop in sensitivity (sometimes called fatigue) may be expected. The extent of the drop below the tabulated sensitivity values depends on the severity of the operating conditions.

(continued on next page)

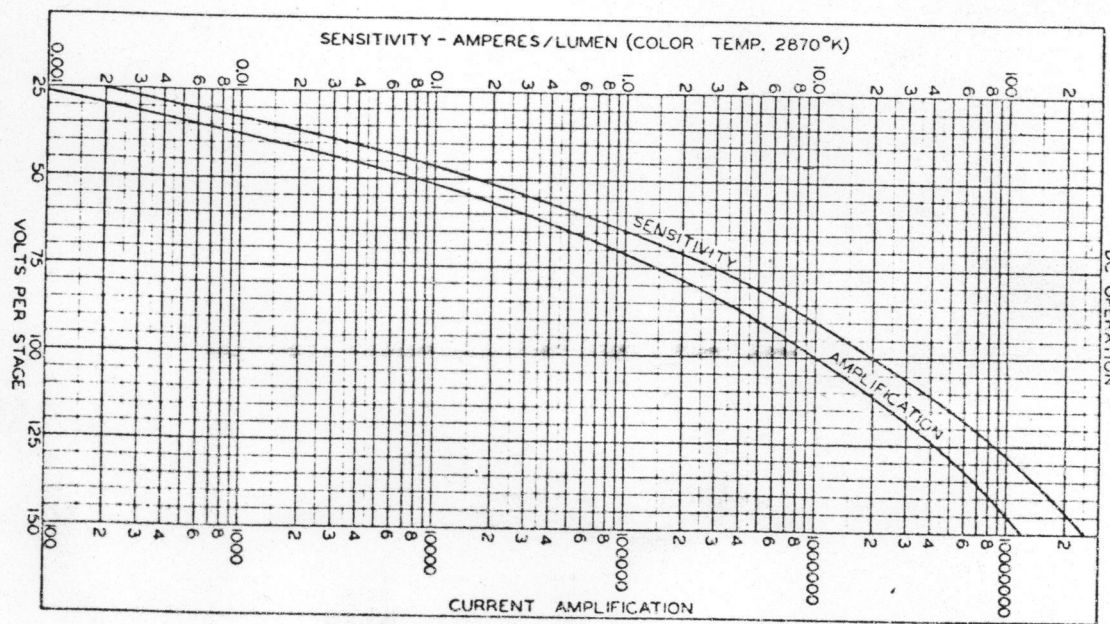
→ Indicates a change.

SEPT. 1, 1950 TUBE DEPARTMENT 92CL-6547R2
 RADIO CORPORATION OF AMERICA, HARRISON, NEW JERSEY

JUNE 23, 1950

TUBE DEPARTMENT

92CL-6547R2



AVERAGE CHARACTERISTICS DC OPERATION



IP28

IP28

MULTIPLIER PHOTOTUBE

9-STAGE TYPE WITH S-5 RESPONSE

SPECTRAL-SENSITIVITY CHARACTERISTICS OF PHOTOTUBE HAVING S-5 RESPONSE

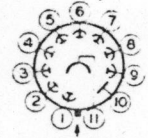
FOR EQUAL VALUES OF RADIANT FLUX AT ALL WAVELENGTHS

DATA

General:
 Spectral Response S-5
 Wavelength of Maximum Response. 3400 ± 500 angstroms
 Cathode:
 Minimum Projected Length* 15/16"
 Minimum Projected Width* 5/16"
 Direct Interelectrode Capacitances:
 Anode to Dynode No. 9 4 μuf
 Anode to All Other Electrodes 6.5 μuf
 Maximum Overall Length 3-11/16"
 Maximum Seated Length 3-1/8"
 Seated Length to Center of Cathode 1-15/16" ± 3/32"
 Length, Base Seat to Center of Useful Cathode Area 1-15/16" ± 3/32"
 Maximum Diameter 1-5/16"
 Eulb. T-9
 Mounting Position Any
 Ease Small-Shell Submagnal 11-Pin, Non-Hygroscopic

Basing Designation for BOTTOM VIEW 11K

Pin 1- Dynode No. 1	Pin 7- Dynode No. 7
Pin 2- Dynode No. 2	Pin 8- Dynode No. 8
Pin 3- Dynode No. 3	Pin 9- Dynode No. 9
Pin 4- Dynode No. 4	Pin 10- Anode
Pin 5- Dynode No. 5	Pin 11- Cathode
Pin 6- Dynode No. 6	



DIRECTION OF INCIDENT RADIATION

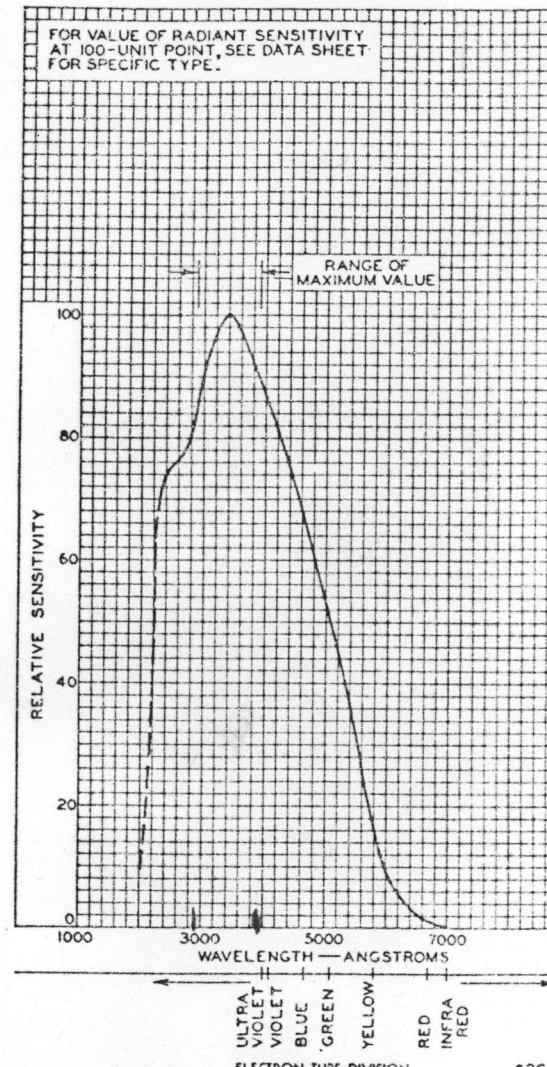
Maximum Ratings, Absolute Values:
 ANODE-SUPPLY VOLTAGE (DC or Peak AC)¹ 1.25 kV
 SUPPLY VOLTAGE BETWEEN DYNODE No. 9 and ANODE (DC or Peak AC) 250 max. volts
 PEAK ANODE CURRENT 5 max. ma
 AVERAGE ANODE CURRENT² 0.5 max. ma
 AMBIENT TEMPERATURE 75 max. °C

Characteristics:
 With 100 volts per dynode stage and 100 volts between dynode No. 9 and anode

DC Anode Dark Current*	Min.	Average	Max.	μamp
	-	-	0.1	

* On plane perpendicular to indicated direction of incident radiation.
 † Referred to cathode.
 ‡ Averaged over any interval of 30 seconds maximum.
 § At 25°C. Dark current due to thermionic emission and ion feedback may be reduced by the use of refrigerants.
 ¶ For maximum signal-to-noise ratio, operation below 1000 volts is recommended.

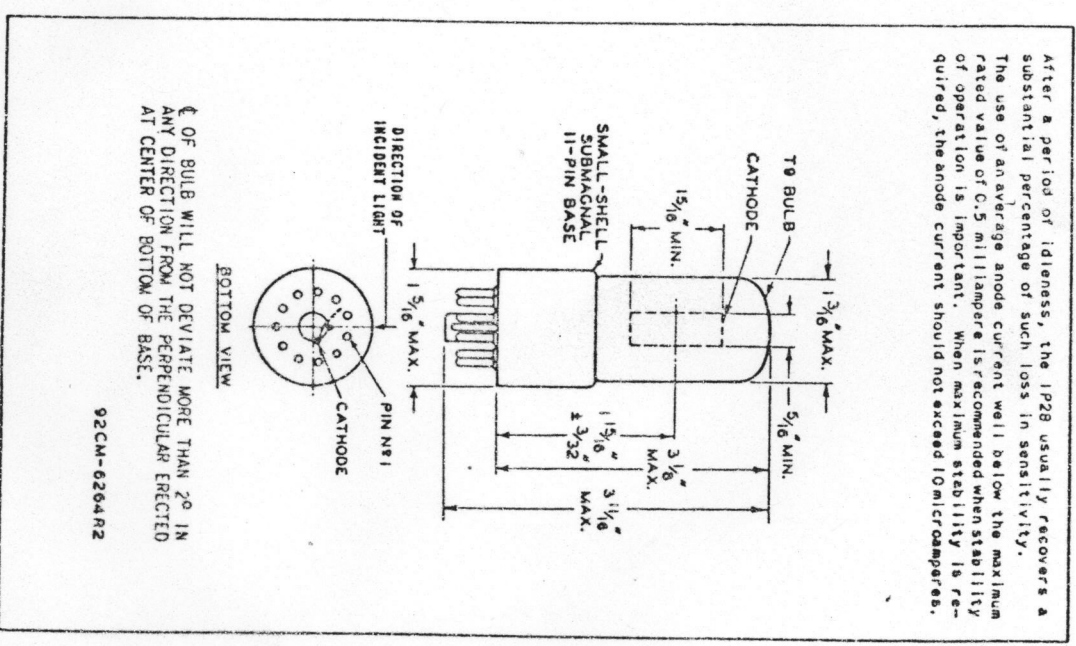
← Indicates a change.



SEPT. 1, 1950 TUBE DEPARTMENT DATA
 RADIO CORPORATION OF AMERICA, HARRISON, NEW JERSEY

SEPT. 1, 1950 TUBE DEPARTMENT
 RADIO CORPORATION OF AMERICA, HARRISON, NEW JERSEY

MULTIPLIER PHOTOTUBE



† OF BULB WILL NOT DEVIATE MORE THAN 20° IN ANY DIRECTION FROM THE PERPENDICULAR ERRECTED AT CENTER OF BOTTOM OF BASE.

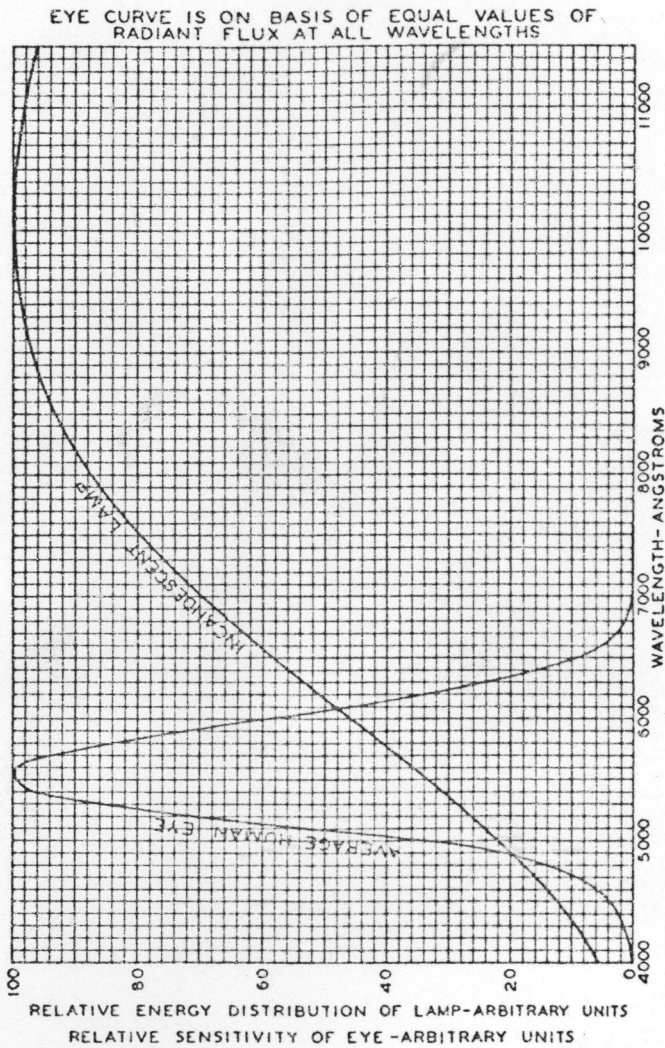
92CM-6264R2

After a period of idleness, the IP28 usually recovers a substantial percentage of such loss in sensitivity. The use of an average anode current well below the maximum rated value of 0.5 milliamperes is recommended when stability of operation is important. When maximum stability is required, the anode current should not exceed 10 micromperes.

MULTIPLIER PHOTOTUBE



SPECTRAL CHARACTERISTIC OF HUMAN EYE & OF TUNGSTEN LAMP AT COLOR TEMPERATURE OF 2870 °K



OCT. 20, 1947

TUBE DEPARTMENT
RADIO CORPORATION OF AMERICA, HARRISON, NEW JERSEY

92CM-6435R1



PHOTOTUBE CLASSIFICATION CHART

When choosing tube types, the equipment designer should refer to the RCA PREFERRED TYPES LIST and its companion list - TYPES NOT RECOMMENDED FOR NEW EQUIPMENT DESIGN - both of which appear in the General Section.

Response	S-1	S-3	S-4	S-5	S-8	S-9	S-10	S-
SINGLE-UNIT PHOTOTUBES								
Vacuum Types	917 919 922 [Ⓜ] 925 6570 [Ⓜ]	926 [Ⓜ]	1P39 929 934 5653	935		1P42 [*]		
Gas Types	1P40 1P41 [*] 868 918 921 [Ⓜ] 923 924 [*] 927 928 [*] 930 6405/ 1640 [Ⓜ]	1P29	1P37 5581 5582 [Ⓜ] 5583					
TWIN PHOTOTUBES								
Vacuum Types			5652					
Gas Types	920		5584					
MULTIPLIER PHOTOTUBES								
Vacuum Types			1P21 [Ⓜ] 931-A [Ⓜ] 6323 [Ⓜ] 6328 [Ⓜ] 6472 [Ⓜ]	1P28 [*]	1P22 [*]		6217 ^{**}	5811 6195 634 637 665 681
PHOTOCONDUCTIVE CELLS See Semiconductor Device Section								
<ul style="list-style-type: none"> Ⓜ Cartridge type. Ⓜ Low-microphonic type. Ⓜ Head-on type. Ⓜ Non-directional type. Ⓜ For headlight-control service. Ⓜ 9-stage type. Ⓜ 10-stage type. Ⓜ 13-stage type. 								

4-56

TUBE DIVISION
RADIO CORPORATION OF AMERICA, HARRISON, NEW JERSEY

PHOTOTUBE CLASS. CHART

