OPERATING INSTRUCTIONS

EX05

HA060002   Issue 1 30/9/90

INTRODUCTION

The EX05 ion source is a high performance ion source suitable for use as an etching source in Auger, or X-Ray Photoelectron Spectroscopy (XPS) experiments. It is also suitable for use as an ion source for Secondary Ion Mass Spectrometry (SIMS), Secondary Neutral Mass Spectrometry (SNMS), and Low Energy Ion Scattering (LEIS) experiments.

The EX05 gun has an electron impact source, and may be used with inert gases to provide ion beams in the energy range 0.1 to 5 keV.

DESCRIPTION OF THE EX05

The construction of the EX05 ion gun is illustrated schematically in Fig.1.

The ion source is an electron impact source, equipped with 2 filaments suitable for use with high purity inert gases.

Gas is supplied to the source region via the gas inlet valve from a high pressure (1 atmosphere) supply. Differential pumping of the source permits an analysis chamber vacuum of better than 5E-7 mbar during operation.

The ion optical column for focussing the beam onto the sample consists of 2 lenses, followed by 2 pairs of plates for beam scanning.

TECHNICAL SPECIFICATION

Operating Voltage	:	0.1 → 5keV.
Maximum Current	:	>6μA (at 5kV, 10mA emission, 15mm working distance)
Minimum Spot Size	:	<120μm (at 5kV, 15mm)
Maximum Current Density	:	>50μA mm^{-2} (5mAcm^{-2}) (at 1μA, 5kV, 15mm)
Maximum Scanned Area	:	5mm x 5mm (5kV, 30mm)
Power Supplies	:	400X with 346 or 384 scan unit
Ion Gun Lead	:	400X-200-1
Mounting	:	FC38 rotatable conflat flange (200mm port length for 30mm working distance)
Pumping	:	Differential pumping of source (single stage via tapped FC38 conflat flange)
Gas Inlet	:	Via FC19 conflat flange

FILAMENT: FIL 35 (PART NUMBER FOR USA)

RECOMMENDED PUMPING AND GAS REQUIREMENTS

VG Microtech recommend that your EX05 is used under the following conditions:-

Differential Pumping	>5 Ls^{-1} (at the source) for Argon
Chamber Pumping	>150 Ls^{-1} for Argon
Source Gas Purity	99.999% purity
EX05 Port Length	185mm to 230mm

It should be noted that the EX05 will in fact operate with a lower pumping speed at the source, but this will lead to an increased analysis chamber pressure.

To achieve the above source pumping speed, it is recommended that the pumping tube to the source is kept to the shortest length and maximum diameter possible, and a source pump with a pumping speed of >50Ls^{-1} (for Argon) is used. (Using standard1½" (38mm) O.D. tubing, the tube length should be kept to <1m to achieve a 5Ls^{-1} pumping speed at the source).

RECOMMENDED OPERATING CONDITIONS

The source operates with a gas load between $5x10^{-5}$mbarLs^{-1} and $5x10^{-4}$mbarLs^{-1}. If the pumping speed at the position at which the source pressure is measured is known, and is S, this will correspond to a measured pressure of (Gas Load)/S mbar.

The chosen operating conditions will be a compromise between the maximum etch rate possible, minimum beam spot size possible (in order to obtain the best quality crater possible) and in some cases, minimum chamber pressure possible.

It is suggested that operating the source at a gas load of just less than 10^{-4} Ls^{-1} will give a suitable balance between these requirements.

FITTING THE EX05 ION GUN

The EX05 ion gun should be fitted with the orientation of the beam scan plates as close as possible to the X and Y translation motions of the sample. The orientation of the scan plates can be seen by examining the orientation of the slot in the nose of the gun.

The gas inlet should be connected to the FC19 flange at the rear of the gun, in such a way that it is possible to at least rough pump the volume between the gas admit leak valve and the source isolation valve (fig 3). When fitting the gas line, it should be noted that the user will need to remove the ion source cover (fig 7) to change filaments, and, therefore, the gas line should be constructed in such a way that this can easily be done. To obtain the fastest response possible to source pressure adjustments, the gas inlet leak valve should be fitted on or as near as possible to the EX05. The volume up to the gas inlet valve should be at a pressure, to ensure that any small leaks in the gas line do not result in contamination of the source gas.

400X POWER SUPPLY

FRONT PANEL CONTROLS

The function of the front panel controls of the 400X high voltages supply (Fig 2) are described in this section.

RV1: Extractor Voltage
RV1 selects either a low extraction voltage (0 to 10V) for Low Energy Ion Scattering experiments, or a high extraction voltage (internally pre-selected) for Secondary Ion Mass Spectrometry (SIMS) experiments and Auger/ESCA depth profiling experiments.

RV2: Source Emission Current Fine Control
RV2 selects 30% to 100% of the emission current selected by switch S2.

S2: Emission Current Coarse Control.
S2 selects emission currents of fixed values in the range 2μA to 10mA.

RV3: Beam Energy Fine Control.
RV3 selects a continuously variable beam energy of 0 to 1kV above the energy selected by S3.

S3: Beam Energy Coarse Control.
S3 provides a switchable beam energy from 0 to 4kV in steps of 0.5kV.

S4: Focus Lens Coarse Control

RV4: Focus Lens Fine Control

S5: Spot Size Lens Coarse Control

RV6: Spot Size Lens Fine Control

RV5: Not used

RV7: Not used

LP3: LP3 indicates whether or not the ion beam is blanked when LP3 is illuminated the beam is unblanked. (Blanking of the beam is operated by selection of zero emission; this may drive the filament current low).

REAR PANEL CONNECTIONS

Inputs:

PL1	:	Power 240 V A.C.
SK3	:	Beam gating TTL (LO = beam on)

Outputs:

SK1	:	Beam energy (0.1 → 5kV), lens and source outputs
SK2	:	
SK4	:	Beam energy monitor o/p (0 to 10V for 0 to 5kV)
SK5	:	Not used

INITIAL OPERATION OF THE EX05

In this section, initial operation of the EX05 following a bakeout of the system is described.

INITIAL CHECKS

1. Ensure that, with reference to Fig 3 and the system valve layout, the gas supply lines and valves to the EX05 source can be identified.

2. Check all electrical connections with reference to Fig 4.

3. After checking that the gas valves to the source and gas cell are closed, evacuate the gas feed lines up to these valves.

4. Close the pumping valve to the supply line, and admit a high purity inert gas (research grade is recommended) to the gas feed lines. NB. IMPURE GAS WILL SEVERELY REDUCE FILAMENT LIFETIME.

5. Ensure that the pressure in the differential pumping line is better than 10^{-8} mbar.

FILAMENT OUTGASSING

1. Unscrew the four 400X retaining screws, and pull the supply forward to give access to the filament current limit potentiometer on the right hand side of the unit (see Fig 6).

2. Turn this potentiometer fully anti-clockwise.

3. Ensure that 400X power supply settings are:-
   S1 - "standby"
   S2 - fully anti-clockwise "EMISSION CURRENT"
   S3 - fully anti-clockwise (0kV) "SOURCE ENERGY"

4. Switch mains power to the 400X supply.

5. Slowly turn the current limit potentiometer clockwise to increase the filament current (shown on meter M1), and allow the filament to outgas. Ensure that the pressure in the differential pumping line does not rise above 10^{-7} mbar.

6. Continue with step 5 until the current does not increase as the current limit potentiometer is adjusted. This process will take approximately 1 hour.

7. Switch off the mains supply to 400X supply.

8. Switch the filament change over switch (Fig 6) to change to the second filament.

9. Repeat steps 4 to 8 to outgas the second filament.

10. After outgassing the second filament increase emission in steps to 10mA ensuring that the source pressure does not rise above 10^{-7} mbar.

11. If the selected emission does not register the requested level, turn the current limit potentiometer clockwise until the selected full scale emission is just achieved.

12. Return 400X power supply to instrument rack.

INITIAL GUN ALIGNMENT

1. Admit gas to the source region via the source admit valve to give a pressure in the differential pumping line of 10^{-6} to 10^{-5} mbar.

2. Ensure the following 400X settings:
   S1 - "standby"
   S2 - fully anti-clockwise (10μA) "EMISSION CURRENT"
   S3 - fully anti-clockwise (0kV) "SOURCE ENERGY"
   S4, S5 - 6,6)
   RV1 - "High" "EXTRACTOR"

3. Switch mains power to 400X and beam scan unit

4. Wait until the filament current on meter M1 has risen and settled.

5. Switch S1 to "HT"

6. Turn S3 clockwise SLOWLY, until the beam energy on meter M1 is 5kV. (RV3 fully clockwise).

7. Check that LP3 is illuminated, showing the beam to be unblanked.

8. Set the scan unit to low magnification.

9. Increase the emission to 2mA by switch S2. "EMISSION CURRENT"

10. Adjust S5 "SPOT SIZE" and RV6 until a current is registered at the sample.

11. Maximise this current with S5 and RV6. "SPOT SIZE"

12. Focus the beam onto the sample with S4 and RV4. "FOCUS"

13. Repeat steps 11 and 12 until a maximum sample current is obtained.

14. Adjust the gas pressure and repeat steps 11 to 14 until the gas pressure is optimised.

The EX05 is now aligned and ready for operation. If the beam energy is adjusted, it may be necessary to re-optimise the sample current following steps 11 to 13.

SWITCHING OFF THE EX05

1. Turn S2 anti-clockwise to give 10μA emission
2. Slowly turn S3 fully anti-clockwise to 0kV.
3. Switch S1 to "standby"
4. Switch mains power to 400X power supply off.
5. After 5 minutes close gas admit valves to the source to stop gas flow.

ROUTINE OPERATION OF THE EX05

In this section, the operation of the EX05 and its associated power supplies is described. It is assumed that the filament has previously been thoroughly outgassed. IF A NEW FILAMENT HAS BEEN INSTALLED, OR THE SYSTEM HAS BEEN BAKED, THE FILAMENTS MUST BE DEGASSED. FAILURE TO DO MAY SEVERELY REDUCED THE LIFE-TIME OF THE FILAMENTS.

1. Ensure that the gas supply line to the source has been evacuated, and that a suitable supply of high purity (>99.99% purity) has then been provided up to the gas inlet valves.

2. Ensure that the pressure in the differential pumping line is better than 10^{-8} mbar.

3. Introduce gas into the source region, such that the pressure in the differential pumping line is in the region of 10^{-6} to 10^{-5} mbar.

4. Ensure that 400X power supply controls are as follows:

	S1	-	Standby
EMISSION CURRENT	S2	-	10μA emission
SOURCE ENERGY	S3	-	0kV
EXTRACTOR	RV1	-	"High" for normal operation 0 → 10V for LEISS
	LP3	-	Illuminated (ie Beam unblanked)

5. Switch on mains power to 400X and beam scan unit.

6. Wait for the filament current to rise and settle on meter M1.

7. Switch on the HT with switch S1, and select the desired beam energy with S3 and RV3.

8. Increase the emission current to the desired value with S2 and RV2. This emission will be displayed on meter M2 (NB Meter M2 reads 10mA full scale, irrespective of the setting of S2).

9. Adjust the source pressure and emission current as required. (N.B. For optimum performance, the optimum pressure must be set precisely).

10 Adjust S5 and RV6 and S4 and RV4 to select the required current, to focus the beam on the sample.

11. Check the beam current, and repeat step 10 is necessary.

12. Adjust the beam scan unit magnification to give the required field of view.

NEUTRAL BEAM OPERATION (EX05F)

To obtain a neutral beam from the EX05 FAB gun, and measure the equivalent ion current (i.e. the neutral 'current'), the following steps should be followed :-

1 Set up the EX05F in the ion beam mode.

2. Select 'neutral beam' operation on the front panel of the549 unit.

3. Admit gas to the collision cell while measuring the unsuppressed sample current, I_N. This current may be adjusted by use of the spot size control, and collision cell gas flow.

4. Select 'ion beam' operation from the 549 front panel.

5. Measure the unsuppressed ion current, I_u while scanning beam over an area of approximately 2mm x 2mm.

6. Measure the suppressed (i.e. true) ion current. I_T.

7. Calculate the ratio R given by

$$R = (I_u - I_N - I_T) / I_T$$

8. The neutral equivalent current is then given by

$$I\ Equiv = I_N / R$$

9. Return the 549 to neutral beam mode, and adjust the collision cell pressure (and spot size control if necessary) to give the desired neutral equivalent current.

CHANGING THE FILAMENTS

The EX05 filaments can be changed without removing the whole gun from the vacuum chamber. To replace the filaments, the following procedure should be followed with reference to Fig. 7 ensuring that gloves are worn when handling in vacuum parts:-

1. Let the vacuum system up to atmospheric pressure of nitrogen or argon. *We have 8 bolts on LEED/TPD chamber*

2. Undo the 6 M6 bolts which retain the ion source cover, and remove the ion source cover. (Item 1).

3. Loosen the 3 M3 screws which retain the end plate, and remove the end plate and O-Ring (this will probably remain located in the end plate). (Items 2 and 3)
4. Remove the ceramic spacer (item 4).

5. Remove the filament cup assembly (item 5).

6. Undo the 4 grub screws (2 per filament) which retain the 2 filament assemblies, and remove. (see fig 8).

7. Fit 2 new filament assemblies (VG Microtech part no. ~~FIL 31)~~. Ensure that the filaments are set to a height of 6mm above the cup, and spaced 7mm apart (± 3.5mm from the centre). *

8. Carefully tighten the 4 grub screws to secure the 2 filaments, ensuring their heights remain 6mm above the cup, and their spacing remains at 7mm.

9. Carefully refit the filament cup, while locating the filament connector pins.

10. Refit the ceramic over the filament cup.

11. Refit the O-ring and end plate and tighten the 3 M3 retaining screws while the end plate is pushed fully home.

12. Replace the old gasket, refit the ion source cover and tighten the 8 x M8 retaining bolts.

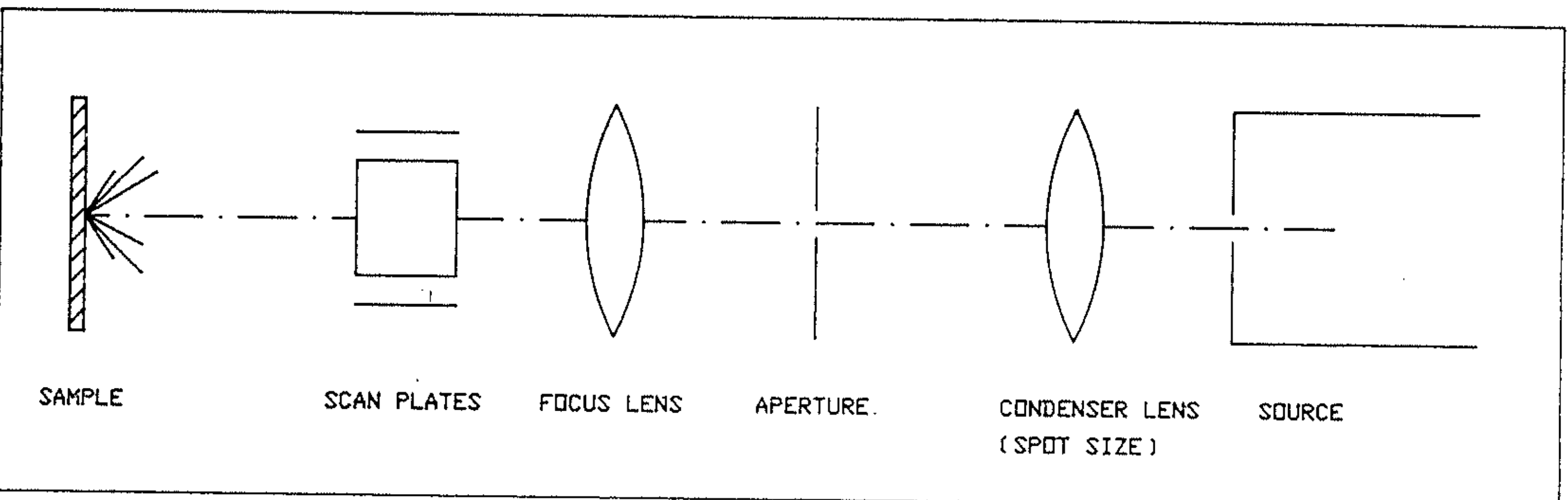
* IN EUROPE ORDER PART # 31a
IN USA ORDER PART # FIL 35 (9/93) @ $145 for pair

EX05 MECHANICAL SPARES KIT (SPK19)

DESCRIPTION	QUANTITY
Filament	6
O-Ring	1
Ceramic Spacer	1
Filament Cup Assy	1
Grub Screw, M2 x 2	4
Washers. M1.6	6
Screw, M1.6 x 12	2
Screw, M1.6 x 8	2
Ceramic Bush	4
Screw, M3 x 6	6
Filament Jig	1

MICROTECH

Figure 1 Schematic of ION OPTICAL COLUMN



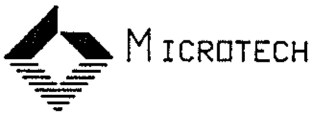
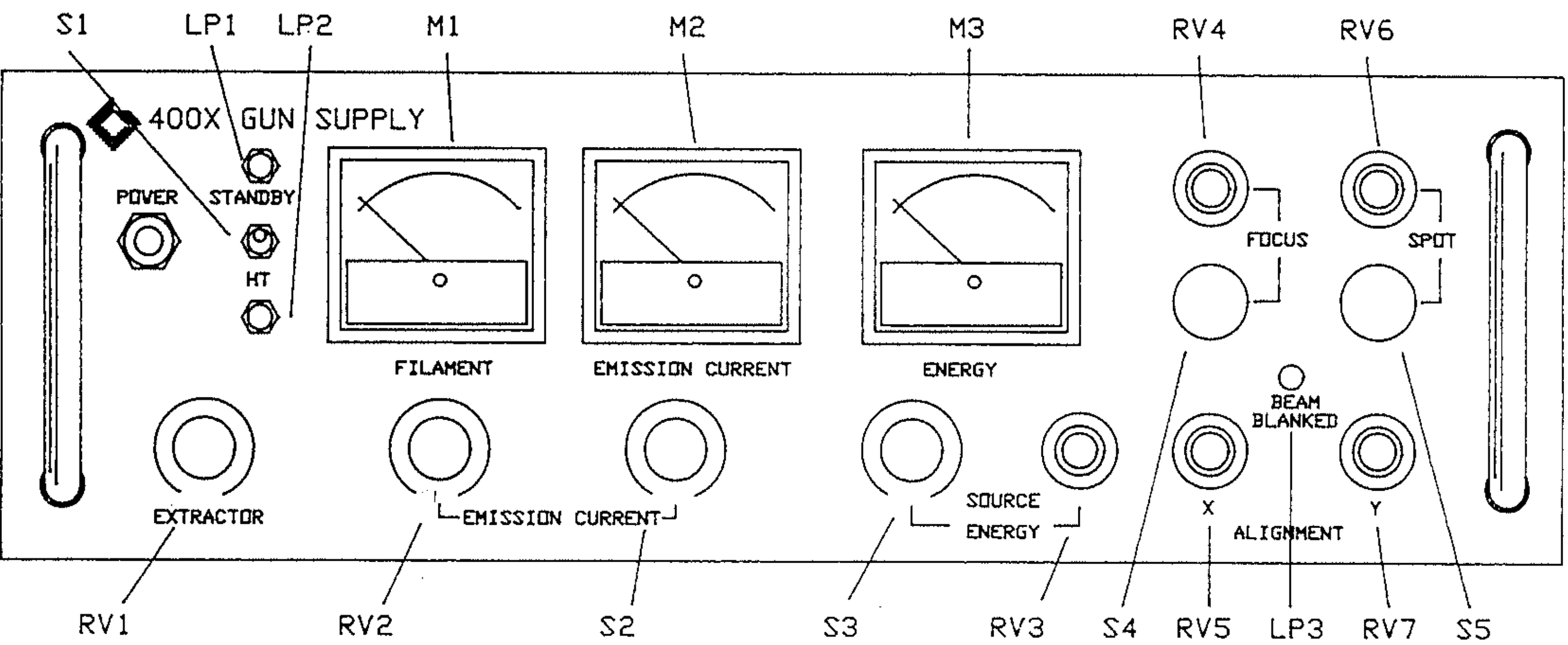
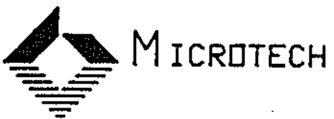


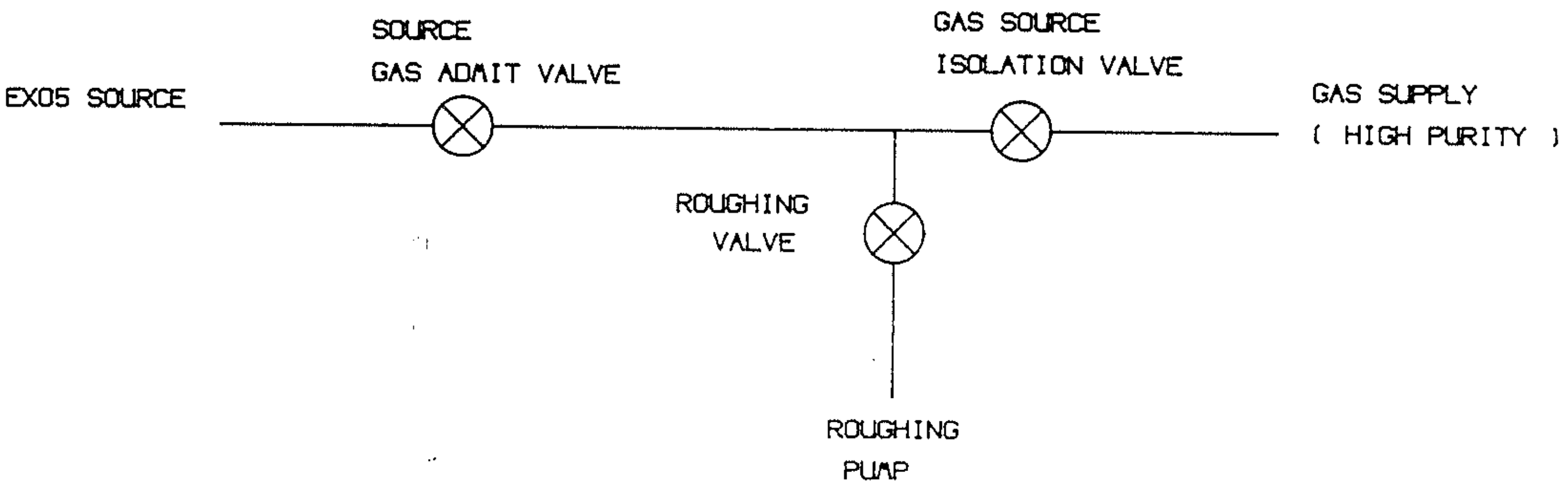
Figure 2: 400X POWER SUPPLY

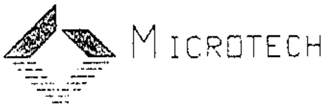




MICROTECH

Figure 3: EXØ5 VALVE LAYOUT

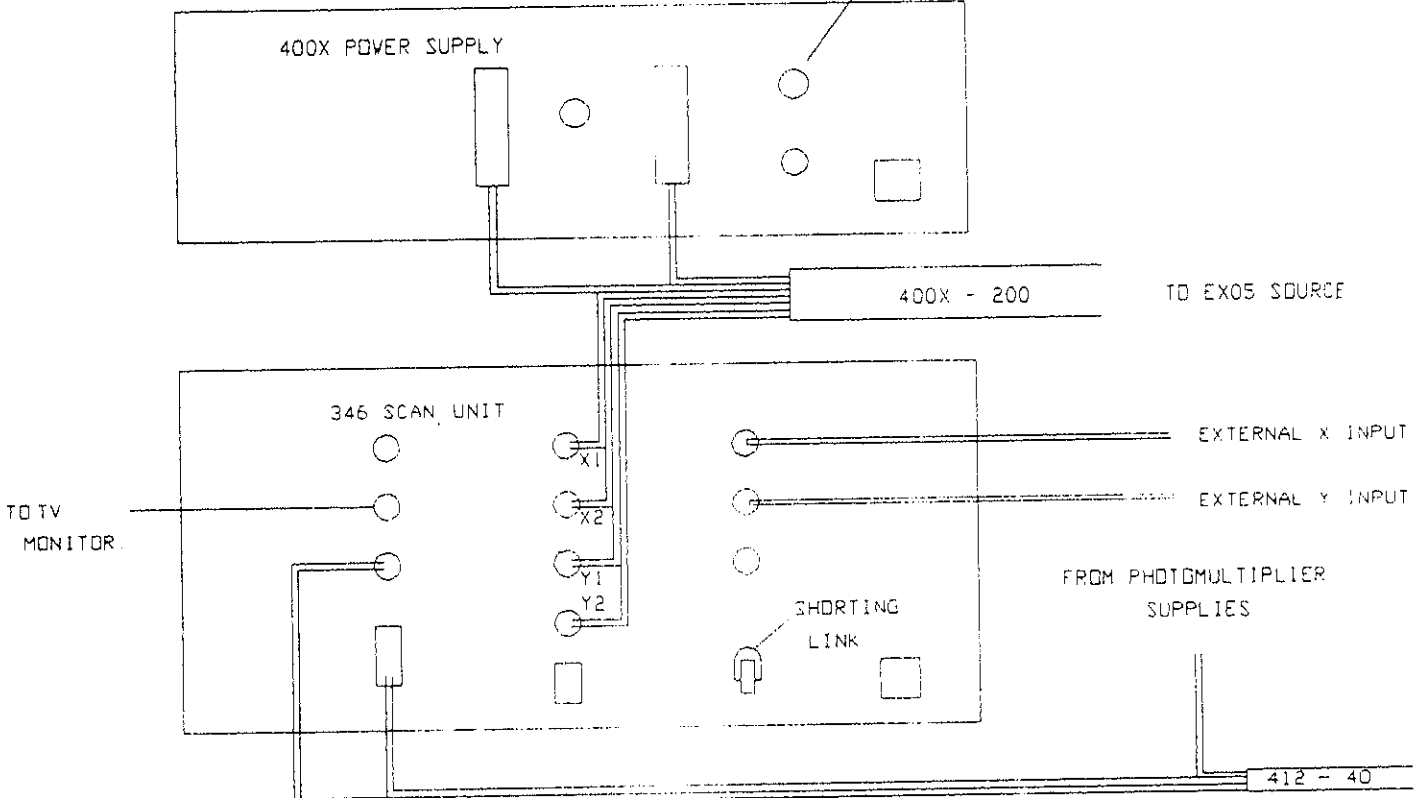




MICROTECH

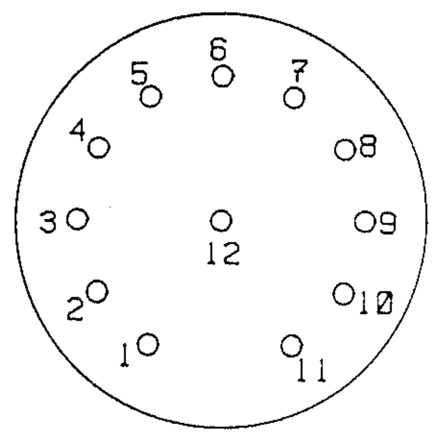
Figure 4: EX05 INTERCONNECTIONS

400X/346



MICROTECH

Figure 5 EX05 FEEDTHROUGH CONNECTIONS



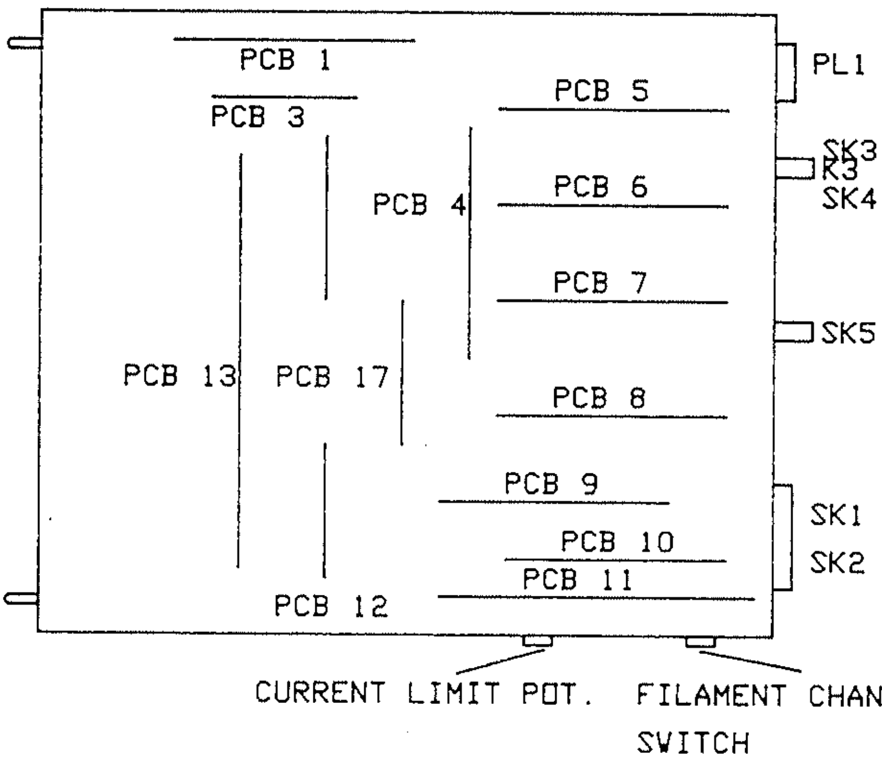
FEEDTHROUGH

VIEWED FROM ATMOSPHERIC SIDE

Pin	Connection	
1	X1	SCAN PLATES
2	Y1	SCAN PLATES
3	X2	SCAN PLATES
4	Y2	SCAN PLATES
5	FOCUS	
6	CONDENSER	(SPOT SIZE)
7	SOURCE	
8	FIL. 2	
9	FIL. COMMON	
10	FIL. 1	
11	EXTRACTOR	
12	DRIFT	

MICROTECH

Figure 6 400X BOARD LAYOUT



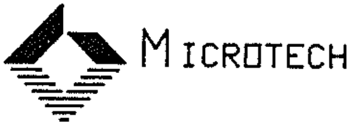


Figure 7: EX05 SOURCE ASSEMBLY

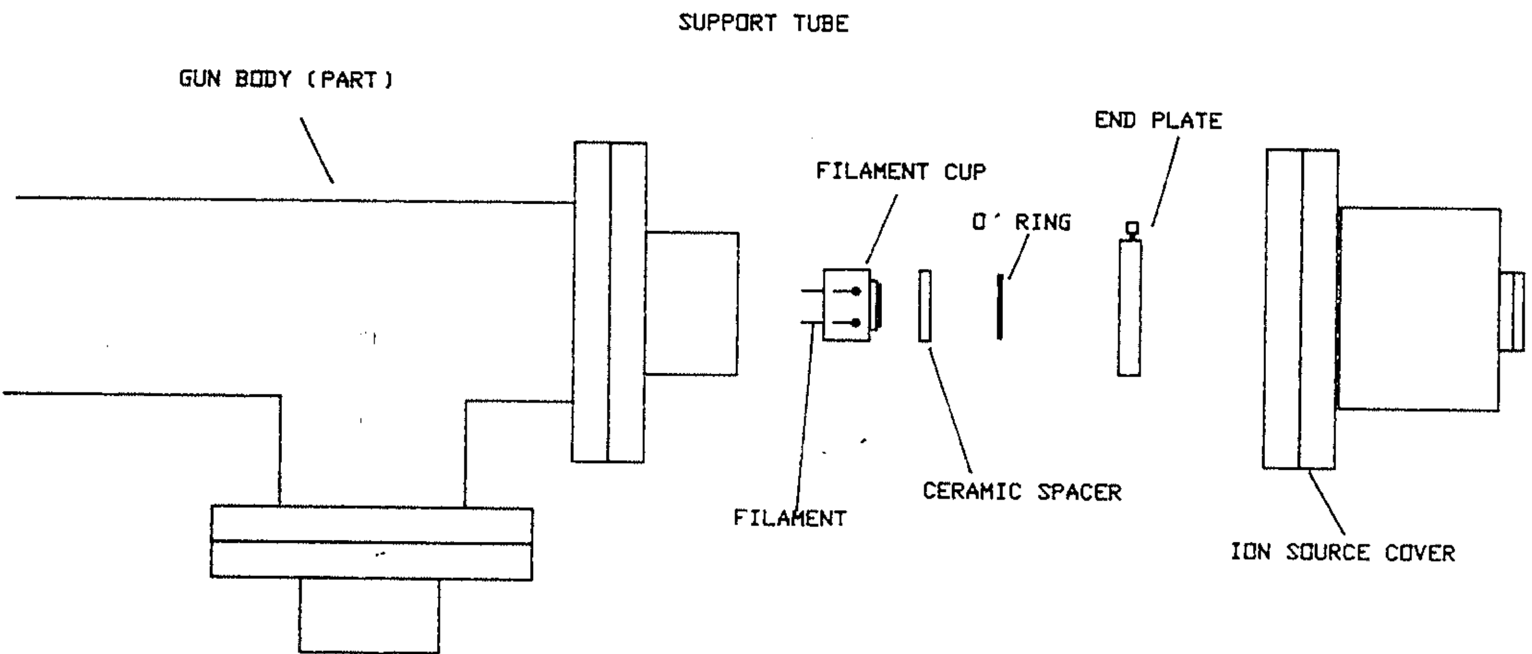
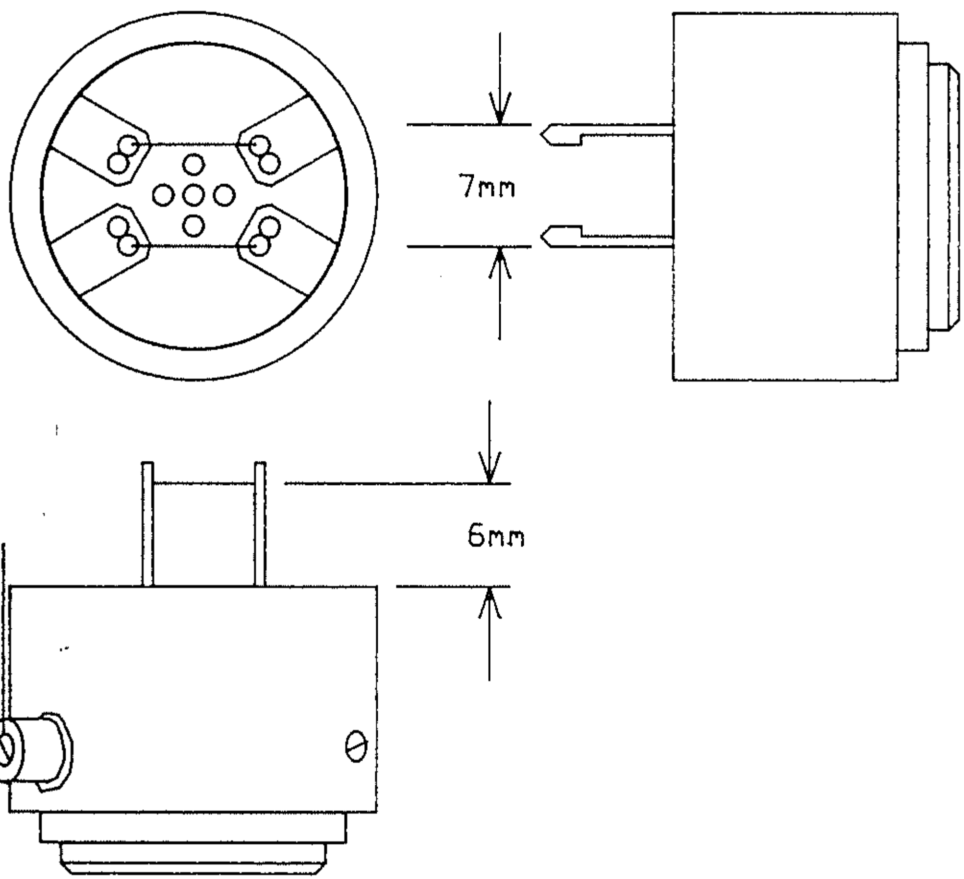


Figure 8: EX05 FILAMENT CUP



MICROTECH

Figure 4: EXO5 INTERCONNECTIONS 400X/346

SHORTING LINK OR LEAD FROM BEAM BLANK SIGNAL.

400X POWER SUPPLY

400X - 200

TO EXO5 SOURCE

346 SCAN UNIT.

X1

X2

Y1

Y2

EXTERNAL X INPUT

EXTERNAL Y INPUT

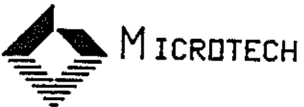
TO TV MONITOR.

FROM PHOTOMULTIPLIER SUPPLIES

SHORTING LINK

412 - 40

TO PHOTOMULTIPLIER



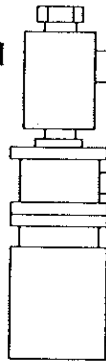
MICROTECH

Figure 9: EX05F INTERCONNECTIONS 400X/346/549

1m of 42mmø pipe
OR
0.5m of 36mmø pipe

Minimum number of bends
(typically 1 or 2)

25 litre/second
valve (CR38)



Bellows section

Ion gauge

Gas load
$\leqslant 1 \times 10^{-3}$ mbar ls^{-1}

EX05

Gas load to analysis
chamber $\leqslant 1 \times 10^{-4}$ mbar ls^{-1}

Turbo pump
OR
Diffusion pump/LN_2 trap
50 litre/second at throat

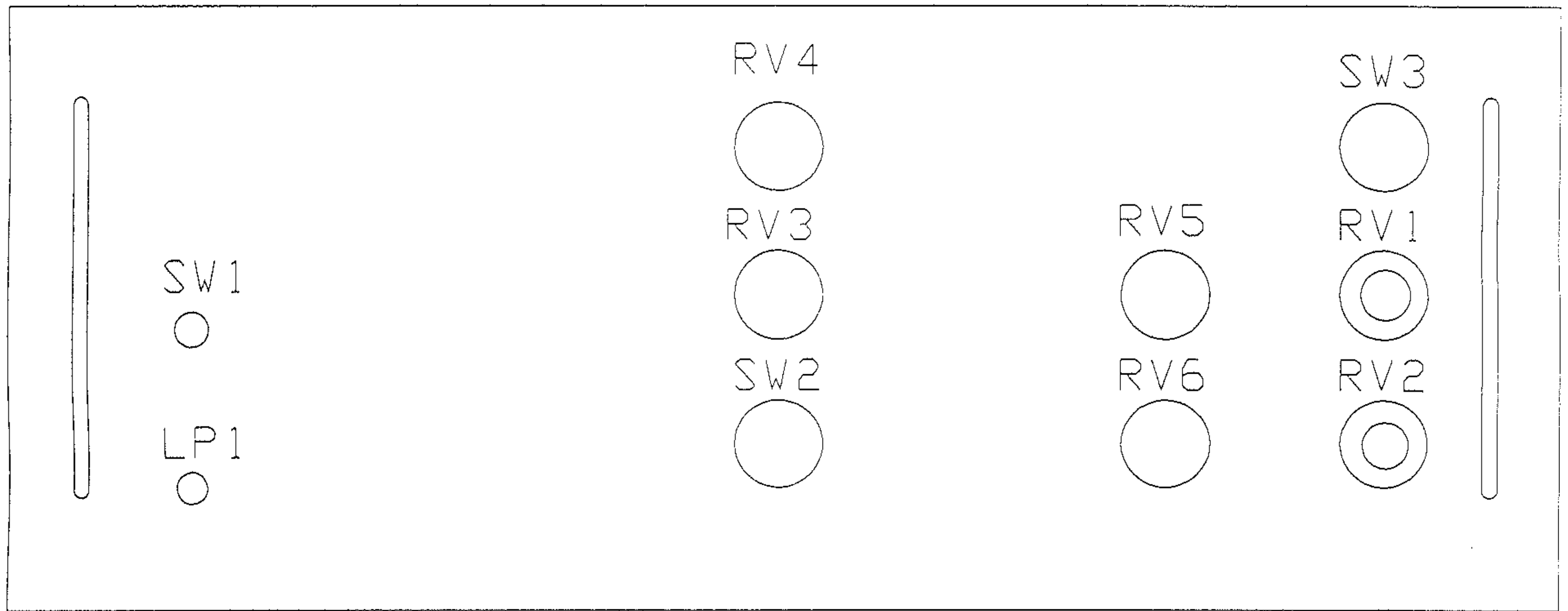


FIGURE 2