

JEM-2100

ELECTRON MICROSCOPE

For the proper use of the instrument, be sure to read this instruction manual. Even after you read it, please keep the manual on hand so that you can consult it whenever necessary.

JEM-2100

ELECTRON
MICROSCOPE



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NOTATIONAL CONVENTIONS AND GLOSSARY

■ General notations

- **CAUTION** – : Points requiring great care and attention when operating the device to avoid damage to the device itself.
-  : Additional points to remember regarding the operation.
-  : A reference to another section, chapter or manual.
- 1, 2, 3** : Numbers indicate a series of operations that achieve a task.
- ◆ : A diamond indicates a single operation that achieves a task.
- Reference: Useful information for you.
- Input:** Text that you are to type appears in **bold**.
-  : Keys on the keyboard are denoted by enclosing their names in a box.
- File:** The names of menus, commands, or parameters displayed on the screen are denoted with **bold** letters.
- File–Exit** : Selecting a menu item from a pulldown menu is denoted by linking the menu and the item with a dash (–).
For example, **File–Exit** means selecting **Exit** from the **File** menu.

■ Mouse terminology

- Mouse pointer: A mark, displayed on the screen, which moves following the movement of the mouse. It is used to specify a menu item, command, parameter value, and other items. Its shape changes according to the situation.
- Click: To press and release the left mouse button.
- Right-click: To press and release the right mouse button.
- Double-click: To press and release the left mouse button twice quickly.
- Drag: To hold down the left mouse button while moving the mouse.

CONTENTS

SAFETY PRECAUTIONS

PRECAUTIONS FOR USE

1. GENERAL

2. SPECIFICATIONS

2.1	PERFORMANCE	2-1
2.2	ELECTRON OPTICAL SYSTEM.....	2-3
2.2.1	Irradiation System	2-3
2.2.1a	Electron gun (Thermal electron emission type).....	2-3
2.2.1b	Condenser Lens (CL).....	2-3
2.2.2	Image Forming System	2-3
2.2.2a	Lens.....	2-3
2.2.2b	Aperture	2-3
2.2.2c	Stigmator.....	2-3
2.3	SPECIMEN STAGE.....	2-4
2.4	PHOTOGRAPHING SYSTEM	2-4
2.5	VACUUM SYSTEM.....	2-4
2.6	OPERATION CONTROL SYSTEM	2-5
2.7	INSTALLATION REQUIREMENTS.....	2-5
2.7.1	Electric Power and Cooling Water (Customer Provided).....	2-5
2.7.2	Installation Room	2-5
2.8	NITROGEN GAS DISPLACING FACILITY.....	2-5
2.9	DIMENSION AND WEIGHT	2-6

3. COMPOSITION AND CONSTRUCTION

3.1	COMPOSITION.....	3-1
3.2	TOOLS	3-2
3.3	MICROSCOPE COLUMN	3-3
3.3.1	Exterior View	3-3
3.3.2	Column Interior	3-4
3.3.3	Locations of Electron Lenses and Coils.....	3-5
3.4	LOCATIONS OF CONTROL PANELS	3-6
3.5	RAY DIAGRAMS	3-7
3.5.1	Illumination System	3-7
3.5.1a	Transmission electron image mode ray pass	3-7
3.5.1b	NBD/EDS/CBD mode ray pass	3-8
3.5.2	Imaging System.....	3-9
3.5.2a	Mag mode	3-9
3.5.2b	Diffraction mode	3-10

4. DESCRIPTION OF CONTROLS

4.1	COLUMN.....	4-1
4.1.1	Condenser Aperture Assembly.....	4-1

4.1.2	Condenser Minilens Shift Screws.....	4-1
4.1.3	Specimen Holder	4-1
4.1.4	Goniometer.....	4-2
4.2	CONTROL PANELS.....	4-3
4.2.1	Control Panel L1.....	4-3
4.2.2	Control Panel R1.....	4-6
4.2.3	Control Panel L2.....	4-8
4.2.4	Control Panel R2.....	4-9
4.2.5	Control Panel SC	4-10
4.2.6	Power Supply Console.....	4-11
4.2.6a	Exterior view and control panels.....	4-11
4.2.6b	Control panel P1 (SIP power supply).....	4-12
4.2.6c	Control panel P3.....	4-12
4.3	PC WINDOWS.....	4-13
4.3.1	Starting the Application Program	4-13
4.3.1a	TEM Server	4-13
4.3.1b	TEM Controller	4-13
4.3.2	TEM Controller Window.....	4-14
4.3.3	Shortcut Buttons	4-14
4.3.4	Main Window (Data Display Area).....	4-15
4.3.4a	Indications in the left section.....	4-15
4.3.4b	Indications in the center section	4-16
4.3.4c	Indications in the right section	4-17
4.3.5	Windows That Can Be Accessed Using The Menu Bar and Shortcut Buttons	4-18
4.3.5a	File.....	4-18
4.3.5b	Dialogue	4-19
4.3.5c	Monitor.....	4-29
4.3.5d	Property	4-33
4.3.5e	Option.....	4-36
4.3.5f	Maintenance	4-40
4.3.5g	Display	4-45
4.3.5h	JEOLS	4-45
4.3.5i	Help.....	4-45
4.3.6	Emergency (Alarms) Window.....	4-46

5. OPERATION

5.1	STEPS TO TAKE IN AN EMERGENCY	5-1
5.1.1	Power Failure.....	5-1
5.1.2	Cooling Water Stoppage.....	5-1
5.1.3	Faulty Operation	5-1
5.1.4	Emergency Shutdown.....	5-1
5.2	STARTUP AND SHUTDOWN.....	5-2
5.2.1	Startup.....	5-2
5.2.2	Shutting Down.....	5-2
5.3	FILM LOADING.....	5-3
5.3.1	Loading Films into the Dispensing Magazine.....	5-3
5.3.2	Inserting/Removing the Magazines into/from the Camera Chamber	5-3

5.4	SPECIMEN EXCHANGE	5-6
5.4.1	Loading a Specimen on the Specimen Holder.....	5-6
5.4.2	Inserting the Specimen Holder in the Microscope Column.....	5-7
5.4.3	Removing the Specimen Holder from the Goniometer.....	5-8
5.5	ELECTRON BEAM GENERATION	5-9
5.5.1	Turning on the Accelerating Voltage	5-9
5.5.2	Beam Generation.....	5-12
5.5.3	Condenser Lens Alignment.....	5-14
5.5.4	Beam Generation Suspension.....	5-14
5.5.5	Turning off the Accelerating Voltage	5-15
5.5.6	Turning on the High Voltage Using the Automatic Mode	5-15
5.6	APERTURES	5-17
5.6.1	Condenser Lens (CL) Aperture	5-17
5.6.2	Objective Lens (OL) Aperture	5-18
5.6.3	Field-limiting Aperture	5-19
5.7	ILLUMINATION SYSTEM ADJUSTMENT	5-20
5.7.1	Aligning the Illumination System	5-20
5.7.2	Condenser Lens Astigmatism Correction	5-21
5.7.3	CL Deflection Coil Adjustment	5-21
5.7.3a	Tilt X and Y adjustment.....	5-22
5.7.3b	Shift X and Y adjustment.....	5-23
5.8	CENTERING CURRENT AND VOLTAGE AXES	5-24
5.8.1	Current Axis	5-24
5.8.2	Voltage Axis	5-25
5.9	OBJECTIVE LENS (OL) ADJUSTMENT.....	5-26
5.9.1	OL Astigmatism Correction	5-26
5.9.2	Medium Magnification.....	5-26
5.9.3	High Magnification	5-27
5.9.4	Focusing	5-28
5.9.4a	Focusing using image wobbler.....	5-28
5.9.4b	Focusing using Fresnel fringes.....	5-30
5.9.5	Focusing Using Point Images	5-31
5.10	ELECTRON DIFFRACTION	5-32
5.10.1	Selected Area Diffraction.....	5-32
5.10.2	Microbeam Electron Diffraction	5-33
5.10.3	High-Dispersion Electron Diffraction	5-34
5.11	SPECIAL OBSERVATION.....	5-36
5.11.1	Bright-Field Image	5-36
5.11.2	Dark-Field Image	5-36
5.11.3	Low-Magnification Image	5-37
5.12	ANTICONTAMINATION DEVICE.....	5-39
5.12.1	Filling with Liquid Nitrogen	5-39
5.12.2	Returning the Anti-Contamination Device to Room Temperature	5-40
5.13	PHOTOGRAPHY	5-43
5.13.1	Film Number and Film Text	5-43
5.13.2	Manual Exposure.....	5-44
5.13.3	Automatic Exposure	5-44

5.13.4	Multiple Exposure	5-45
5.13.5	Image Observation.....	5-46
5.13.6	Film Processing	5-48
5.14	HIGH RESOLUTION ELECTRON MICROSCOPY	5-50
5.15	SPECIAL OPERATION	5-54
5.15.1	Minimum Dose Exposure System (MDS).....	5-54
5.15.2	Free Lens Control (FLC).....	5-56
5.15.3	Selecting Magnifications and Camera Lengths	5-57
5.15.3a	Selecting usable magnifications and camera lengths	5-57
5.15.3b	Selecting unusable magnifications and camera lengths	5-57
5.15.3c	Restoring unusable magnifications and camera lengths.....	5-57
5.15.4	Setting a Reference Magnification	5-58
5.15.5	Saving Alignment Data	5-59
5.15.5a	Saving.....	5-59
5.15.5b	Loading.....	5-59
5.15.6	Saving Lens Alignment Data.....	5-60
5.15.6a	Saving.....	5-60
5.15.6b	Loading.....	5-61

6. MAINTENANCE




6.1	CHANGING THE FILAMENT OF THE ELECTRON GUN.....	6-2
6.1.1	Checking if the Filament of the Electron Gun is Burned Out	6-2
6.1.2	Venting the Electron Gun Chamber	6-4
6.1.3	Changing the Filament.....	6-6
6.1.4	Adjusting the Wehnelt Cap.....	6-8
6.1.5	Re-evacuating the Electron Gun Chamber	6-8
6.1.6	Degassing the Filament	6-9
6.2	CHANGING THE SMALL FLUORESCENT SCREEN	6-12
6.3	INSULATION GAS REPLENISHMENT.....	6-14
6.3.1	Characteristics of Insulation Gas (SF ₆ Gas)	6-14
6.3.2	Precautions for Handling the Insulation Gas	6-14
6.3.3	Replenishing Electron Gun Gas Chamber with SF ₆ Gas	6-14
6.3.4	Replacing the Gas in the Electron Gun Gas Chamber.....	6-15
6.3.5	Replenishing the HT Tank with SF ₆ Gas	6-17
6.4	CLEANING THE COLUMN PARTS	6-18
6.5	BAKING OUT THE COLUMN.....	6-18
6.6	TROUBLESHOOTING	6-21
6.6.1	Concerning Start-up.....	6-21
6.6.1a	When it is impossible to start up the microscope	6-21
6.6.1b	When the microscope stops automatically some time after start-up.....	6-21
6.6.1c	When the message, “Beam Not Ready” appears.....	6-21
6.6.2	Concerning Electron Beam.....	6-21
6.6.2a	When no electron beam appears on the fluorescent screen	6-21
6.6.2b	When the electron beam is not generated.....	6-22
6.6.3	Concerning the Specimen Movement and Tilting	6-22
6.6.3a	When the specimen cannot be moved or tilted.....	6-22
6.6.4	Concerning Photographing	6-22
6.6.4a	When the Exp. Time shows *** even though the enough	

irradiation.....	6-22
6.7 INSTRUCTIONS CONCERNING NITROGEN GAS.....	6-23
6.7.1 Stopping and Resuming Supply of Nitrogen Gas.....	6-23
6.7.1a Stopping supply of nitrogen gas.....	6-23
6.7.1b Resuming supply of nitrogen gas.....	6-24
6.7.2 Replacement of Nitrogen Gas Cylinder (If Used).....	6-25
6.7.3 Connection to Nitrogen Gas Supply Piping	6-25
6.8 CONCERNING THE LIFT AND THE LIFT POLE.....	6-25
6.9 CONSUMABLES AND MAINTENANCE PARTS.....	6-26
6.9.1 JEM-2100 Microscope Console and Column	6-26
6.9.2 Objective Lens Aperture	6-27
6.9.2a UHR configuration.....	6-27
6.9.2b HR and HT configurations.....	6-27
6.9.2c CR configuration.....	6-27
6.9.2d HC configuration.....	6-28
6.9.3 EM-23120 TMP Evacuation System.....	6-28

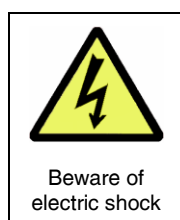
SAFETY PRECAUTIONS

For the proper use of the instrument, be sure to read the following safety precautions prior to starting operation or maintenance. They contain important information related to safety. Contact your JEOL service office whenever you are unclear about any operation or maintenance.

The signs for safety precautions and their meanings used in this instruction manual are as follows:

-  **DANGER:** An imminent hazardous situation which, if not avoided, will result in death or serious injury.
-  **WARNING:** A potentially hazardous situation which, if not avoided, could result in death or serious injury.
-  **CAUTION:** A potentially hazardous situation which, if not avoided, could result in minor or moderate injury. Also could mean a potentially hazardous situation, which could result in serious damage to facilities and acquired data.

Parts of this instrument where safety precautions are required are labeled with the signs shown below. Do not touch parts labeled with these signs:



Use the instrument in a proper manner and within the scope of the purposes and usage contained in the brochures and instruction manuals. **Never make modifications such as removing protective parts, exchanging component parts, and defeating safety measures.**

Be sure to read the “Safety Precautions” given in the instruction manuals of the optional attachments for information about the attachments of this instrument.

**WARNINGS**

- **When you handle Sulfur hexafluoride (SF₆) gas, pay proper attention to the ventilation and humidity in the work place.**

- Poisonous gas may be produced by a chemical reaction if a high voltage discharge occurs in SF₆ gas that contains moisture or any other substances. No attempt to open the high voltage tank is recommended since the troubleshooting of the high voltage generating system requires great skilled workmanship to prevent discharge. Contact your JEOL service office for assistance. For refilling of SF₆ gas to the gas chamber of electron gun and the high voltage tank, pay proper attention to humidity in the workspace.
- To prevent an accident due to oxygen deficiency, ventilate the room sufficiently. Insufficient ventilation might result in suffocation.
- Attach a pressure reduction valve to the gas outlet of SF₆ gas cylinder to reduce the secondary (delivery) pressure when it is in use, since the inner pressure of SF₆ gas cylinder is very high (Approximately 3 times that of Freon 12 gas which was previously used very common as a high voltage isolation gas, at room temperature).

- **When you use nitrogen (N₂) gas for venting vacuum chambers or as a substitute for compressed air to drive pneumatic valves and devices, pay proper attention to the ventilation in the room.**

- Although nitrogen gas is inactive and entirely harmless, leakage of a large quantity of gas in an enclosed room could cause suffocation because of insufficient oxygen concentration in the room. If leakage is evident, immediately open the windows and doors to let in fresh air.
- Close the supply valve of the dry nitrogen gas source when the gas is not in use.
- For the gas of venting vacuum chambers, attach a pressure regulator to the gas supply line and set delivery pressure of gas to 0.01 – 0.02MPa on the gauge.



- **Do not open or remove the exterior panels covering the equipment that cannot be opened or removed without use of tools such as screwdrivers, wrenches or keys.**

The equipment contains mechanical moving units, high voltage units and high temperature units inside the panels or covers. By opening or removing the panels, you may have a chance of touching those components and units, which could result in injury caused by being caught, electric shock or burn.

**CAUTIONS**

- **To use dry nitrogen (N₂) gas in the high pressure cylinder (container), handle the cylinder with following precautions:**

- Do not place the cylinder to the location where ambient temperature exceeds 40°C and above. This causes that inner pressure may exceed maximum permissible pressure of the cylinder.
- Do not place the cylinder near the furnace or heating appliance which could heat the cylinder up above 40°C.
- Secure the cylinder by fastening it to the dedicated stand or the wall with chains.

- Keep surrounding space clear to prevent secondary accident caused by falling of the cylinder.
- Never give strong impact to the cylinder.
- Ensure the safety of the cylinder by performing a pressure test periodically.
- Attach a pressure regulator to gas outlet of the cylinder and set delivery pressure of gas to 0.01 – 0.02MPa on the gauge if it is used for venting vacuum chambers.



- **Do not touch the column, ion pump or its surrounding parts while baking the column.**

If you touch those, you might get burned since they are very hot.

- **When you handle liquid nitrogen (LN₂) for filling or draining into/from anti-contamination device and EDS detector, wear appropriate protective eyeglasses and gloves (made of leather or alike) of which liquid nitrogen does not permeate.**

If you touch directly the LN₂ or frosted pouring vessel, you might get frostbitten.



- **Do not disconnect or relocate the connection of the protective ground wire. By doing so, a danger of electrical shock may occur.**

- **Never stand or climb on the console or table of the system, which is not designed and built for the purpose, during operation, maintenance or inspection. There is a danger of electrical shock, fire or damage to the instrument.**

When you stand on a stool trying to pour liquid nitrogen into the anti-contamination device or EDS detector, make sure that the stool is stable and solid and does not have casters.

- **Do not touch the coolant-removal tool of ACD anti-contamination device during or immediately after heating.**

The heater is very hot and there is a danger of getting burned.



- **Do not remove the cover or any parts of the goniometer stage.**

The goniometer stage uses the linear encoder of CDRH class-1 laser products. In general usage, there is no risk of viewing a laser beam. However, when the cover is removed and linear encoders are seen directly with optical instruments (microscopes, or any kind of magnifying glass), eye lesion may occur.

- **When you dispose followings, do it in an environmentally acceptable manner in accordance with the applicable laws and regulations specified by the authorities concerned. If you have any questions, contact the nearest JEOL service center.**

- System itself or any system components, component parts or assemblies.
- SF₆ gas used as the high voltage insulation gas.
- Used rotary pump oil
- Organic solvents used for cleaning of the system parts and assemblies.

PRECAUTIONS FOR USE

Important precautions, which, if not followed, may result in damage to the device itself, are described below.

- **If any abnormality occurs, shut down the instrument immediately and contact your JEOL service office for assistance.**
- **Do not disassemble or reassemble the microscope column. Such work requires great experience and skills. Contact your JEOL service office for assistance whenever such works are required.**
- **Wear thin and lint-free gloves to handle any parts inside the column in order to prevent contamination by perspiration, etc., which could cause charging of electron beam due to oxidization of the parts.**
- **Complete the cleaning or changing of the parts inside the column as quickly as possible. Leaving the parts in the atmosphere oxidizes their surfaces.**
- **Avoid using metal tools.**

Even a slight scratch on a component part might deteriorate the vacuum or cause the electron beam to be improperly deflected.
- **Keep the O-rings and the O-ring contact surfaces free from scratches, dust, lint, etc.**


Even a slight scratch, fine dust or lint may cause the poor vacuum. Also, be sure to use the specified vacuum grease.
- **Do not apply excessive force when attaching or removing parts. It could result in seizure or eccentricity.**

Especially be careful when inserting or removing the pole piece.
- **Use the appropriate tool to turn a screw, bolt and nut, etc.**

Using an inappropriate tool might damage the head or thread of the screw, preventing you from inserting or removing the screw.
- **Do not install any application software or programs on the system computer without our permission.**

The performance of the system control or operating software might be affected, depending on the type of application software installed. If you install software without our permission, we might consider it as a modification of the system.
- **Cover the viewing window with the appropriate protective lid.**

If liquid nitrogen contacts the window glass, there is danger of the glass cracking, causing serious damage even to the interior of the microscope column.
- **Contact your JEOL service office when the installation of instrument and related attachment is required.**
- **A list of parts required periodical replacement is provided. Maintain the system properly by replacing consumables and parts on the list in time. Contact your JEOL service office for any assistance.**

 Please refer Section 6.9 “Consumables and Maintenance Parts” of this manual.

1

GENERAL

The JEM-2100 ultra-high-resolution analytical electron microscope is an advanced version of the JEM-2010 200 kV having the maximum capabilities of ultra-high resolution, high image quality, ease of operation, and stability of performance, and is the next generation of high-resolution analytical TEMs. Various optional attachments such as a scanning image observation device that incorporates provisions for obtaining STEM images, an EDS, an EELS and other features make the JEM-2100 extremely useful in the material, biological and medical fields.

The following are the main features of the JEM-2100 electron microscope:

- New control system

The built-in personal computer displays information and centralizes the programmed control of not only the microscope but also its various attachments. It saves the optimum settings of the lenses and beam deflectors in the computer memory, and restores to reproduce optimum lens and deflector conditions, enabling anyone to use such settings without special expertise. Conventional microscopy, while observing the image on the fluorescent viewing screen, is also possible.

- New goniometer

In comparison with the earlier model, the new goniometer improves the after-drift problem and tilt performance.

If you introduce an optional built-in piezoelectric drive mechanism, it gives you high-precision specimen movement at high magnification. You can also introduce the drift-free image system. This ensures a stable image at high magnification image observation.

- New column mounting design

The microscope column is mounted on the column base which in turn is mounted at the center of mass of the microscope. Passive air-mounts are used to improve the vibration isolation performance of the microscope. This makes it easier for the microscope installation room to meet the requirements for installation. There are times when, if active air mounts are used, the microscope may be easily installed in a room where previously a large-scale anti-vibration system was required.

2

SPECIFICATIONS

2.1	PERFORMANCE.....	2-1
2.2	ELECTRON OPTICAL SYSTEM.....	2-3
2.2.1	Irradiation System	2-3
2.2.1a	Electron gun (Thermal electron emission type).....	2-3
2.2.1b	Condenser Lens (CL).....	2-3
2.2.2	Image Forming System.....	2-3
2.2.2a	Lens.....	2-3
2.2.2b	Aperture	2-3
2.2.2c	Stigmator.....	2-3
2.3	SPECIMEN STAGE.....	2-4
2.4	PHOTOGRAPHING SYSTEM.....	2-4
2.5	VACUUM SYSTEM	2-4
2.6	OPERATION CONTROL SYSTEM	2-5
2.7	INSTALLATION REQUIREMENTS	2-5
2.7.1	Electric Power and Cooling Water (Customer Provided).....	2-5
2.7.2	Installation Room	2-5
2.8	NITROGEN GAS DISPLACING FACILITY.....	2-5
2.9	DIMENSION AND WEIGHT	2-6

2.1 PERFORMANCE

This section covers the principal specifications related to setting up and operating the microscope.

Configuration (Polepiece)	Ultrahigh resolution (UHR) ¹	High resolution (HR) ¹	High specimen tilt (HT) ¹	Cryo polepiece (CR) ¹	High contrast (HC) ¹
Resolution: Point Lattice	0.194 nm 0.14 nm	0.23 nm 0.14 nm	0.25 nm 0.14 nm	0.27 nm 0.14 nm	0.31 nm 0.14 nm
Acc. Voltage: Minimum control step	80, 100, 120, 160, 200 kV 100 V (with U* correction), 50 V (without U* correction)				
Pwer Stability: Acc. voltage OL current	$\leq 2 \times 10^{-6}/\text{min}$ $\leq 1 \times 10^{-6}/\text{min}$				
Objective Lens: Focal length Spherical aberration Chromatic aberration Minimum step	1.9 mm 0.5 mm 1.1 mm 1.0 mm	2.3 mm 1.0 mm 1.4 mm 1.5 mm	2.7 mm 1.4 mm 1.8 mm 1.8 mm	2.8 mm 2.0 mm 2.1 mm 2.0 mm	3.9 mm 3.3 mm 3.0 mm 5.2 mm
Spot Size (diameter):	20 – 200 nm				
TEM mode					1 – 5 μm
EDS mode	0.5 – 25 nm	1.0 – 25 nm	1.5 – 25 nm	2.0 – 45 nm	10 – 500 nm
NBD mode	(alfa selector built-in)	(alfa selector built-in)	(alfa selector built-in)	(alfa selector built-in)	
CBD mode					
CB Diffraction:					
Convergence angle	1.5 – greater than 20 mrad (2α)				
Acceptance angle	$\pm 10^\circ$				
Magnification:					
MAG mode	2000 \times – 1 500 000 \times		1500 \times – 1 200 000 \times	1200 \times – 1 000 000 \times	1000 \times – 800 000 \times
LOW MAG mode	50 \times – 6000 \times				50 \times – 2000 \times
SA MAG mode	8000 \times – 800 000 \times		6000 \times – 800 000 \times	5000 \times – 600 000 \times	5000 \times – 400 000 \times
Camera Length:					
SA diffraction	80 – 2000 mm		100 – 2500 mm		150 – 3000 mm
HD diffraction	4 – 80 m				
HR diffraction ²	333 mm				

2 SPECIFICATIONS

Configuration (Polepiece)	Ultrahigh resolution (UHR) ¹	High resolution (HR) ¹	High specimen tilt (HT) ¹	Cryo polepiece (CR) ¹	High contrast (HC) ¹
Specimen tilting:	±20°	±30°	±40°	±60° ⁴	±38/±30°
Specimen shift:	X, Y: 2 mm Z: ±0.1 mm				X, Y: 2 mm Z: ±0.2 mm
EDS ³ :					
Acceptance angle	0.13 sr				0.09 sr
Take-off angle	25°				20°

¹Choose any one of the modes from the list when you order.

²The high-resolution diffraction chamber (EM-20030) is required. (Optional)

³EDS is optional.

⁴This angle is given when using the high-tilt specimen holder (EM-21030, optional).

2.2 ELECTRON OPTICAL SYSTEM

2.2.1 Irradiation System

2.2.1a Electron gun (Thermal electron emission type)

Emitter:	W or LaB ₆
Electron gun lens:	Electrostatic
Accelerating tube:	6-stage
Filament heating:	DC
Axis alignment:	Two-stage synchronous, electro magnetic
Airlock valve:	Built-in, manual
Filament exchange:	Pneumatic electron gun lift

2.2.1b Condenser Lens (CL)

Lens system:	4-stage (1st CL, 2nd CL, 3rd CL, and condenser mini lens)
Apertures:	10, 50, 70, 200 μm in diameter (with click stops)
Stigmator:	Electromagnetic centering
Axis alignment:	Linked two-stage 4-mode (TEM, EDS, NBD, CBD) independent electromagnetic deflector
Beam tilting:	$\pm 5^\circ$ ($\pm 2^\circ$ in HC mode) all direction

2.2.2 Image Forming System

2.2.2a Lens

6-stage electro-magnetic with rotation free
(Objective lens, objective mini lens, 1st intermediate lens, 2nd intermediate lens, 3rd intermediate lens, projector lens)

2.2.2b Aperture

Motorized objective aperture ^{*1} :	HR, HT, CR configuration: 5, 30, 40, 60 μm in diameter HC configuration: 5, 15, 30, 50 μm in diameter
Motorized URP objective aperture ^{*2} :	10, 25 μm
High contrast aperture ^{*3}	5, 30, 50, 120 μm , manual change with click stop mechanism
Field limit aperture:	10, 20, 50, 120 μm manual change with click stop mechanism

2.2.2c Stigmator

Electro magnetic (built-in centering): 5-stage independent circuit

^{*1} The motorized objective aperture is Standard in CR or HC configuration. Optional in HR or HT.

^{*2} The motorized URP objective aperture is optional.

^{*3} The high contrast aperture is a standard built-in when the polepiece is UHR, HR or HT.

2.3 SPECIMEN STAGE

Side entry 5-axis eucentric goniometer stage	
Bake out heater:	Built-in
Specimen exchange:	Automatic air lock, automatic 2-stage pre-evacuation
Specimen anti contamination device:	Built-in
Specimen holder:	Universal holder (includes quick-exchange specimen base)
Specimen movement	
X, Y axis:	Motor-driven, trackball and pushbuttons, range of movement: ± 1 mm Piezoelectric drive (optional), Range of movement: ± 0.2 μm
Z axis:	Motor-driven, pushbuttons, range of movement: ± 0.2 mm (depending on the microscope configuration)
Specimen tilt	
X tilt:	Motor-driven
Y tilt:	Motor-driven (necessary optional double-tilt holder)
Specimen position display:	Digital (X, Y, Z move, X,Y tilt) Graphical (X, Y move)
Specimen position memory:	Any 100 points read/write
Image shift:	Electromagnetic, ± 2.0 μm (X and Y)/Mag mode
Optional ports:	EDS detector, Backscatter detector, hard X-ray aperture (each one of above)

2.4 PHOTOGRAPHING SYSTEM

Film	
Size:	Choose from A, E, J and S size
Number of load:	Up to 50
Feeding:	Full automatic (single/continuous selectable)
Exchange:	Automatic airlock
Exposure:	Automatic or manual selectable
Data recording on film:	Film number, operator code, accelerating voltage, magnification or camera length, scale bar, text

2.5 VACUUM SYSTEM

Vacuum pump	
Rough evacuation:	Oil rotary pump and oil diffusion pump
Main evacuation:	Sputter-ion pump or turbo molecular pump
Gauges:	Pirani gauges and Penning gauges
Attainable pressure:	Order of 10^{-5} Pa (specimen chamber)

2.6 OPERATION CONTROL SYSTEM

Operation panel:	Located on the side of the viewing chamber. Sets observation conditions.
Computer:	Displays and sets microscope conditions.


2.7 INSTALLATION REQUIREMENTS

2.7.1 Electric Power and Cooling Water (Customer Provided)

Electric power:	200/220/240 V, 10 kVA (7 kVA in regular base) 50/60 Hz
Grounding terminal:	Grounding resistance less than 100 ohms
Cooling water	
Rate of flow:	7.5 l/min
Pressure:	0.2–0.3 M Pa
Temperature:	18–23°C (less than 0.1°C fluctuation)
Tap:	One (TH-12-1/2)
Dried nitrogen gas:	0.01–0.02 M Pa

2.7.2 Installation Room

Floor space:	2800 (W)×3000 (D) ×2800 (H) mm or more
Entrance for delivery:	800 (W) × 1900 (H) mm or more
Temperature:	15 to 25 °C (1 °C/h or less in fluctuation)
Humidity:	60% or less
Stray magnetic field tolerances:	0.1 μT or less
Compressed air:	0.5 MPa

 Install the air conditioner in such a way as to prevent air from blowing on the microscope column.

2.8 NITROGEN GAS DISPLACING FACILITY

- Dry nitrogen gas: For venting the specimen holder, camera chamber and microscope column, the customer is requested to provide dry nitrogen gas.

Inlet pressure:	0.02 MPa (0.2 kg/cm ²)
-----------------	------------------------------------
- Nitrogen gas bombe with pressure gauge or room piping with two-stage pressure controller.

Hose joint:	ISO 7/1 Rc 1/4
Primary pressure gauge:	0 – 25 MPa (Maximum input pressure: 15 MPa)
Secondary pressure gauge:	0 – 0.1Mpa

2.9 DIMENSION AND WEIGHT

Dimension	Height (mm)	Width (mm)	Depth (mm)	Mass (kg)
Electron microscope	2,440	2,250	1,570	1,100
Power supply	1,750	570	800	370
Right console	810	810	790	100
Left console	810	560	850	80
High tension tank	1,350	720	510	170
Rotary pump ¹	410	205	270	33
Air compressor ²	510	430	210	16
Film desiccator ³	800	400	250	40
Lift pole ⁴		930	1,730	80

1: Pump number varies depend on the evacuation system configuration.

EM-23110 SIP evacuation: 1 rotary pump

EM-23120 TMP evacuation: 2 rotary pumps

2: Applies when using EM-08010 air compressor (optional, this does not have a CE mark).

3: Applies when using EM-DSC10E (optional).

4: Uses when disassembling the microscope.



COMPOSITION AND CONSTRUCTION

3.1	COMPOSITION.....	3-1
3.2	TOOLS	3-2
3.3	MICROSCOPE COLUMN	3-3
3.3.1	Exterior View	3-3
3.3.2	Column Interior	3-4
3.3.3	Locations of Electron Lenses and Coils.....	3-5
3.4	LOCATIONS OF CONTROL PANELS	3-6
3.5	RAY DIAGRAMS	3-7
3.5.1	Illumination System	3-7
3.5.1a	Transmission electron image mode ray pass	3-7
3.5.1b	NBD/EDS/CBD mode ray pass	3-8
3.5.2	Imaging System.....	3-9
3.5.2a	Mag mode	3-9
3.5.2b	Diffraction mode	3-10

3.1 COMPOSITION

The figure below shows the layout when using the EM-23110 SIP evacuation unit.

~~✎~~ In the microscope equipped with the EM-23120 TMP, two rotary pumps are configured.

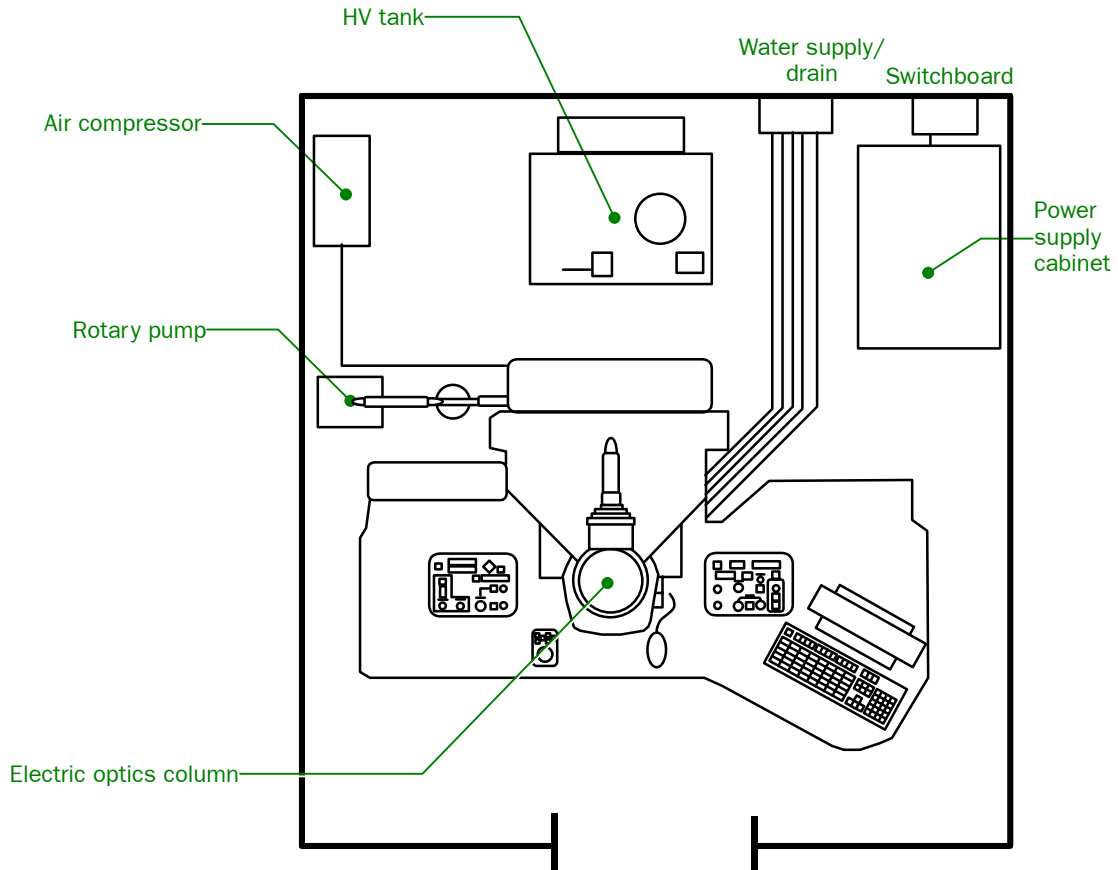


Fig. 3.1 A sample layout diagram

3.2 TOOLS

The following tools are supplied with the microscope for use in disassembling and assembling the electron gun and microscope column. Users do not use some of the tools; however, they should carefully store the tools, as they will be required for professional maintenance work.

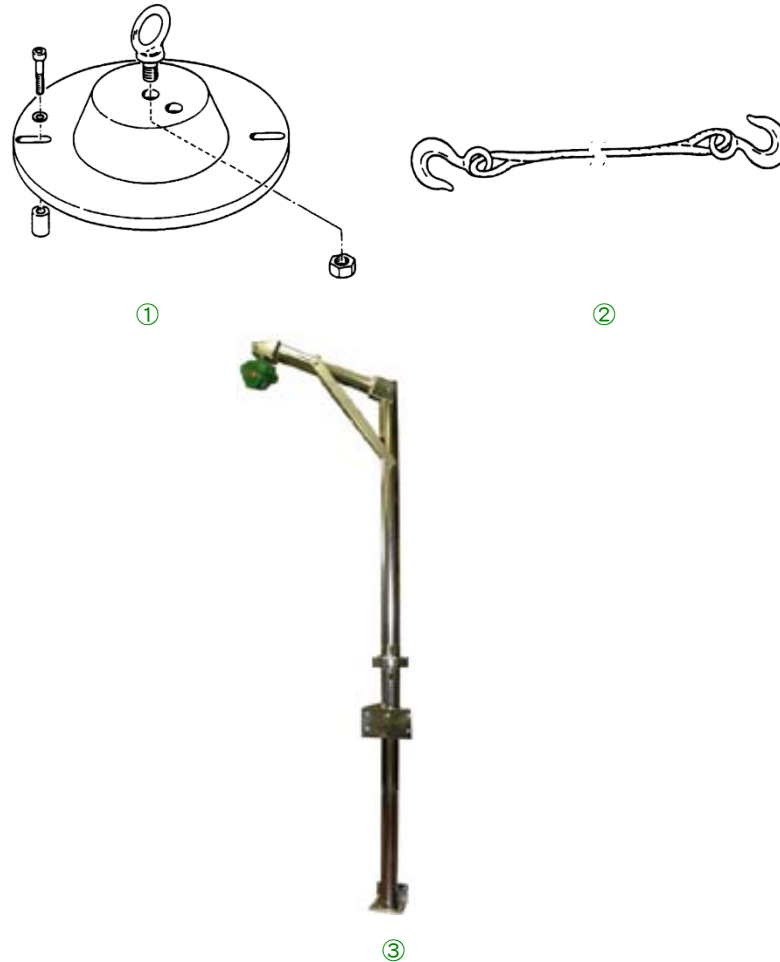


Fig. 3.2 Maintenance tools

- ① Lens lifting tool
Used for disassembling and reassembling the anode chamber and lenses.
- ② Wire rope with hooks
Used for lifting the HV tank inner parts.
- ③ Lift
Used for lifting the lens, electron gun assembly, HV tank parts, and other parts.
~~✗~~ The lift is used only by a service engineer, customer do not use them and should not move or assemble them.

3.3 MICROSCOPE COLUMN

3.3.1 Exterior View

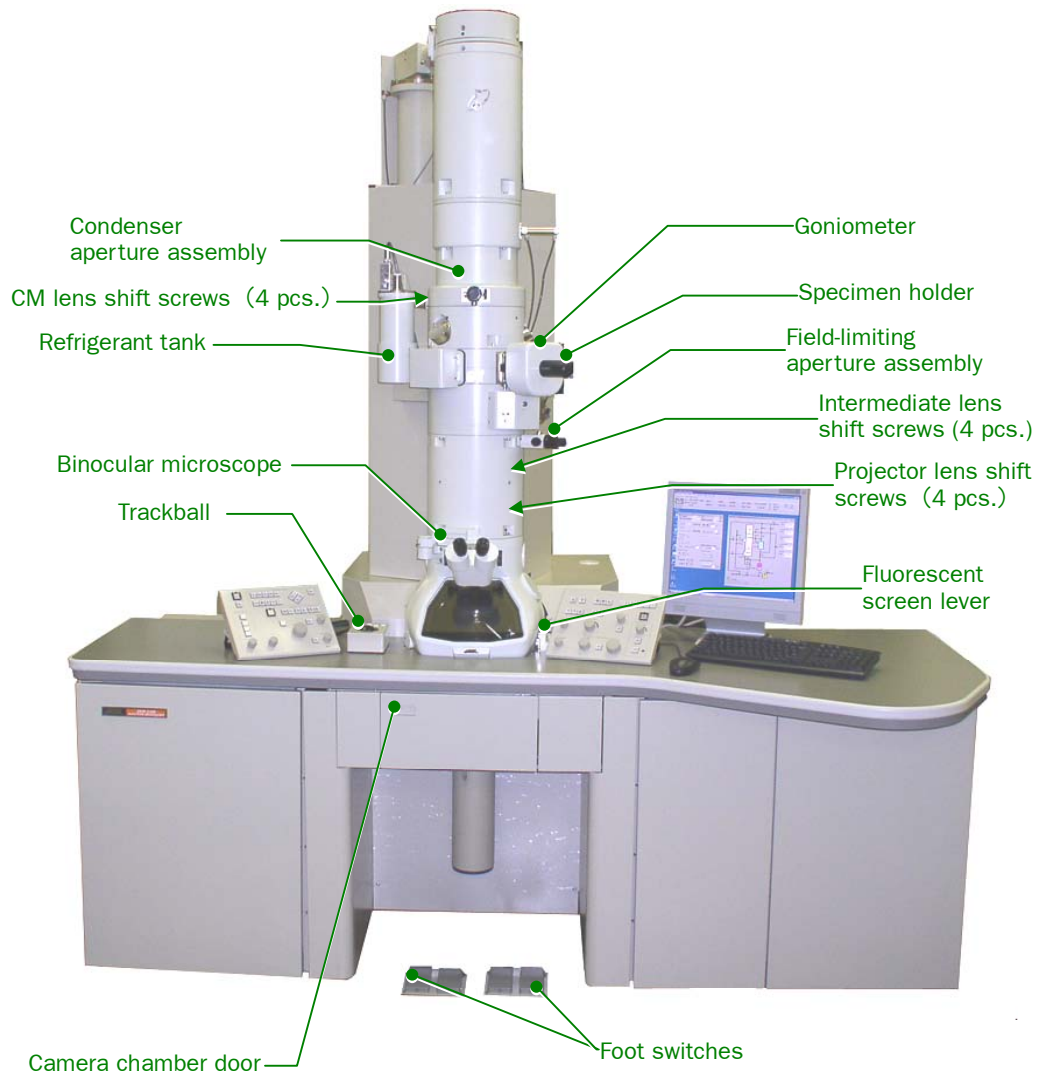


Fig. 3.3 Column exterior

The external appearance might differ among the basic JEM-2100 microscope. It depends on what optional attachments are included.

3.3.2 Column Interior

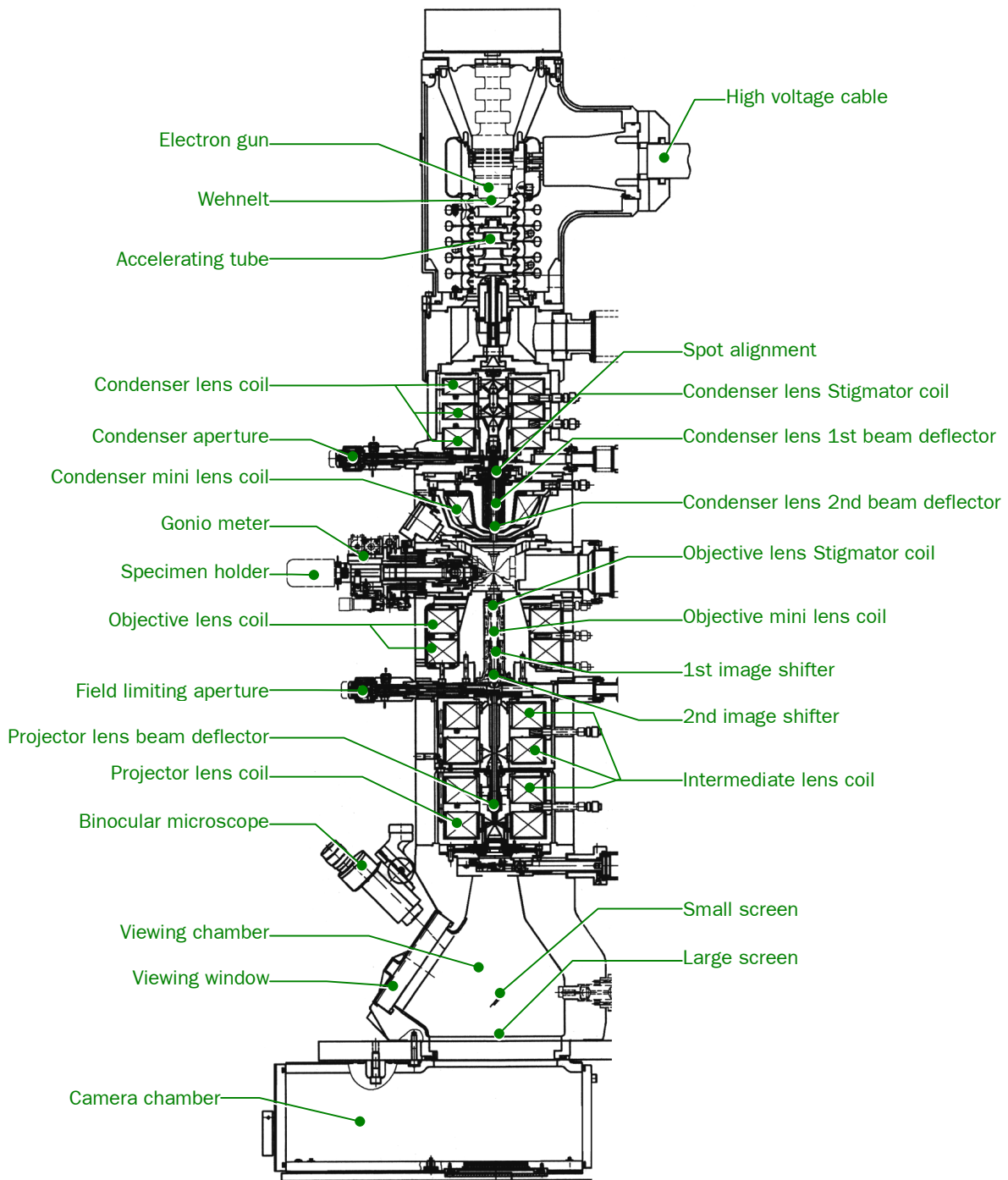



Fig. 3.4 Cross section of column

3.3.3 Locations of Electron Lenses and Coils

 The condenser mini-lens coil is not composed in the HC configuration.

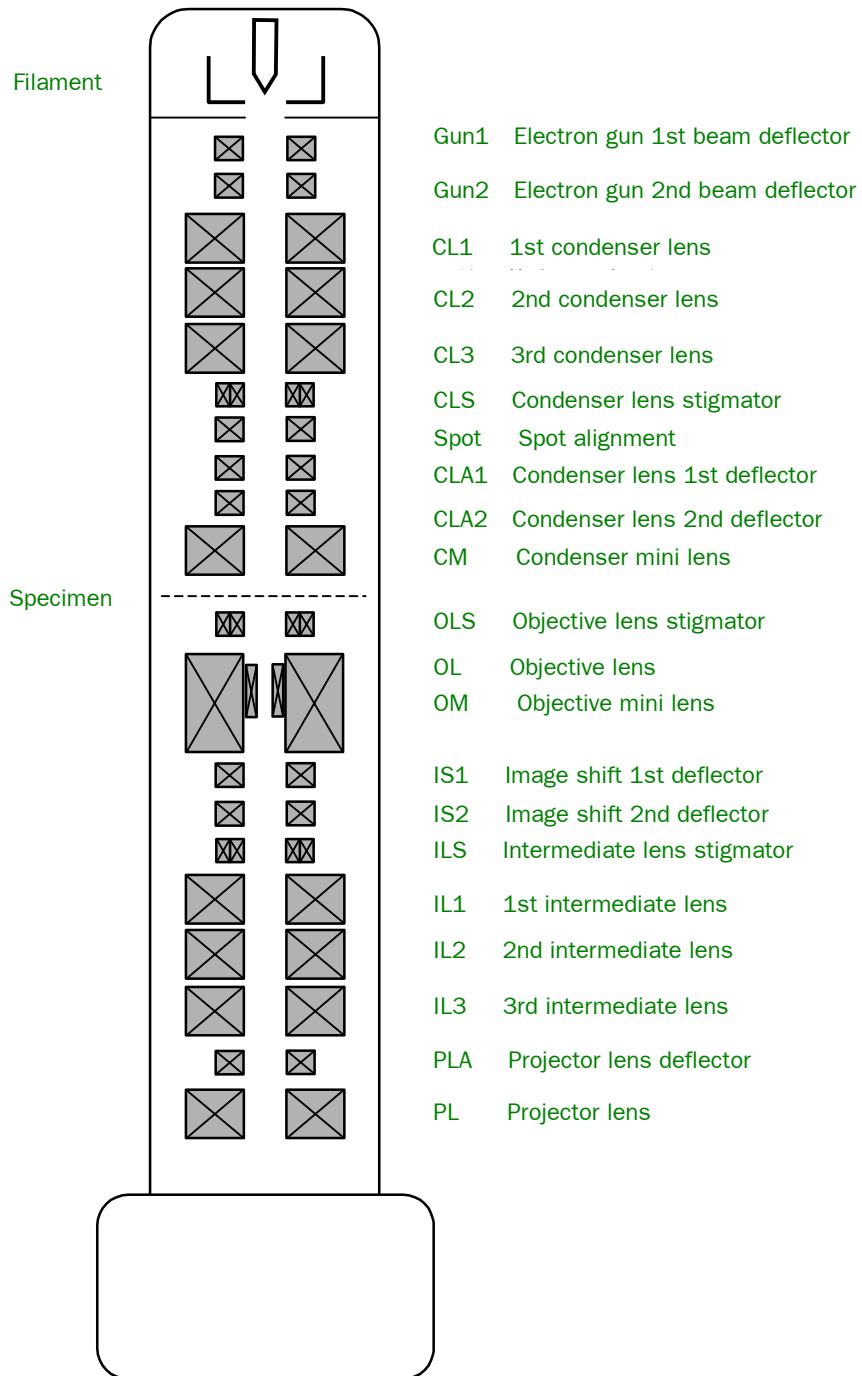


Fig. 3.5 Location of lenses and coils

3.4 LOCATIONS OF CONTROL PANELS

Control panel L2 is accessible by opening the Cover L2, and Control panel R2 is accessible by opening Cover R2. The computer is accessible by opening Cover PC.

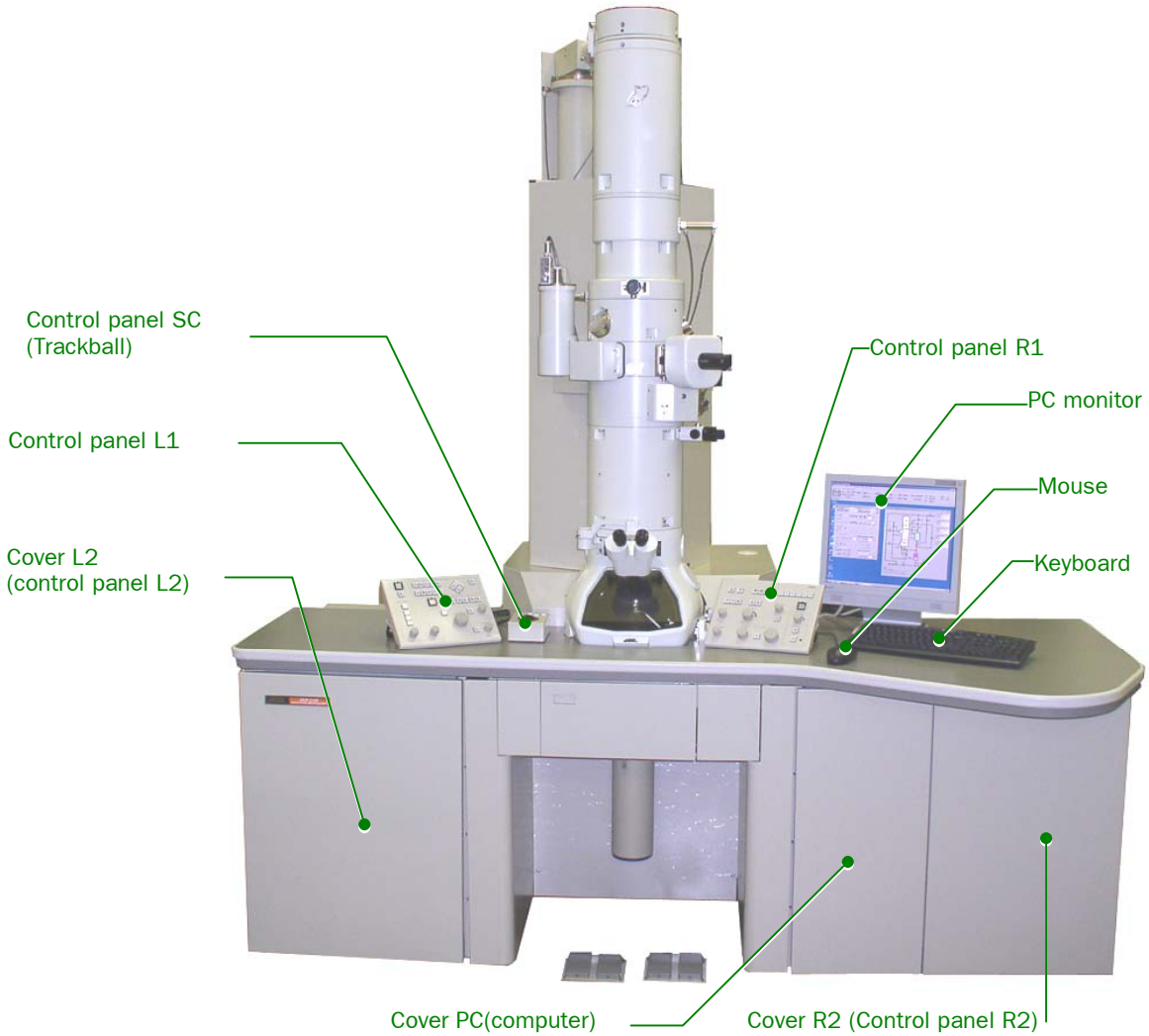


Fig. 3.6 Locations of control panels

3.5 RAY DIAGRAMS

3.5.1 Illumination System

- TEM mode: Wide area parallel illumination mode for transmission image observation.
- NBD mode: Small convergence angle micro-area illumination mode for micro-area diffraction.
- EDS mode: High current density micro-area illumination mode for micro-area analysis.
- CBD mode: Wide range changeable convergence angle micro-area illumination mode for convergent electron beam diffraction.

○: Appropriate, △: Possible but not recommend, ×: Impossible

Irradiation mode	TEM	NBD	EDS	CBD
Low-mag image observation	○	×	×	×
High-mag image observation	○	△	△	△
SA diffraction	○	△	△	△
Micro-micro diffraction	△	○	△	△
CB diffraction	△	○	○	○
EDS analysis	△	○	○	○
EELS analysis	○	○	○	○

3.5.1a Transmission electron image mode ray pass

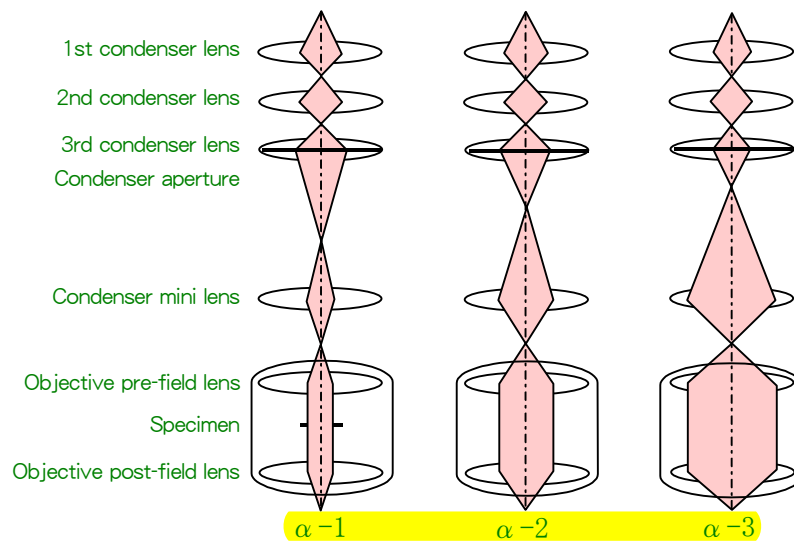


Fig. 3.7 Illumination system ray pass

✎ You can change the size of a parallel illumination region, remaining the condenser lens aperture size.

- $\alpha = 1$: Suitable for over 200 000 magnification
- $\alpha = 2$: Suitable for between 50 000 to 200 000 magnification
- $\alpha = 3$: Suitable for under 50 000 magnification

3.5.1b NBD/EDS/CBD mode ray pass

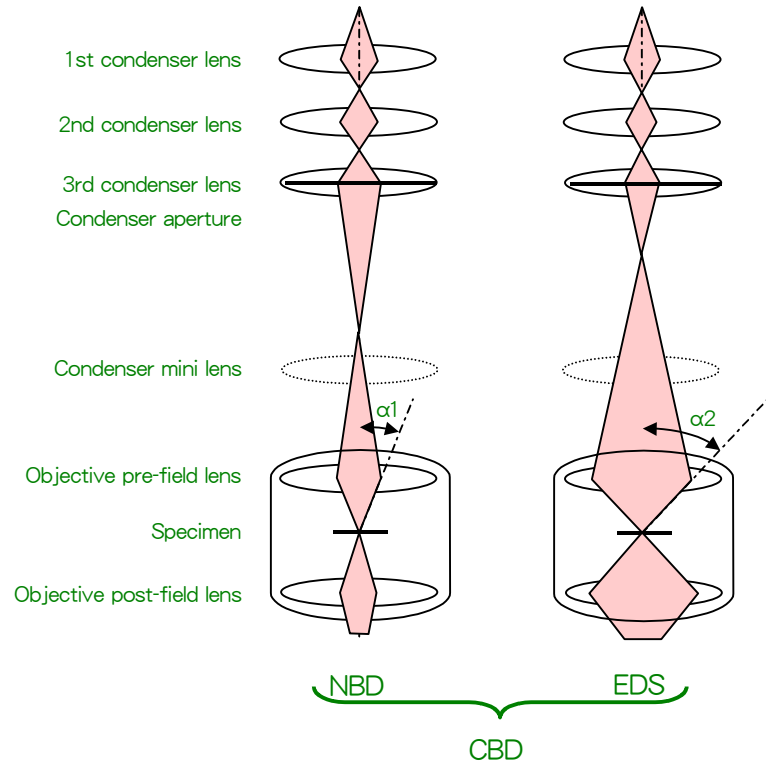


Fig. 3.8 NBD/EDS/CBD mode ray pass

3.5.2 Imaging System

3.5.2a Mag mode

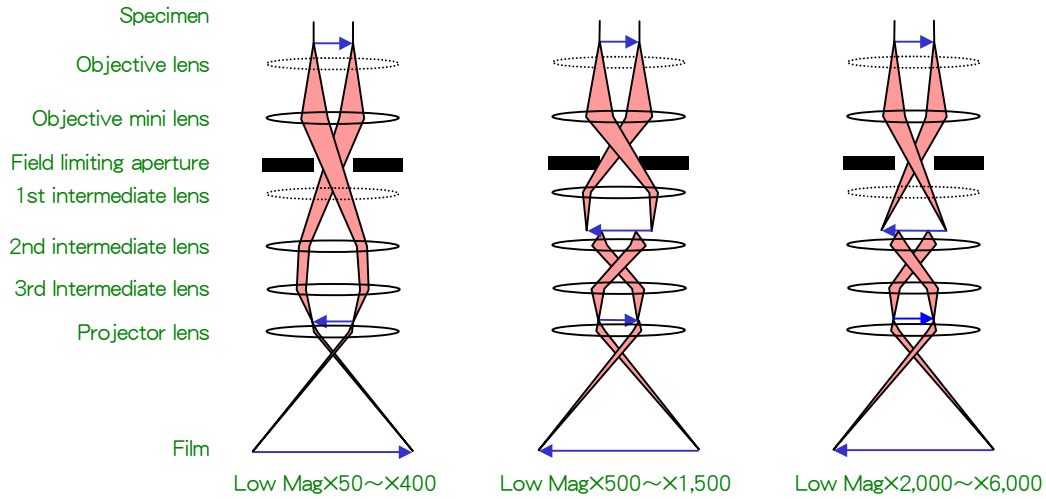


Fig. 3.9 Low-mag mode ray pass

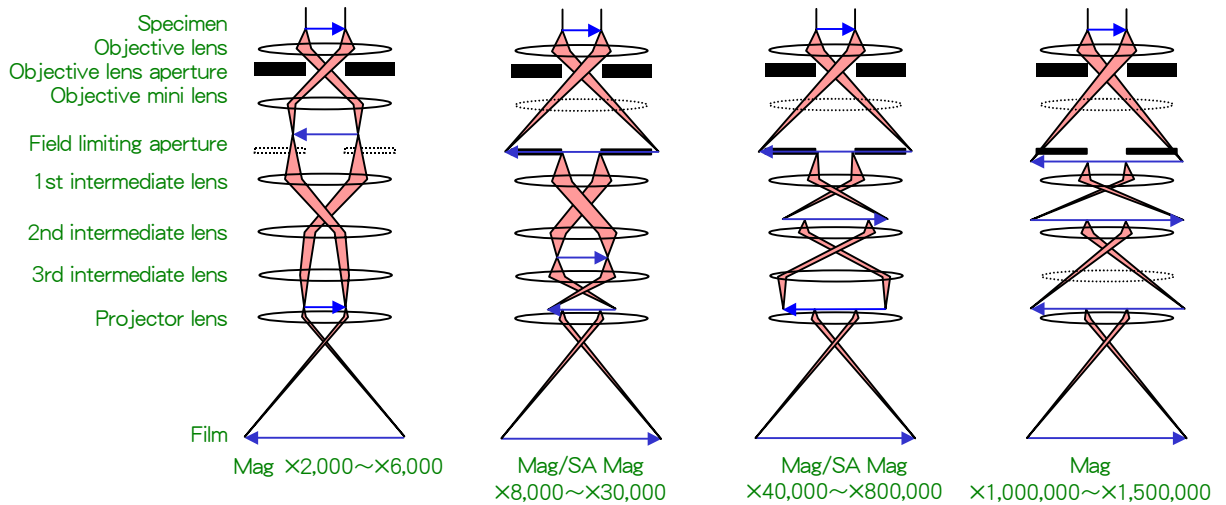


Fig. 3.10 Mag/SA mag mode ray pass

3.5.2b Diffraction mode

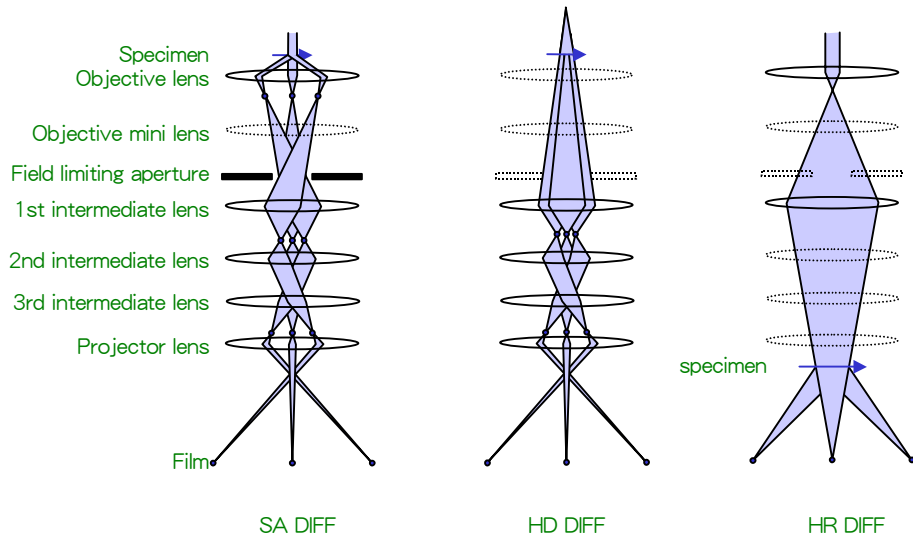


Fig. 3.11 Diffraction mode ray pass

4

DESCRIPTION OF CONTROLS

4.1	COLUMN.....	4-1
4.1.1	Condenser Aperture Assembly.....	4-1
4.1.2	Condenser Minilens Shift Screws.....	4-1
4.1.3	Specimen Holder.....	4-1
4.1.4	Goniometer.....	4-2
4.2	CONTROL PANELS.....	4-3
4.2.1	Control Panel L1.....	4-3
4.2.2	Control Panel R1.....	4-6
4.2.3	Control Panel L2.....	4-8
4.2.4	Control Panel R2.....	4-9
4.2.5	Control Panel SC.....	4-10
4.2.6	Power Supply Console.....	4-11
4.2.6a	Exterior view and control panels.....	4-11
4.2.6b	Control panel P1 (SIP power supply).....	4-12
4.2.6c	Control panel P3.....	4-12
4.3	PC WINDOWS.....	4-13
4.3.1	Starting the Application Program.....	4-13
4.3.1a	TEM Server.....	4-13
4.3.1b	TEM Controller.....	4-13
4.3.2	TEM Controller Window.....	4-14
4.3.3	Shortcut Buttons.....	4-14
4.3.4	Main Window (Data Display Area).....	4-15
4.3.4a	Indications in the left section.....	4-15
4.3.4b	Indications in the center section.....	4-16
4.3.4c	Indications in the right section.....	4-17
4.3.5	Windows That Can Be Accessed Using The Menu Bar and Shortcut Buttons.....	4-18
4.3.5a	File.....	4-18
	■ Photo History window.....	4-18
4.3.5b	Dialogue.....	4-19
	■ High Voltage Control window.....	4-20
	■ Operation window.....	4-22






■ Specimen Position window.....	4-27
■ Film Camera Property window.....	4-28
4.3.5c Monitor.....	4-29
■ Status Monitor window	4-30
4.3.5d Property	4-33
■ Valve Status window	4-34
■ EOS Property window.....	4-35
■ Specimen Property window.....	4-36
4.3.5e Option.....	4-36
■ MDS window.....	4-37
■ FLC (Free Lens Control) Panel window.....	4-38
■ MAG Select window	4-39
■ Lens/DEF Memory window	4-39
4.3.5f Maintenance	4-40
■ Alignment Panel for Maintenance window	4-41
■ Bake Out/ACD Heat window	4-42
■ Aperture Adjust window	4-44
■ Stage Limit window	4-44
4.3.5g Display.....	4-45
4.3.5h JEOLS	4-45
4.3.5i Help	4-45
4.3.6 Emergency (Alarms) Window	4-46

4.1 COLUMN

4.1.1 Condenser Aperture Assembly

- Condenser aperture control knobs (see Fig. 4.1)

Knob 1 Selects an aperture.

Knob1 position					
Aperture size	○	○	○	○	∞ (open)
Aperture diameter	φ200 μm	φ70 μm	φ50 μm	φ10 μm	

Knobs 2 and 3 Move the aperture in the X or Y direction.

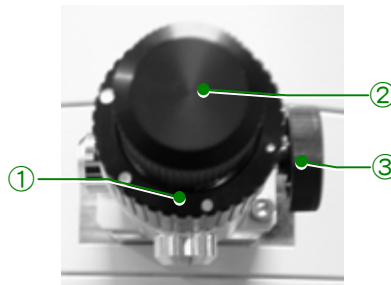




Fig. 4.1 Condenser lens aperture knobs

4.1.2 Condenser Minilens Shift Screws

Used for aligning the illumination system.

-  The condenser minilens shift screws are adjusted in the factory at shipment. You do not have to adjust them.
-  The condenser minilens is not included in the HC configuration.

4.1.3 Specimen Holder

Used to insert/retract a specimen into/from the electron beam path.

4.1.4 Goniometer

The built-in motor tilts the specimen, which is loaded in a specimen holder mounted on the goniometer stage.

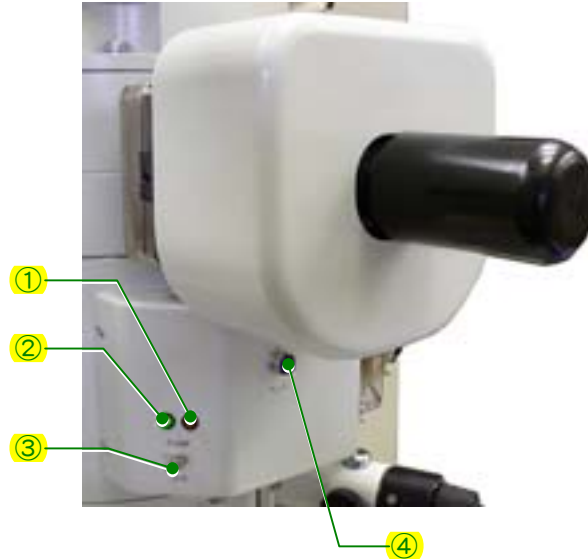



Fig. 4.2 Goniometer

- ① **Green lamp**
Indicates, when lit, that the goniometer is ready for loading of a specimen holder.
- ② **Yellow lamp**
Indicates, when lit, that the roughing vacuum pump is evacuating the goniometer.
- ③ **PUMP/AIR switch**
Setting this switch to PUMP evacuates the goniometer (the yellow lamp lights up during evacuation) and setting this switch to AIR opens the goniometer to the atmosphere.
 Set the switch to the desired position while pulling it out.
- ④ **Connector**
Used for optional specimen holders such as a double-tilt specimen holder.

4.2 CONTROL PANELS

4.2.1 Control Panel L1

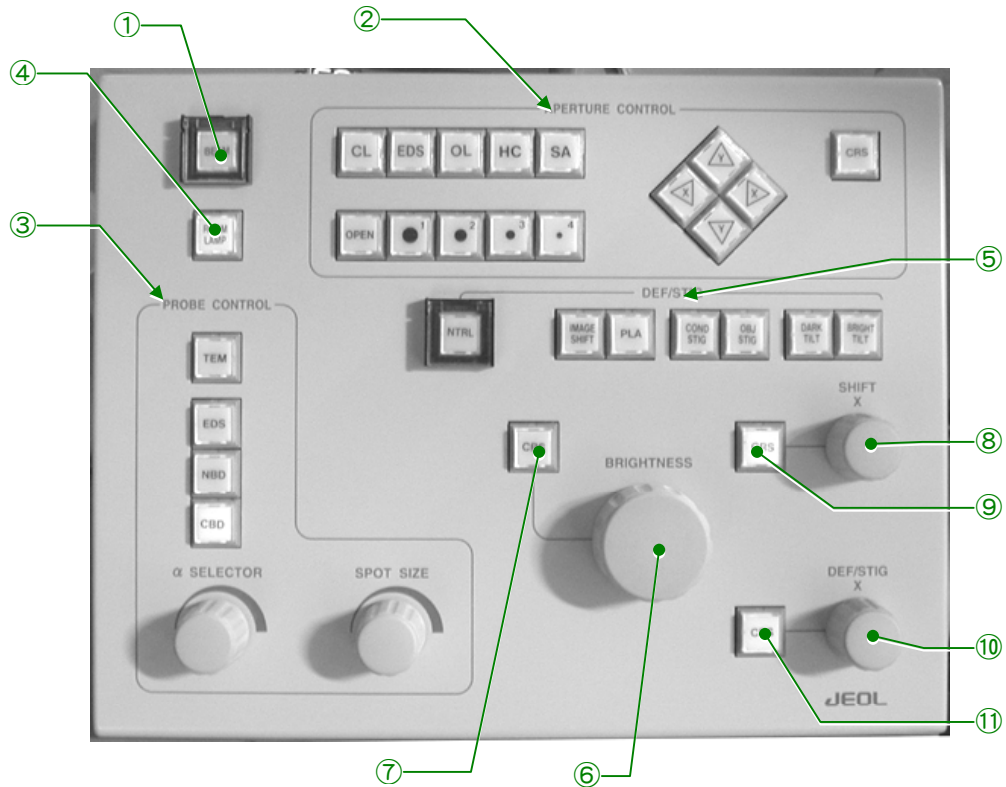


Fig. 4.3 Control panel L1

① BEAM switch

Pressing this switch when the built-in lamp is not lit starts to emit electron beams. Pressing this switch when the lamp is lit stops emitting electron beams. This switch function is the same as that of Filament ON and OFF in the High Voltage Control window (☞ Fig. 4.22).

② APERTURE CONTROL

Pressing one of the motor-driven aperture switches (CL, EDS, OL, HC or SA) lights the built-in lamp; the aperture-selector switches (OPEN, 1, 2, 3 and 4) and X and Y arrow switches then control the selected motor-driven aperture.

✍ You cannot select the aperture if it is not motor-driven.

• Aperture switches

- CL Selects the condenser aperture.
- EDS Selects the hard X-ray aperture.
- OL Selects the objective aperture.
- HC Selects the high-contrast objective aperture.
- SA Selects the field-limiting aperture.

• Aperture selector switches

Pressing one of these switches selects the corresponding aperture number (size) of the selected aperture assembly.

- OPEN: The aperture is open.
- 1 Selects aperture number 1.
 - 2 Selects aperture number 2.
 - 3 Selects aperture number 3.
 - 4 Selects aperture number 4.

- X and Y arrow switches

Move the aperture in the X and Y directions.

- CRS (Coarse) switch

When this switch is on, the distance the aperture moves when the X or Y switch is pressed increases by a factor of 16.

③ PROBE CONTROL

- Illumination mode selector switches (TEM, EDS, NBD and CBD)

TEM switch Turning this switch on lights the built-in lamp and sets the illumination mode to the TEM (wide-area illumination) mode.

EDS switch Turning this switch on lights the built-in lamp and sets the illumination mode to the EDS (high-current density micro-area illumination) mode.

NBD switch Turing this switch on lights the built-in lamp and sets the illumination mode to the NBD (small convergence angle micro-area illumination) mode.

CBD switch Turning this switch on lights the built-in lamp and sets the illumination mode to the CBD (wide range changeable convergence angle micro-area illumination) mode.

- α SELECTOR knob

Varies the convergence angle while the illuminating spot size remains constant. Turning this knob clockwise decreases the CM lens current and increases the illuminating angle. Turning the knob fully clockwise decreases the CM lens current to zero.

- SPOT SIZE knob

Turning this knob increases or decreases the spot size (the size of the electron beam when converged to minimum size using the BRIGHTNESS knob). The spot size decreases as the SPOT SIZE number increases and the spot size is increased as the SPOT SIZE number decreases.

④ ROOM LAMP switch

Turns on and off the room lamp when a lamp is provided.

⑤ DEF/STIG switches

Pressing one of these switches lights up the built-in lamp and sets the SHIFT knobs (L1-⑧, R1-③) or DEF/STIG knobs (L1-⑤, R1-④) to control the selected coil current. Pressing the switch again turns off the built-in lamp and holds the selected coil current to the value it has when this switch is pressed (the built-in lamp dims).

IMAGE SHIFT switch Shifts the image at high magnifications.

PLA switch Adjusts the projector lens deflector coil current during shifting of the diffraction spot or specimen image.

COND STIG switch Adjusts the condenser lens stigmator coil current during condenser lens astigmatism correction.

- | | |
|--------------------|--|
| OBJ STIG switch | Pressing this switch sets the objective lens stigmator coil to the current stored in the selected memory and sets the DEF/STIG (L1-⑤ and R1-④) knobs to adjust the current. Used for objective-lens astigmatism correction. |
| DARK TILT switch | Pressing this switch sets the condenser lens beam deflector coil to the current stored in the selected memory and sets the SHIFT and DEF/STIG knobs to adjust the current. Used to tilt the electron beam when observing dark-field images. |
| BRIGHT TILT switch | Pressing this switch sets the condenser lens beam deflector coil to the current stored in the selected memory and sets the SHIFT and DEF/STIG knobs to adjust the current. Used to tilt the electron beam when observing bright-field image. |
| NTRL switch | Pressing this switch brightens the built-in lamp and clears the current data from the memory corresponding to the selected switch. |
- ⑥ **BRIGHTNESS knob**
Converges and spreads the electron beam.
 - ⑦ **BRIGHTNESS CRS switch**
When this switch is on, the change in current per notch of the BRIGHTNESS knob (L1-⑥) is increased by 16 times.
 - ⑧ **SHIFT X knob**
Shifts the electron beam in the X direction by varying the condenser lens beam deflector coil current. The electron gun 1st beam deflector coil current is adjustable when DEF Select – Gun is selected from the Alignment Panel for Maintenance window.
 - ⑨ **SHIFT CRS switch**
When this switch is on, the change in current per notch of the SHIFT knobs (L1-⑧, R1-③) is increased by 16 times.
 - ⑩ **DEF/STIG X knob**
Varies the X current in the coil selected by the DEF/STIG switch or from the Alignment Panel for Maintenance window (☞ Fig. 4.47-①).
 - ⑪ **DEF-STIG CRS switch**
When this switch is on, the change in current per notch of the DEF/STIG knobs (L1-⑤, R1-④) is increased by 16 times.

4.2.2 Control Panel R1

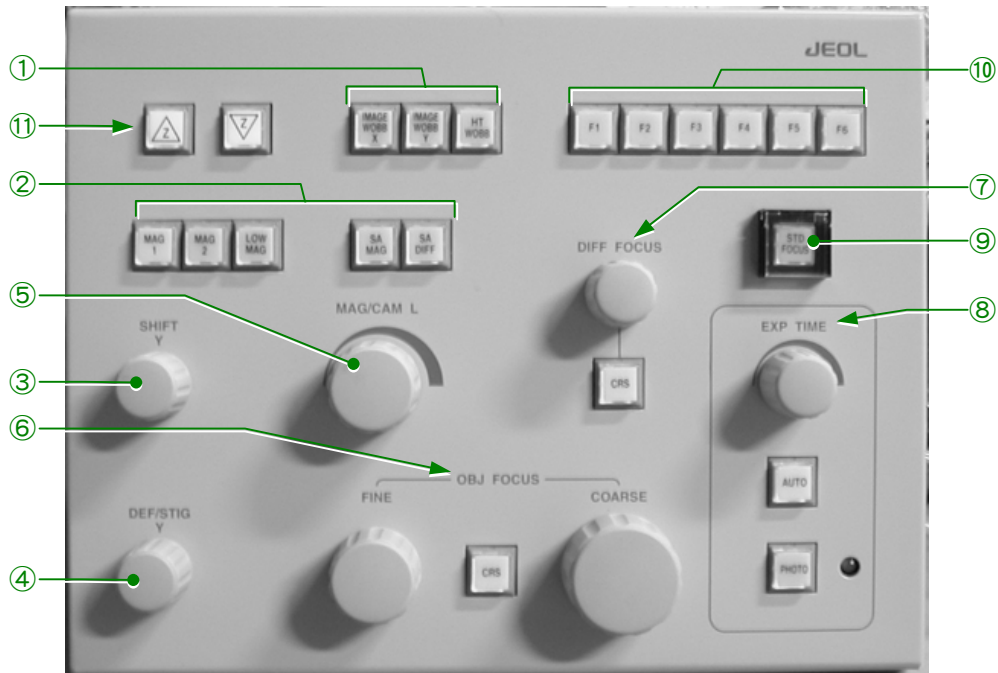


Fig. 4.4 Control panel R1

① Wobbler switches
IMAGE WOBB X

Used for focusing. The 1st and 2nd beam deflector coil currents vary periodically while this switch is on. If the image is out of focus, it wobbles in the X direction. This switch has the same function as the ImageX button in the Alignment Panel for Maintenance window in Fig. 4.47.

IMAGE WOBB Y

Used for focusing. The 1st and 2nd beam deflector coil currents vary periodically while this switch is on. If the image is out of focus, it wobbles in the Y direction. This switch has the same function as the ImageY button in the Alignment Panel for Maintenance window in Fig. 4.47.

HT WOBB

While this switch is on, the high voltage varies periodically, facilitating alignment of the voltage axis. This switch has the same function as the HT button in the Alignment Panel for Maintenance window in Fig. 4.47.

② Function switches

Used to choose an image-forming mode. The magnification or camera length in the selected mode can be varied with the MAG-CAM L knob (R1-⑤) and is displayed on the monitor. The magnification or camera length set by the MAG-CAM L knob is stored so that even if another mode (except for MAG 2 mode) is once selected, the magnification or camera length can be reset to the stored value by selecting the original mode again.

MAG 1 switch	Chooses the normal magnification mode.
MAG 2 switch	Pressing this switch sets the instrument to a specific magnification. This specific magnification is not stored.
LOW MAG switch	Chooses the low-magnification mode.
SA MAG switch	Chooses the selected-area magnification mode.
SA DIFF switch	Chooses the selected-area diffraction mode.

③ SHIFT Y knob

Shifts the electron beam in the Y direction by varying the condenser lens beam deflector coil current. The electron gun 1st beam deflector coil current is varied when DEF Select – Gun is selected from the Alignment Panel for Maintenance window in Fig. 4-47.

④ DEF-STIG Y knob

Varies the Y current in the coil selected by DEF/STIG (L1-⑤) switch or by DEF Select buttons in the Alignment Panel for Maintenance window in Fig. 4-47.

⑤ MAG/CAM L knob

Varies the normal magnification when the MAG 1 or MAG 2 switch (R1-②) is pressed, the low magnification when the LOW MAG switch is pressed. Varies the selected area magnification when SA MAG is selected and the camera length when SA DIFF is selected. Turning this knob clockwise increases the magnification or camera length and turning it counterclockwise decreases the magnification or camera length.

⑥ OBJ FOCUS knob

Focuses the image by varying the objective lens current (objective minilens current in LOW MAG mode).

FINE knob	The change in current resulting from turning the knob by one notch is the smallest.
COARSE knob	The change in current resulting from turning the knob by one notch is the same as when the FINE knob is turned by 16 notches.
CRS Switch	Turning this switch on by pressing it increases the current change resulting from turning the FINE and COARSE knobs by one notch by a factor of 16.

⑦ DIFF FOCUS

Knob	Focuses the field-limiting aperture while the SA MAG switch (R1-②) is on and focuses the diffraction pattern while the SA DIFF switch (R1-②) is on.
CRS switch	Turning this switch on multiplies the change in current resulting from turning the FOCUS knob by one notch by 16.

⑧ EXP TIME/PHOTO

EXP TIME knob

Varies the exposure time. Turning this knob clockwise increases the exposure time and turning it counterclockwise decreases the exposure time.

AUTO switch

Pressing this switch selects the automatic exposure mode and lights up the built-in lamp. Pressing this switch again selects the manual exposure mode (the built-in lamp goes out).

PHOTO switch

Pressing this switch when its lamp is unlit advances a film to the exposure position; the lamp lights up when the film reaches the specified position; the film is exposed and advanced; then the lamp goes out. Pressing this button when the lamp is lit, that is, when a film is in the exposure position, exposes the film.

The timing of the film advancement and the photographing can be set in the Film Camera Property window in Fig. 4.29.

Lamp

Indicates, when lit, that the shutter is open.

⑨ STD FOCUS switch

Pressing this switch sets the objective lens current to the original reference value.

⑩ F switches

Allocate the functions selected by the operator to the F1 to F6 switches.

⑪ Z switches

Shift the specimen in the vertical direction.

4.2.3 Control Panel L2

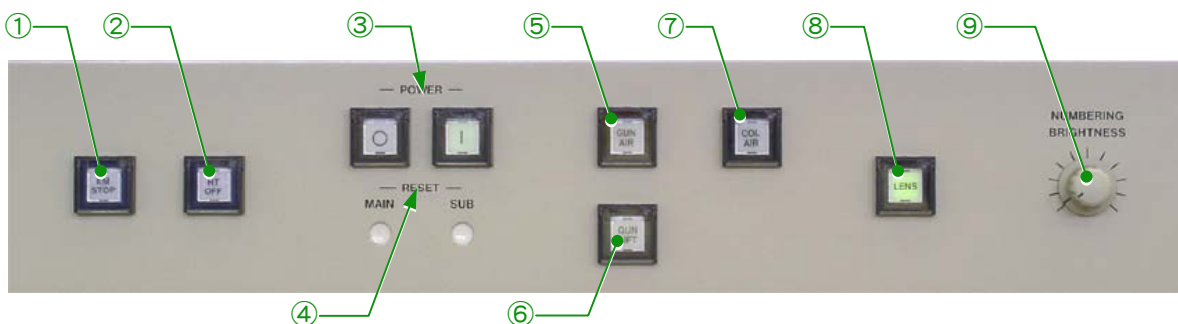


Fig. 4.5 Control panel L2

① EM STOP switch

Used for shutting down the instrument in an emergency.

② HT STOP switch

Used for shutting down high voltage in an emergency.

③ POWER switch

Pressing the (off) switch turns off the instrument and pressing the (on) switch turns on the instrument.

- ④ **RESET button**
 MAIN: Pressing this switch reset the instrument main system.
 SUB: Pressing this switch reset the goniometer sub-system and the panel sub-system.
- ⑤ **GUN AIR switch**
 Turning on this switch vents the electron gun chamber and turning off the switch evacuates the electron gun chamber.
- ⑥ **GUN LIFT switch**
 After venting the electron gun chamber using the GUN AIR (L2-⑤) switch, turning on this switch raises the electron gun lift. Turning off this switch lowers the elctron gun lift.
- ⑦ **COL AIR switch**
 Pressing the switch (the switch lamp lights) vents the microscope column to atmospheric pressure and pressing the switch again (the switch lamp goes out) evacuates the column.
- ⑧ **LENS switch**
 Pressing the switch turns on all power supplies for the lenses, beam deflectors and stigmators.
- ⑨ **BRIGHTNESS knob**
 Adjusts the brightness of the film numbering test.

4.2.4 Control Panel R2



Fig. 4.6 Control panel R2

Variable resistors (round holes):

These switches are for maintenance.

DIP switches (square holes):

These switches turn on and off the lens current and deflector coil current power supplies.

4.2.5 Control Panel SC

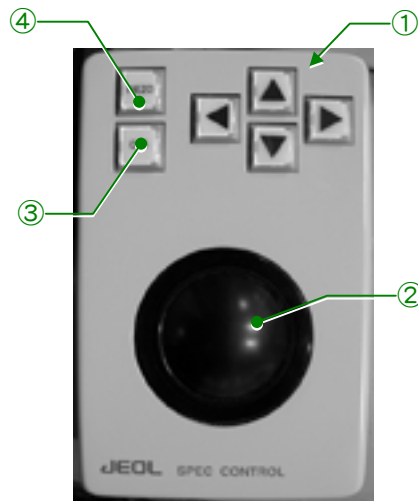



Fig. 4.7 Control panel SC

- ① **Arrow (▲) switches**
These switches move the specimen in the X and Y directions.
- ② **Trackball**
The trackball moves the specimen in the direction in which the ball is turned.
- ③ **CRS switch**
Sets specimen-movement mode. Turning this switch on (the built-in lamp lights) moves the specimen in coarse mode and turning the switch off (the built-in lamp goes out) moves the specimen in fine mode. This switch can also be used for specimen X, Y and Z movements and X and Y tilts.
- ④ **PIEZO switch**
Turning this switch on moves the specimen using a piezoelectric element.
 The optional Piezo Device Movement Power Supply is required.

4.2.6 Power Supply Console

4.2.6a Exterior view and control panels

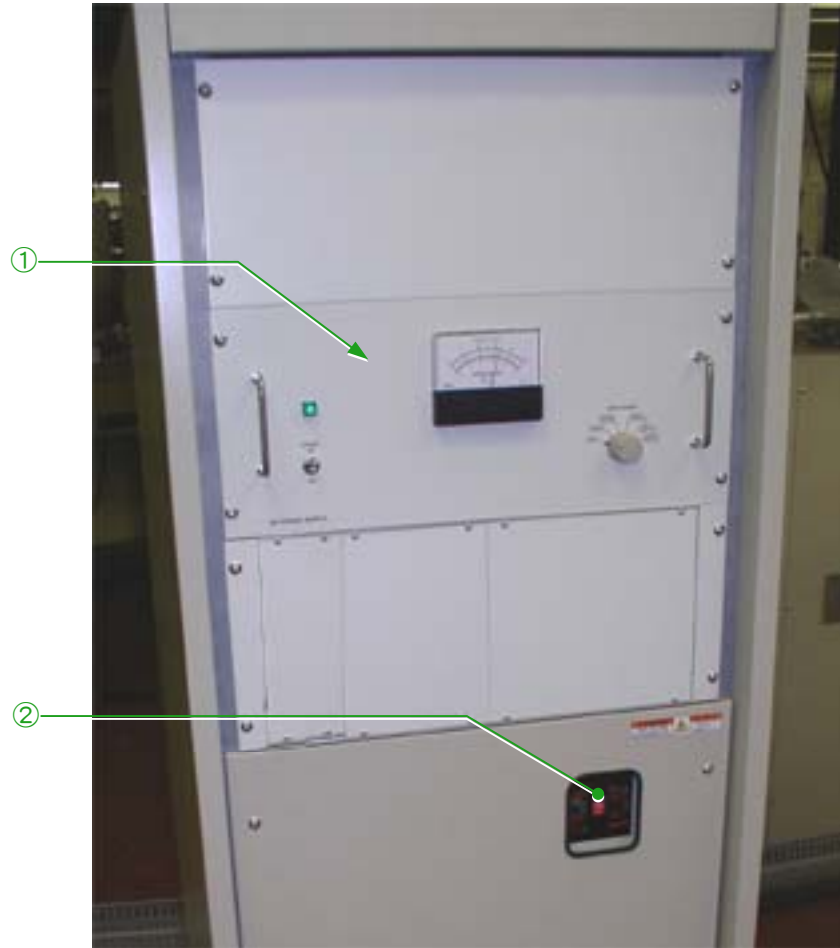


Fig. 4.8 Power Supply console

- ① Control panel P1
SIP power supply (150 L)
- ② Control panel P3
Circuit breaker

4.2.6b Control panel P1 (SIP power supply)

This unit contains the power supply for the 150 L ion pump connected to the electron gun chamber.

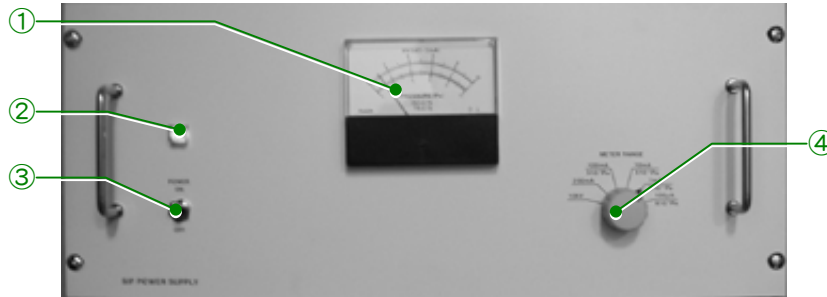


Fig. 4.9 Control panel P1

① Meter

Reads out the value that corresponds to the measurement item selected by the METER RANGE knob (P1-④).

② POWER lamp

Indicates, when lit, that the power is on.

③ POWER switch

Setting this switch to the up position turns on this power supply.

④ METER RANGE knob

Selects the item for the meter (P1-①) to measure and read out.

4.2.6c Control panel P3

A main circuit breaker is mounted on this panel. The breaker should be left on usually.

4.3 PC WINDOWS

4.3.1 Starting the Application Program

4.3.1a TEM Server

- ◆ Double-click on the TEM Server icon (Fig. 4.10) on the PC monitor screen (Fig. 3.6) to start the TEM Server program. A taskbar (Fig. 4.11) containing the buttons relating to the TEM Server appears.



Fig. 4.10 TEM Server icon

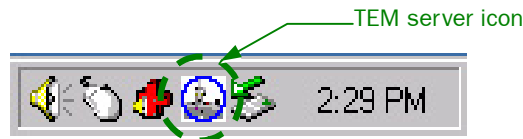


Fig. 4.11 Taskbar

4.3.1b TEM Controller

- ◆ Double-click on the TEM Controller icon (Fig. 4.12) in the PC monitor screen (Fig. 3.6) to start the TEM controller program. The TEM Controller window appears (Fig. 4.13).



Fig. 4.12 TEM Controller icon

- ✍ Be sure to start TEM Server first to start the TEM Controller window.

4.3.2 TEM Controller Window

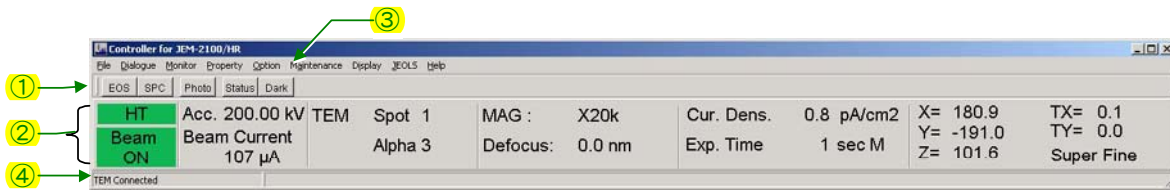


Fig. 4.13 TEM Controller window

① Shortcut buttons

Executes frequently used commands.

☞ For details, refer to Sect. 4.3.3.

② Data display area (Main window)

Displays observation and photographing conditions.

This area (window) is divided into five sections.

☞ For details, refer to Sect. 4.3.4.

③ Menu bar

The menu bar contains the names of the pull-down menus listing available commands.

☞ For details, refer to Sect. 4.3.5.

④ Connecting conditions

Indicates whether the TEM Server is connected or not.

TEM Connected: TEM server is connected.

TEM Disconnected: TEM server is disconnected.

4.3.3 Shortcut Buttons

EOS : Opens the EOS Property window (☞ Sect. 4.3.5d).

SPC : Opens the Specimen Position window (☞ Sect. 4.3.5b).

Photo : Opens the Film Camera Property window (☞ Sect. 4.3.5b).

Status : Opens the Status Monitor window (☞ Sect. 4.3.5c).

Dark : Darkens the monitor screen. To restore brightness, click the mouse button or press any key on the keyboard (☞ Sect. 4.3.5c).

4.3.4 Main Window (Data Display Area)

Fig. 4.14 contains indications in the main window when the system is in TEM mode.

Left section		Center section				Right section	
HT	Acc. 200.00 kV	TEM	Spot 1	MAG : X20k	Cur. Dens. 0.8 pA/cm ²	X= 180.9	TX= 0.1
Beam ON	Beam Current 107 μ A		Alpha 3	Defocus: 0.0 nm	Exp. Time 1 sec M	Y= -191.0	TY= 0.0
TEM Connected						Z= 101.6	Super Fine

Fig. 4.14 Main window

4.3.4a Indications in the left section

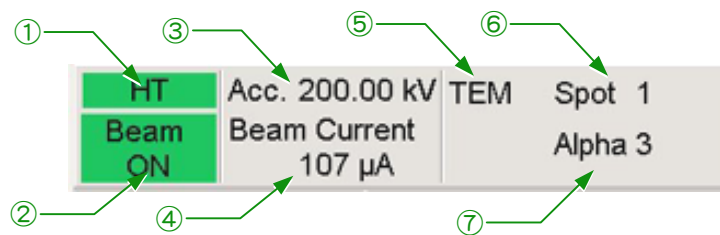


Fig. 4.15 Left main screen

① HT

When HV is on, the HT background turns from gray to green and the HT characters turn from white to black.

② Beam ON (or Beam Ready or Beam Not Ready)

- When electron beams are generated, the background turns green and “Beam On” appears in black (see Figs. 4.15 and 4.16a).
- When it is possible to generate electron beams, the background is gray and “Beam Ready” is displayed in black (see Fig. 4.16b).
- When it is not possible to generate electron beams, the background is gray and “Beam Not Ready” is displayed in white (see Fig. 4.16c).

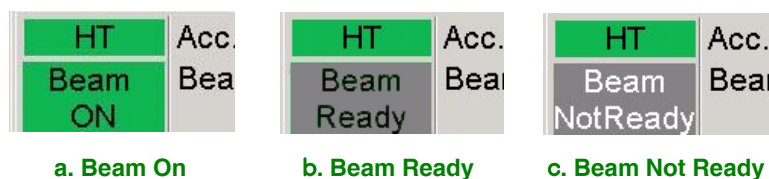


Fig. 4.16

③ Acc.


Accelerating voltage in kV

④ Beam Current

Displays the sum of the dark current and the beam current in μ A.

⑤ TEM

Observation mode: TEM, EDS, NBD or CBD

 When you use the optional EM-24510 Scanning Image Observation Device, “Scanning” is displayed.


⑥ Spot


Spot size

Displays the spot size using a number 1 to 5 in TEM mode and a probe diameter in EDS, NBD, or CBD mode.

⑦ Alpha

Displays the electron beam convergent angle using a number from 1 to 9.

 Nothing is displayed when the instrument is in the HC configuration.

 When you are using the optional EM-24510 Scanning Image Observation Device, the probe size is displayed here.

4.3.4b Indications in the center section

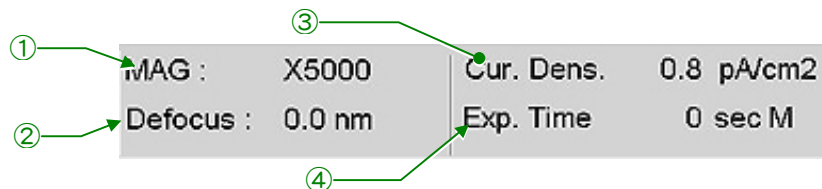


Fig. 4.17 Center main screen

① MAG

Displays the present magnification.

② Defocus

Displays the difference between the reference focus and the present focus in nm.

③ Cur. Dens.

Displays the current density (in pA/cm²) on the fluorescent screen.

④ Exp. Time

Exposure time and exposure mode (M or A). When manual exposure mode is selected, “M” appears at the end of this line and the exposure time can be varied using EXP TIME (R1-⑧) (0.1 to 900.0 and B). When automatic exposure mode is selected instead, “A” appears. In automatic mode, the exposure time corresponding to the current density on the fluorescent screen is displayed.

4.3.4c Indications in the right section

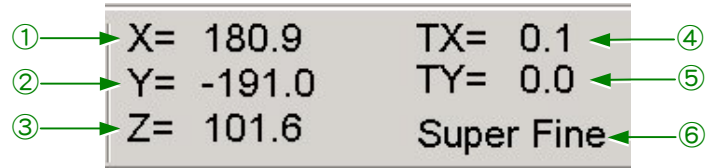


Fig. 4.18 Right main screen

Display units from ① to ③ are μm and for ④ and ⑤ are $^{\circ}$.

① X=

Present specimen position in the X direction.

② Y=

Present specimen position in the Y direction.

③ Z=

Present specimen position in the Z direction.

④ TX=

Present specimen tilt in the X direction.

⑤ TY=

Present specimen position in the Y direction when a double tilt specimen holder is in use.

⑥ Super Fine

When the PIEZO switch (Control panel SC-④) is pressed, Super Fine is displayed.

The optional Piezo Device Movement Power Supply is required. If it is not installed, you cannot perform piezo drive.

4.3.5 Windows That Can Be Accessed Using The Menu Bar and Shortcut Buttons

Set out below is brief information on the contents of the windows and the functions of the buttons and indications in the windows. See Chapter 5, “Operation” for more details.

4.3.5a File

- Photo history
Opens the Photo History window. The window contains the photographing history.
- Exit
Terminates the TEM Controller.

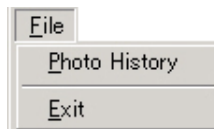


Fig. 4.19 File menu

■ Photo History window

- ◆ Select File – Photo History from the menu bar.
Data obtained during photography and displayed in the main window are listed in the Photo History window (☞ Fig. 4.20).

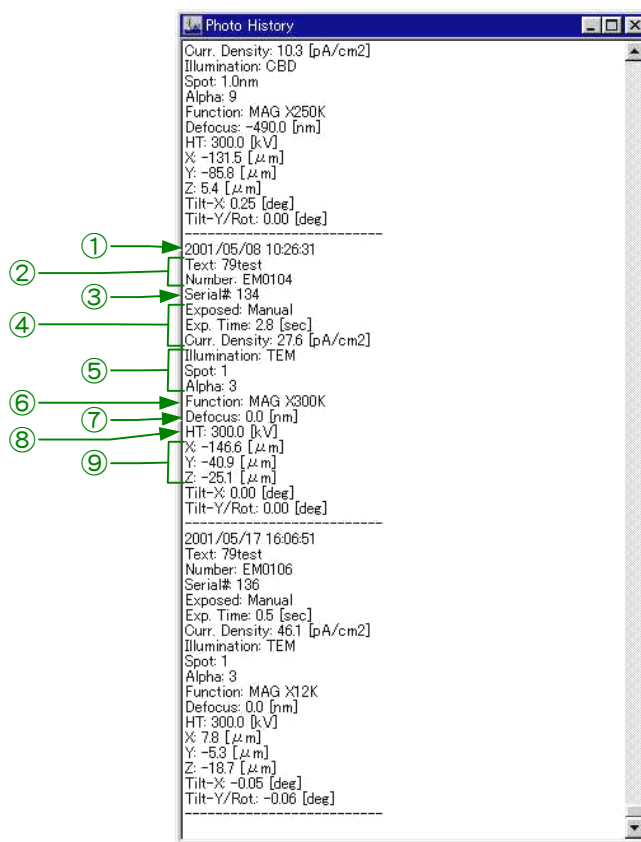


Fig. 4.20 Photo History window

- ① Date and time of the photo
- ② Film information

Text	Printed text
Number	Number printed on the film
- ③ Total number of films exposed up to now
- ④ Photographing conditions

Exposed	Exposure mode
Exp. Time	Exposure time
Curr. Density	Current density on the fluorescent screen
- ⑤ Illuminating conditions

Illumination	Illumination mode
Spot	Spot size
Alpha	Alpha selector number
- ⑥ Magnification, camera length, or filter lens current conditions
- ⑦ Amount of defocus
- ⑧ Accelerating voltage
- ⑨ Specimen position

4.3.5b Dialogue

- High Voltage Control
Opens the High Voltage Control window. Using this window, you can set the high voltage.
- Operation
Opens the Operation window. Using this window, you can set the operating conditions.
- Specimen Position
Opens the Specimen Position window. Using this window, you can display and set the specimen position.
- Photo Set
Opens the Film Camera Property window. Using this window, you can display and set the status of the electron beam density and photo film.

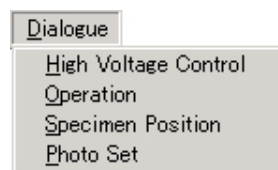


Fig. 4.21 Dialogue menu

High Voltage Control window

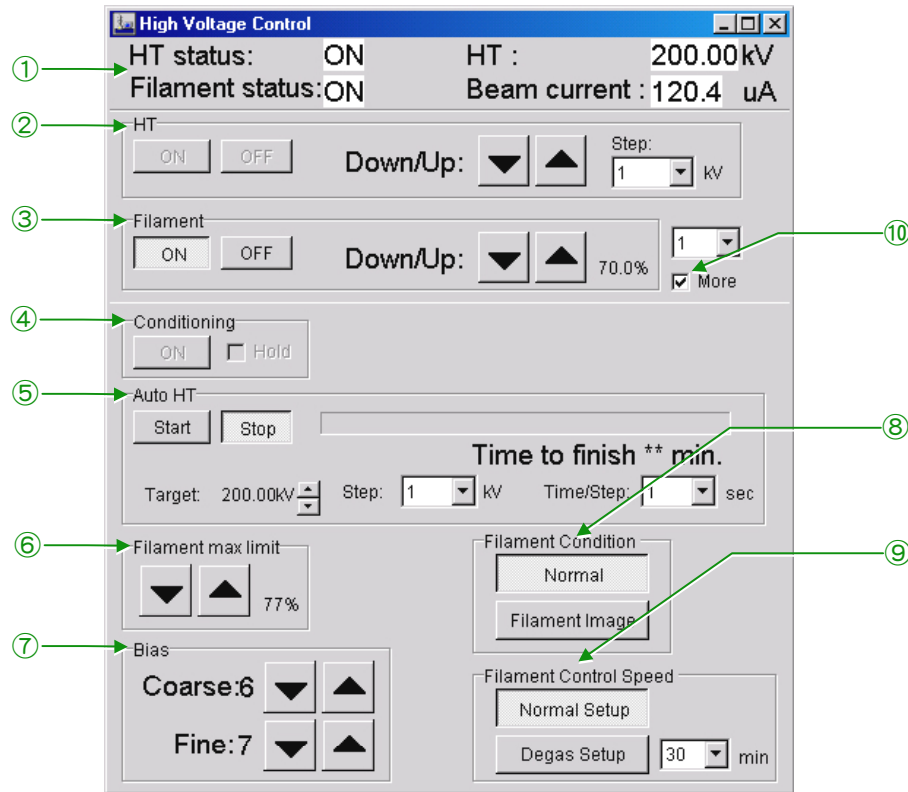


Fig. 4.22 High Voltage Control window







Fig. 4.22 shows the High Voltage Control window when the accelerating voltage is applied and the electron beam is being emitted.

① High voltage settings

- HT status: Displays one of the following messages.
 - Not Ready: Appears when the accelerating voltage is not ready to be turned on.
 - Ready: Appears when you can turn on the accelerating voltage.
 - On: Appears when the accelerating voltage is being applied.
 - On (blink): Appears when the accelerating voltage is being changed.
 - Off (blink): Appears when the accelerating voltage is stopped.
- Filament status: Displays one of the following messages.
 - Not Ready: Appears when the beam is not ready to be turned on.
 - Ready: Appears when you can turn on the beam.
 - On: Appears when the beam is being emitted.
 - On (blink): Appears when the beam emission is being changed.
- HT: Displays accelerating voltage presently being applied (in kV).
- Beam Current: Displays beam current presently being applied (in μA)

② HT

- ON: When HT Status is Ready, clicking on this button turns on the accelerating voltage; when HT Status is Not Ready, this button is inoperable.
- OFF: Turns off the accelerating voltage.

- ▼▲ buttons: Increases or decreases the accelerating voltage by the amount specified in the Step input box each time the button is clicked.
 - Step: Specifies the voltage change every time the ▼ or ▲ button is clicked on.
-  You cannot operate the ON and OFF buttons while electron beams are being emitted. You can operate the ▼▲ buttons and Step during emission.
- ③ Filament
- ON: Turns on beam emission.
 - OFF: Turns off beam emission.
 - ▼▲ buttons: Increases or decreases the beam emission. The ratio of the set emission value to the maximum appears at the right of the buttons. In the combo box the change value appears every time the ▼ or ▲ button is clicked.
-  You cannot set the emission higher than that set in the Filament max limit ⑥.
-  You cannot turn on the filament if Filament status is Not Ready.
- ④ Conditioning
- Implements HT conditioning.
-  Use this button only when a JEOL service engineer asks you to operate.
- ⑤ Auto HT
- Start: Automatically steps up or steps down the accelerating voltage.
 - Stop: Automatically stops stepping up or stepping down the accelerating voltage and holds it steady.
 - Target: Specifies the desired accelerating voltage using the ▼▲ buttons.
 - Step: Specifies the voltage change per step in automatic step up mode.
 - Time/Step: Specifies the time between steps in automatic step up mode.
-  If the ON button is not selected in HT ②, you cannot use Auto HT.
-  When you specify Step and Time/Step, the required time is displayed after “Time to finish” under the status bar.
- ⑥ Filament max limit
- Specify the maximum current applied to the filament.
- ⑦ Bias
- Specify the bias electrode setting for pulling out electron beams.
- ⑧ Filament Condition
- Specify the filament status in use.
- Normal: Click on this button when observing ordinary images.
 - Filament Image: Click on this when observing a filament image.
- ⑨ Filament Control Speed
- Specify the ascending speed of the filament current.
- Normal Setup: Applies the current to the filament at the speed set in the factory.
 - Degas Setup: Click on this button when degassing the filament. Specify the ascending time in the combo box.
- ⑩ More
- When you select this, the items from 4 to 9 appear on the screen. This is not selected in default setting.

■ Operation window

This window opens when you click on Operation in the Dialogue menu in the TEM Controller menu bar.

● Standard tab

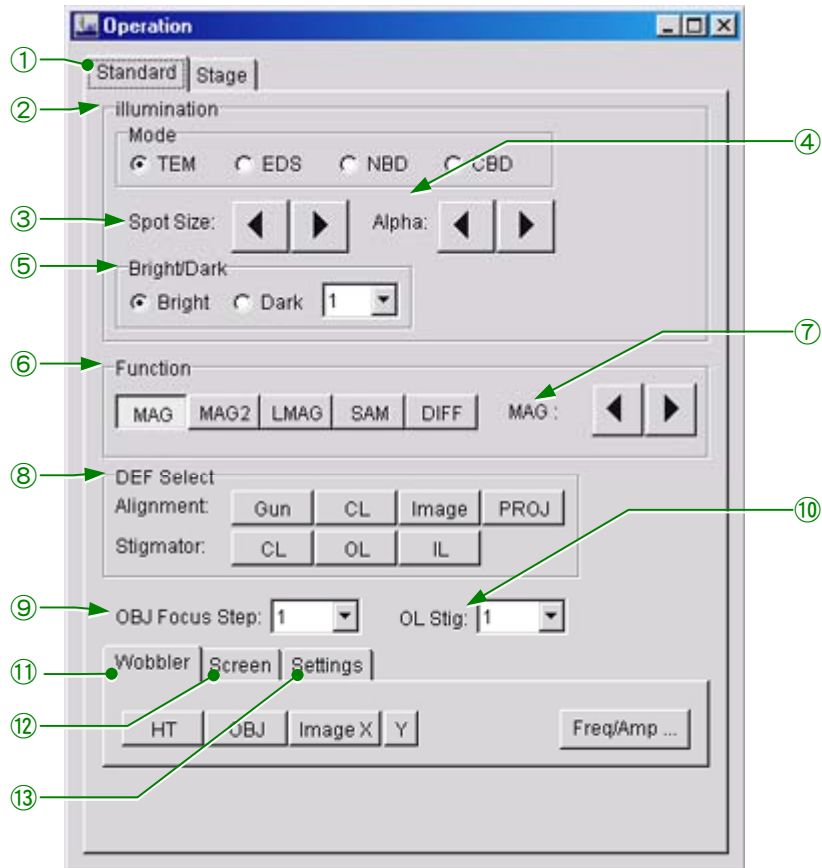


Fig. 4.23 Standard (Operation window)

- ① **Standard tab**
Open the Standard tab.
- ② **Mode**
The radio buttons select the TEM, EDS, NBD, or CBD illumination mode.
~~✗~~ You cannot select NBD and CBD in the HC configuration.
- ③ **Spot Size**
The arrows (◀ ▶) change the beam spot size. Each time you click on the right arrow (▶) button, the spot size (minimized using the BRIGHTNESS control) increases by one step. Every time you click on the left arrow (◀), the spot size decreases by one step.
- ④ **Alpha**
The ◀ and ▶ buttons change the convergent angle.
~~✗~~ This button is not displayed in the HC configuration.
- ⑤ **Bright/Dark**
The radio buttons select the bright-field or dark-field image mode.

⑥ Function

Specifies the imaging system mode. You can change the magnification, camera length in the selected mode using the arrow buttons. Since these settings are saved when the mode is changed, you can restore these settings by selecting the previous mode.

- MAG Normal magnification
- MAG2 Special magnification (no memory in this mode). You can change the magnification using the MAG/CAM L knob (R1-⑤) if necessary.
- LMAG Very low magnification mode.
- SAM Selected-area magnification mode.
- DIFF Selected-area diffraction mode. You can change the camera lengths for selected-area diffraction, high-resolution diffraction, and high-dispersion diffraction using the MAG/CAM L knob if necessary. The settings are displayed in the data display of the TEM Controller window.

⑦ MAG

When the MAG, MAG2 or LWO MAG switch is pressed, the magnification can be changed using the arrow buttons. When SAM is selected, the selected area magnification can be changed. When DIFF is selected, the camera length can be changed. Each time you click on the right arrow (▶) button, the setting increases by one step. Each time you click on the left arrow (◀) button, the setting decreases by one step.

⑧ DEF Select

Assigns functions to the SHIFT knobs (L1-⑧ and R1-③) and the DEF/STIG knobs (L1-⑩ and R1-④).

Alignment

- Gun Assigns Gun Shift to the SHIFT knobs, and Gun Tilt to the DEF/STIG knobs.
- CL Assigns Beam Shift to the SHIFT knobs and Beam Tilt to the DEF/STIG knobs.
- Image Assigns image shift to the DEF/STIG knobs.
- PROJ Assigns PL alignment to the DEF/STIG knobs.

Stigmator

- CL Assigns CL astigmatism correction to the DEF/STIG knobs.
- OL Assigns OL astigmatism correction to the DEF/STIG knobs.
- IL Assigns IL astigmatism correction to the DEF/STIG knobs.

⑨ OBJ Focus Step

Changes the objective lens focus control step size.

⑩ OL Stig

Up to 5 sets of settings for the OL astigmatism-correction coil can be recorded using this input box. You can restore the instrument to a desired set of OL astigmatism-correction conditions by selecting the memory number from this box.

⑪ Wobbler tab

Opens the Wobbler window containing the following selection buttons for the wobblers.

- HT Oscillates the accelerating voltage. It is used for voltage-axis alignment.
- OBJ Oscillates the OL current. It is used for current-axis alignment.
- Image X Oscillates the image in the X direction.
- Y Oscillates the image in the Y direction.
- Freq/Amp Opens the EOS Property window (☞ Figs. 4.38, 4.39). You can specify the frequency and amplitude of each wobbler.

⑫ Screen tab



Fig. 4.24 Screen window

- OPEN Raises the large fluorescent screen to the angle specified using the radio buttons.
- Angle Specifies the angle (7° or 90°) to which to raise the fluorescent screen when you click on the OPEN button.

⑬ Settings tab



Fig. 4.25 Settings window

- OUF Selects the amount to underfocus the image. Settings—OFF, 1: small, 2: medium, and 3: large.
- MAG2 Specifies the currently selected magnification as the default setting when MAG2 is selected using the Function switch (R1-②) and the MAG/CAM L knob (R1-⑤).
- STD Focus Sets up with the focus value predefined by JEOL.

● Aperture tab

This window is used for operating the motor-driven aperture assembly when it is installed. You cannot operate the aperture in this window when the aperture is not motor-driven.

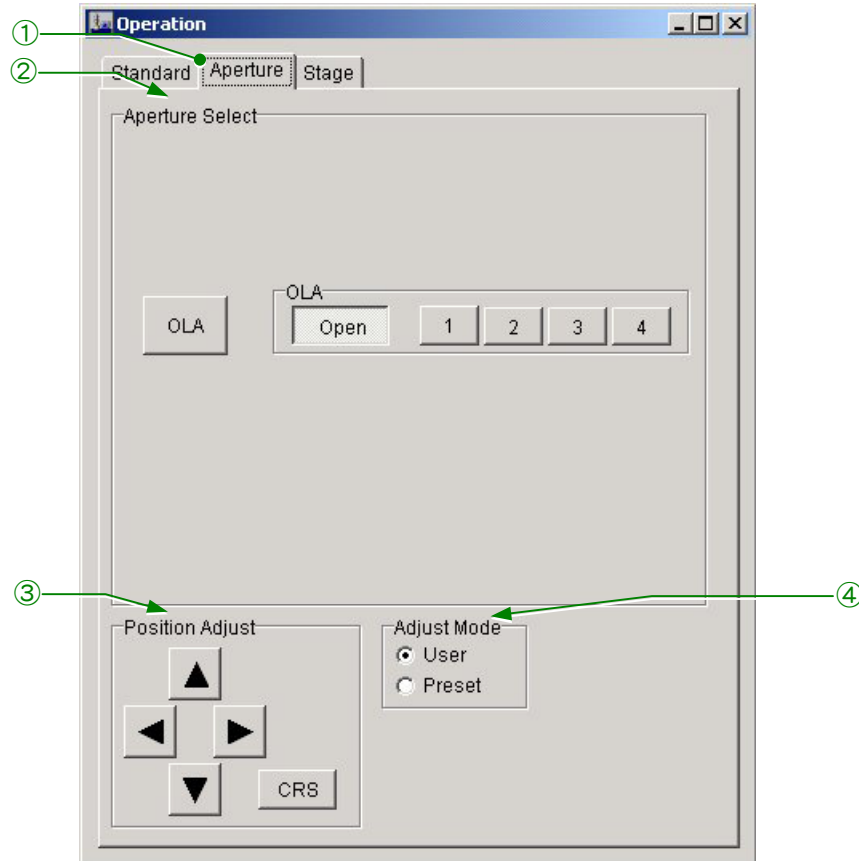



Fig. 4.26 Aperture (Operation window)

- ① **Aperture tab**
Open the Aperture tab.
- ② **Aperture Select**
Select the aperture to insert and the aperture diameter to use.
 You cannot operate the aperture in this window when the aperture is not motor-driven.
- ③ **Position Adjust**
 - X, Y arrow buttons: Using these buttons, adjust the position of the motor-driven aperture selected in Aperture Select.
 - CRS: Clicking on this button increases the movement by 16 times when you press the arrow button.
- ④ **Adjust Mode**
Switches fine-adjustment modes of the aperture position.
 - User: Adjusts the whole position of the aperture.
 - Preset: Stores the position proper to the aperture number in memory.

● **Stage tab**

You can access this tab only while a specimen holder is inserted in the microscope column.

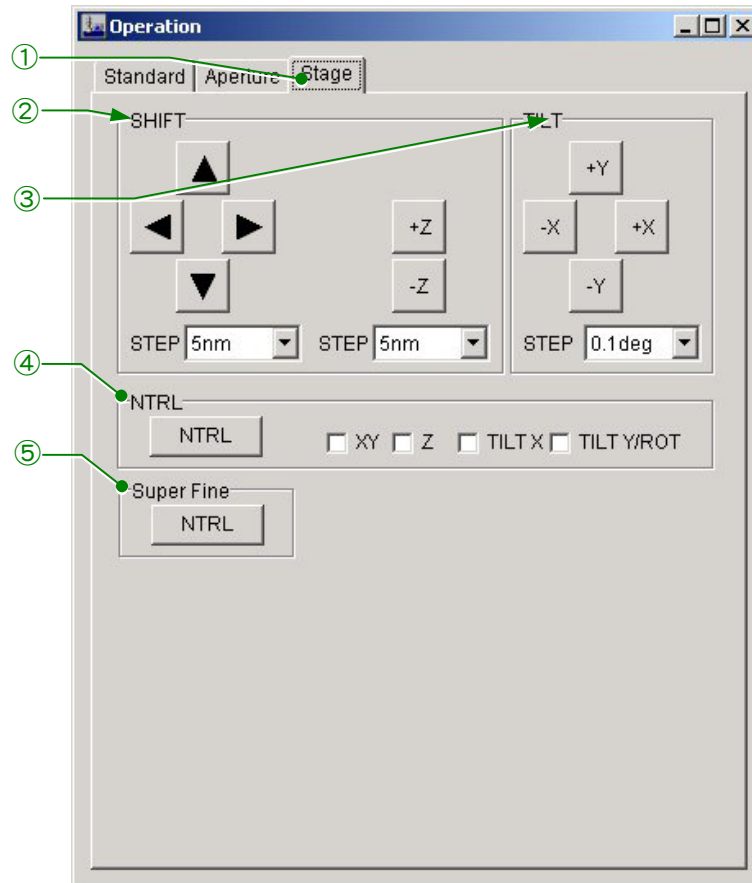


Fig. 4.27 Stage (Operation window)

- ① **Stage tab**
Open the Stage tab.
- ② **SHIFT**
Moves the specimen in the direction corresponding to the arrow button that you click on. The $\pm Z$ buttons move the specimen in the Z direction. The STEP input boxes specify the amount of movement per step.
- ③ **TILT**
Tilts the specimen in the direction corresponding to the TILT button that you click on. The tilt per step can be specified using the STEP input box below the buttons.
~~✗~~ Using the single-tilt holder configuration, tilting in the Y direction is not possible.
- ④ **NTRL**
Resets the SHIFT and TILT control settings to the middle positions.
- ⑤ **Super Fine**
Clicking on the NTRL button moves the stage to the middle positions of the piezo movement.
~~✗~~ For piezo movement, the optional Piezo Device Movement Power Supply is required.

■ Specimen Position window

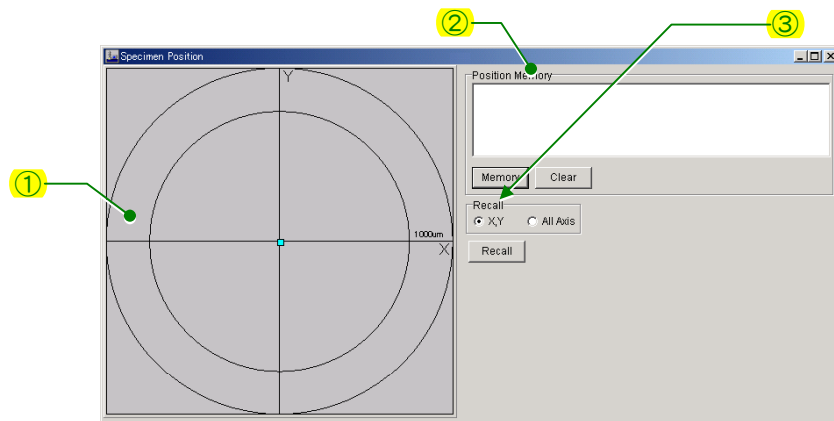


Fig. 4.28 Specimen Position window

- ① **Specimen position indicator**
Indicates the specimen position, viewed from the Z axis, which is being observed or which was recorded using the Memory button (② in Fig. 4.28).
- ② **Position Memory**
- **Memory** Records the present observation position. The coordinates of the recorded specimen position are displayed on the window above and the position is displayed in the left window.
 - **Clear** Erases the presently selected specimen position records from the memory.
- ③ **Recall**
- **Recall** Clicking on this button moves the specimen stage to the position whose coordinates are stored and selected from the Position Memory window (② in Fig. 4.28).
 - XY** When selected, moves the specimen stage to the X and Y coordinates.
 - All Axis** When selected, moves the specimen stage to the X, Y, and Z coordinates.

■ Film Camera Property window

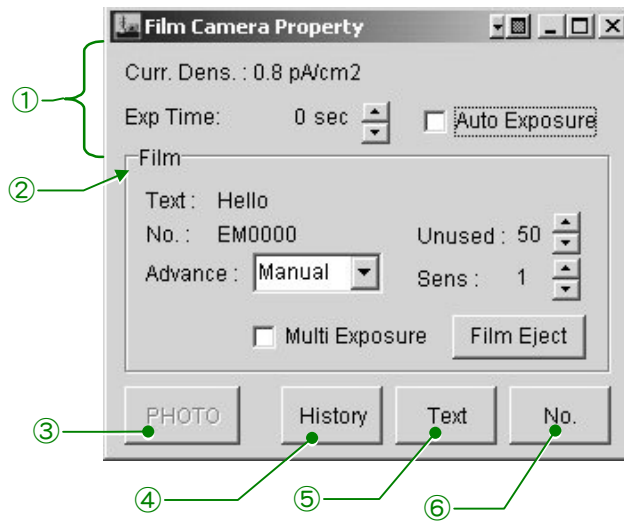


Fig. 4.29 Film Camera Property window

① Basic information

- Curr. Dens. Beam current density (in pA/cm²) on the fluorescent screen.
- Exp Time Exposure time; in manual mode, variable using the up arrow (▲) or down arrow (▼) button.
- Auto Exposure Checking this sets the camera to automatic-exposure mode.

② Film

- Text Text to print on the film
- No. Film number to print on the film
- Advance: Film feed switch
 - Manual Manual mode: pressing the PHOTO switch (R1-⑧) moves the film cassette into photographing position.
 - Auto1 Automatic mode 1: after an exposure started using the PHOTO switch (R1-⑧) ends, an unexposed film cassette moves to photographing position.
 - Auto2 Automatic mode 2: pressing the PHOTO switch (R1-⑧) moves the film cassette to the photographing position to expose the film.
- Unused Number of unused films. The number can be varied using the ▲ and ▼ buttons.
- Sens Exposure meter sensitivity. The sensitivity can be changed using the ▲ and ▼ buttons.
- Multi Exposure Check to set the camera to double-exposure mode.
- Film Eject Clicking on this button moves the film to the receiving magazine.

③ PHOTO

Clicking on this button advances the film and photographs following the mode specified in the Advance box.

④ History

Opens the Photo History window (☞ Fig. 4.20).

⑤ Text

Clicking on this button opens the Text Input Box. You can input text to put on the film. To do this, enter the text using the keyboard and click on the OK button.

⑥ No.

Clicking on this button opens the No. Input Box. You can input a film number. Do this using the keyboard. Then click on the OK button. Click instead on Cancel to close the box without saving the input.

4.3.5c Monitor

- Status

Opens the Status Monitor window. Using this window, you can display the operating conditions of the microscope and the status of the alarms.

- Vac Sys

Opens the Valve Status window. This window contains the evacuation system diagram.

- Dark Window

Dims the monitor screen.

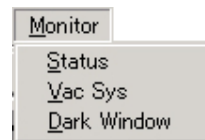


Fig. 4.30 Monitor menu

■ **Status Monitor window**

① **Standard tab**

The information shown in this window is the same as that shown in the TEM Controller main window.

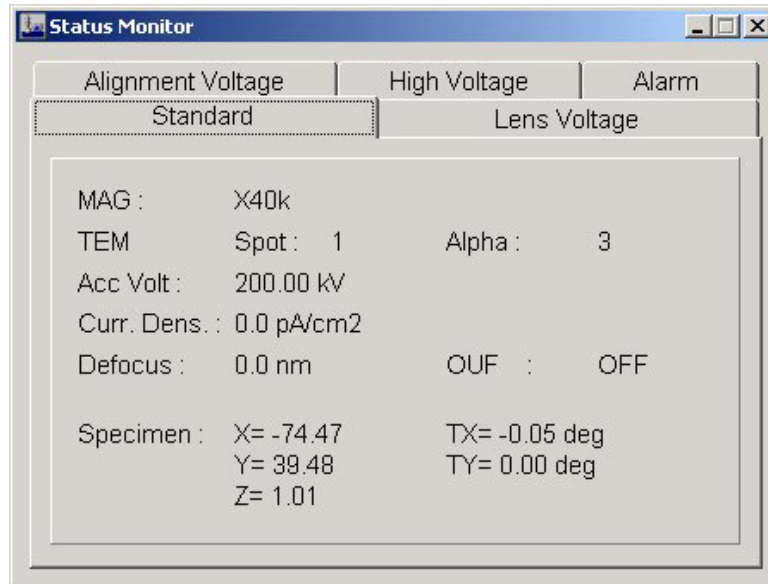


Fig. 4.31 Standard (Status Monitor window)

② **Lens Voltage tab**

Displays the lens voltages.

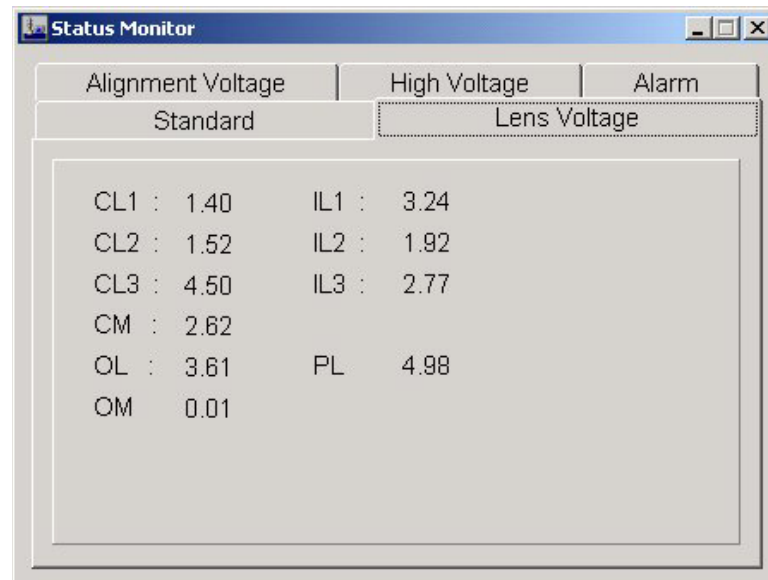
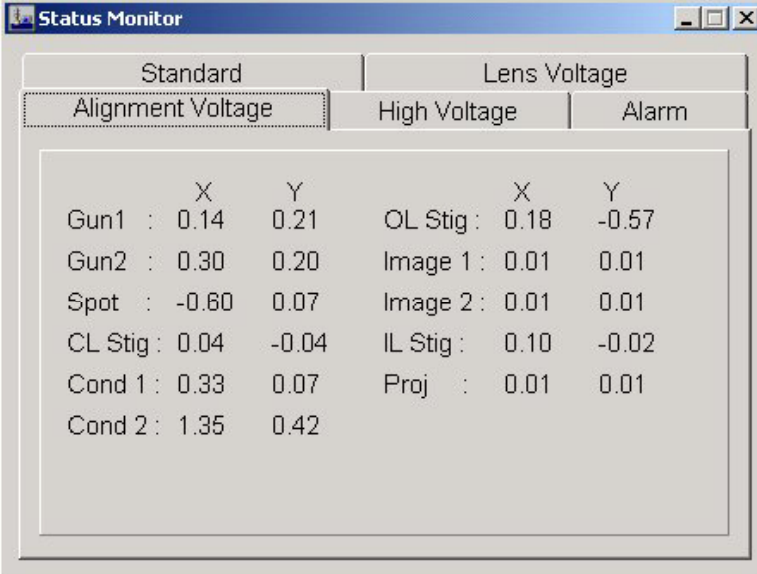


Fig. 4.32 Lens Voltage (Status Monitor window)

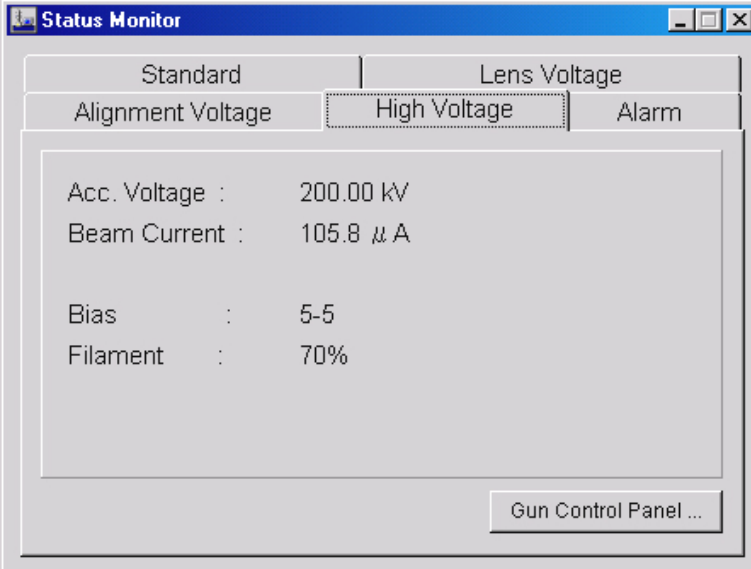
- ③ Alignment Voltage tab
Displays the beam deflector voltages.



Standard			Lens Voltage		
Alignment Voltage			High Voltage		Alarm
	X	Y		X	Y
Gun1 :	0.14	0.21	OL Stig :	0.18	-0.57
Gun2 :	0.30	0.20	Image 1 :	0.01	0.01
Spot :	-0.60	0.07	Image 2 :	0.01	0.01
CL Stig :	0.04	-0.04	IL Stig :	0.10	-0.02
Cond 1 :	0.33	0.07	Proj :	0.01	0.01
Cond 2 :	1.35	0.42			

Fig. 4.33 Alignment Voltage (Status Monitor window)

- ④ High Voltage tab
Displays the accelerating voltage and beam current.



Standard		Lens Voltage	
Alignment Voltage		High Voltage	
Acc. Voltage :	200.00 kV		
Beam Current :	105.8 μ A		
Bias :	5-5		
Filament :	70%		

Gun Control Panel ...

Fig. 4.34 High Voltage (Status Monitor window)

- Acc. Voltage: Present accelerating voltage
- Beam Current: Present beam current
- Bias: Present bias setting
- Filament: Present filament setting
- Gun Control Panel...: Clicking on this button opens the High Voltage Control window (☞ Fig. 4.22).

⑤ Alarm tab

Displays the status of the air compressor, vacuum pumps, Penning gauge and reservoir. An indicator lamp turns red when an abnormality occurs in the corresponding system.

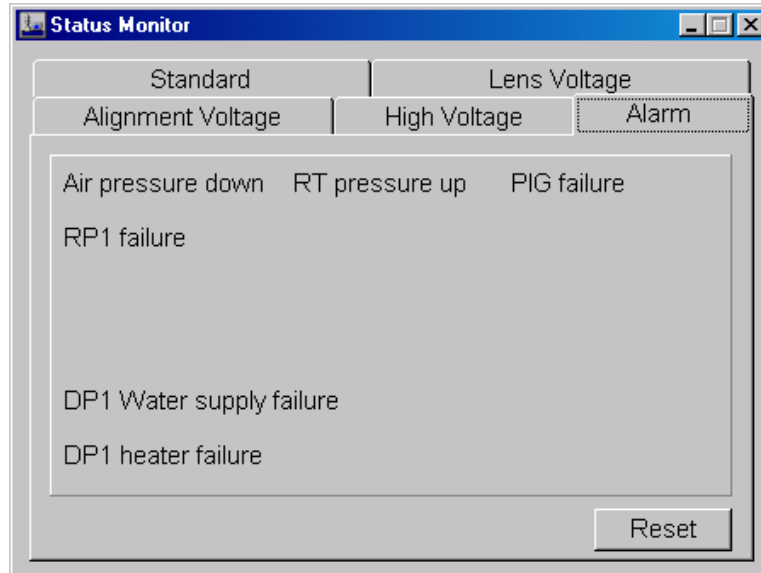


Fig. 4.35 Alarm (Status Monitor window)

✍ Fig. 4.35 shows the case for the EM-23110 SIP Vacuum Pump Unit. The following items are displayed.

- AIR pressure down: Air compressor pressure down supplying compressed air to the microscope.
- RT pressure up: Vacuum pressure up in the reservoir tank
- PIG failure: Penning vacuum gauge failure
- RP1 failure: Rotary pump 1 failure
- DP1 water supply failure: Diffusion pump cooling-water system failure
- DP1 heater failure: Diffusion pump heater circuit failure

✍ The following items are displayed for the EM-23120 TMP Vacuum Pump Unit.

- AIR pressure down: Air compressor pressure down supplying compressed air to the microscope.
- RT pressure up: Vacuum pressure up in the reservoir tank
- PIG failure: Penning vacuum gauge failure
- RP1 failure: Rotary pump 1 failure
- RP2 failure: Rotary pump 2 failure
- DP1 water supply failure: Diffusion pump cooling-water system failure
- DP1 heater failure: Diffusion pump heater circuit failure
- TMP failure: Turbomolecular pump revolution failure

4.3.5d Property

- EOS
Opens the EOS Property window. This window is used to set the wobbler conditions.
- Stage
Opens the Specimen Property window. This window is used to set the goniometer operating conditions.



Fig. 4.36 Property menu

Valve Status window

- Vacuum system (system diagram)
 - Displays conditions of electromagnetic and pneumatic valves, statuses of Pirani gauges and their readings. Each of the valve lamps lights while the corresponding valve is open and is out while the valve is closed.

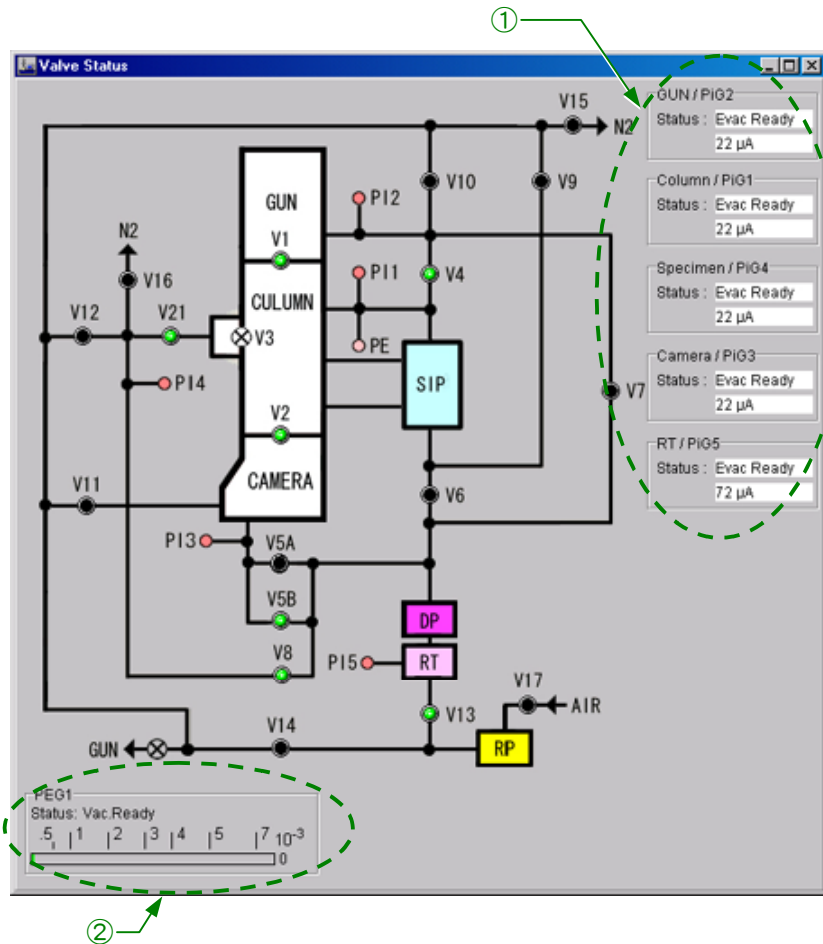


Fig. 4.37 Valve Status window

① Pirani gauge status

- GUN/PiG2: Gun chamber (PI2) status and Pirani gauge reading
- Column/PiG1: Column (PI1) status and Pirani gauge reading
- Specimen/PiG4: Specimen chamber (PI4) status and Pirani gauge reading
- Camera/PiG3: Camera chamber (PI3) status and Pirani gauge reading
- RT/PiG5: Reservoir 1 (PI5) status and Pirani gauge reading

Fig. 4.37 shows the case for the EM-23110 SIP Vacuum Pump Unit. There are cases when the Pirani gauge is not displayed, depending on the pumping system configuration.

② PEG1

Displays the status of the Penning gauge; as the pressure decreases, the status changes from OFF through Evac. Low and Evac. High to Vac. Ready.

■ **EOS Property window**
 ● **Wobbler Freq/Amp tab**

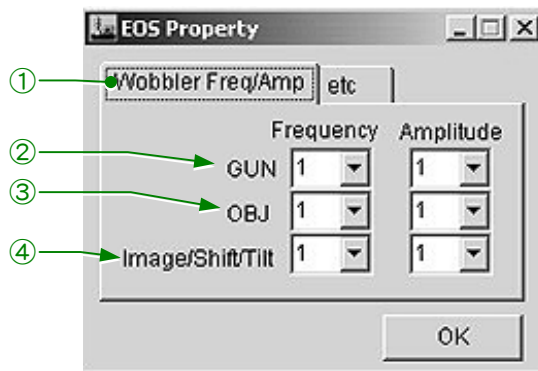


Fig. 4.38 Wobbler Freq/Amp (EOS Property window)

- ① **Wobbler Freq/Amp**
 Open the Wobbler Freq/Amp tab.
- ② **GUN**
 Frequency Sets wobbler frequency for the gun 1st deflection coil.
 Amplitude Sets wobbler amplitude for the gun 1st deflection coil.
- ③ **OBJ**
 Frequency Sets wobbler frequency for the objective lens.
 Amplitude Sets wobbler amplitude for the objective lens.
- ④ **Image/Shift/Tilt**
 Frequency Sets wobbler frequency for image, electron beam shift and tilt.
 Amplitude Sets wobbler amplitude for image, electron beam shift and tilt.

● **etc tab**

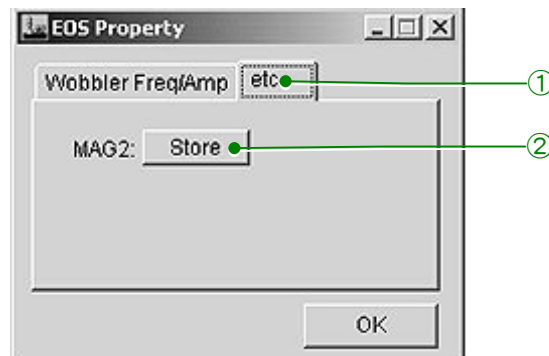


Fig. 4.39 etc (EOS Property window)

- ① **etc tab**
 Open the etc tab.
- ② **Store**
 While the MAG2 function button (R1-②) is pressed, clicking on Store sets the default value of MAG2 to the present magnification.

■ Specimen Property window

This window is used for the specimen holder settings.

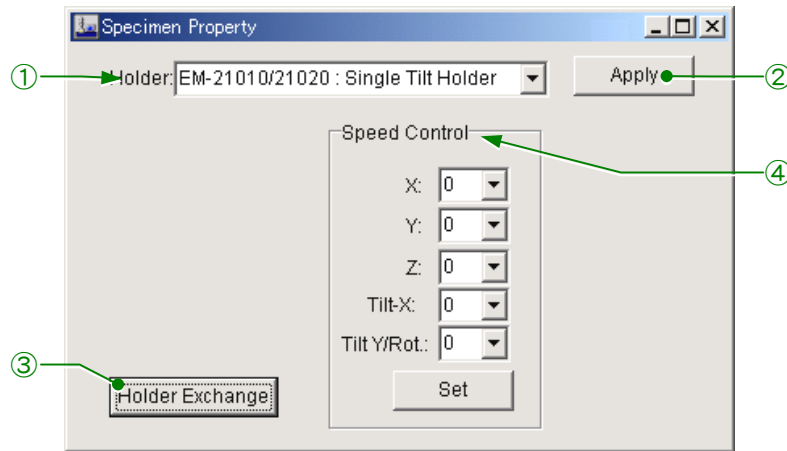


Fig. 4.40 Specimen Property window

① Holder

Select the holder in use from the list.

② Apply

Specifies the holder selected at ①.

③ Holder Exchange

Sets the X, Y, Z, Tilt X and Y controls to their central positions. Click on this button before you unload the specimen holder.

④ Speed Control

Adjusts speeds. To do this, click on the triangle button to open the pop-up window containing a list of available speeds; click on the speed you want to use; then, click on the Set button.

4.3.5e Option

MDS	Opens the MDS window. This window is used for taking photos in MDS mode.
Free Lens Control	Opens the Free Lens Control window. This window is used for setting lens current.
Mag Select	Opens the Mag Select window. This window is used for setting magnifications and camera lengths.
Lens/Def Memory	Opens the Lens/Def Memory window.



Fig. 4.41 Option menu

■ MDS window

This window is used for performing the minimum dose exposure system (MDS).

☞ For details of the MDS, refer to Sect. 5.15.1.

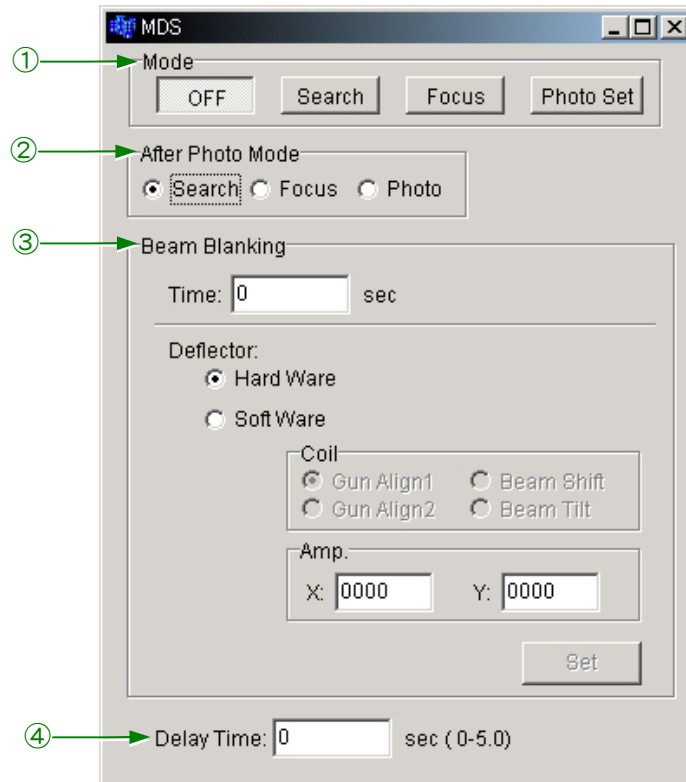


Fig. 4.42 MDS window

- ① **Mode**
 - Off Switches from MDS to normal mode.
 - Search Switches to MDS Search mode.
 - Focus Switches to MDS Focus mode.
 - Photo Set Switches to MDS Photo set mode.
- ② **After Photo Mode**
 - Sets the default mode after completion of photography.
- ③ **Beam Blanking**
 - Time Sets the beam blanking time.
 - Deflector Sets the beam blanking method.
- ④ **Delay Time**
 - Sets the delay time.

■ FLC (Free Lens Control) Panel window

This window is used for performing the free lens control.

☞ For details of free lens control, refer to Sect. 5.15.2.

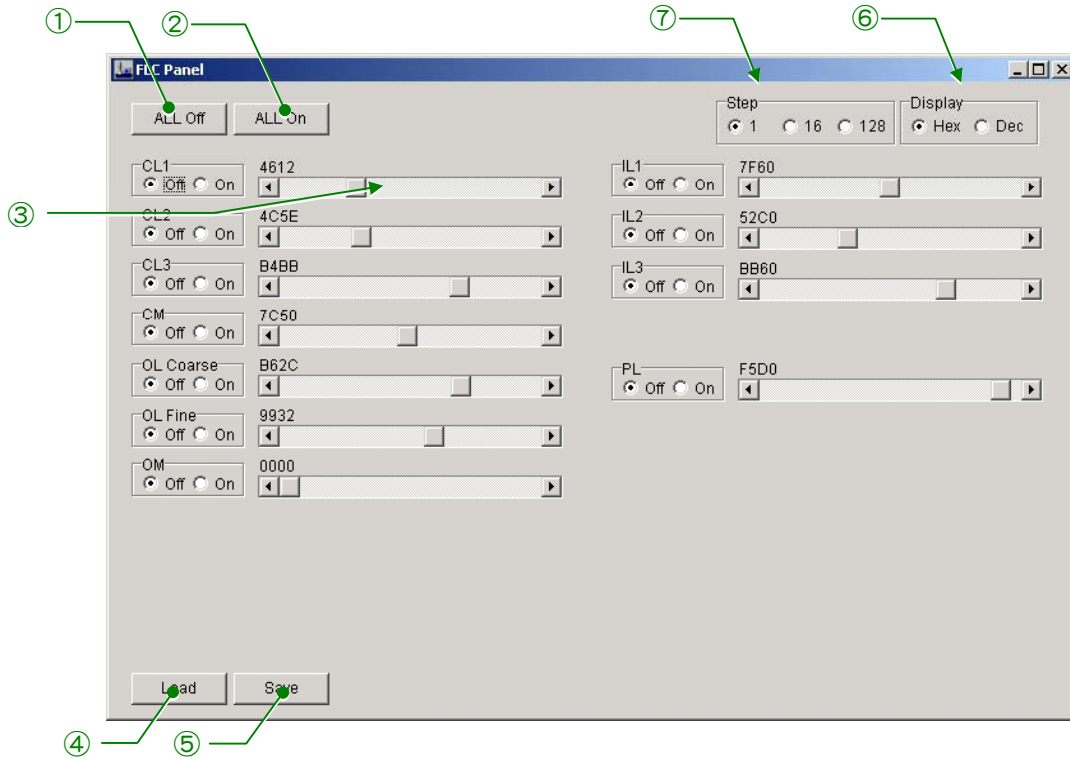


Fig. 4.43 FLC Panel window

- ① **ALL Off**
Turns off the controls of all lenses.
- ② **ALL On**
Turns on the controls of all lenses.
- ③ **Control slider**
Sets the lens current you want to use.
- ④ **Load**
Loads the recorded lens current from a file.
- ⑤ **Save**
Saves the present lens current.
- ⑥ **Display**
Selects whether to display the lens current in hexadecimal or decimal.
- ⑦ **Step**
Sets the step size for lens current.

■ MAG Select window

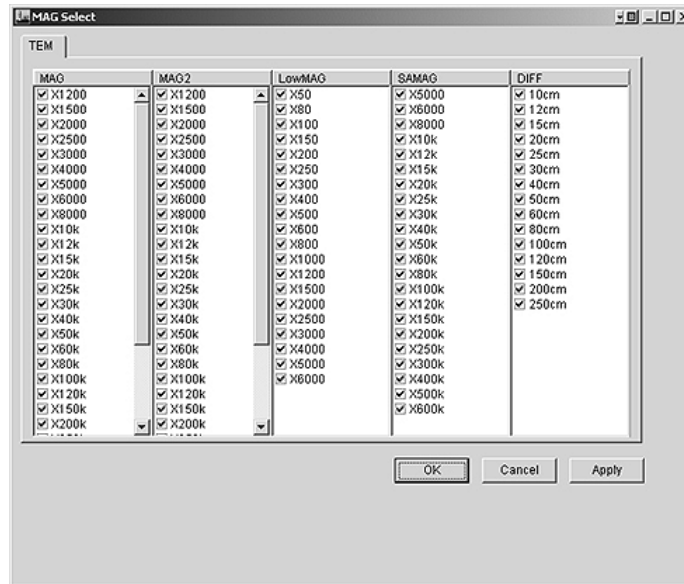


Fig. 4.44 MAG Select window

When you turn the MAG/CAM L knob (R1-⑤), the image appears at those magnifications and camera lengths having check marks. Deselecting the check boxes in this window disables the corresponding magnifications and camera lengths.

■ Lens/DEF Memory window

You can save the desired lens and beam deflector coil currents using this window.

For details, refer to Sect. 5.15.6.

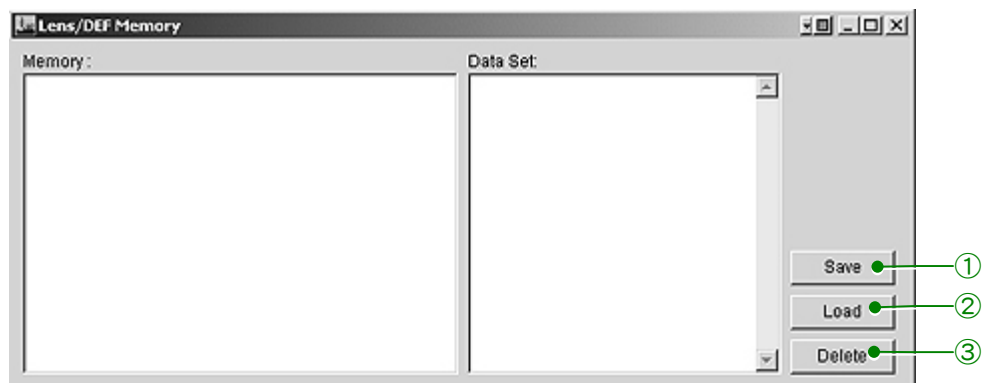


Fig. 4.45 Lens/DEF Memory window

① Save

Pressing this button opens the Lens/DEF Memory Option window. Select the lens and deflector that you want to save in Lens/DEF Memory Option window. The lens name and deflector are displayed in the Memory and Data Set boxes respectively.

② Load

Pressing this button retrieves the current and sets the corresponding lens to that value.

③ Delete

Pressing this button deletes the saved data.

4.3.5f Maintenance

• Alignment

Opens the Alignment Panel for Maintenance window. This window is used for lens alignment.

• ACD & Bake

Opens the Bake Out/ACD Heat window. This window is used to bake out the microscope column and heat the anti-contamination device (ACD).

• Aperture

Opens the Aperture Adjust window. This window is used for setting apertures.

• Stage Limit

Opens the Stage Limit window.

• Network:

- Connect Connects the TEM Server.
- Disconnect Disconnects the TEM Server.

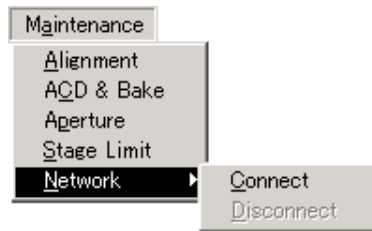


Fig. 4.46 Maintenance menu

■ Alignment Panel for Maintenance window

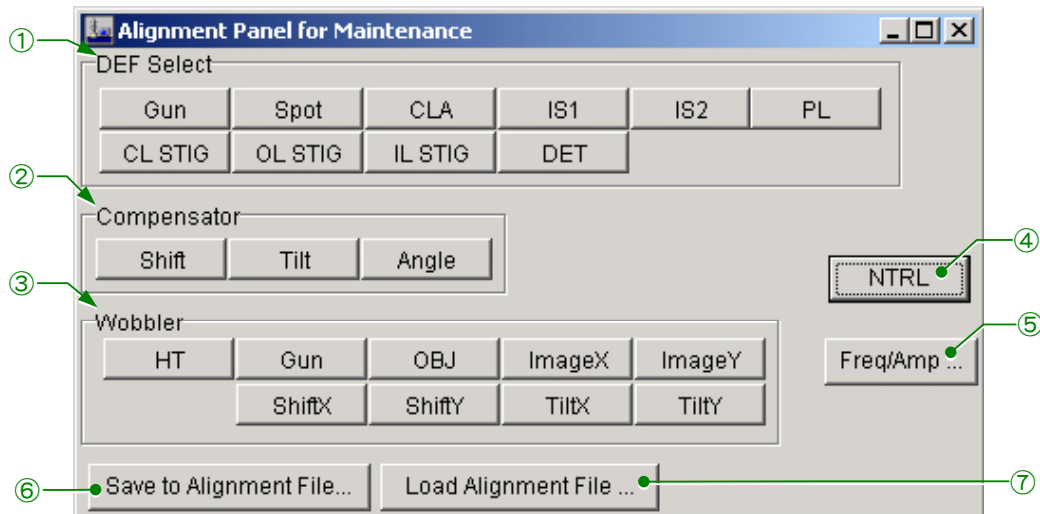


Fig. 4.47 Alignment Panel for Maintenance window

① DEF Select

Assigns functions to the SHIFT knobs (L1-⑧ and R1-③) and the DEF/STIG knobs (L1-⑩ and R1-④). Except during gun alignment, the SHIFT knobs are assigned for Beam Shift (CLA).

- Gun Assigns Gun Shift to the SHIFT knobs and Gun Tilt to the DEF/STIG knobs.
- Spot Assigns spot alignment to the DEF/STIG knobs.
- CLA Assigns Beam Shift to the SHIFT knobs and Beam Tilt to the DEF/STIG knobs.
- IS1 Assigns image shift 1 to the DEF/STIG knobs.
- IS2 Assigns image shift 2 to the DEF/STIG knobs.
- PL Assigns PL alignment to the DEF/STIG knobs.
- CL STIG Assigns CL astigmatism correction to the DEF/STIG knobs.
- OL STIG Assigns OL astigmatism correction to the DEF/STIG knobs.
- IL STIG Assigns IL astigmatism correction to the DEF/STIG knobs.
- DET Used for alignment when an additional detector is attached.

② Compensator

This is used for balancing the beam deflection in the two-stage deflectors. This takes effect when the wobbler is used.

- Shift Assigns the DEF/STIG knobs to Shift Balance.
- Tilt Assigns the DEF/STIG knobs to Tilt Balance.
- Angle Assigns the DEF/STIG knobs to Angle Balance.

③ Wobbler

- HT Clicking on this switch oscillates the accelerating voltage. This switch is used to align the voltage axis with the optical axis.
- Gun Clicking on this switch varies the gun 1st deflection coil current periodically. This switch is used for optical axis alignment.
- OBJ Clicking on this switch varies the objective lens current periodically. This switch is used to align the current axis with the optical axis.

- Image X/Y Clicking on this switch varies the image-shift coil current periodically. This switch is used for focusing.
 - Anode Clicking on this switch varies the 2nd anode voltage periodically. This switch is used for gun axis alignment.
 - Shift X/Y Clicking on this switch varies the CL deflection coil current periodically. This switch is used to adjust Shift Balance.
 - Tilt X/Y Clicking on this switch varies the CL deflection coil current periodically. This switch is used to adjust Tilt Balance.
- ④ NTRL
Resets the lens compensation coil settings selected at DEF Select ① to the middle position.
- ⑤ Freq/Amp...
Opens the EOS Property window (☞ Fig. 4.38).
- ⑥ Save to Alignment File...
Saves data on the astigma and deflection coil currents.
- ⑦ Load Alignment File...
Loads astigma and deflection coil current data in the memory.

■ **Bake Out/ACD Heat window**

● **ACD Heat tab**



Fig. 4.48 ACD Heat (Bake Out/ACD Heat window)

- ① ACD Heat tab
Opens the ACD Heat tab.

② **ACD Heat**

Turns on and off the heater in the liquid nitrogen tank of the anti-contamination device. Used for warming the tank to room temperature.

● **Bake Out tab**

This window is used for baking out the column and stage.

☞ For details of baking out, refer to Sect 6.5.

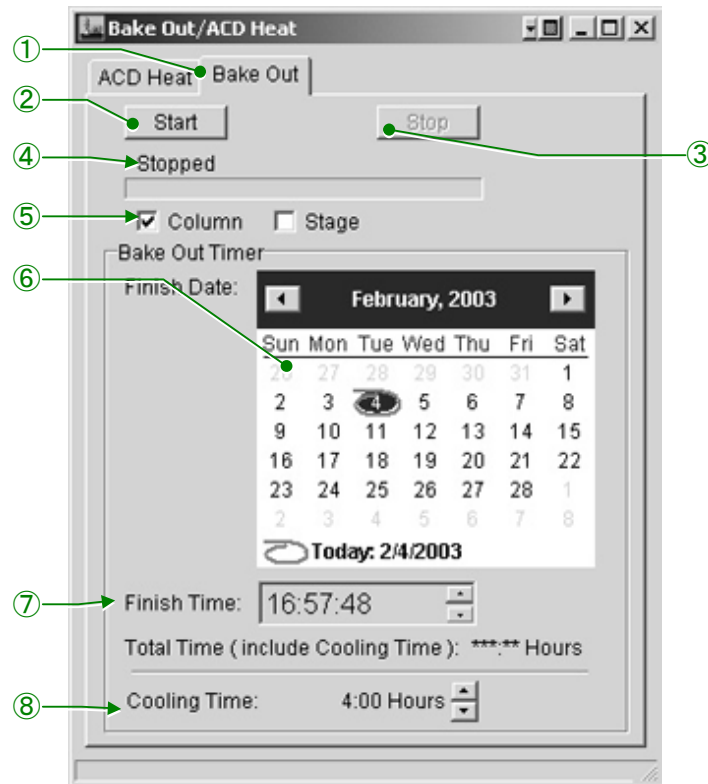


Fig. 4.49 Bake Out (Bake OUT/ACD Heat window)

- ① **Bake Out tab**
Opens the Bake Out tab.
- ② **Start**
Starts the baking.
- ③ **Stop**
Stops the baking.
- ④ **Baking Status**
Indicates the status of baking—Baking, Cooling, and Stopped.
- ⑤ **Places to bake**
Checked sections will be baked.
- ⑥ **Calendar buttons**
Specify the date to finish baking.
- ⑦ **Finish Time**
Specify the time (hours, minutes, and seconds) to finish baking. Use arrow buttons.
- ⑧ **Cooling Time**
Specify the length of time for cooling. Use arrow buttons.

Aperture Adjust window

This window is used for aperture control if the motor-driven aperture assembly is installed.

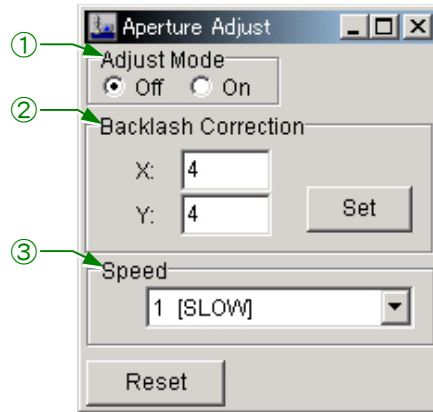


Fig. 4.50 Aperture Adjust window

- ① **Adjust Mode**
Turns on/off Adjust Mode.
- ② **Backlash Correction**
Used for backlash correction.
- ③ **Speed**
Adjusts the speed of movement.

Stage Limit window

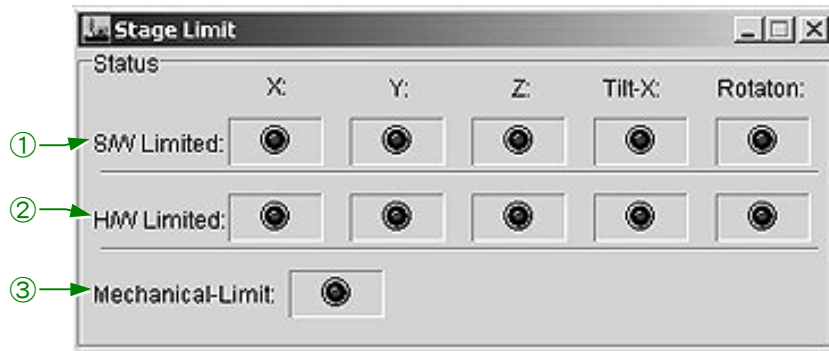


Fig. 4.51 Stage Limit window

- ① **S/W Limited indicators**
Indicate, when lit, that the present specimen position or tilt has reached a preset software limit.
- ② **H/W Limited indicator**
Indicates, when lit, that the stage has reached a hardware limit.
- ③ **Mechanical-Limit indicator**
Indicates, when lit, that the specimen holder is in contact with the aperture or other parts in its environment.

4.3.5g Display

Put In Order

Rearranges the screen's contents.

Stay On Top

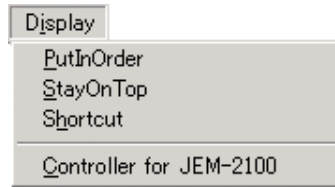
Places the TEM Control window on top of the others.

Shortcut

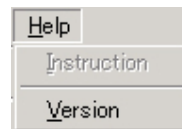
Displays the Short Cut window (shortcut buttons described in Sect. 4. 3.3).

Window name

Displays the window name you are using.

**Fig. 4.52 Display menu****4.3.5h JEOLS**

This command is used for maintenance. For routine operation, there is no need to open it or modify any of the settings.

4.3.5i Help**Fig. 4.53 Help menu**

Instruction

Displays operational instructions.

Version

Displays the software versions.

4.3.6 Emergency (Alarms) Window

This window appears when an abnormality is detected in the microscope. The items concerning the abnormalities are underlined and the corresponding lamps light up (Fig. 4.54 shows the abnormality in EMS OVER: electron beam emission over).

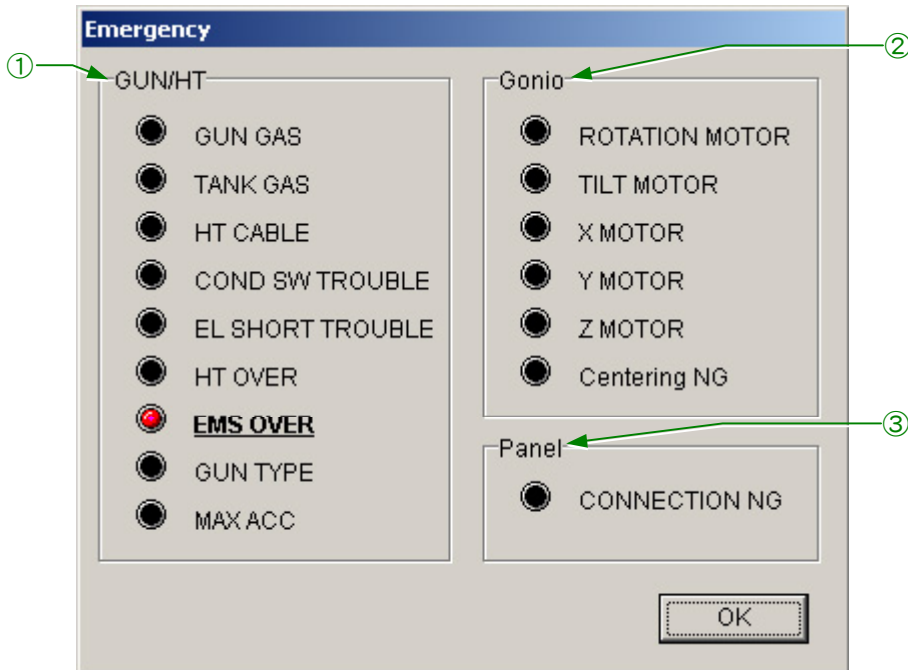



Fig. 4.54 Emergency window

- ① **GUN/HT**
Items concerning the high voltage and electron beam generation
 - ② **Gonio**
Items concerning the goniometer
 - ③ **Panel**
This item is underlined and the red lamp lights up when the connection of the control panel cable(s) is abnormal.
-  This window disappears when the cause of the abnormality is removed. The abnormality sign remains displayed, even if you click on OK, unless the abnormality is removed.

5

OPERATION

5.1	STEPS TO TAKE IN AN EMERGENCY	5-1
5.1.1	Power Failure.....	5-1
5.1.2	Cooling Water Stoppage.....	5-1
5.1.3	Faulty Operation.....	5-1
5.1.4	Emergency Shutdown.....	5-1
5.2	STARTUP AND SHUTDOWN.....	5-2
5.2.1	Startup	5-2
5.2.2	Shutting Down.....	5-2
5.3	FILM LOADING.....	5-3
5.3.1	Loading Films into the Dispensing Magazine.....	5-3
5.3.2	Inserting/Removing the Magazines into/from the Camera Chamber	5-3
5.4	SPECIMEN EXCHANGE	5-6
5.4.1	Loading a Specimen on the Specimen Holder.....	5-6
5.4.2	Inserting the Specimen Holder in the Microscope Column.....	5-7
5.4.3	Removing the Specimen Holder from the Goniometer.....	5-8
5.5	ELECTRON BEAM GENERATION.....	5-9
5.5.1	Turning on the Accelerating Voltage	5-9
5.5.2	Beam Generation.....	5-12
5.5.3	Condenser Lens Alignment.....	5-14
5.5.4	Beam Generation Suspension.....	5-14
5.5.5	Turning off the Accelerating Voltage.....	5-15
5.5.6	Turning on the Electron Beam Using the Automatic Mode.....	5-15
5.6	APERTURES.....	5-17
5.6.1	Condenser Lens (CL) Aperture	5-17
5.6.2	Objective Lens (OL) Aperture	5-18
5.6.3	Field-limiting Aperture.....	5-19
5.7	ILLUMINATION SYSTEM ADJUSTMENT	5-20
5.7.1	Aligning the Illumination System	5-20
5.7.2	Condenser Lens Astigmatism Correction.....	5-21
5.7.3	CL Deflection Coil Adjustment.....	5-21
5.7.3a	Tilt X and Y adjustment.....	5-22

5.7.3b	Shift X and Y adjustment	5-23
5.8	CENTERING CURRENT AND VOLTAGE AXES	5-24
5.8.1	Current Axis	5-24
5.8.2	Voltage Axis	5-25
5.9	OBJECTIVE LENS (OL) ADJUSTMENT	5-26
5.9.1	OL Astigmatism Correction	5-26
5.9.2	Medium Magnification	5-26
5.9.3	High Magnification.....	5-27
5.9.4	Focusing.....	5-28
5.9.4a	Focusing using image wobbler	5-28
5.9.4b	Focusing using Fresnel fringes	5-30
5.9.5	Focusing Using Point Images	5-31
5.10	ELECTRON DIFFRACTION	5-32
5.10.1	Selected Area Diffraction	5-32
5.10.2	Microbeam Electron Diffraction.....	5-33
5.10.3	High-Dispersion Electron Diffraction	5-34
5.11	SPECIAL OBSERVATION	5-36
5.11.1	Bright-Field Image.....	5-36
5.11.2	Dark-Field Image.....	5-36
5.11.3	Low-Magnification Image	5-37
5.12	ANTICONTAMINATION DEVICE	5-39
5.12.1	Filling with Liquid Nitrogen.....	5-39
5.12.2	Returning the Anti-Contamination Device to Room Temperature.....	5-40
5.13	PHOTOGRAPHY	5-43
5.13.1	Film Number and Film Text.....	5-43
5.13.2	Manual Exposure	5-44
5.13.3	Automatic Exposure	5-44
5.13.4	Multiple Exposure	5-45
5.13.5	Image Observation.....	5-46
5.13.6	Film Processing	5-48
5.14	HIGH RESOLUTION ELECTRON MICROSCOPY	5-50
5.15	SPECIAL OPERATION	5-54
5.15.1	Minimum Dose Exposure System (MDS).....	5-54
5.15.2	Free Lens Control (FLC)	5-56
5.15.3	Selecting Magnifications and Camera Lengths	5-57
5.15.3a	Selecting usable magnifications and camera lengths.....	5-57
5.15.3b	Selecting unusable magnifications and camera lengths.....	5-57
5.15.3c	Restoring unusable magnifications and camera lengths	5-57
5.15.4	Setting a Reference Magnification.....	5-58
5.15.5	Saving Alignment Data.....	5-59
5.15.5a	Saving.....	5-59
5.15.5b	Loading.....	5-59
5.15.6	Saving Lens Alignment Data.....	5-60
5.15.6a	Saving.....	5-60
5.15.6b	Loading.....	5-61

The abbreviations L1, R1 and SC, appearing in parentheses after the names of panel controls, designate the respective control panels.

Various objective polepieces can be installed in this instrument. This chapter presents operational procedures that apply when the EM-20710 (ultrahigh resolution polepiece) is used.

Either the EM-23110 or the EM-23120 vacuum system is incorporated in this instrument. The EM-23110 system uses an SIP (sputter ion pump). The EM-23120 system uses a TMP (turbo-molecular pump). This chapter deals with the EM-23110 system.

5.1 STEPS TO TAKE IN AN EMERGENCY

The **Emergency** window (☞ Fig. 4.54) appears when an abnormality is detected in the microscope.

5.1.1 Power Failure

The microscope automatically shuts down safely when power fails. When power returns, restart the microscope (☞ Sect. 5.2.1).

5.1.2 Cooling Water Stoppage

If a water failure continues for a long time, the high voltage power and lens power supplies turn off and the evacuation system goes into safe condition. When the supply of cooling water recommences, restart the microscope (☞ Sect. 5.2.1).

5.1.3 Faulty Operation

The microscope is protected by various safety devices.

5.1.4 Emergency Shutdown

In case of emergency, shut down the microscope by turning off the power distribution board switch. The microscope goes into safe condition. Consult JEOL service personnel.

5.2 STARTUP AND SHUTDOWN

5.2.1 Startup

1. Open the cooling water supply valve.
2. Turn on the power distribution board switch and open the nitrogen gas supply valve.
3. Press the POWER (on) switch (L2-③) to turn on the microscope.
4. Turn on the computer (PC).
5. Start up the TEM server program (☞ Sect. 4.3.1a).
6. Start up the TEM Controller program (☞ Sect. 4.3.1b).

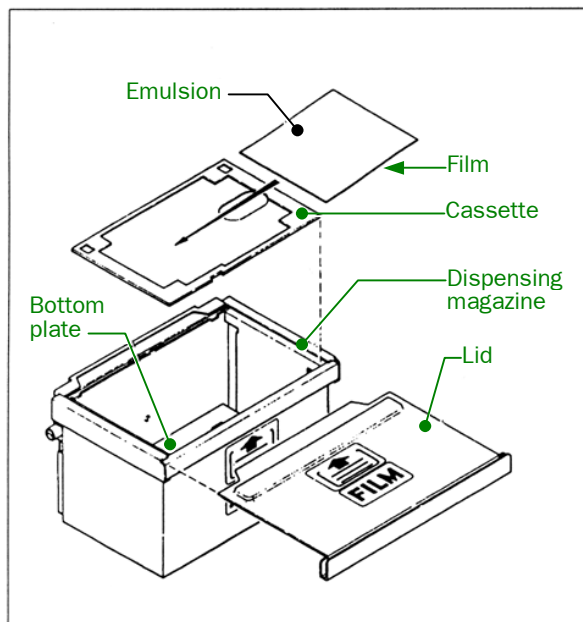
5.2.2 Shutting Down

1. Turn off electron beam emission and turn off high voltage (☞ Sections. 5.5.4 and 5.5.5).
2. Remove the specimen holder (☞ Sect. 5.4.3).
3. Remove all apertures from the beam path (or set it to bulb).
4. Terminate the TEM Controller.
5. Terminate the TEM Server.
6. Shut down the computer.
7. Shut down the microscope using the POWER (off) switch (L2-③).
8. Wait for 5 to 10 minutes; then close the water supply valve and turn off the power distribution board switch.
9. Close the nitrogen gas supply valve.

5.3 FILM LOADING

5.3.1 Loading Films into the Dispensing Magazine

1. Under safelight conditions in the darkroom, insert an unexposed film into each cassette with the emulsion side facing up (☞ Fig. 5.1).
2. Remove the lid from the dispensing magazine (☞ Fig. 5.2) and fully depress the bottom plate until it latches.
Up to 50 cassettes can be loaded in one magazine.
⚠ Do not mistake the dispensing magazine for the receiving magazine.
3. Place the loaded cassettes in the dispensing magazine and replace the magazine lid.



Dispensing magazine



Receiving magazine

Fig. 5.1 Loading films into the dispensing magazine Fig. 5.2 Magazines

5.3.2 Inserting/Removing the Magazines into/from the Camera Chamber

1. Open the nitrogen gas supply valve and turn the camera chamber door handle clockwise until it stops.
The door will open in 5 minutes.
2. Close the nitrogen supply valve.
⚠ If the gas supply valve is closed or the cylinder is empty, the camera chamber door does not open.
⚠ If the door does not open in five minutes after turning the door handle clockwise, turn the handle fully counterclockwise; turn the handle clockwise again; then wait for another five minutes. Repeat these steps until the door opens.
3. Draw out the magazine drawer by pulling the handle (☞ Fig. 5.3).

4. If there is an empty dispensing magazine in the magazine drawer, remove it by lifting it out. Then place the dispensing magazine loaded with unexposed films in the magazine stand.
 - ✎ If the magazine is not placed properly in the magazine stand, it will be impossible to push it smoothly into the magazine stand.
 - ✎ Two dispensing magazines and two receiving magazines (☞ Fig. 5.2) are provided in order to enhance throughput. While one dispensing magazine is being used, the other can be kept in the optional desiccator so that the loaded films are dried and ready to use at any time. Also, one receiving magazine is always ready to replace the other in the camera chamber.
 - ✎ When handling the magazines, be careful not to drop the magazine lid.



Fig. 5.3 Magazine stand

5. If there is a receiving magazine loaded with exposed films in the magazine drawer, remove it by lifting it up, and replace it with an empty receiving magazine.
6. Push the magazine drawer into the camera chamber as far as it will go.
7. Close the camera chamber door; press the door handle toward the door and turn the handle counterclockwise as far as it will go.
 - ✎ Before closing the camera chamber door, check the O-ring and its contact surfaces for dust, lint, and other foreign matter. A dirty O-ring might cause vacuum trouble in the camera chamber.
8. Input the number of unused films (the number of films loaded in the dispensing magazine) in the **Film Camera Property** window (☞ Fig. 5.4 in Sect. 4.3.5b).

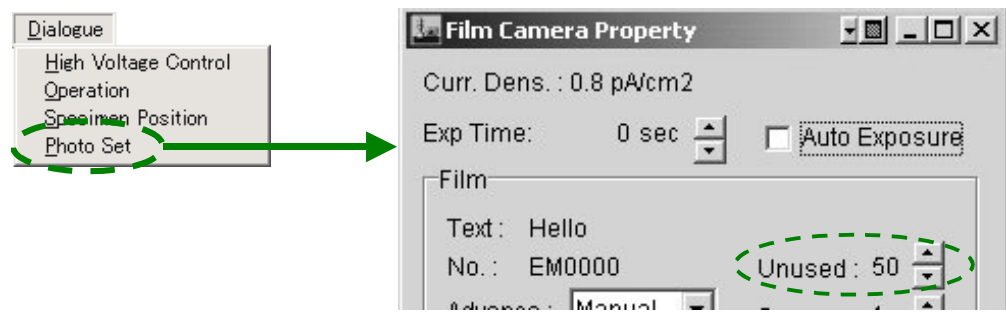



Fig. 5.4 Entering the number of unused films

5.4 SPECIMEN EXCHANGE

5.4.1 Loading a Specimen on the Specimen Holder

This section presents operational procedures that apply when the EM-21010 (SCSH) standard holder /EM-21020 (QR) quick exchange specimen mount is used.

 For information on the other specimen holders, refer to each respective instruction manual.

1. Insert the cartridge handling tool into the cartridge clamp hole at the end of the specimen holder; open the clamp by tilting the tool; then remove the cartridge from the holder.
2. Loosen the specimen retainer screws; rotate the specimen retainer; then remove the specimen.
3. Place a specimen grid with the specimen facing upward in the specimen cartridge.
4. Return the specimen retainer to the original position and secure it with the specimen retainer screws.

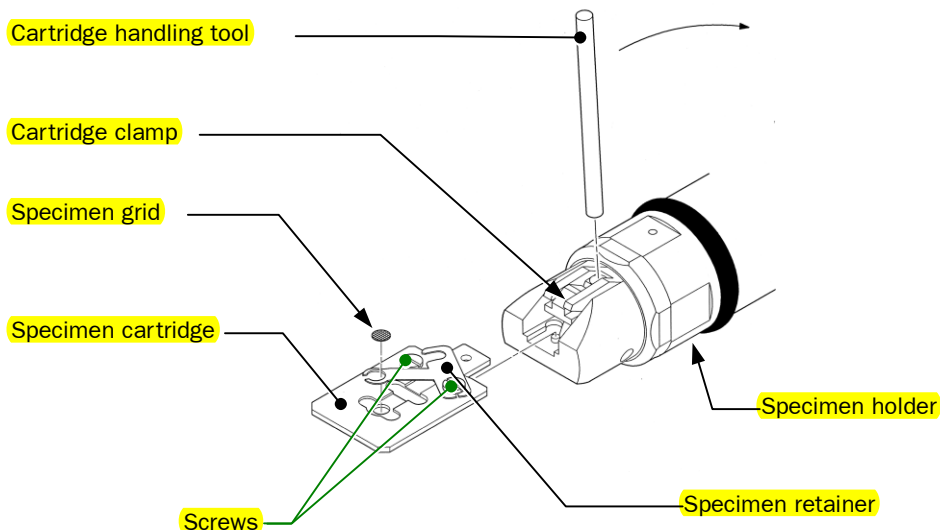





Fig. 5.5 Specimen holder

5. Insert the cartridge handling tool into the cartridge clamp hole at the end of the specimen holder and open the clamp.
6. Attach the cartridge to the holder so that the guide hole on the cartridge aligns with the guide pin on the clamp; then clamp the cartridge by returning the tool to the clamping position.
The cartridge should be firmly secured in the clamp (there should be no gap between the cartridge and the clamp).

5.4.2 Inserting the Specimen Holder in the Microscope Column

⚠ CAUTION

- Be careful no to pinch your fingers between the specimen holder and the goniometer.
- Always hold the specimen holder while the holder is being inserted into the goniometer. If you do not do so, the specimen holder may hit the goniometer causing damage to the goniometer due to the force of the vacuum.

1. Make sure that there is no dust and/or lint on the specimen holder O-ring.
2. Align the specimen holder guide pin with the guide groove on the microscope column (or goniometer); push the holder into the goniometer until it stops and set the goniometer PUMP/AIR switch to PUMP.
The yellow lamp lights up, and evacuation of the goniometer commences.
 Do not turn the holder while carrying out this step.
3. Insert the specimen holder further into the goniometer.
 - a. Turn the specimen holder clockwise after making sure that the green lamp (① in Fig. 4.2) on the goniometer is lit.
 - b. Push the holder into the goniometer as far as it will go.
 - c. Turn it fully clockwise.
 - d. Push it further into the goniometer until it stops ( Fig. 5.8).
The yellow lamp (② in Fig. 4.2) on the goniometer goes out.
4. Select **Property – Stage** in the **TEM Controller** main menu to open the **Specimen Property** window.
5. Select the specimen holder name from the list in the Holder box in the window; then click on **Apply** in the window.
 Omitting this step might cause operational trouble with the goniometer.

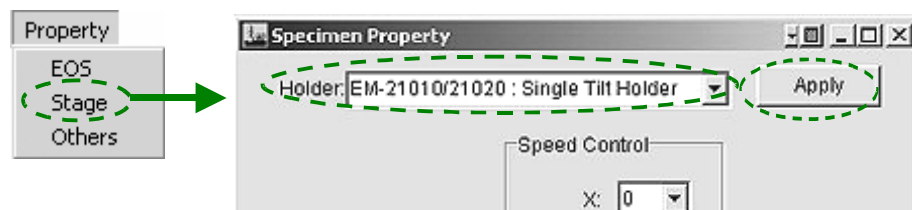


Fig. 5.6 Specimen Property window

5.4.3 Removing the Specimen Holder from the Goniometer

1. Turn off the electron beam (☞ Sect. 5.5.4).
2. Select **Property – Stage** in the **TEM Controller** main menu to open the **Specimen Property** window.
3. Click on **Holder Exchange** in the window to move the specimen to the origin.
 ☞ When a double-tilt specimen holder is used, click on **Holder Exchange** again.

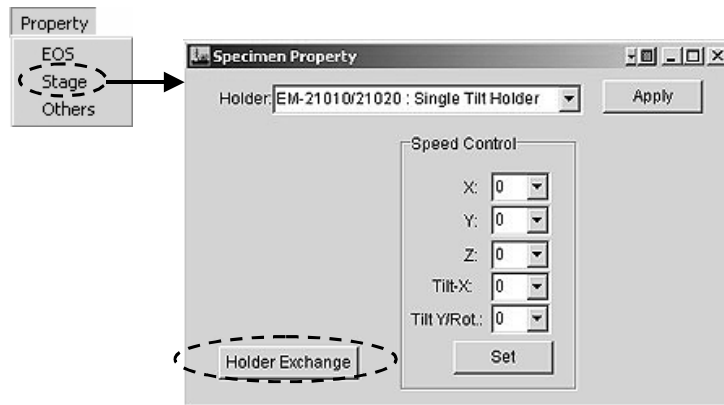


Fig. 5.7 “Holder Exchange” selection

4. Open the nitrogen gas supply valve.
5. Remove the holder from the goniometer as follows:
 - a. Pull the specimen holder until it stops.
 - b. Turn it fully counterclockwise.
 - c. Pull it a bit until it stops.
 - d. Turn it fully counterclockwise.
 - e. Set the PUMP/AIR switch on the goniometer to AIR, and wait 30 seconds.
 - f. Remove the holder from the goniometer.
6. Close the nitrogen gas supply valve.

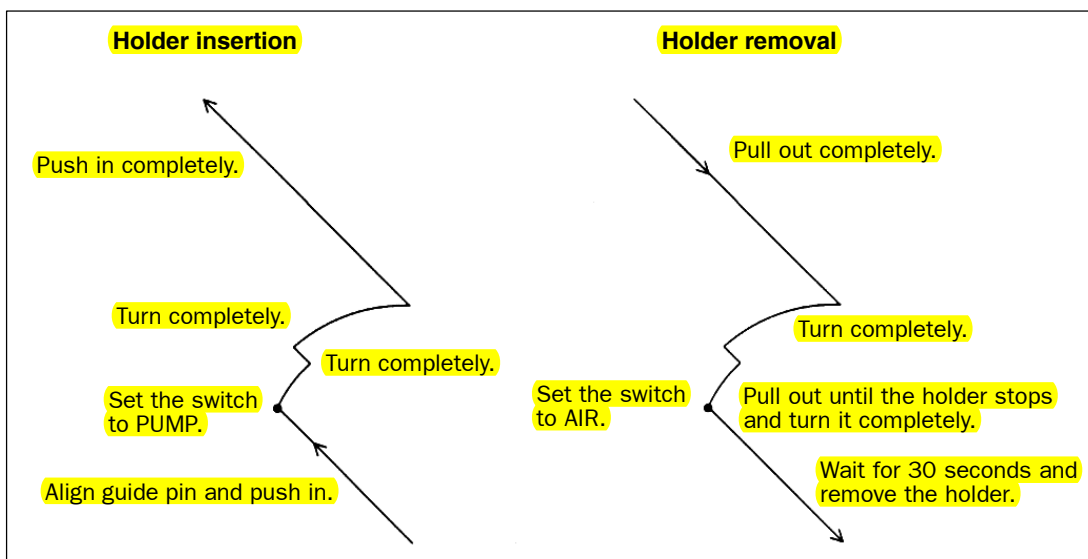


Fig. 5.8 Holder insertion and removal

5.5 ELECTRON BEAM GENERATION

The **High Voltage Control** window (☞ Fig. 4.22) has controls for generating the electron beam.

5.5.1 Turning on the Accelerating Voltage

1. Make sure that the high voltage tank pressure gauge on the high voltage tank reads 0.05 MPa or more.
 - ☞ If the reading is less than 0.05 MPa, refill the tank with SF₆ gas (☞ Chap. 6).
2. Make sure that the reading of the column pressure gauge is 1×10⁻⁴ Pa or lower.
 - ☞ The column pressure gauge (used to measure the pressure in the microscope column) is located on the SIP power supply (☞ Sect. 4.2.6b).
3. Make sure that the HT background in the **TEM Controller** main window is green, and the HT status in the **High Voltage Control** window (Figs. 4.16 and 5.9) is Ready.

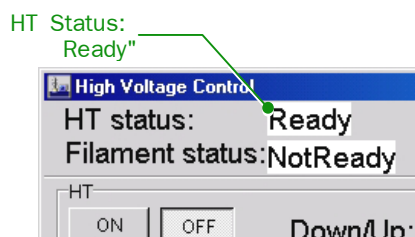


Fig. 5.9 High Voltage Control window

4. Make sure that the specimen holder is inserted into the goniometer.
 - Beam generation is impossible if the specimen holder is retracted from the column.
5. Set a target voltage in the **High Voltage Control** window using the up/down buttons (▼ and ▲) (☞ Fig.5.10).
 - ☞ The increment in voltage may be changed using the up/down buttons which can be selected from the Step drop out window (☞ Fig. 5.10).
6. Click on HT-ON (☞ Fig. 5.10) to start high voltage generation.
 - ☞ HT Status ON in the **High Voltage Control** window blinks and the **Accelerating Voltage** window is displayed. While the **Accelerating Voltage** window is open, you cannot access any other windows (☞ Fig. 5.11).

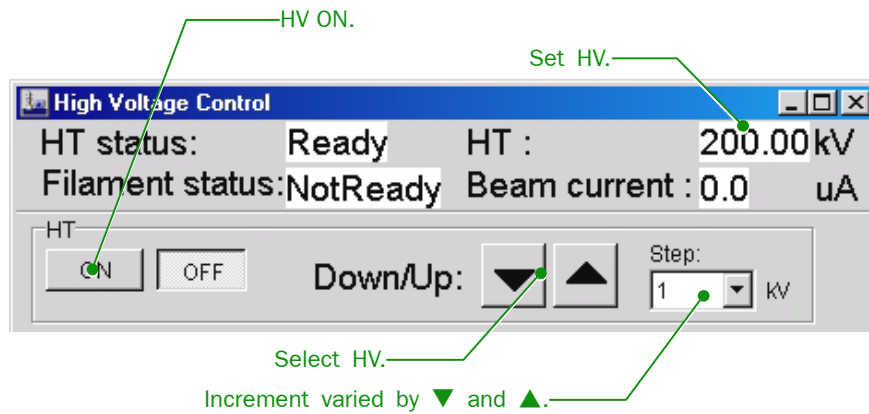


Fig. 5.10 High voltage Control window starting HV generation



Fig. 5.11 Accelerating Voltage window

7. Wait until the Beam Current (detection current) in the **High Voltage Control** window (see Fig. 5.12) becomes stable within the range shown on the table below. If it does not, carry out Steps a to e below.

Table 1 High voltage and beam current

High voltage (kV)	Beam current (μA)
80	$40 \pm 10\%$
100	$50 \pm 10\%$
120	$60 \pm 10\%$
160	$80 \pm 10\%$
200	$100 \pm 10\%$

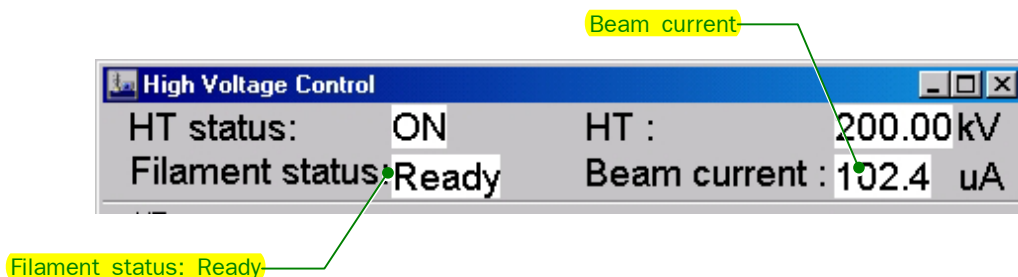


Fig. 5.12 High Voltage Control window

- a. Minimize the accelerating voltage and make sure that Filament Status in the **High Voltage Control** window is Ready (☞ Fig. 5.12).
- b. Click on Filament **ON** in the **High Voltage Control** window or press the Beam button (L1-①) on the control panel to generate the electron beam.
 - ✍ While the electron beam is being generated, the **Filament** window opens. While the **Filament** window is open, you cannot access any other windows (☞ Fig. 5.14).
 - ✍ The detection current added to the beam current is displayed as Beam Current in the **High Voltage Control** window.
- c. Wait until the Beam Current in the **High Voltage Control** window becomes stable; then click on Filament **OFF** in the **High Voltage Control** window (☞ Fig. 5.13) or press the Beam button (L1-①) to turn off the beam.
 - ✍ Filament Status ON in the **High Voltage Control** window blinks and the Filament window is displayed.
 - ✍ While the **Filament** window is open, you cannot access any other windows.
- d. Increase the accelerating voltage by 20 kV and click on Filament **ON** in the **High Voltage Control** window (☞ Fig. 5.13).
- e. Repeat Step b above until the voltage reaches the target voltage.
 - ✍ If the beam current increases excessively, the high voltage is turned off and the beam current reading falls to zero. When this happens, decrease the high voltage by one step and click on HT **ON** in the **High Voltage Control** window again.

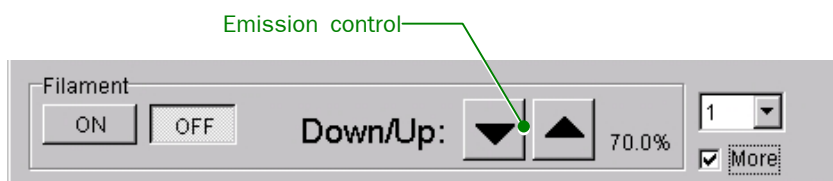


Fig. 5.13 Generating high voltage

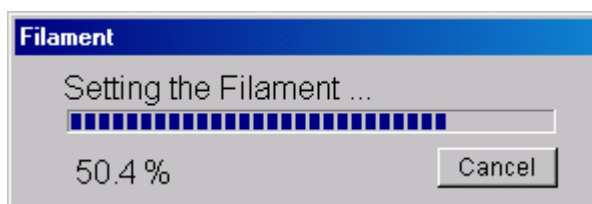


Fig. 5.14 Filament window

5.5.2 Beam Generation

1. Remove the condenser, objective and field limiting apertures from the beam path.
 - Align the largest circle (○) of aperture knob 1 with the dot (●) mark on the aperture knob.
2. Make sure that the specimen holder is inserted into the goniometer.
 - Unless the specimen holder is inserted into the microscope column, the electron beam will not be turned on.
3. Make sure that the image observation chamber isolation valve (V2) is open.
 - If V2 is closed, the electron beam will not be turned on. The status of the valve is indicated in the **Valve Status** window (☞ Fig. 4.37).
4. Turn on the electron beam as follows:
 - a. Set the desired percentage to the set maximum beam emission using the Filament **Down/Up** buttons in the **High Voltage Control** window (☞ Fig. 5.15).
 - ✎ The percentage to be selected cannot exceed the value that is preset in Filament max limit in the **High Voltage Control** window (☞ Fig. 5.15) at the time of shipment from the factory. Do not modify the value.
 - b. Click on Filament **ON** in the **High Voltage Control** window or press the Beam button (L1-①) on the control panel to generate the electron beam.
 - ✎ While the electron beam is being generated, the **Filament** window opens. While the **Filament** window is open, you cannot access any other windows (☞ Fig. 5.14).
 - ✎ The detection current added to the beam current is displayed as Beam Current in the **High Voltage Control** window (☞ Fig. 5.12).
 - c. Set Beam Current in the **High Voltage Control** window to 10 μA using the Filament up and down triangle buttons and the Bias Coarse and Fine triangle buttons (☞ Fig. 5.15).
 - ✎ If the reading of Beam Current does not change when Filament **ON** is clicked, it can be considered that the filament is burned out. If that is so, replace it with a new one (☞ Sec. 6.1).
 - ✎ The beam current is given by the difference between the readings of Beam Current when Filament **ON** is clicked and when Filament **OFF** is clicked.
5. Set the spot size to TEM 2 – 3 as follows:
 - a. Turn on TEM (L1-③).
 - b. Set SPOT SIZE in the TEM Controller main window to SPOT 2 using the SPOT SIZE (L1-③) and α 3 using the α SELECTOR (L1-③).
6. Make sure that all the lens switches (L3-⑧) are on; then press MAG2 (r1-②). A specified magnification of 5000 \times is obtained. If it is not, correct it by referring to Section 5.15.4.
7. Turn the BRIGHTNESS knob (L1-⑥) to see if the electron beam appears on the fluorescent screen. If you find the screen partly illuminated, proceed to the next step. If you don't, proceed to Step 10 below.
 - ✎ If you turn the BRIGHTNESS knob too far, the alarm beeps.
8. Adjust the SHIFT X and Y knobs (L1-⑧ and R1-③) and the BRIGHTNESS knob (L1-⑥) to the brightest beam spot condition.

9. When screen brightness increases and starts to get too bright, turn on PLA (R2-⑤) or click on DEF Select **PL** in the **Alignment Panel for Maintenance** window; adjust the SHIFT X and Y knobs (L1-⑧ and R1-③) and the BRIGHTNESS knob (L1-⑥) to the brightest beam spot condition again; then align the condenser lens optical axis, referring to Section 5.5.3.
10. Find the electron beam as follows:
 - a. Press Bright Tilt (R2-⑤) or click on DEF Select **CLA** in the **Alignment Panel for Maintenance** window; then press N (R2-⑤) or click on **NTRL** (☞ Fig. 4.47) in the **Alignment Panel for Maintenance** window.
Data for the 1st and 2nd condenser lens beam deflectors are neutralized (middle positions of their controls).
 - b. Click on DEF Select **Gun** (☞ Fig. 4.47) in the **Alignment Panel for Maintenance** window and on **Wobbler Gun** (☞ Fig. 4.47); then turn the BRIGHTNESS knob back and forth through its middle control position to find the electron beam.
 - c. Center the beam and maximize brightness using the SHIFT X and Y knobs (L1-⑧ and R1-③) and the BRIGHTNESS knob (L1-⑥).
 - d. Click on DEF Select **Gun** (☞ Fig. 4.47) in the **Alignment Panel for Maintenance** window and on **Wobbler Gun** (☞ Fig. 4.47) to turn them off.
 - e. Adjust the SHIFT X and Y knobs (L1-⑧ and R1-③) and the BRIGHTNESS knob (L1-⑥) to the brightest beam spot condition. When screen brightness increases and starts to get too bright, turn on PLA (R2-⑤) or click on DEF Select **PL** in the **Alignment Panel for Maintenance** window; adjust the SHIFT X and Y knobs (L1-⑧ and R1-③) and the BRIGHTNESS knob (L1-⑥) to the brightest beam spot condition again.

✍ If you increase screen brightness excessively while PLA (R2-⑥) and DEF Select **PL** are off, there is danger of damaging the fluorescent screen.

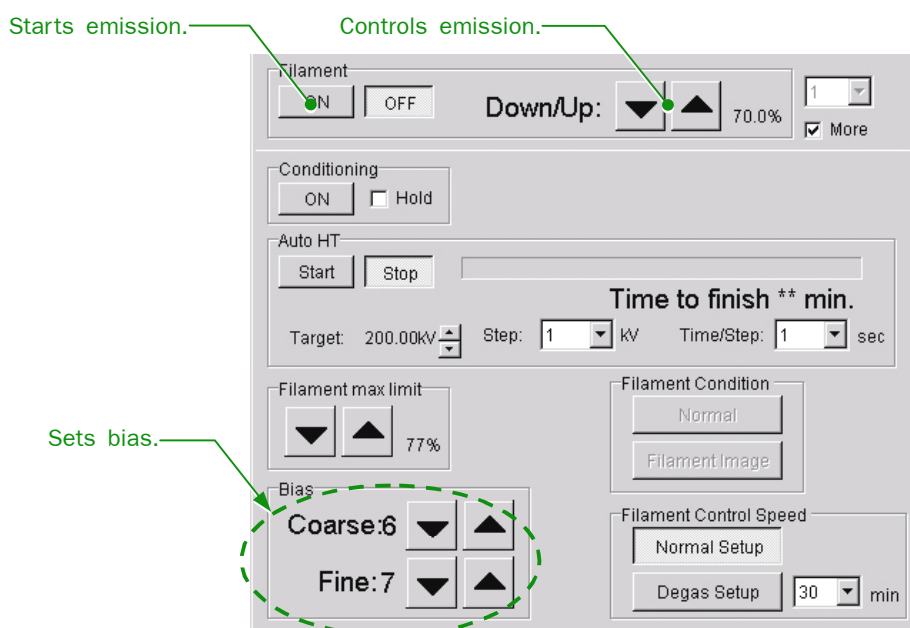


Fig. 5.15 Generating high voltage

5.5.3 Condenser Lens Alignment

Condenser lens alignment is required after generating an electron beam.

1. Set the magnification to 20 000X and obtain the smallest possible beam spot using the BRIGHTNESS knob (L1-⑥).
2. Set the spot size to TEM1 - Spot 3 (TEM Controller window) using the SPOT SIZE knob (L1-③).
3. Click on DEF Select **Gun** in the **Alignment Panel for Maintenance** window (☞ Fig. 4.47); then manipulate the SHIFT X and Y knobs (L1-⑧) and R1-③) to center the beam spot on the fluorescent screen.
4. Set the spot size to TEM5 - Spot 3 (TEM Controller window) using the SPOT SIZE knob (L1-③).
5. Turn on BRIGHT TILT (L1-⑤) or click on DEF Select **CLA** in the **Alignment Panel for Maintenance** window (☞ Fig. 4.47); then manipulate the SHIFT X and Y knobs (L1-⑧) and R1-③) to center the beam spot on the fluorescent screen.
6. Repeat Steps 2 to 6 until the electron beam stays at the center of the screen.

5.5.4 Beam Generation Suspension

1. Press the BEAM button (L1-①) or click on Filament **OFF** in the **High Voltage Control** window (☞ Fig. 5.16).
 - ☞ Clicking on the **OFF** button opens a message window telling whether or not the filament can be turned off.
 - ☞ Turning off the BEAM switch does not open the message window. Instead, the filament is turned off, and the Filament window opens (☞ Fig. 5.17).
2. Click on the **OK** button to turn off the filament.
 - ☞ Filament Status: ON in the **High Voltage Control** window blinks and the Filament window is displayed.
 - ☞ While the **Filament** window is open, you cannot access any other windows (☞ Fig.5.17).
3. When the filament shutdown is complete, the **Filament** window closes.

Turn off filament.



Fig. 5.16 High Voltage Control window(Turning off the filament)

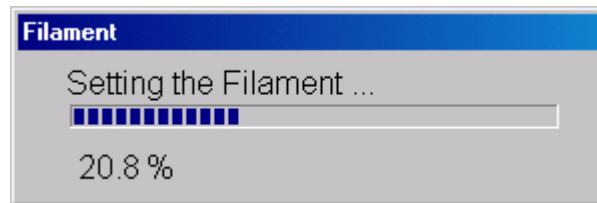


Fig. 5.17 Filament window(Status of turning off the filament)

5.5.5 Turning off the Accelerating Voltage

1. Click on HT **OFF** in the **High Voltage Control** window (☞ Fig. 5.18).
 - ✍ Clicking on the **OFF** button opens a message window telling whether or not the accelerating voltage can be turned off.
 - ✍ While the electron beam is being emitted from the filament, the accelerating voltage cannot be turned off.
2. Click on the **OK** button in the message window to turn off the accelerating voltage.
 - ✍ HT Status: OFF in the **High Voltage Control** window blinks and the **Accelerating Voltage** window is displayed.
 - ✍ While the **Accelerating Voltage** window is open, you cannot access any other windows (☞ Fig.5.11).
3. When the accelerating voltage is shut down completely, the **Accelerating Voltage** window closes.

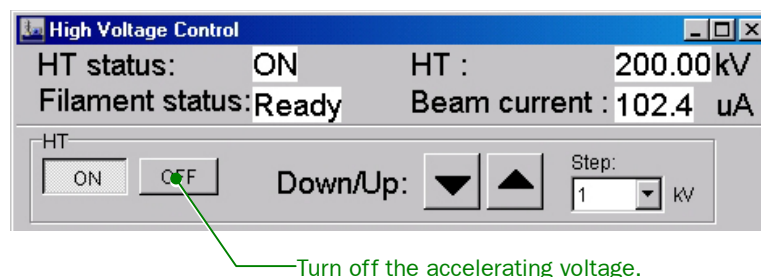


Fig. 5.18 High Voltage Control window(Turning off the accelerating voltage)

5.5.6 Turning on the High Voltage Using the Automatic Mode

The accelerating voltage can be set to the desired kV automatically using the Auto HT Start and Stop buttons. This section presents the procedure for raising the accelerating voltage from the state in which the accelerating voltage has not been turned on to the desired accelerating voltage.

✍ The procedure is true of the procedure for lowering the accelerating voltage.

1. Click on HT ▼ or ▲ button in the **High Voltage Control** window so that HT: reads, say, 100 kV (☞ Fig.5.19).
 - ✍ You can change the increment in voltage using the Step pop-out window (☞ Fig. 5.19).

2. Click on HT – **ON** (☞ Fig. 5.19) to turn on and step up the accelerating voltage.
 - ✍ HT Status **ON** in the **High Voltage Control** window blinks and the **Accelerating Voltage** window is displayed. While the **Accelerating Voltage** window is open, you cannot access any other windows (☞ Fig. 5.11).
3. Click on Auto HT ▼ or ▲ button in the **High Voltage Control** window so that Target: reads the target voltage, for example, 200 kV (☞ Fig.5.19).
4. Set Auto HT Step to an appropriate voltage (☞ Fig.5.19).
5. Set Auto HT Time/Step to an appropriate time (sec) (☞ Fig.5.19).
 - ✍ Once the target voltage, Step and Time/Step, have been input, the time required for raising the accelerating voltage to the target voltage is displayed under the Auto HT status bar as Time to finish (**min).
6. Click on Auto HT **Start** to increase the accelerating voltage up to the target voltage.
 - ✍ Unless HT **ON** is on, **Start** does not function.
 - ✍ While the accelerating voltage is being raised, beam emission is impossible.
 - ✍ If you want to interrupt stepping up the accelerating voltage, click on Auto HT **Stop**. Stepping up the accelerating voltage stops at a voltage when **Stop** is clicked.

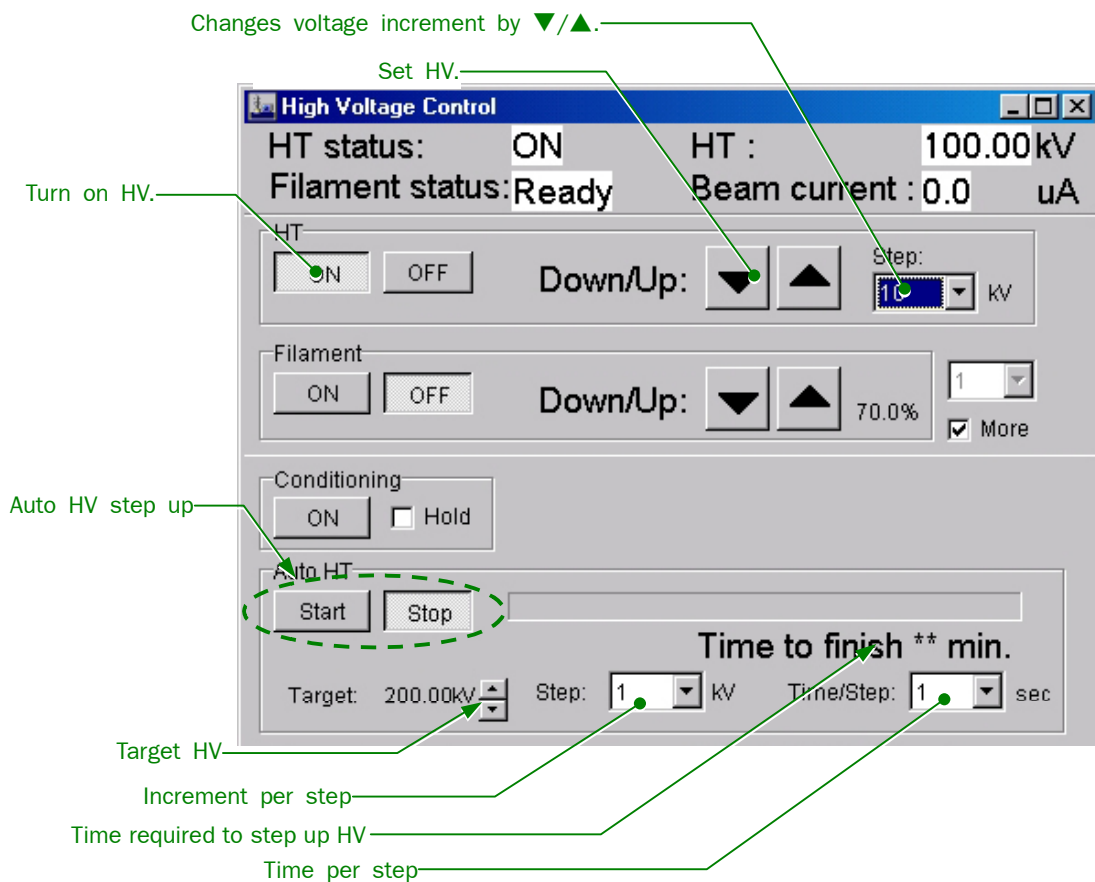


Fig. 5.19 High Voltage Control window(Auto HT stepping up)

5.6 APERTURES

This section presents the procedure for manually inserting and retracting the aperture into and from the microscope column. Motor-driven apertures, however, are controlled by the APERTURE CONTROL buttons (L1-②).

5.6.1 Condenser Lens (CL) Aperture

The CL aperture (☞ Fig.5.20) is used to control illumination area, angle, and brightness on the specimen. Larger apertures give larger illumination angles and brighter illumination.

1. Set the microscope to MAG mode; adjust the BRIGHTNESS knob (L1-⑥) for the smallest possible beam spot on the fluorescent screen; then center the beam on the screen using the SHIFT knobs (L1-⑧, R1-③).
2. Insert the largest aperture into the column using the aperture knob (1) (☞ Fig. 5.20).
If the aperture does not appear on the screen, adjust the aperture knobs (2) and (3) to find the aperture.
3. Confirm that the largest aperture is roughly centered on the screen and then insert the desired aperture using the aperture knob (1).
☞ Refer to Section 4.1.1 for the relation of the aperture size to the knob position.
✍ The smaller the aperture, the higher the image quality but the darker the image.

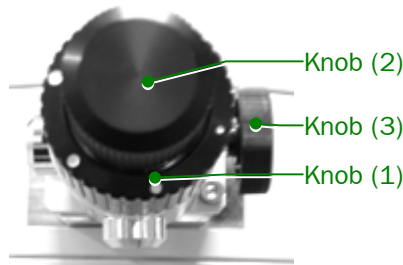


Fig. 5.20 CL Aperture knobs

4. Slowly turn the BRIGHTNESS knob (L1-⑥) clockwise.
✍ If the electron beam moves off the screen center as you turn the BRIGHTNESS knob clockwise, center the beam using the aperture knobs (2) and (3). (☞ Fig.5.21a).
5. Adjust aperture knobs (2) and (3) so that the beam expands and contracts coaxially when you turn the BRIGHTNESS knob (L1-⑥) back and forth through the focus position (☞ Fig.5.21b).

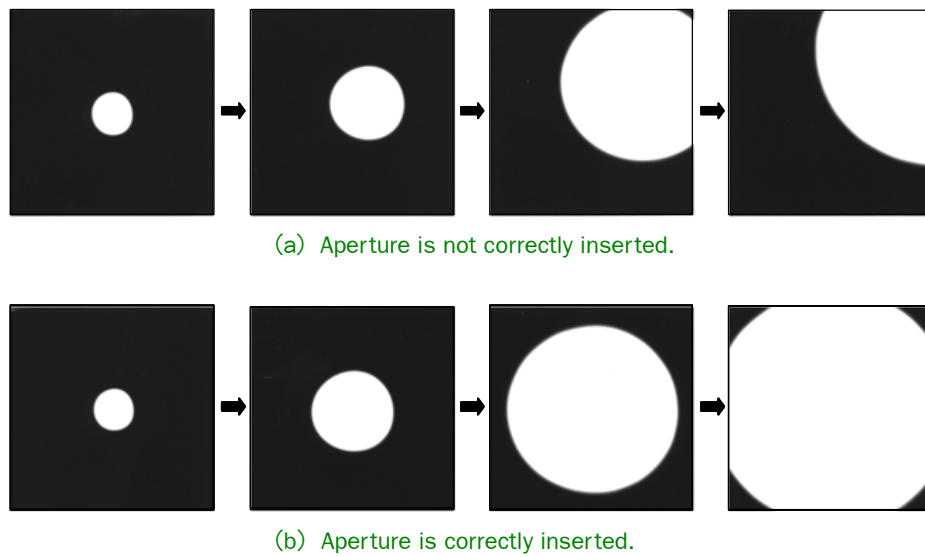


Fig. 5.21 CL Aperture centering

5.6.2 Objective Lens (OL) Aperture

The OL aperture is used to control the angle of beam scattering caused by the specimen. It plays an important role in governing image contrast and resolving power.

1. Insert a specimen into the beam path (☞ The appropriate instruction manual for the specimen holder) and press the Function SA DIFF switch (R1-②).
Spread the electron beam within the fluorescent screen using the BRIGHTNESS knob (L1-⑥).
2. Obtain a caustic spot using the DIFF FOCUS knob (R1-⑦) as shown below.
3. If the caustic spot is off the center of the screen, turn on the PLA switch (L1-⑤) or click on DEF Select **PLA** in the **Alignment Panel for Maintenance** window. Center the spot using the DEF/STIG knobs (L1-⑩, R1-④) of DEF Select **PL**. Turn off PLA after centering.

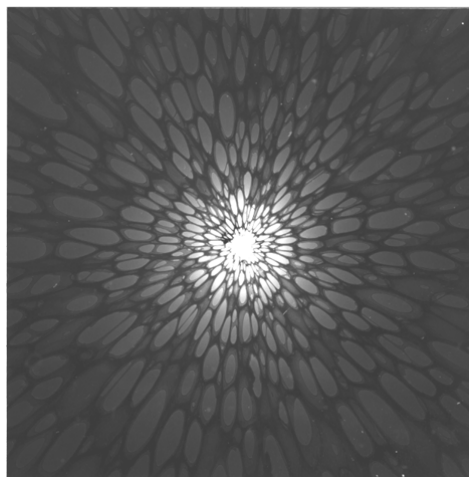


Fig. 5.22 Caustic spot

4. Obtain the smallest possible illumination spot using the BRIGHTNESS knob (L1-⑥) and adjust the SHIFT-X and -Y knobs (L1-⑧, R1-③) so that the illumination spot coincides with the screen center.
5. Insert the desired objective aperture into the beam path using the objective aperture knob (1).
6. Focus the aperture image (shadow) using the DIFF FOCUS knob (R1-⑦).
7. Adjust aperture knobs (2) and (3) so that the caustic spot lies in the center of the caustic spot (☞ Fig.5.23). This centers the aperture.

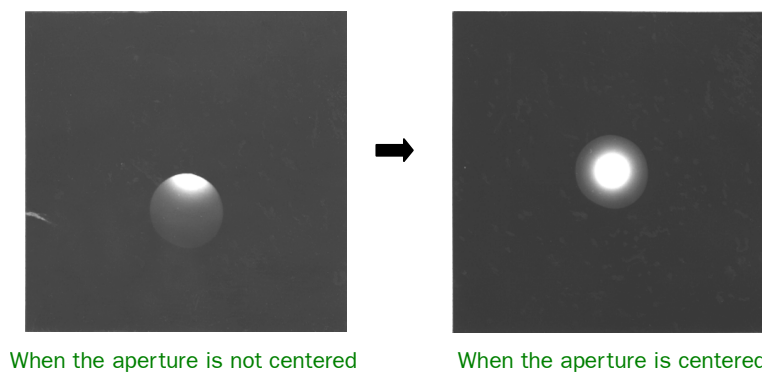


Fig. 5.23 Objective aperture centering

5.6.3 Field-limiting Aperture

The field-limiting aperture is used to select a region from the specimen in which you can observe diffraction patterns.

1. Set the R1-② function to SA MAG, MAG 1 or MAG 2; then select the desired magnification using the MAG/CAM L knob (R1-⑤).
2. Insert the desired aperture into the beam path using the aperture knob (1).
3. Focus the aperture (shadow) on the fluorescent screen using the DIFF FOCUS knob (R1-⑦).
☞ The DIFF FOCUS knob is inoperable in the MAG 1 and 2 modes.
4. Using the specimen control (SC-①) or aperture knobs (2) and (3), select the field of view you want to observe.

5.7 ILLUMINATION SYSTEM ADJUSTMENT

5.7.1 Aligning the Illumination System

1. Select **Maintenance** from the **TEM Controller** menu bar and click on **Alignment** to open the **Alignment Panel for Maintenance** window.

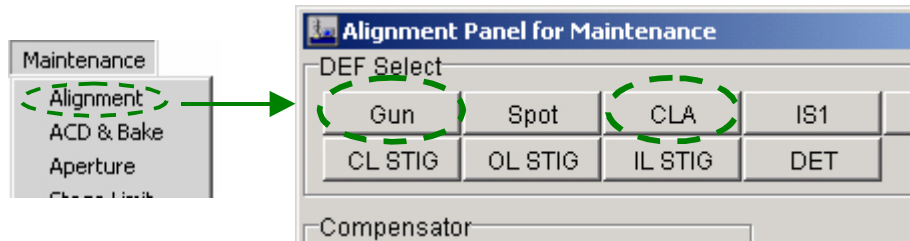


Fig. 5.24 Alignment Panel for Maintenance window (Aligning the illumination system)

2. Set the magnification to 40 000X.
3. Set the SPOT SIZE knob (L1-③) to 1 and focus the electron beam using the BRIGHTNESS knob (L1-⑥).
4. Click on DEF Select Gun in the **Alignment Panel for Maintenance** window.
5. Center the electron beam using the SHIFT knobs (L1-⑧, R1-③).
6. Set the SPOT SIZE knob (L1-③) to 5 and focus the electron beam using the BRIGHTNESS knob (L1-⑥).
7. Press the BRIGHT TILT switch (L1-⑤) or click on the DEF Select **CLA** in the **Alignment Panel for Maintenance** window.
8. Center the electron beam using the SHIFT knobs (L1-⑧, R1-③).
9. Repeat steps 3 to 8 above until the electron beam stays at the center of the screen when the SPOT SIZE knob setting is changed.

5.7.2 Condenser Lens Astigmatism Correction

If astigmatism is present in the condenser lens, the electron beam, when brought to a focus on the fluorescent screen, is elongated and brightness is insufficient. If this happens, correct the astigmatism of the condenser lens in such a way that the shape of the electron beam spot rounds out.

1. Select **Maintenance** from the **TEM Controller** menu bar and click on **Alignment** to open the **Alignment Panel for Maintenance** window (👉 Fig.5.25).

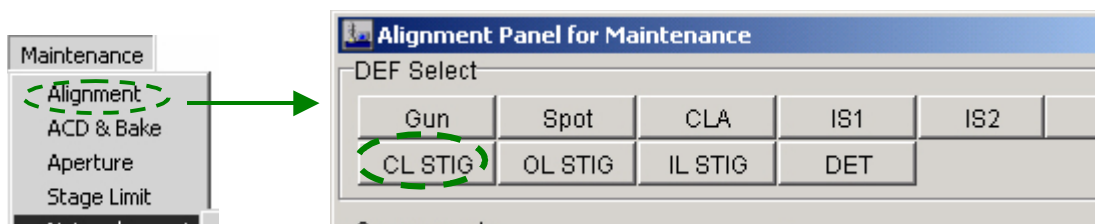


Fig. 5.25 Alignment Panel for Maintenance window (Correcting CL astigmatism)

2. Insert a condenser lens aperture into the beam path.
3. Focus the beam using the BRIGHTNESS knob (L1-⑥).
4. Press the COND STIG switch (L1-⑤) or click on the DEF Select **CL STIG** in the **Alignment Panel for Maintenance** window.
5. Slowly turn the BRIGHTNESS knob back and forth through the focus position and adjust the DEF/STIG knobs (L1-⑩, R1-④) so that the shape of the electron beam spot becomes round immediately before and after the focus position.
 - ✍ When you turn the BRIGHTNESS (L1-⑥) knob slowly back and forth through the focus position, the electron beam spot is elliptical if astigmatism exists in the condenser lens.

5.7.3 CL Deflection Coil Adjustment

- ◆ Select **Maintenance** from the **TEM Controller** menu bar and click on **Alignment** to open the **Alignment Panel for Maintenance** window (👉 Fig.5.26).

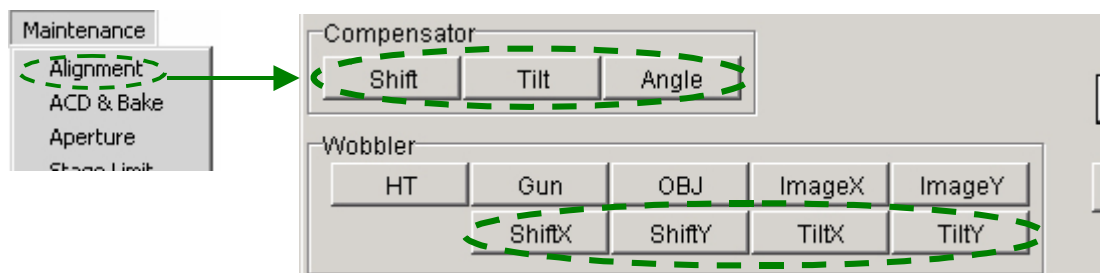


Fig. 5.26 Alignment Panel for Maintenance window (Deflection-coil adjustment using the circled buttons)

5.7.3a Tilt X and Y adjustment

Tilt X and Y adjustments consist of adjusting the ratio of the currents in the upper and lower CL deflection coils so that the electron beam spot remains stationary when the electron beam is tilted.

1. Select **Maintenance** in the **TEM Controller** menu bar. Click on **Alignment** to open the **Alignment Panel for Maintenance** window, and set the magnification to 40 000X.
2. Focus the electron beam using the BRIGHTNESS knob (L1-⑥).
3. Press BRIGHT TILT (I1-⑤) or click on DEF Select **CLA** in the **Alignment Panel for Maintenance** window.
4. Center the electron beam using the SHIFT knobs (L1-⑧, R1-③).
5. Click on Compensator **Tilt** in the **Alignment Panel for Maintenance** window (☞ Fig.5.26).
6. Click on the Wobbler-**Tilt X** button in the **Alignment Panel for Maintenance** window.

Unless the ratio of the currents in the upper and lower deflection coils is adjusted properly, the electron beam spot splits into two parts.
7. Unify the split spot using the DEF/STIG X knob (L1-⑩).
 - ✎ When the beam spot moves off the screen, lower the magnification and continue adjustment.
 - ✎ If the electron beam spot splits into two parts in the Y direction, click on Compensator **Angle** in the **Alignment Panel for Maintenance** window (☞ Fig.5.26); then unify the split spot using the DEF/STIG X knob (L1-⑩). After making sure that the spot is unified, click on Compensator **Angle** to turn it off.
8. Click on the Wobbler-**Tilt X** button in the **Alignment Panel for Maintenance** window to turn it off.
9. If the electron beam moves off the screen center as you turn the BRIGHTNESS knob, center the beam using the SHIFT X and Y knobs (L1-⑧, R1-③) after pressing BRIGHT TILT (L1-⑤) or clicking on DEF Select **CLA** in the **Alignment Panel for Maintenance** window.
10. Click on the Wobbler-**Tilt Y** button in the **Alignment Panel for Maintenance** window, and the beam spot splits into two parts in the Y direction.
11. Unify the split spot using the DEF/STIG Y knob (L1-④).
 - ✎ When the beam spot moves off the screen, lower the magnification and carry on adjustment.
 - ✎ If the electron beam spot splits into two parts in the X direction, click on Compensator **Angle** in the **Alignment Panel for Maintenance** window (☞ Fig.5.26); then unify the split spot using the DEF/STIG Y knob (R1-③). After making sure that the spot is unified, click on Compensator **Angle** to turn it off.
12. If the electron beam moves off screen center as you rotate the BRIGHTNESS knob, center the beam using the SHIFT X and Y knobs (L1-⑧, R1-③) after pressing BRIGHT TILT (L1-⑤) or clicking on DEF Select **CLA** in the **Alignment Panel for Maintenance** window.
13. Click on the Compensator **Tilt** button again to turn it off.

5.7.3b Shift X and Y adjustment

Shift X and Y adjustments consist of adjusting the ratio of the currents in the upper and lower CL deflection coils so that the caustic spot tilt remains unchanged when the caustic spot is shifted.

1. Select **Maintenance** from the **TEM Controller** menu bar; click on **Alignment** to open the **Alignment Panel for Maintenance** window; then press the SA DIFF switch (R1-②) to enter DIFF mode.
2. Turn the BRIGHTNESS knob (L1-⑥) fully counterclockwise.
3. Adjust the DIFF FOCUS knob (R1-⑦) to obtain a caustic spot on the fluorescent screen.
4. Click on Compensator **Shift**.
5. Click on Wobbler **Shift X**.
Unless the ratio of the currents in the upper and lower deflection coils is adjusted properly, the caustic spot splits into two parts in the X direction.
6. Unify the split spot using the DEF/STIG X knob (L1-⑩).
✍ When the caustic spot moves off screen, shorten the camera length and carry on adjustment.
✍ If the electron spot splits into two parts in the Y direction, click on Compensator **Angle** in the **Alignment Panel for Maintenance** window (☞ Fig.5.26); then unify the split spot using the DEF/STIG X knob (L1-⑩). After making sure that the spot is unified, click on Compensator **Angle** to turn it off.
7. Click on Wobbler **Shift X** to turn it off.
8. If the caustic spot moves off the screen center as you turn the BRIGHTNESS knob, center the beam using the DEF/STIG X and Y knobs (L1-⑩, R1-④) after pressing BRIGHT TILT (L1-⑤) or clicking on DEF Select **CLA** in the **Alignment Panel for Maintenance** window.
9. Click on Wobbler **Shift Y**.
Unless the ratio of the currents in the upper and lower deflection coils is adjusted properly, the caustic spot splits into two parts in the Y direction.
10. Unify the split spot using the DEF/STIG Y knob (R1-④).
✍ When the caustic spot moves off the screen, shorten the camera length and carry on adjustment.
✍ If the electron spot splits into two parts in the X direction, click on Compensator **Angle** in the **Alignment Panel for Maintenance** window (☞ Fig.5.26); then unify the split spot using the DEF/STIG Y knob (R1-④). After making sure that the spot is unified, click on Compensator **Angle** to turn it off.
11. Click on Wobbler **Shift Y** again to turn it off.
12. Click on Compensator **Shift Y** again to turn it off.
13. If the caustic spot moves off screen center as you turn the BRIGHTNESS knob, center caustic spot using the DEF/STIG X and Y knobs (L1-⑩, R1-④) after pressing BRIGHT TILT (L1-⑤) or clicking on DEF Select **CLA** in the **Alignment Panel for Maintenance** window.

5.8 CENTERING CURRENT AND VOLTAGE AXES

- ◆ Select **Maintenance** from the **TEM Controller** menu bar and click on **Alignment** to open the **Alignment Panel for Maintenance** window (☞ Fig.5.27).

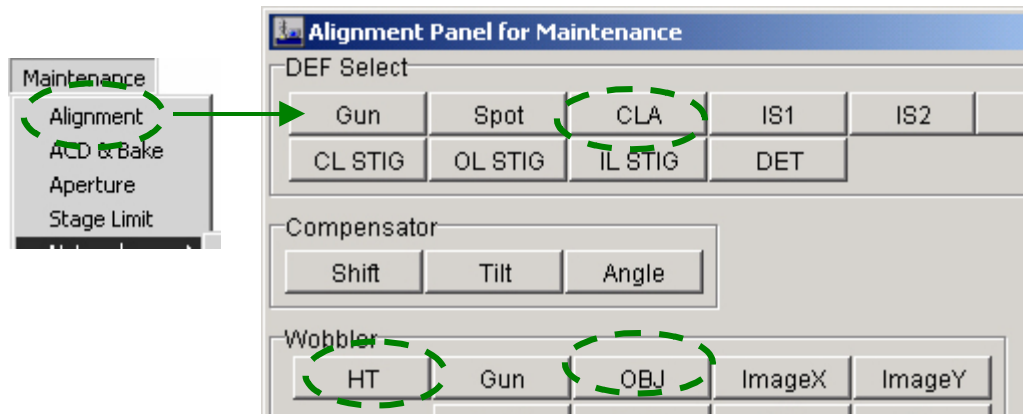


Fig. 5.27 Alignment Panel for Maintenance window
(Centering the Current and Voltage axes using the circled buttons)

5.8.1 Current Axis

Adjust the microscope optical axis in such a way that the image stays at the center of the fluorescent viewing screen even if the objective lens current is changed.

1. Select **Maintenance** from the **TEM Controller** menu bar; click on **Alignment** to open the **Alignment Panel for Maintenance** window; then press the MAG 1 switch (R1-②) to obtain an image at an appropriate magnification in MAG mode.
2. Focus the image using OBJ FOCUS (R1-⑥).
3. Spread the electron beam fully across the fluorescent screen, and move a conspicuous object in the image to the center of the screen.
4. Click on Wobbler **OBJ**; the image then expands and contracts periodically.
5. Press the BRIGHT TILT switch (L1-⑤) or click on DEF Select **CLA** in the **Alignment Panel for Maintenance** window.
6. Adjust DEF/STIG (L1-⑩, R1-④) so that the image expands and contracts around the center of the fluorescent screen.
7. Click on Wobbler **OBJ** again to turn it off.

5.8.2 Voltage Axis

Adjust the microscope optical axis in such a way that the image stays at the center of the fluorescent viewing screen even if the accelerating voltage is changed.

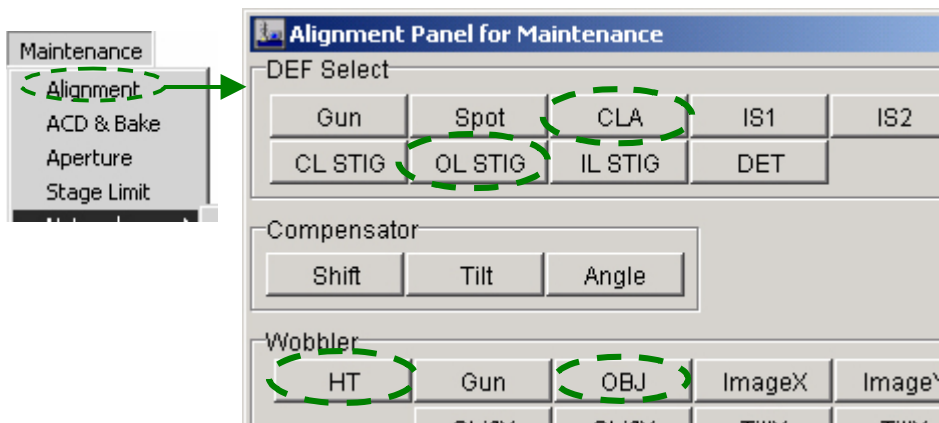
1. Select **Maintenance** from the **TEM Controller** menu bar; click on **Alignment** to open the **Alignment Panel for Maintenance** window; then obtain an image at an appropriate magnification in MAG mode.
2. Focus the image using OBJ FOCUS (R1-⑥).
3. Spread the electron beam fully across the fluorescent screen and move a conspicuous object in the image to the center of the screen.
4. Press the HT WOBB switch (R1-①) or click on Wobbler **HT** in the **Alignment Panel for Maintenance** window; the image then expands and contracts periodically.
5. Press the BRIGHT TILT switch (L1-⑤) or click on DEF Select **CLA** in the **Alignment Panel for Maintenance** window (☞ Fig.5.27).
6. Adjust DEF/STIG (L1-⑩, R1-④) so that the image expands and contracts around the center of the fluorescent screen.
7. Press the HT WOBB switch or click on Wobbler **HT** in the **Alignment Panel for Maintenance** window to turn it off (☞ Fig.5.27).

5.9 OBJECTIVE LENS (OL) ADJUSTMENT

5.9.1 OL Astigmatism Correction

If the correction of objective lens astigmatism is inadequate, it is very difficult to obtain an in-focus image. In other words, no matter how you try to focus the image, you cannot find the right focusing position due to the effect of astigmatism.

- ◆ Select **Maintenance** from the **TEM Controller** menu bar and click on **Alignment** to open the **Alignment Panel for Maintenance** window (👉 Fig.5.28).



**Fig. 5.28 Alignment Panel for Maintenance window
(Correcting objective lens astigmatism)**

5.9.2 Medium Magnification

Perforated, thin plastic films reinforced with carbon are recommended as test specimens for astigmatism correction.

1. Press the MAG 1 switch (R1-②) to turn it on ; then set the magnification to 20 000× in MAG mode.
2. Adjust the BRIGHTNESS (L1-⑥) knob for optimum brightness of the image.
3. Press BRIGHT TILT (I1-⑤) or click on DEF Select **CLA** (👉 Fig.5.28); then adjust the SHIFT knobs (L1-⑧, R1-③) to center the beam.
4. Focus the image using OBJ FOCUS (R1-⑥).
5. Move the image of a suitable hole on the specimen to the center of the screen using the SC-① X,Y buttons or CS-② trackball.
6. Press OBJ STIG (L1-⑤) or click on DEF Select **OL STIG** in the **Alignment Panel for Maintenance** window.
7. Adjust the OBJ FOCUS (R1-⑥) knobs so that Fresnel fringes (white lines seen along the edge of the hole in a slightly overfocused condition) appear along the rim of the hole (👉 Fig.5.29b). If there is astigmatism in the objective lens, asymmetrical Fresnel fringes appear along the rim of the hole.
 - ✍ In this event, the distance between the line and the edge of the hole (👉 “d” in Fig. 5.29) is not equal all the way around the hole.

8. Adjust the DEF/STIG X and Y knobs (L1-⑩, R1-④) so that Fresnel fringes appear to be symmetric (☞ “d” in the figure below becomes constant in all directions).

✂ If the objective aperture or the specimen is contaminated, or the objective aperture is not correctly inserted in the beam path, or the voltage axis is not properly centered, it may be impossible to correct astigmatism completely.

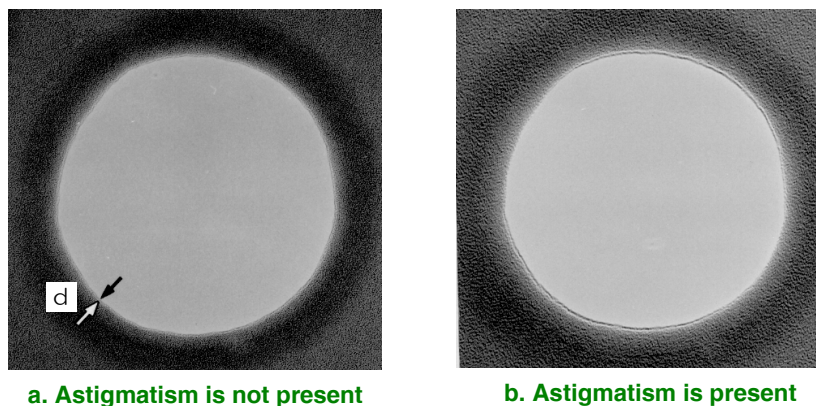
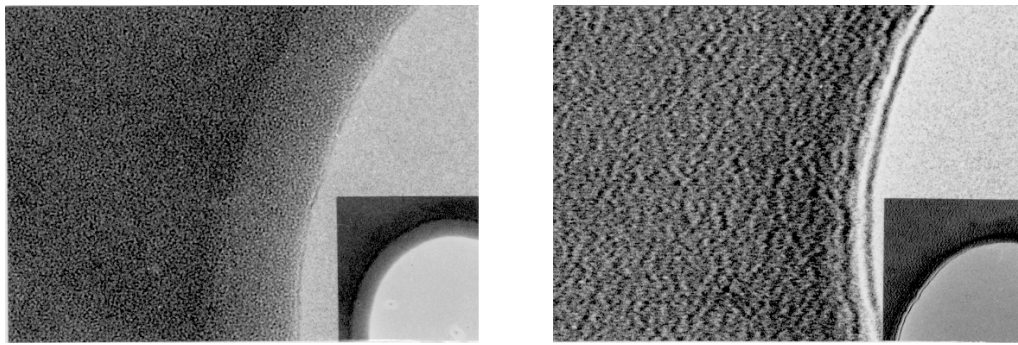


Fig. 5.29 OL astigmatism at medium magnification

5.9.3 High Magnification

Amorphous specimens (the supporting film itself or the specimen itself) are used for astigmatism correction at high magnifications.

1. Select **Maintenance** from the **TEM Controller** menu bar; click on **Alignment** to open the **Alignment Panel for Maintenance** window; set the magnification to 100 000× or higher in MAG mode.
2. Adjust the BRIGHTNESS (L1-⑥) knob for optimum brightness of the image.
3. Press BRIGHT TILT (L1-⑤) or click on DEF Select **CLA** in the **Alignment Panel for Maintenance** window; then adjust the SHIFT X and Y knobs (L1-⑧, R1-③) to center the beam.
4. Adjust the OBJ FOCUS COARSE and FINE knobs (R1-⑥) to focus the image.
5. Move a suitable image of an amorphous region on the specimen to the center of the screen using the trackball (SC-②) or X,Y buttons (SC-①).
6. Press OBJ STIG (L1-⑤) or click on DEF Select **OL STIG** in the **Alignment Panel for Maintenance** window (☞ Fig.5.28).
7. Slowly turn OBJ FOCUS back and forth through the focus position to observe the variation of phase contrast (☞ Fig.5.30b).
8. Adjust DEF/STIG (L1-⑩, R1-④) so that point images due to phase contrast appear to be distinctively independent (☞ Fig. 5.30a below).



a. Film hole when astigmatism is not present

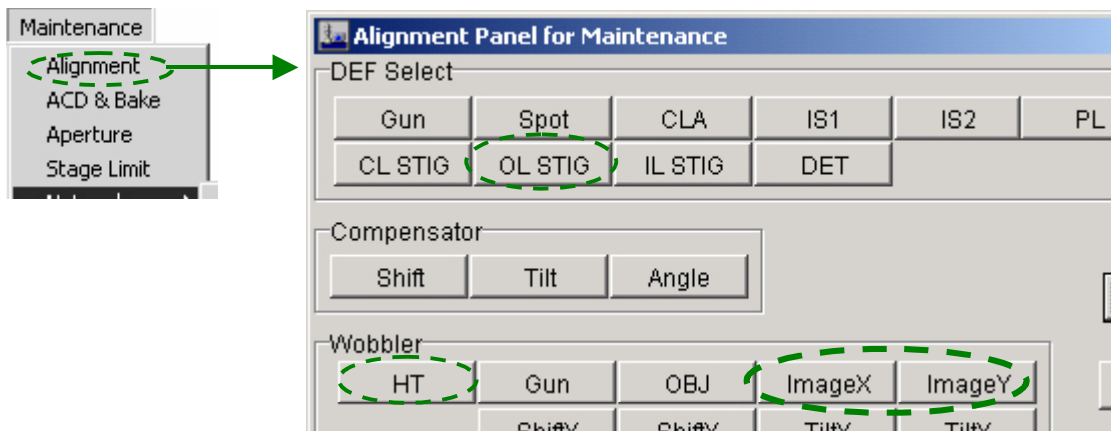
b. Film hole when astigmatism is present

Fig. 5.30 OL astigmatism at high magnification

5.9.4 Focusing

Focusing images at low magnifications can readily be performed using the image wobbler. However, since the image wobbler is not so helpful at high magnifications, focusing using Fresnel fringes instead, is quite useful. Furthermore, focusing using point images is better suited at very high magnifications.

- ◆ Select **Maintenance** from the **TEM Controller** menu bar and click on **Alignment** to open the **Alignment Panel for Maintenance** window (👉 Fig.5.31).



**Fig. 5.31 Alignment Panel for Maintenance window
(Focusing the image using the circled buttons)**

5.9.4a Focusing using image wobbler

1. Press the MAG 1 switch (R1-②) to obtain an image at an appropriately low magnification in MAG mode.
2. Press the IMAGE WOBB X or Y switch (R1-①) or click on the Wobbler **Image X or Y** button in the **Alignment Panel for Maintenance** window.
 - ✗ Unless the image is in focus, it oscillates and looks like a double image.
 - ✗ If an objective aperture or the slit is in the beam path, the field of view will be obstructed. To avoid this, use the larger aperture or remove both the aperture and slit from the beam path.

3. Adjust the OBJ FOCUS (R1-⑥) knobs so that the image stops oscillating and the double image is unified (Fig. 5.32, “JUST-Focus”).

If you cannot unify the image, objective lens astigmatism may be present. Correct the astigmatism (☞ Section 5.9.2, “Medium magnification”).

4. Turn off IMAGE WOBB X or Y (R1-①) or click on Wobbler **Image X** or **Y** to turn it off.

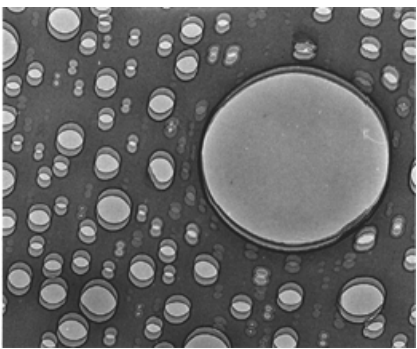
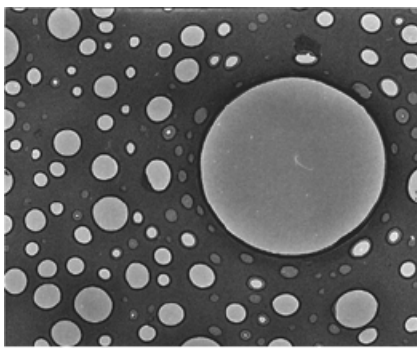
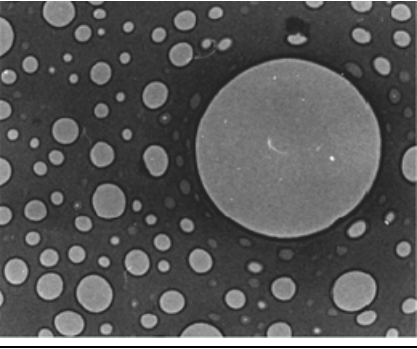
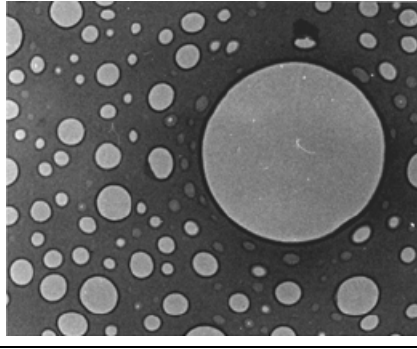
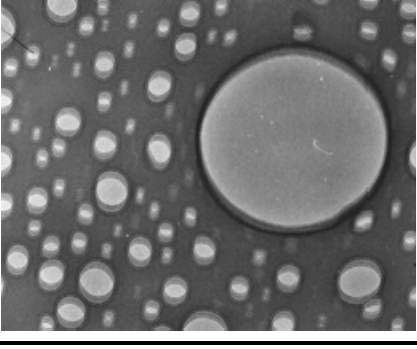
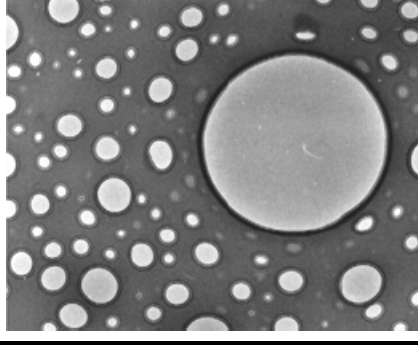
	WOBBLER switch (Image Wobbler)	
	ON (bright)	OFF (dark)
Under Focus The specimen is too high ⇒Lower the specimen		
JUST Focus The specimen height is just right.		
Over Focus The specimen is too low ⇒Raise the specimen		

Fig. 5.32 Turning on and off the image wobbler

5.9.4b Focusing using Fresnel fringes

1. Obtain the sharpest image using the OBJ FOCUS COARSE knob (R1-⑥).
 2. Adjust the OBJ FOCUS FINE knob (R1-⑦) for exact focus by turning it clockwise and counterclockwise while observing the object that is highest in contrast.
 - ✍ It is recommended that you focus on a hole in the specimen supporting film or foreign particles.
 3. When the hole image is used, the change of appearance of the image contour with the change of focal length in the objective lens is as shown below. Turning the FINE focus knob counterclockwise from a focused condition produces an underfocus condition in which a bright (Fresnel) fringe appears outside the boundary (☞ Fig.5.33a), resulting in the formation of a high-contrast contour. As the FINE focus knob is turned further counterclockwise, the bright fringe becomes wider.
 4. On the other hand, turning the FINE focus knob clockwise from a focused condition produces an overfocus condition in which a bright fringe appears inside the boundary (☞ Fig.5.33c). As the FINE focus knob is turned clockwise, the distance between the contour of the hole and the fringe becomes larger.
 5. The exact focus condition is between the under- and overfocus conditions. As the FINE focus knob is turned clockwise from an underfocus condition to an overfocus condition, the bright fringe narrows and eventually disappears at exact focus (☞ Fig.5.33b).
 6. As the FINE focus knob is turned beyond this focused condition, an unclear focus condition is produced and then the bright fringe appears inside the boundary, indicating overfocus.
 7. Focus the image or slightly under-focus the image using the OBJ FOCUS FINE knob (R1-⑦).
- ✍ In photography, the optimum focal condition does not always mean exact focus. To enhance image contrast, the most useful focus frequently lies at a slight under-focus condition. This is especially true of such specimens as biological ultra-thin sections.

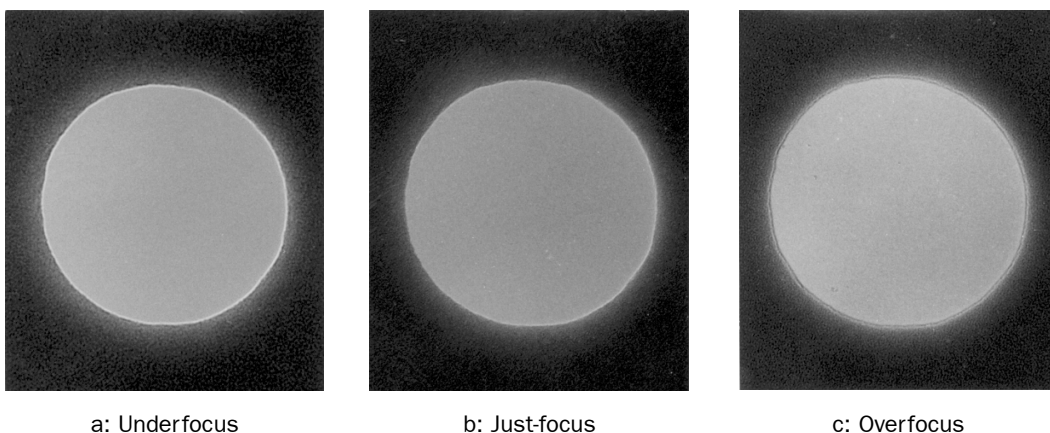


Fig. 5.33 Focusing using Fresnel fringes

5.9.5 Focusing Using Point Images

When focusing at $100\,000\times$ magnification or higher, using out-of-focus Fresnel fringes in conjunction with particle images in the background greatly enhances the accuracy of focusing. To do this, first focus on an image, using the Fresnel fringe, as accurately as possible; then focus using the particle image in such a way that each particle exhibits minimum contrast. Fig. 5.34 shows images of a holy carbon when focus is changed from under- through in- to over-focus (from left to right), illustrating the variation of the appearance of Fresnel fringes and particle images in the background.

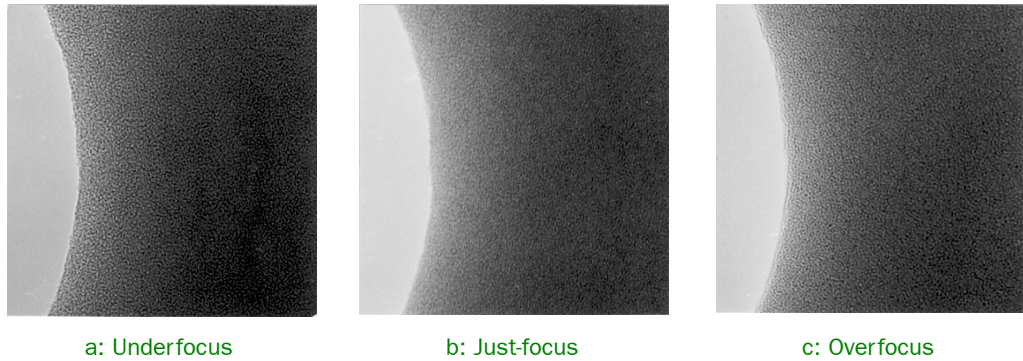


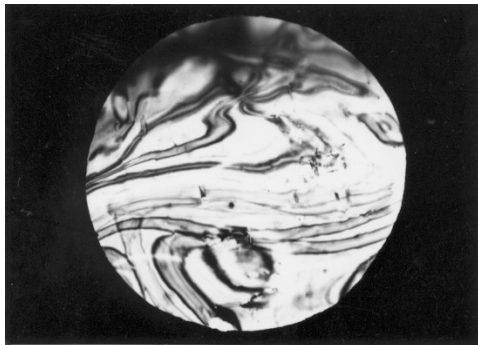
Fig. 5.34 Fresnel fringes and particle images in the background

5.10 ELECTRON DIFFRACTION

5.10.1 Selected Area Diffraction

The electron ray that passes through the specimen area selected by the field-limiting aperture forms both the picture image and the diffraction pattern. Therefore, the diffraction pattern which corresponds directly to the material that is causing the pattern can be obtained.

1. Make sure that all procedures in Sections 5.7, "Illumination System Adjustment," 5.8, "Centering Current and Voltages Axes," and 5.9, "Objective Lens Adjustment" are complete; then obtain a TEM image of interest on the fluorescent screen.
2. Press the SA MAG switch (R1-②) to set the microscope to SA MAG mode.
3. Adjust the MAG/CAM L knob (R1-⑤) to choose the desired magnification.
4. Move the desired field of view to the screen center using the arrow buttons (SC-①) or trackball (SC-②) (☞ Fig.5.35a).
5. Insert a field-limiting aperture into the electron beam path.
A selected-area image appears on the fluorescent screen.
6. Turn the BRIGHTNESS knob clockwise to darken the image sufficiently.
7. Press the SA DIFF switch (R1-②) and the diffraction pattern appears on the fluorescent screen.
8. Adjust the MAG/CAM L knob (R1-⑤) for the desired camera length.
9. Adjust the DIFF FOCUS knob(R1-⑦) to obtain the sharpest diffraction pattern (☞ Fig.5.35b).



a: Selected area image



b: Selected area diffraction image

Fig. 5.35 Selected area diffraction

5.10.2 Microbeam Electron Diffraction

The electron ray that passes through the specimen area selected by finely focusing the electron beam itself instead of using the field-limiting-aperture also forms both the picture image and the diffraction pattern. Microarea diffraction, nanoarea diffraction, and convergent beam electron diffraction are included in this category.

1. Make sure that all procedures in Sections 5.7, "Illumination System Adjustment," 5.8, "Centering Current and Voltages Axes," and 5.9, "Objective Lens Adjustment" are complete; then obtain a TEM image of interest on the fluorescent screen.
2. Press the MAG 1 (R1-②) button to set the microscope to MAG mode.
3. Select the desired magnification using the MAG-CAM L knob (R1-⑤).
4. Move the desired field of view to the center of the screen using the arrow buttons (SC-①) or trackball (SC-②).
5. Focus the image using the OBJ FOCUS knobs (R1-⑥).
6. Carry out a multiple exposure as follows:
 - a. Check Multi Exposure in the Film Camera Property window to enter the multiple-exposure mode.
 - b. Photograph the image by pressing the PHOTO switch (R1-⑧) to move the film to the photographing position, and again pressing the PHOTO switch.
 - ✍ The exposed film remains at the photographing position after completion of the first exposure.
7. Press the NBD switch (L1-③).
8. Focus the beam using the BRIGHTNESS knob (L1-⑥).
9. Adjust the SPOT SIZE knob (L1-③) to the desired spot size.
10. Using the SHIFT knobs (L1-⑧, R1-③), move the electron beam to the field of view to be studied.
11. Press the SA DIFF switch (R1-②).
12. Set the desired camera length using the MAG-CAM L knob (R1-⑤).
13. Adjust the size of the diffraction spot by turning the α SELECTOR knob (L1-③) and changing the condenser aperture size.
14. Press the MAG 1 switch (R1-②).
15. Carry out the second exposure in multiple-exposure mode. To do this, press the PHOTO switch (R1-⑧) once again. The second exposure on the same film takes place.
16. Press the SA DIFF switch (R1-②) and record the pattern in manual exposure mode (an exposure time of about 30 seconds will be suitable).
17. Click on the Film Eject button in the Film Camera Property window.
 - ✍ The exposed film moves to the receiving magazine.

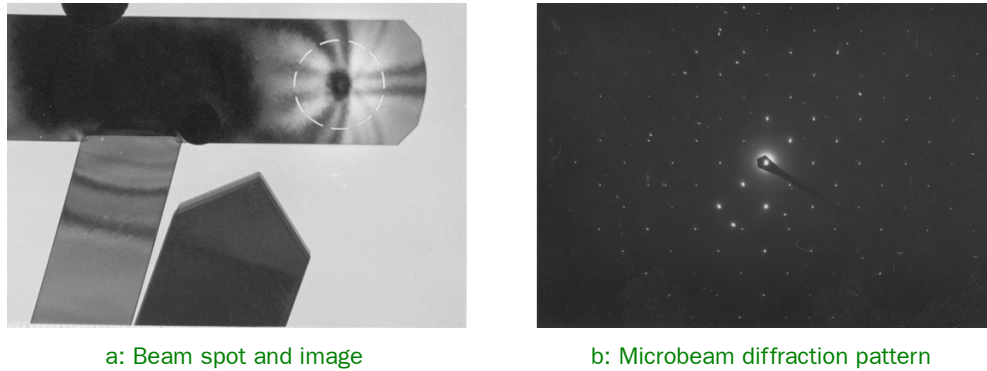




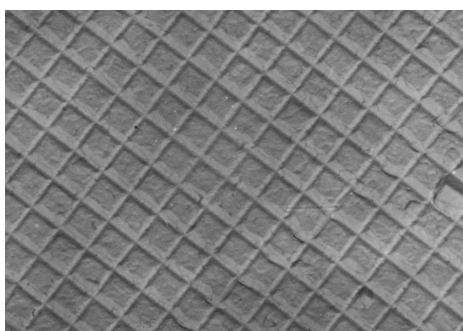
Fig. 5.36 Microbeam electron diffraction

5.10.3 High-Dispersion Electron Diffraction

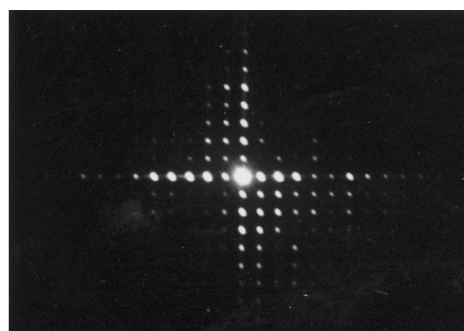
The maximum lattice spacing that can be analyzed by the selected area diffraction method is on the order of 10 nanometers. This can be extended, however, to 1,000 nanometers by using the high-dispersion electron diffraction method. Since, however, using this method the specimen easily becomes charged with electrons, coat the specimen with carbon on both sides if the specimen conductivity is very low.

1. Make sure that all procedures in Sections 5.7, "Illumination System Adjustment," 5.8, "Centering Current and Voltages Axes," and 5.9, "Objective Lens Adjustment" are complete.
2. Insert the specimen into the electron beam path and obtain a TEM image of interest on the fluorescent screen.
3. Press the MAG 1 (R1-②) button.
4. Select the desired magnification using the MAG-CAM L knob (R1-⑤).
5. Select the desired field of view using the SC-① X and Y buttons or SC-② trackball (☞ Fig.5.37a).
6. Press the LOW MAG switch (R1-②).
7. Set the magnification to about 500 \times ; then focus the image using the OBJ FOCUS knobs (R1-⑥).
8. Adjust the BRIGHTNESS knob (L1-⑥) to expand the beam to show the entire specimen.
9. Move the field of view to be studied to the center of the screen using the SC-① X and Y buttons or SC-② trackball.
10. Insert a small condenser aperture (10 or 20 μm in diameter).
11. Insert the 5 μm objective aperture into the beam path and center it correctly.
12. Photograph the image, if necessary.
13. Press the SA DIFF switch (R1-②).
14. Select a camera length longer than 400 cm using the MAG/CAM L knob.
 - ✍ The camera length can be varied from 8 to 200 cm, 400 cm and longer, and set to 33.3 cm. The 8 to 200 cm camera lengths are for selected-area electron diffraction, the 400 cm and longer camera lengths are for high-dispersion electron diffraction, and the 33.3 cm camera length is for high-resolution electron diffraction.

-  For high-resolution electron diffraction, the EM-20030 high-resolution electron diffraction attachment supplied to order is required.
 -  If you cannot make the camera length longer than 400 cm, setting in the **Mag Select** window might be inappropriate. Reset the camera length in the **Mag Select** window, referring to Section 5.15.3.
- 15.** Make sure that the direct spot is on the screen using DFF FOCUS (R1-⑦). If the spot cannot be found, find it as follows:
 - a.** Press LOW MAG (R1-②).
 - b.** Turn the BRIGHTNESS knob (L1-⑥) clockwise.
 - c.** Center the spot using the SHIFT knobs (L1-⑧, R1-③).
 - d.** Press SA DIFF X(R1-②) again.
 - e.** Adjust DFF FOCUS (R1-⑦) for the sharpest possible spot.
 - 16.** Photograph the image in manual exposure mode.



a: Micrograph of optical replica



b: Corresponding high-dispersion diffraction pattern

Fig. 5.37 High dispersion diffraction

5.11 SPECIAL OBSERVATION

The objective lens splits the electrons that have passed through the specimen into two groups, a transmitted-electron group which forms a real picture image (a bright-field image), and a diffracted-electron group which in turn forms a diffracted-electron image (a dark-field image). Generally, the dark-field images are dimmer than bright-field images but the contrast of the dark-field images is characteristically high.

5.11.1 Bright-Field Image

1. Obtain a selected-area image (☞ Sect. 5.10.1).
2. Insert an objective aperture into the electron beam path (☞ Sect. 5.6.2).
3. Adjust the objective aperture position using aperture assembly knobs 2 and 3 so that the direct spot passes through the aperture.
 - ✎ The center spot in the diffraction pattern is called the direct spot and other spots are called diffraction spots.
4. Press the MAG 1 switch (R1-②) to enter MAG mode.
5. Select the desired magnification using the MAG/CAM L knob (R1-⑤).
6. A bright-field image (Fig. 5.38a) appears on the fluorescent screen.

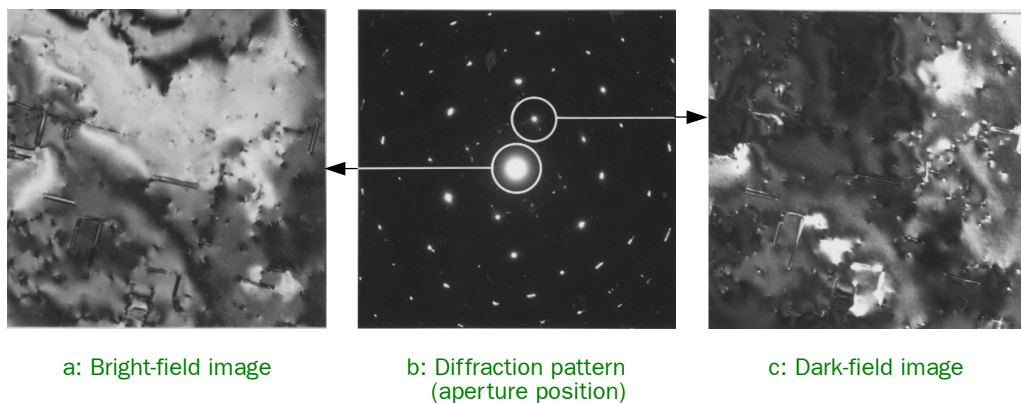


Fig. 5.38 Bright/dark field images

5.11.2 Dark-Field Image

To obtain a dark-field image, proceed as follows:

1. Obtain a selected-area image (☞ Sect. 5.10.1).
2. Insert an objective aperture into the electron beam path (☞ Sect. 5.6.2).
3. Adjust the objective aperture position using the aperture assembly knobs 2 and 3 so that the direct spot passes through the aperture.
 - ✎ The center spot in the diffraction pattern is called the direct spot and other spots are called diffraction spots.
4. Press the DARK TILT switch (L1-⑤).
5. Adjust the objective aperture position using the DEF/STIG X and Y knobs (L1-⑩, R1-④) so that the desired diffraction spot passes through the aperture.
6. Press the MAG 1 switch (R1-②) to enter MAG mode.

7. Select the desired magnification using the MAG/CAM L knob (R1-⑤).
8. Adjust the image brightness using the BRIGHTNESS knob (L1-⑥).
9. Press BRIGHT TILT (L1-⑤) or click on DEF Select **CLA** in the **Alignment Panel for Maintenance** window; then adjust the SHIFT knobs (L1-⑧, R1-③) to center the beam.
10. A dark-field image (Fig. 5.58c) appears on the fluorescent screen.




5.11.3 Low-Magnification Image

The TEM low-magnification mode is provided for searching for the field of view over a wide area of the specimen. Since the objective lens current is turned off in this mode, the OL aperture cannot be used; instead, the field-limiting aperture is used to enhance the image contrast.



**Fig. 5.39 Alignment Panel for Maintenance window
(Observing low-magnification images)**

1. Select **Maintenance** from the **TEM Controller** menu bar; click on **Alignment** to open the **Alignment Panel for Maintenance** window (☞ Fig.5.39).
2. Obtain an image at an appropriately low magnification in MAG mode as follows:
 - a. Carry out column alignment (☞ Sects. 5.7 to 5.9).
 - b. Remove the objective and field-limiting apertures from the beam path (☞ Sect. 5.6).
 - c. Press the LOW MAG switch (R1-②).
 - d. Select the desired magnification with the MAG/CAM L knob (R1-⑤).
 - e. Adjust the image brightness using the BRIGHTNESS knob (L1-⑥).
 - f. Press BRIGHT TILT (L1-⑤) or click on DEF Select **CLA** in the **Alignment Panel for Maintenance** window; then adjust the SHIFT knobs (L1-⑧, R1-③) to center the beam on the screen.
3. Center the current axis as follows:
 - a. Click on Wobbler **OBJ** in the **Alignment Panel for Maintenance** window.
 - b. Press the BRIGHT TILT switch (L1-⑤), or click on DEF Select **CLA**.
 - c. Adjust the DEF/STIG knobs (L1-⑩, R1-④) so that the image expands and contracts around the center of the fluorescent screen.
 - d. Click on Wobbler **OBJ** again to turn it off.

4. Correct astigmatism as follows:
 - a. Press OBJ STIG (L1-⑤), or click on DEF Select **IL STIG**.
 - b. Press the IMAGE WOBB X switch (R1-①) to turn it on, and focus the image using the OBJ FOCUS knob (R1-⑥).
 - c. Press the IMAGE WOBB X switch (R1-①) again to turn it off, and press the IMAGE WOBB Y switch (R1-①) to turn it on.
 A double-image appears on the fluorescent screen.
 - d. Adjust the DEF STIG Y knob (R1-④) to unify the double image.
 - e. Press the IMAGE WOBB Y switch (R1-①) to turn it off, and press the IMAGE WOBB X switch (R1-①) to turn it on.
 A double-image appears on the fluorescent screen.
 - f. Adjust the DEF STIG X knob (L1-⑩) to unify the double image.
 - g. Repeat steps b to f until the image remains unified.
5. Focus the image using the image wobbler ( Sect. 5.9.4a).

5.12 ANTICONTAMINATION DEVICE

The anti-contamination device greatly reduces specimen contamination due to electron-beam irradiation. It is therefore extremely useful to use this device when observing specimens such as those that are very precious and will be stored after microscopy, those that require high magnification and high resolution, and those that serve for micro-area diffraction studies. Also, even in normal microscopy, the device is convenient when microscopists require more time to search for the desired fields of view and focus images.

5.12.1 Filling with Liquid Nitrogen

⚠ CAUTION

- Be careful to prevent oxygen deficiency in the room where the microscope is installed since the anti-contamination device uses liquid nitrogen.
- When filling or draining liquid nitrogen into/from the anti-contamination device, wear appropriate protective eyeglasses, and gloves (made of leather or the like) that liquid nitrogen will not permeate.
- When you stand on a stool trying to pour liquid nitrogen into the anti-contamination device, make sure that the stool is stable and solid and does not have casters.

1. Make sure that the column pressure is below 0.1 Pa (10^{-3} Torr) and the ground indication lamp does not light when its switch is pressed (Fig.5.40).

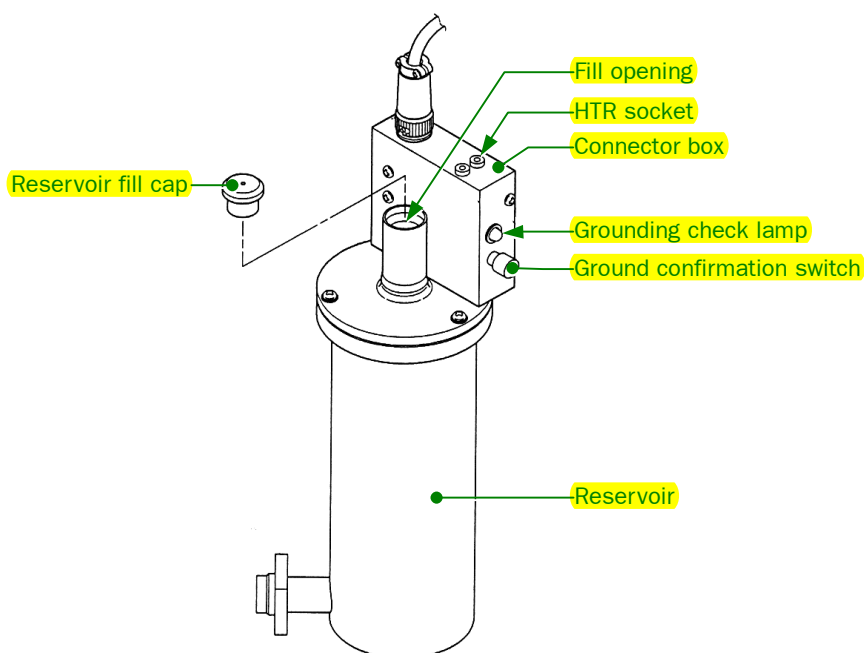


Fig. 5.40 Anti-contamination device reservoir assembly

- ✎ When liquid nitrogen is poured into the reservoir of the anti-contamination device when column pressure is above 0.1 Pa (10^{-3} Torr)—i.e., when the pressure is not low enough—residual water vapor will condense into a liquid on the surface of the cold trap, thereby building up electric charge in the trap. If this occurs, the astigmatism of the objective lens increases and the image or the beam itself becomes unstable.
- ✎ The column pressure is displayed in the PEG1 section in the Valve Status window (☞ Fig.4.37).
- ✎ If the ground indication lamp lights when its switch is pressed, consult JEOL service personnel.

2. Cover the viewing window with the appropriate protective lid.

⚠ CAUTION

If liquid nitrogen contacts the window glass, there is danger of the glass cracking, causing serious damage even to the interior of the microscope column.

3. Remove the coolant tank fill cap and insert the appropriate funnel into the fill opening.
4. Fill the tank with liquid nitrogen.
5. Wait 15 minutes or so; then refill the tank.
6. Remove the funnel and reinstall the fill cap.
 - ✎ If it is absolutely necessary to vent the column while the trap is cold, first drain the liquid nitrogen and then heat the trap up to ambient temperature (☞ Sect. 5.12.2).

5.12.2 Returning the Anti-Contamination Device to Room Temperature

If the microscope is evacuated for a long time, for example overnight, and the temperature of the cold trap increases gradually, a large amount of gas from the trap might be emitted into the microscope column. Also, if the column is vented when the trap is cooled, water vapor condenses on the trap, causing the build-up of an electric charge. Before you perform this operation, therefore, drain the liquid nitrogen and heat the trap up to ambient temperature.

1. Put the appropriate protective lid on the viewing window.

⚠ CAUTION

If liquid nitrogen contacts the window glass, there is a danger of the glass cracking, causing serious damage even to the interior of the microscope column.

2. Remove the tank fill cap.

3. Wear appropriate protective eyeglasses and gloves (made of leather or the like) so that liquid nitrogen will not permeate. Insert the coolant evaporator (Fig. 5.42) into the tank as follows:
 - a. Slide the protective tube as far in as it will go (Fig.5.43).
 - b. Mount the coolant evaporator onto the coolant inlet port.
 - c. Insert the heater assembly into the coolant tank and insert the heater plug into the HTR socket on the connector box (See Fig. 5.43).
4. Select **Maintenance** from the **TEM Controller** menu bar; click on **ACD & Bake** to open the **Bake Out/ACD Heat** window; then click on the **ACD Heat** tab to open the **ACD Heat** window.
5. Click on the **ACD Heat On** button.
The evacuation system enters ACD mode (SIP is off).

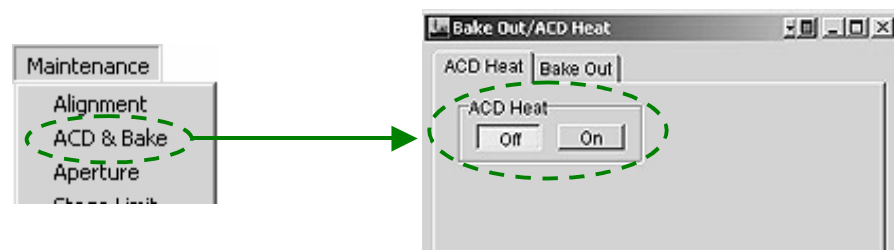


Fig. 5.41 Bake Out/ACD Heat window

- ✎ If the plug for the coolant evaporator is disconnected while the built-in indication lamp is lit, the lamp will remain lit. If this happens, connect the plug to the tank again, and wait until the lamp goes out.
- ✎ If you want to interrupt heating, press and hold down the left mouse button on the **Bake Out/ACD Heat – Off** button 2 to 3 seconds until the lamp goes out.
- ✎ Do not dismount the coolant evaporator during or immediately after heating. The heater is very hot, and there is a danger of burns.

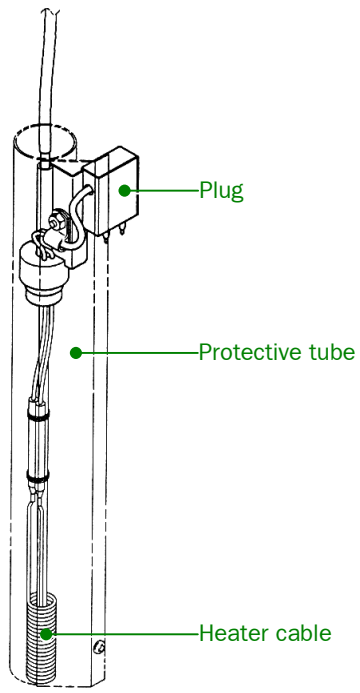


Fig. 5.42 Coolant evaporator (Heater assembly)

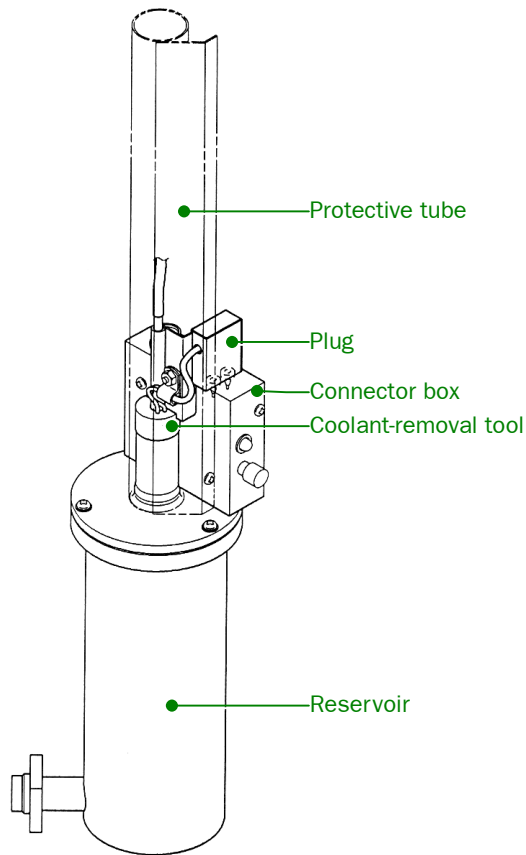


Fig. 5.43 Coolant evaporator(Mounted on the anti-contamination device)

5.13 PHOTOGRAPHY

5.13.1 Film Number and Film Text

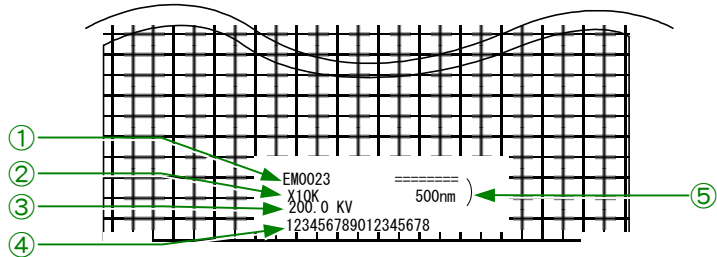


Fig. 5.44 Printing data on the micrograph

- ① **Film number**
Click on the **No.** button in the **Film Camera Property** window to open the film number entry box. Enter a desired film number; the number appears in the Film frame in the **Film Camera Property** window (☞ Fig. 5.45).
- ② **Magnification or camera length**
Magnification is entered in MAG mode, and camera length in DIFF mode, automatically.
- ③ **Accelerating voltage**
Entered automatically.
- ④ **Text (specimen name, etc.)**
Click on the **Text** button in the **Film Camera Property** window to open the text entry box. Enter a desired text and the text appears in the Film frame in the **Film Camera Property** window (☞ Fig. 5.45).
- ⑤ **Scale bar**
The calibrated length of the bar corresponds to the length on the specimen. This does not appear in the DIFF mode. The scale bar is printed automatically.

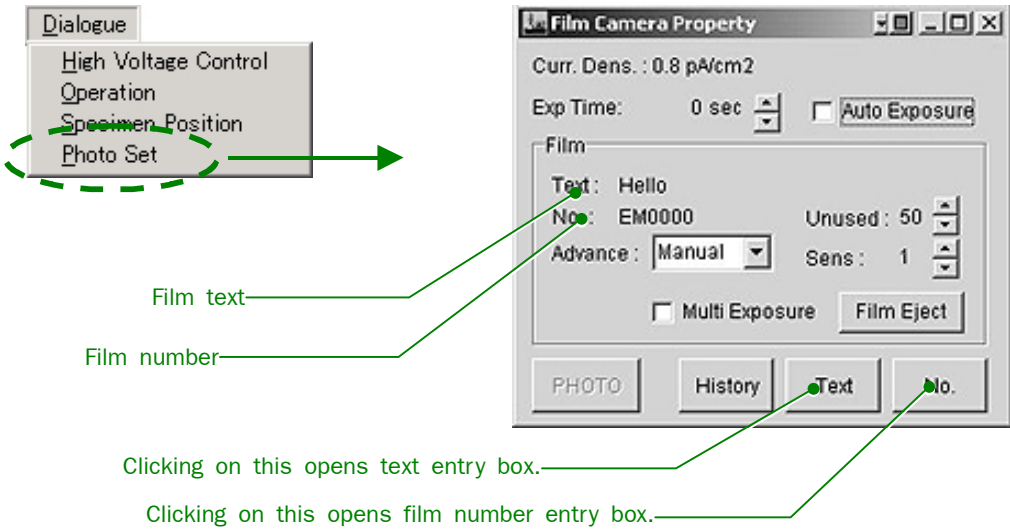


Fig. 5.45 Film Camera Property window(Printing film number and text)

5.13.2 Manual Exposure

1. Turn off the AUTO switch (R1-⑧) or remove the check mark from the Auto Exposure box of the **Film Camera Property** window to enter the manual exposure mode (☞ Fig. 5.46).
2. Choose the desired exposure time using the EXP TIME knob (R1-⑧) or the Exp Time arrow buttons (▲ and ▼) in the **Film Camera Property** window.
3. Press the PHOTO switch (R1-⑧) to move the film to the photographing position.
 - ☞ To move the film automatically, open the drop-down window by clicking on the Advance menu button, then select Automatic from the Advance menu.
4. Press the PHOTO switch (R1-⑧) again to photograph the image.
 - ☞ The lamp located to the left of the switch lights while the shutter is open. The film moves into the receiving magazine after completion of photographing.

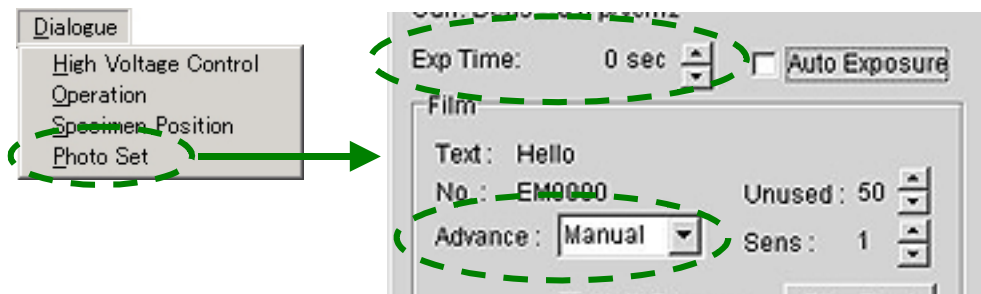


Fig. 5.46 Film Camera Property window(Manual exposure mode)

5.13.3 Automatic Exposure

1. Press the AUTO switch (R1-⑧) (the built-in lamp lights up) or check Auto Exposure in the **Film Camera Property** window to enter the automatic exposure mode.
2. Adjust BRIGHTNESS (L1-⑥) for appropriate image brightness.
 - ☞ The exposure time is determined by the total amount of electrons falling onto either the small or large fluorescent screen. The correct exposure time can only be obtained if the beam spreads over the entire screen. If the beam irradiates only part of the large screen, use the small screen for measuring exposure time.
3. Press the PHOTO switch (R1-⑧) to move the film to the photographing position.
 - ☞ To move the film automatically, open the drop-down window by clicking on the Advance menu button, then select Automatic from the Advance menu.

4. Press the PHOTO switch (R1-⑧) again to photograph the image.
 - ✍ The lamp located to the left of the switch blinks while the shutter is open. The film moves into the receiving magazine after completion of photographing.

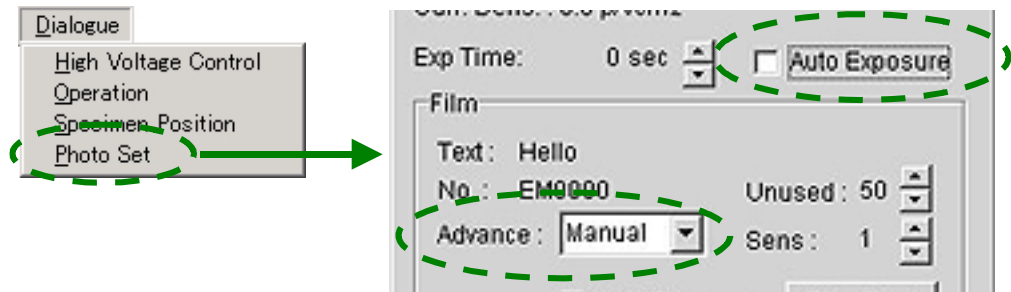


Fig. 5.47 Film Camera Property window(Auto Exposure mode)

5.13.4 Multiple Exposure

1. Check Multi Exposure in the **Film Camera Property** window to enter the multiple-exposure mode (☞ Fig. 5.48).
2. Photograph the image by pressing the PHOTO switch (R1-⑧) to move the film to the photographing position, and pressing the PHOTO switch again.
 - ✍ The exposed film remains in photographing position after completion of the first exposure.
3. Press the PHOTO switch (R1-⑧) once again.
 - ✍ The second exposure on the same film takes place.
4. Click on the **Film Eject** button in the **Film Camera Property** window.
 - ✍ The exposed film moves to the receiving magazine.

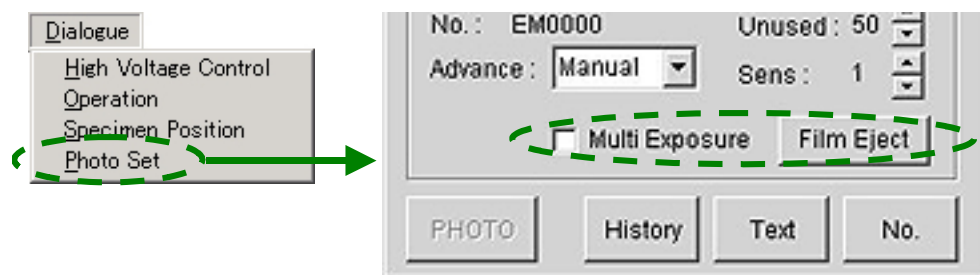


Fig. 5.48 Film Camera Property window(Multiple-Exposure mode)

5.13.5 Image Observation

Below is the procedure for observing ordinary TEM images in automatic exposure mode:

1. Insert the specimen holder together with the specimen into the microscope column (☞ Sect. 5.4).
2. Turn on the electron beam (☞ Sect. 5.5).
3. Press MAG1 (R1-②) to enter MAG 1 mode; set the magnification to about 40 000×; then obtain the beam on the fluorescent screen.

If the beam cannot be obtained, do the following:

 - a. Use a larger condenser aperture and decrease the magnification.
 - b. Slowly turn the BRIGHTNESS knob counterclockwise from the fully clockwise position.
 - c. Press the LOW MAG button (R1-②) and search for the beam.
 - d. Remove the specimen holder from the column; unload the specimen from the holder; insert the specimen holder without the specimen into the column; then search for the beam again.

✍ The electron beam cannot be turned on unless the specimen holder is in the column.
 - e. Find the beam on the fluorescent screen.

Once you find the beam on the screen, insert the specimen into the column.
4. Press the STD FOCUS button (R1-⑨) to set the objective lens current to the reference value.
5. Adjust the BRIGHTNESS knob (L1-⑥) for optimum brightness.
6. Center the current and voltage axes (☞ Sect. 5.8).
7. Move the field of view for microscopy to the screen center using the SC-① X and Y buttons or SC-② trackball.
8. Record the specimen position in the **Specimen Position** window, as necessary (☞ Fig. 5.49).

✍ Up to 100 specimen positions can be recorded using the **Specimen Position** window.

 - a. Click on **Memory** in the **Specimen Position** window.
 - b. The coordinates of the recorded specimen positions marked in the left section of the **Specimen Position** window are listed in the Position Memory box.

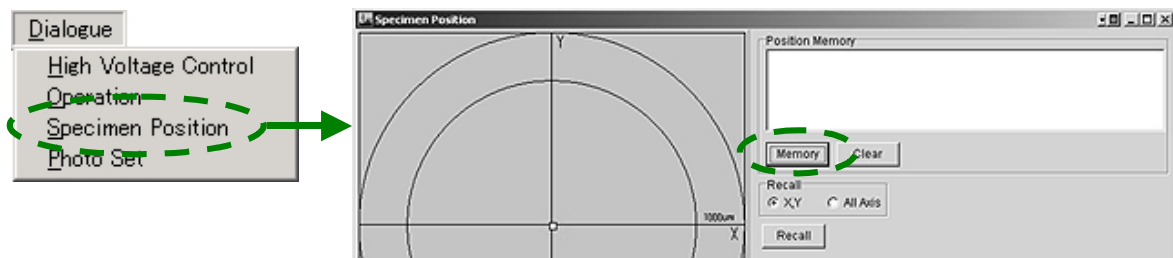




Fig. 5.49 Specimen Position window

9. Select the image mode using FUNCTION (R1-②).
10. Select the magnification or the camera length using the MAG-CAM L knob (R1-⑤).

- 11.** When MAG1,2 or LOW MAG is selected, focus the image using the OBJ FOCUS knobs (R1-⑥). When SA DIF is selected, use DIFF FOCUS.

 Adjust the objective lens according to its magnification ( Section 5.9).

- Focusing is carried out as follows:

- a.** Push the fluorescent screen lever to place the small screen in the beam path.

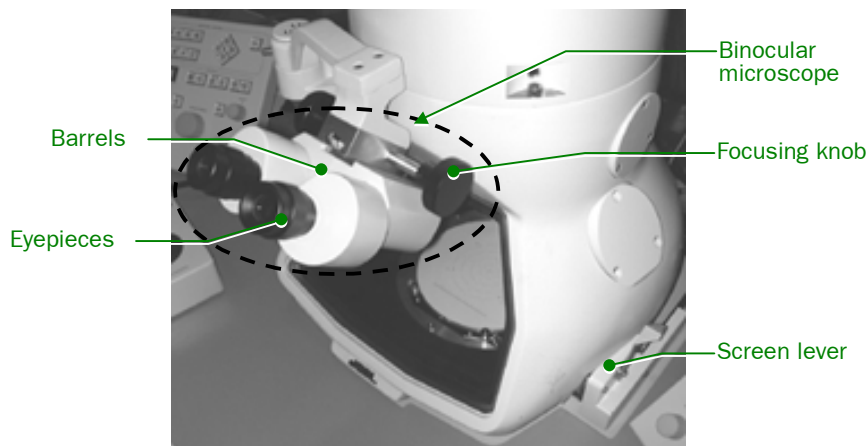







Fig. 5.50 Image observation chamber

- b.** Adjust the binocular focusing knob to focus the binocular microscope onto the small screen.
-  The interocular distance (the distance between the lens barrels) can be adjusted.
-  Adjust one of the eyepieces so that both lens barrels focus at the same time.
- c.** Turn on the IMAGE WOBB X or Y (R1-①) or click on Wobbler **Image X** or **Image Y** in the **Alignment Panel for Maintenance** window.
- d.** If the beam wobbles or splits into two, adjust the OBJ FOCUS (R1-⑥) to obtain a single stable beam.
- e.** Observe a conspicuous image, with clear contours, on the small fluorescent screen using the binocular microscope.
- If a double image appears, adjust the specimen height using the Z CONT switches (R1-⑩), so as to obtain a single stationary image. A double image also appears when focus is in under- or over-focus condition.
- f.** Turn off the IMAGE WOBB X or Y switch (R1-①) or click on Wobbler **Image X** or **Image Y** in the **Alignment Panel for Maintenance** window to turn it off.
- 12.** Adjust the BRIGHTNESS knob (L1-⑥) so that Exp. Time in the TEM Controller main window reads the desired exposure time.
- 13.** Press the PHOTO switch (R1-⑧) with the small screen placed in the electron beam path. When the PHOTO switch built-in lamp lights (the film is at the photographing position), press the PHOTO switch again. If the lamp was already lit, it is not necessary to press the PHOTO switch again.
-  Refer to Section 5.13.3 for automatic photographing mode.
-  The EXP switch lamp lights while the shutter is open. The PHOTO switch lamp goes out when the exposed film moves into the receiving magazine.
-  The PHOTO switch lamp will not light up if no more film remains in the dispensing magazine.

- ✂ The exposure time is determined by the total amount of electrons falling onto either the small or large fluorescent screen. The correct exposure time can only be obtained if the beam spreads over the entire screen. If the beam irradiates only part of the large screen, use the small screen for measuring exposure time.

5.13.6 Film Processing

1. Unload the receiving magazine from the camera chamber (☞ Sect. 5.3.2).
2. Remove the lid from the receiving magazine in the darkroom and remove the cassettes from the magazine under the safelight (red lamp).
3. Carefully remove the film from the cassette (☞ Fig. 5.51).

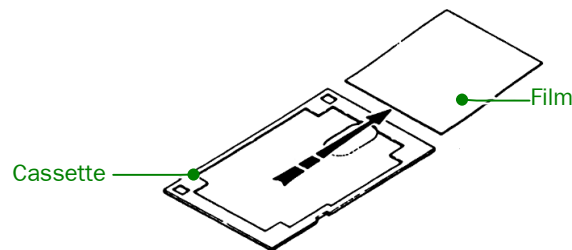


Fig. 5.51 Removing the film from the cassette

4. Immerse the film in developer (at $20 \pm 0.5^\circ\text{C}$); leave it in until the exposed image becomes sufficiently visible usually three or four minutes (☞ Fig. 5.52).

During the development process, stir the developer or move the film in order to avoid developing marks.

- ✂ If only a few films are to be processed, developing trays may be used. However, if many films are to be processed at one time, it is recommended that you use suitable tanks and hangers (stainless steel or polyvinyl chloride tanks are the best).

5. Immerse the film for approximately 30 seconds in a stop bath (2 to 3% glacial acetic acid solution, 18 to 21°C).

Doing so arrests development, which prevents the film from becoming spotty and prolongs the effectiveness of the fixer.

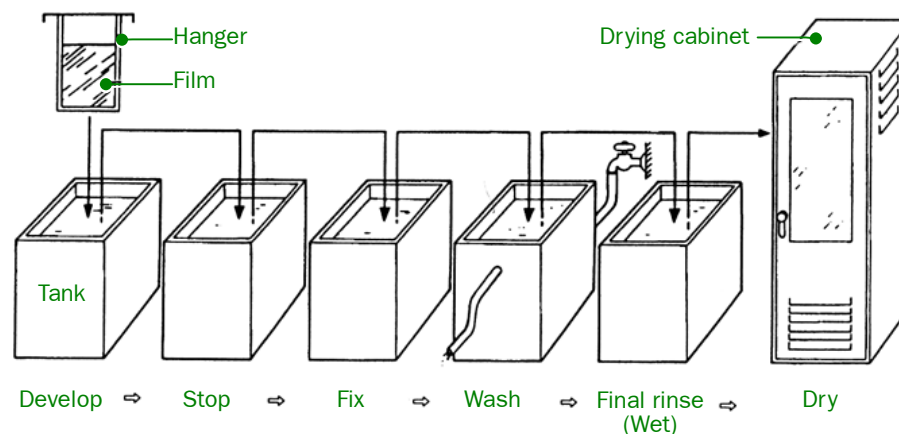



Fig. 5.52 Film processing

6. Immerse the film in a rapid acid hardening fixer (at 18 to 21°C); leave it in for approximately ten minutes (the fixing time should be at least two or three times the time it takes for the negative to clear).
This dissolves the photosensitive silver halides (the white part of the film) and makes the unexposed part of the film transparent. Then, processing can be carried out under ordinary light.
7. Wash the film in running water (at 15 to 20°C) for 30 to 60 minutes.
This removes the complex salt and fixing solution. The washing time can be considerably reduced by immersing the film in a rinse accelerator prior to washing it in running water.
8. Immerse the film in a final rinse bath (a weak solution of anionic surfactant, 18 to 21°C) and leave it in for approximately 30 seconds (or wipe both surfaces of the film carefully with a soft sponge).
Doing this reduces the time required for drying the film and prevents blisters from developing on the film.
9. Dry the film in a drying cabinet (the cabinet need not be large); or dry it naturally by hanging it in a well-ventilated, dust-free place away from direct sunlight.
10. Store the dried film in a negative envelope (made of polyethylene, cellophane, or similar material; avoid envelopes made of PVC); keep the envelope in a dry place away from direct sunlight.

 Consequences of faulty film processing and handling are listed in the table below (assuming proper exposure time).

Appearance	Possible cause
● No picture	<input type="radio"/> Film inserted into the cassette upside-down
● Complete blackening	<input type="radio"/> Magazine lid inadvertently opened while being carried
● Fogging	<input type="radio"/> Faulty safelight
	<input type="radio"/> Film processing date has expired
● High density	<input type="radio"/> Developer temperature too high
● Low density	<input type="radio"/> Developer temperature too low
● Too grainy	<input type="radio"/> Developing time too long
● Uneven density	<input type="radio"/> Developing time too short
	<input type="radio"/> Weak developer
● Spotty staining (mottled)	<input type="radio"/> Developer agitation insufficient
	<input type="radio"/> Film electrically charged before developing
● Scratches, streaks	<input type="radio"/> Film emulsion surface rubbed
● Film discolored	<input type="radio"/> Fixing and rinsing insufficient
● Moldy film	<input type="radio"/> Method and place of storage unsuitable
	<input type="radio"/> Drying insufficient
● Extraneous particulates	<input type="radio"/> Impurities in tap water
● Blisters on film	<input type="radio"/> Water droplets left on film before drying
● Reticulation	<input type="radio"/> Tap water temperature too high

5.14 HIGH RESOLUTION ELECTRON MICROSCOPY

● Small aperture angle

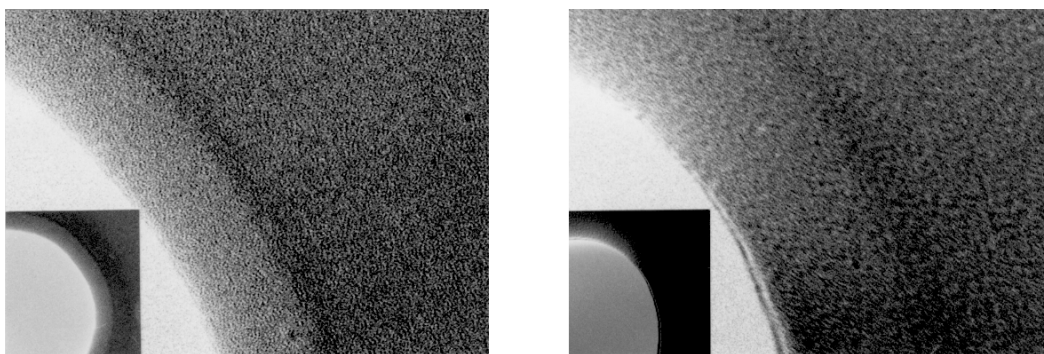
In electron microscopy, the smaller the aperture angle, the higher the coherency of the electron beam, allowing us to obtain higher-resolution micrographs. Therefore, it is logical to choose a small condenser aperture (100 or 40 micrometers in diameter) and to adjust the BRIGHTNESS knob for a 2 to 4 s exposure for photography. If, however, you want to minimize the aperture angle by using even smaller apertures, you can only do this with a loss of the brightness of the image. You must compromise as to whether resolution or brightness is desired.

The α -SELECTOR knob (L1-③) changes the aperture angle. The selected aperture (Alpha) number is displayed in left section of the TEM Controller main window (☞ Sect. 4.3.4a). Alpha No. 3 covers the whole range of magnifications except when very high-resolution photographs are required. It is recommended to use Alpha No. 2 or 1 for microscopy at very high magnifications requiring small aperture angles. The situation is summarized as follows:

- α -SELECTOR No. 3: Full magnification range
- α -SELECTOR No. 2: 100,000 \times or higher
- α -SELECTOR No. 1: 500,000 \times or higher

● Properly aligned voltage center

When the voltage axis is well aligned, the rim of a hole in the film can be seen as shown on the left in Fig. 5.53. The particle image (due to phase contrast) in the background is quite distinct and the whole edge of the hole appears clearly. If the voltage axis is not aligned sufficiently as in the right picture, the particle image tends to elongate in one direction and the edge looks as if astigmatism is present. Before you take photographs at high magnification, perform voltage axis adjustments at the magnification you want to use for photography (☞ Sect. 5.8).



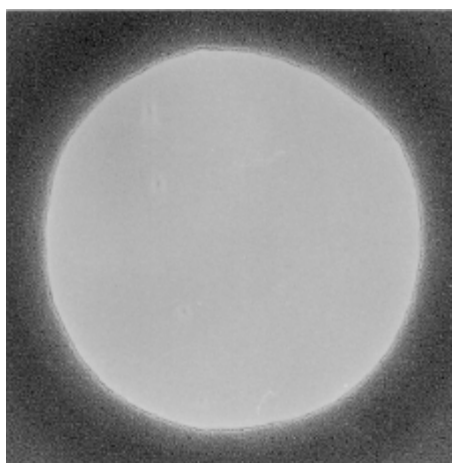
a. Film hole when the voltage axis is aligned

b. Film hole when the voltage axis is not aligned

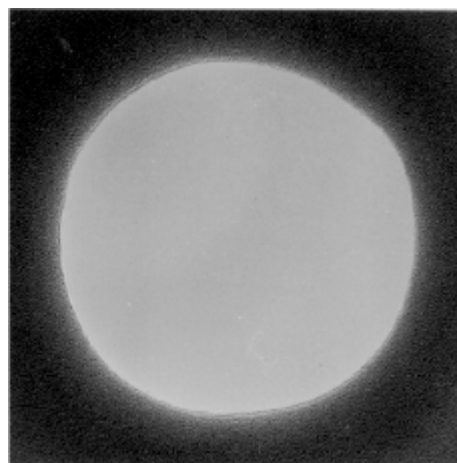
Fig. 5.53 Adjusting the voltage axis

- **Correct objective aperture positioning**

The left picture in Fig. 5.54 shows a hole image photographed when the objective aperture is inserted correctly. The particle image in the background is quite distinct and the whole edge of the hole appears clearly. The right picture shows the image when the aperture is not inserted correctly. The particle image tends to elongate in one direction and the edge looks as if astigmatism is present. If this occurs, readjust the aperture position.



a. Film hole when the aperture is inserted correctly

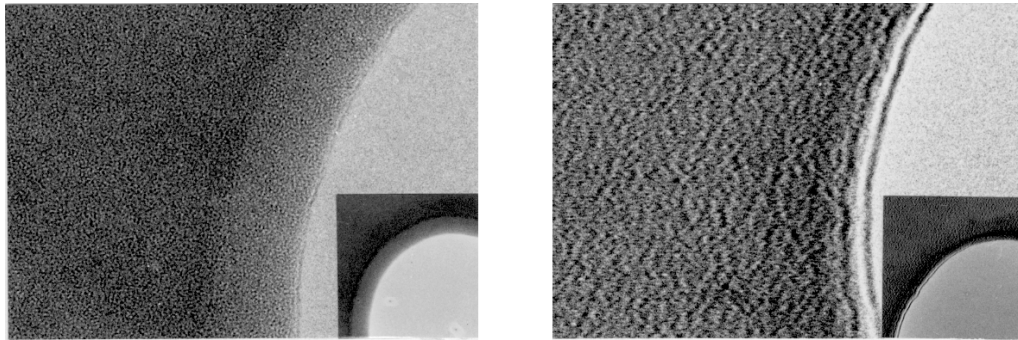


b. Film hole when the aperture is not inserted correctly

Fig. 5.54 Centering the objective aperture

- **Objective lens astigmatism correction**

If the correction of objective lens astigmatism is inadequate, it is very difficult to obtain an in-focus image. In other words, no matter how hard you try to focus the image, you cannot find the right focusing position due to the effect of astigmatism—the focal plane is different for two axes, one axis being in focus but the other being out of focus. The left picture in Fig. 5.55 shows a hole image photographed when objective lens astigmatism is corrected successfully. The particle image in the background is quite distinct and the whole edge of the hole is sharp enough in all directions. The right picture shows the image when astigmatism exists in the objective lens. The particle image tends to elongate in one direction, and asymmetrical Fresnel fringes appear along the rim of the hole, indicating that there is astigmatism. Correction should be performed at the highest magnification setting that you expect to use and once the astigmatism has been corrected, no further correction will be needed in the lower ranges of magnification. If the amount or direction of astigmatism changes with time, perhaps astigmatism resulting from aperture or stage contamination exists. If this occurs, take the necessary steps, referring to the appropriate maintenance manual.



a. Film hole when the astigmatism is not present b. Film hole when the astigmatism is present

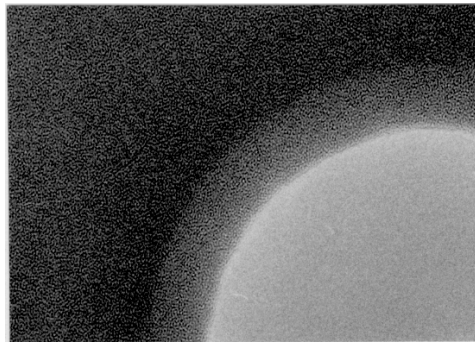
Fig. 5.55 Correcting objective lens astigmatism

When astigmatism has to be checked at a magnification of $100\,000\times$ or higher, it might be expedient to use both the Fresnel fringe and the particle image. To do this, perform correction first using the Fresnel fringe as accurately as possible; then use the particle image in such a way that each particle can be seen clearly and independently.

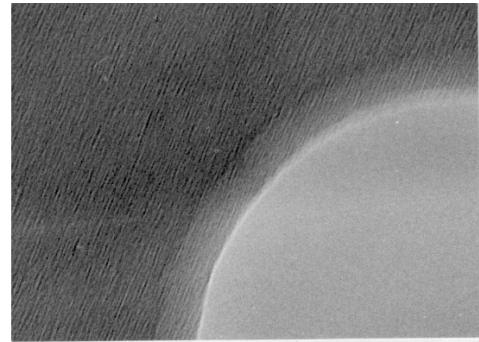
● Specimen preparation

If the specimen is unstable, the image inevitably drifts. The micrograph on the left in Fig. 5.56 is taken when there is no drift. The particle image in the background is quite distinct and the whole edge of the hole is sharp enough in all directions. The right picture shows the image when image drift occurs. The particle image drifts, resulting in softness of the image in one direction. The conceivable causes of image drift and remedial steps are as follows:

- Broken, creased, unsecured, or weakened supporting film
- ☞ Take utmost care when you make the supporting film and place the film onto the grid, and reinforce it using glue or carbon deposition.
- Curved grid
- ☞ Replace the grid with a (irrespective of new or used) better quality grid.
- Electrically charged specimen or supporting film
- ☞ Coat the surface of the specimen with evaporated carbon.



a. Film hole when there is no image drift



b. Film hole when there are some image drifts

Fig. 5.56 Image drift

● Other considerations

- If the specimen is contaminated, it is difficult to focus the image correctly, and photographs obtained will be unclear even though the image is properly focused. In order to prevent contamination caused by electron beam bombardment, avoid irradiating the specimen for a long time.
- Do not use a magnification higher than that necessary for resolving the feature of interest.
- Photograph the image with as short an exposure time as possible (two to four seconds will be adequate).
- If the aperture is contaminated, it may cause astigmatism. If this happens, clean it.

5.15 SPECIAL OPERATION

5.15.1 Minimum Dose Exposure System (MDS)

The MDS photographing technique used for searching for a field of view when the area to be photographed is not illuminated by the electron beam considerably reduces the total amount of electron beam irradiation on the specimen; consequently, the region to be photographed is protected from being contamination or damage by electron beam irradiation.

- ✍ The MDS technique consists of three modes; namely, Search, Focus, and Photo Set. To use this technique change the mode in the sequence of Search, Focus, and Photo Set.
- ✍ Settings are stored in the microscope memory, but readjusting these settings each time you use the MDS technique is recommended.

1. Select **Option** from the **TEM Controller** menu bar and click on **MDS** to open the **MDS** window (☞ Fig. 5.57).
2. Enter the MDS mode initial conditions as follows;
 - a. Click on the After Photo Mode Search radio button (☞ Fig. 5.57, ②); then enter the necessary information in the Beam Blanking Time, Beam Blanking conditions (☞ Fig. 5.57, ③) and Delay Time input boxes (☞ Fig. 5.57, ④).

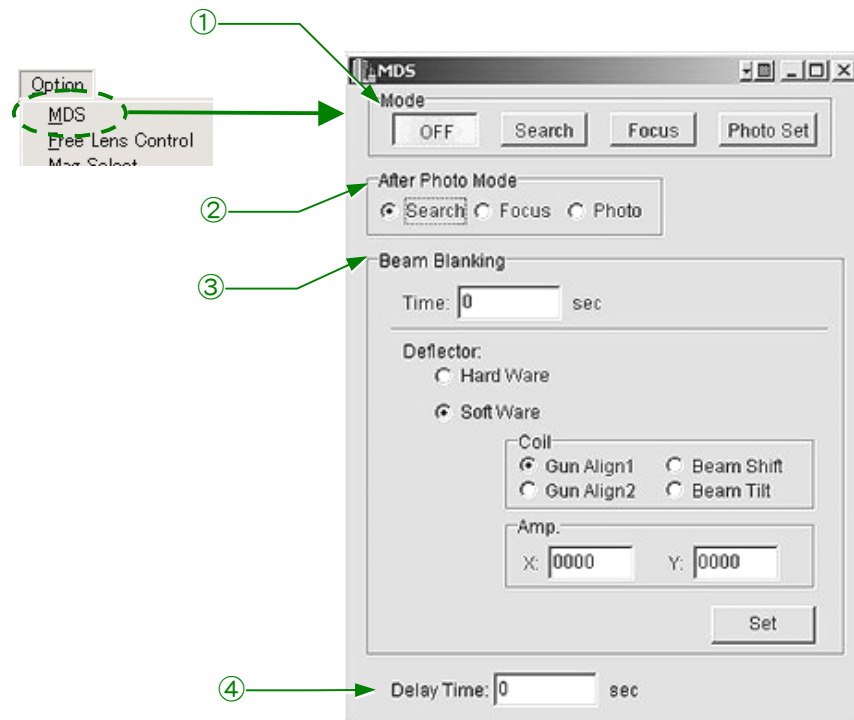


Fig. 5.57 MDS window

- Beam Blanking Time is the time during which the electron beam is blanked just before the camera shutter opens.
- Beam Blanking Conditions are conditions under which the beam is blanked.

- Delay Time is the time from when the camera shutter opens after beam blanking time has elapsed to when exposure starts.
 - ✍ After entering all necessary information, press the **Enter** key and all the inputs will take effect.
- b.** Select **Photo Set** (☞ Fig. 5.57, ①) from the **MDS** window.
 - c.** Choose the desired magnification, brightness, and photographing conditions.
 - ✍ Contract the electron beam to the minimum required for observing the desired field of view. Set the exposure time using the manual exposure mode.
 - 3.** Select **Search** (☞ Fig. 5.57, ①) from the **MDS** window.
 - 4.** Choose the desired magnification, brightness, and field-search conditions.

Choose an appropriately low magnification and expand the electron beam to reduce the electron beam current density on the specimen. A low magnification image can also be obtained by selecting the DIFF mode and by widely changing the setting of the DIFF FOCUS control.
 - 5.** Select **Focus** (☞ Fig. 5.57, ①) from the **MDS** window.
 - a.** Choose the desired magnification, brightness, and focus conditions.
 - ✍ Use magnifications higher than those used in Photo Set mode. Contract the electron beam as much as possible to focus the image without difficulty.
 - b.** Repeat Steps Search→Focus→Photo Set→Search until the movement of the electron beam is minimized.
 - c.** Select **Focus** from the **MDS** window.
 - 6.** Press the IMAGE SHIFT switch (L1-⑤) or click on DEF Select **IS1** in the **Alignment Panel for Maintenance** window (☞ Fig. 4.48).
 - 7.** Move the electron beam onto the specimen area where you want to focus using the SHIFT X and Y knobs (L1-⑧, R1-③); then move the field of view for focusing to the center of the screen using the DEF/STIG knobs.
 - ✍ Make sure that the field of view for focusing does not overlap the field of view for photography, which you will select using Photo Set mode.
 - 8.** Make sure that the conditions in each mode are correctly set.
 - 9.** Search for the field of view to photograph in Search mode.
 - 10.** Focus the image in Focus mode.
 - 11.** Photograph the image as follows:
 - a.** Press the PHOTO switch (R1-⑧).

The instrument enters Photo Set mode and automatically performs photography. After completing photography, the system proceeds to the mode specified using the After Photo Mode radio button.
 - b.** Click on **OFF** (☞ Fig. 5.57, ①) in the **MDS** window to switch the mode from MDS to normal, if you want.

5.15.2 Free Lens Control (FLC)

Using the FLC function, you can change all lens currents independently to produce special lens excitation conditions. You can save these conditions in the built-in computer as necessary.

1. Select **Option** from the **TEM Controller** menu bar and click on **Free Lens Control** to open the **FLC Panel** window (Fig. 5.59).
2. Click on either the desired lens On radio buttons or the **ALL On** button.
3. Drag the scroll buttons or click on the arrow buttons (◀ and ▶) in the window to change the lens currents.
 - ✎ Clicking on the Display Hex radio button displays lens settings in hexadecimal; clicking on the Dec radio button displays them in decimal.
 - ✎ The current change per step can be selected by clicking on the Step radio buttons.

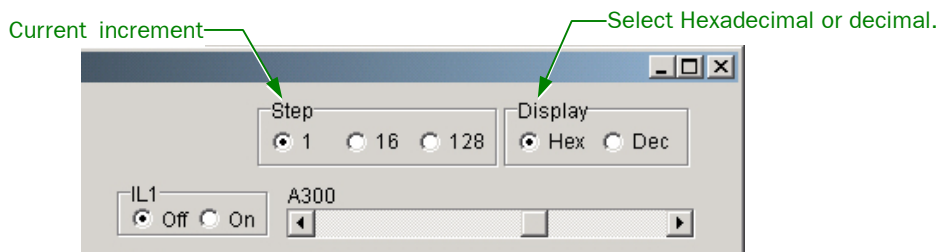


Fig. 5.58 Free Lens Control window(Display and Step control)

4. Click on **Save** to save the file containing the lens current settings
 - ✎ Clicking on **Save** opens the window in which you specify the name of the file and the folder.
 - ✎ Click on **Load** to retrieve the file.
5. Click on the lens Off radio buttons or the **ALL Off** button to terminate free lens control.
 - ✎ To return to normal lens control, make sure to select the **All Off** or all the lens Off radio buttons; otherwise the FLC function remains on.

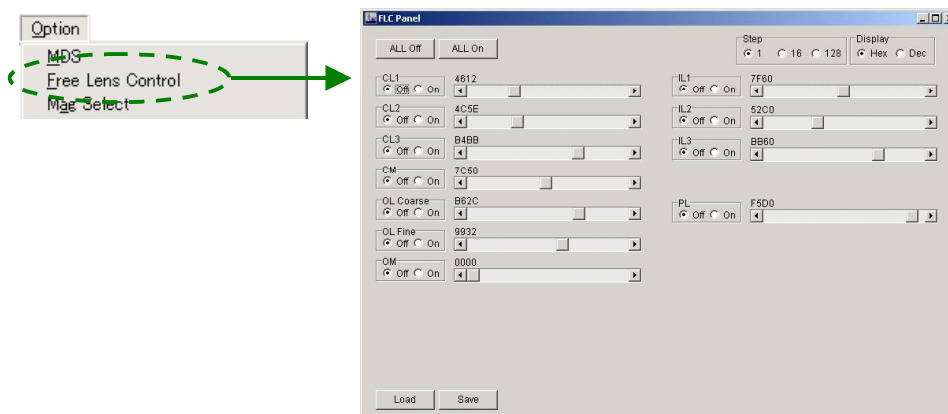



Fig. 5.59 FLC Panel screen

5.15.3 Selecting Magnifications and Camera Lengths

5.15.3a Selecting usable magnifications and camera lengths

You can select specific magnifications and camera lengths.

- ◆ Select **Option** from the **TEM Controller** menu bar and click on **Mag Select** to open the **MAG Select** window (see Fig. 5.60).

 All magnifications and camera lengths are checked as the default setting.

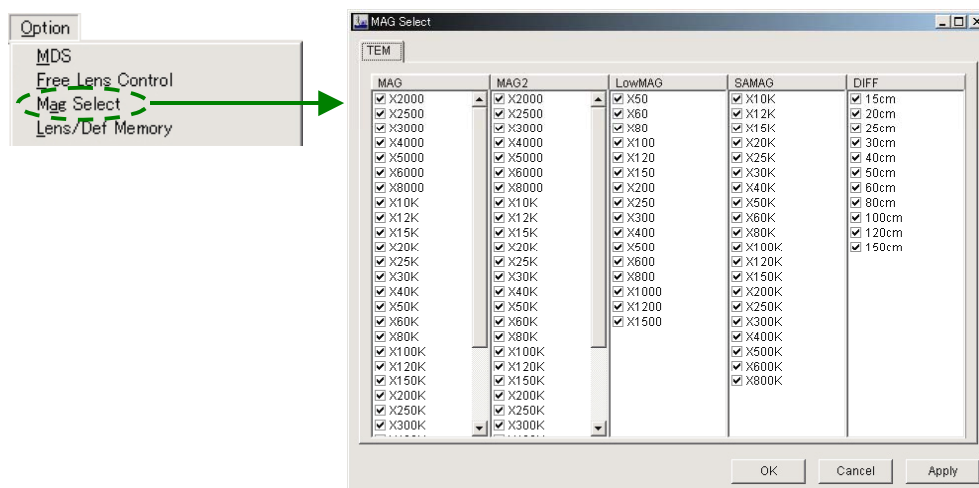




Fig. 5.60 MAG Select window
(All magnifications and camera lengths are checked.)

5.15.3b Selecting unusable magnifications and camera lengths

1. Deselect the magnifications or camera lengths that you do not want to use. To do this, remove the check mark by clicking on the checkbox corresponding to the magnification or camera length that you do not want to use.
2. Click on the **Apply** button.
3. Click on the **OK** button to exit **MAG Select**.
 Deselected magnifications and camera lengths are now unusable. If, for instance, you deselect $\times 10K$, the magnification changes from $\times 8000$ to $\times 12K$, skipping $\times 10K$.

5.15.3c Restoring unusable magnifications and camera lengths

1. Check the magnifications or camera lengths that you want to restore.
2. Click on the **Apply** button.
3. Click on the **OK** button to exit **MAG Select**.
 The checked magnifications or camera lengths are now available.

5.15.4 Setting a Reference Magnification

A reference magnification (magnification setting obtained when MAG 2 is pressed) can be specified as follows:

1. Press MAG2 (R1-②).
2. Choose an appropriate magnification using the MAG/CAM knob (R1-⑤).
3. Click on the **Standard** tab in the **Operation** window (☞ Fig. 5.61).
4. Click on **Settings**.
5. Click on **MAG2** to open the confirmation window.
6. Click on the **OK** button in the confirmation window.

The reference magnification is specified and the magnification selected by Step 2 above is obtained when MAG2 (R1-①) is pressed. If you want to modify the magnification, repeat the above steps.

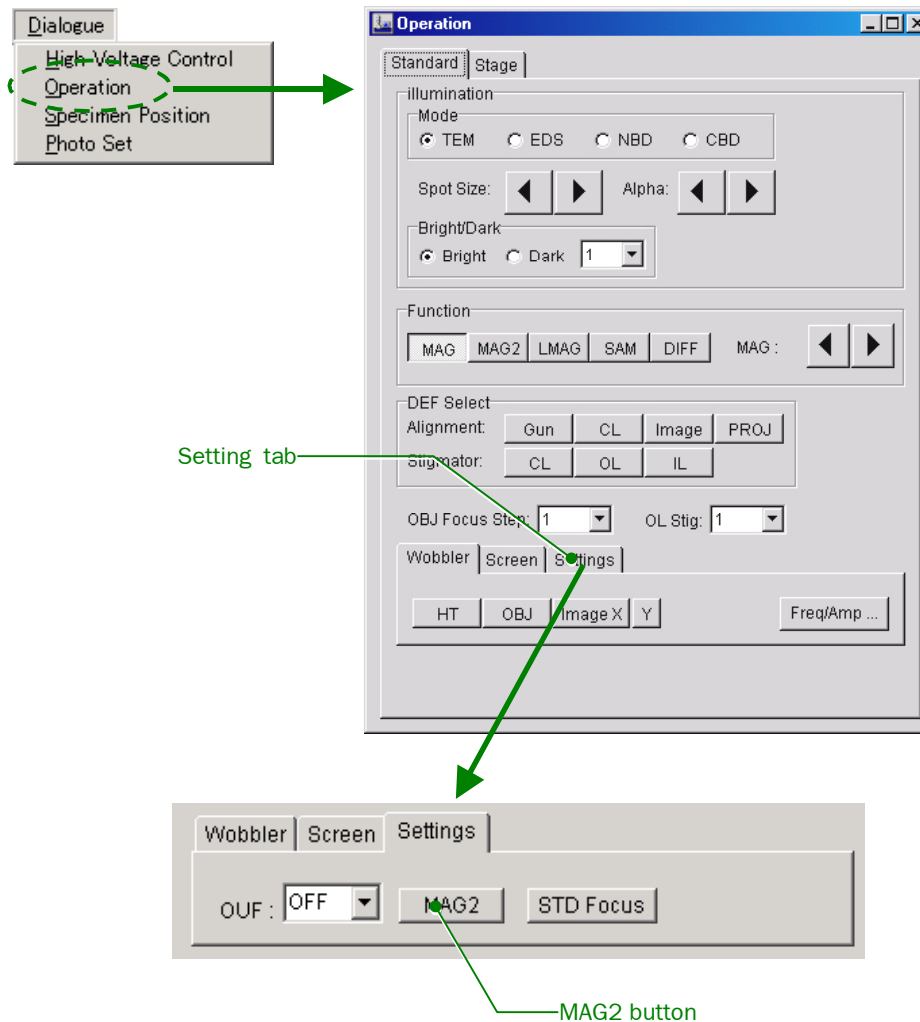


Fig. 5.61 Operation window

5.15.5 Saving Alignment Data

All the alignment data can be saved in the built-in computer and retrieved to restore alignment conditions when necessary. This is particularly useful in saving the alignment data set under special conditions or in finding the lost beam using the saved data with which the most preferable alignment conditions have been obtained.

- ◆ Select **Maintenance** from the **TEM Controller** menu bar and click on **Alignment** to open the **Alignment Panel for Maintenance** window (☞ Fig. 5.62).

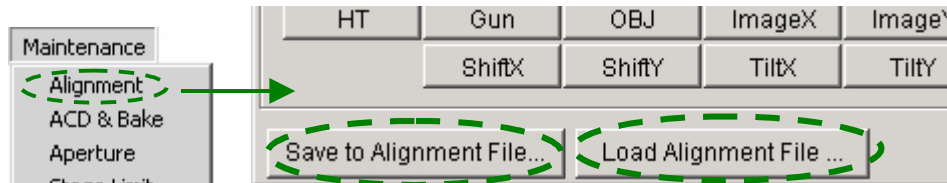


Fig. 5.62 Alignment Panel for Maintenance window (Saving and reading alignment data)

5.15.5a Saving

1. Click on **Save to Alignment File...** (☞ Fig. 5.62).
2. Enter the file name and save it.

5.15.5b Loading

1. Click on **Load Alignment File...** (☞ Fig. 5.62).
2. Click on the desired file name.

5.15.6 Saving Lens Alignment Data

To record and restore only the illuminating-system alignment conditions, do the following:

- ◆ Select **Maintenance** from the **TEM Controller** menu bar and click on **Lens/Def Memory** to open the **Lens/Def Memory** window (☞ Fig. 5.63).

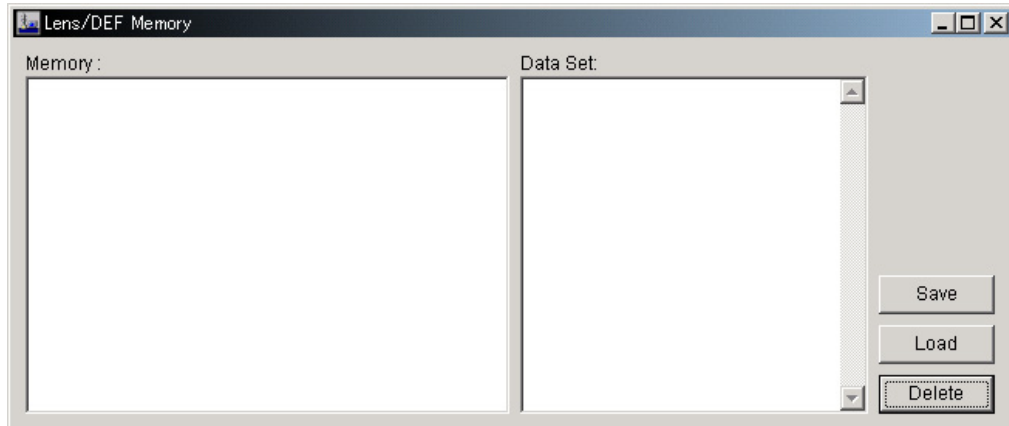


Fig. 5.63 Lens/Def Memory window

5.15.6a Saving

1. Click on **Save** in the **Lens/Def Memory** window to open the **Lens/Def Memory Option** window.
2. Enter the name of the data from the keyboard (☞ Fig. 5.64).
Fig. 5.64 shows when “test” is entered as an example.
3. Click on the checkboxes corresponding to the lens alignment conditions that you want to save.
Fig. 5.64 shows an example when CL1, CL3, CLA1, and CLA2 are selected. If you want to select all the lenses or deflection coils, click on the **All Lens** or **All DEF** button.
4. Click on the **OK** button in the **Lens/Def Memory Option** window to save the selected conditions (☞ Fig. 5.65).

The above procedure completes saving a file containing a set of alignment conditions. A variety of alignment data can be saved with different file names.

✍ A list of the data names appears underneath the column headed “Memory” in the **Lens/DEF Memory** window. Click on any of the data names and the related data will be displayed in the Data Set column in the **Lens/DEF Memory** window. The related data is composed of:

- Magnification and spot size
- Name of the lens and deflection coil
- Lens and deflection coil conditions

(☞ Fig. 5.65)

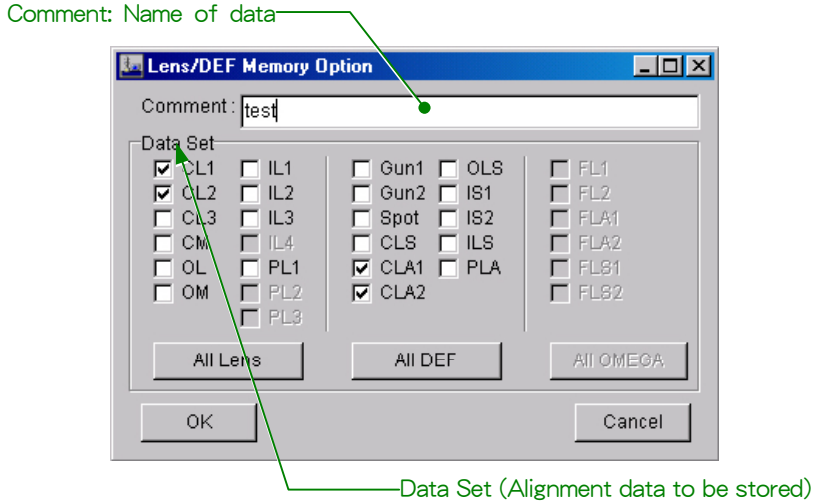


Fig. 5.64 Lens/DEF Memory Option window

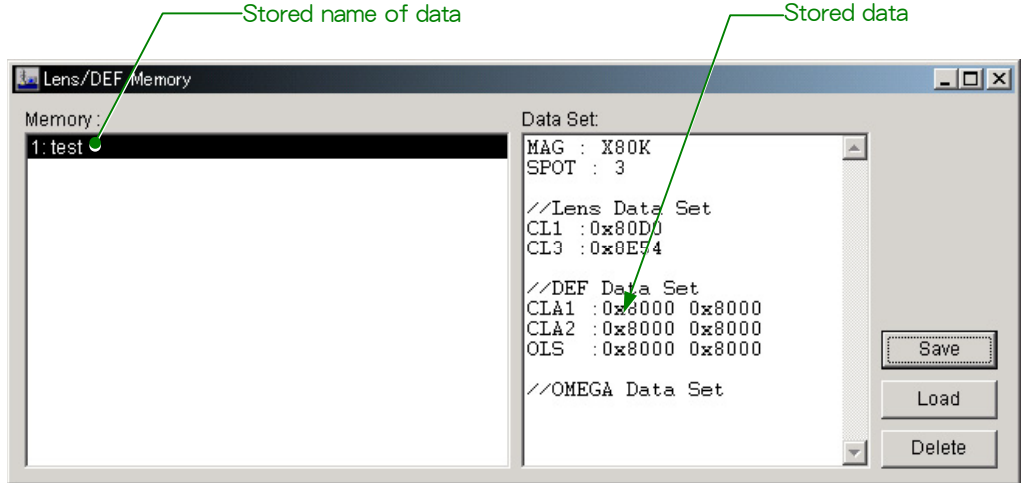


Fig. 5.65 Lens/DEF Memory window(Data Set column)

5.15.6b Loading

1. Click on the desired file name in the **Lens/Def Memory** window.
2. Click on **Load** in the **Lens/Def Memory** window.

The illuminating system is realigned in accordance with the alignment conditions stored in the file.

The lens conditions are restored in free lens control mode. To return to the conditions before restoration, it is necessary to terminate free lens control (Sect. 5.15.2).

The deflection coil conditions are loaded directly to the coil memory.



MAINTENANCE

6.1	CHANGING THE FILAMENT OF THE ELECTRON GUN.....	6-2
6.1.1	Checking if the Filament of the Electron Gun is Burned Out	6-2
6.1.2	Venting the Electron Gun Chamber.....	6-4
6.1.3	Changing the Filament	6-6
6.1.4	Adjusting the Wehnelt Cap.....	6-8
6.1.5	Re-evacuating the Electron Gun Chamber	6-8
6.1.6	Degassing the Filament	6-9
6.2	CHANGING THE SMALL FLUORESCENT SCREEN	6-12
6.3	INSULATION GAS REPLENISHMENT.....	6-14
6.3.1	Characteristics of Insulation Gas (SF ₆ Gas)	6-14
6.3.2	Precautions for Handling the Insulation Gas.....	6-14
6.3.3	Replenishing Electron Gun Gas Chamber with SF ₆ Gas.....	6-14
6.3.4	Replacing the Gas in the Electron Gun Gas Chamber.....	6-15
6.3.5	Replenishing the HT Tank with SF ₆ Gas	6-17
6.4	CLEANING THE COLUMN PARTS	6-18
6.5	BAKING OUT THE COLUMN	6-18
6.6	TROUBLESHOOTING	6-21
6.6.1	Concerning Start-up	6-21
6.6.1a	When it is impossible to start up the microscope.....	6-21
6.6.1b	When the microscope stops automatically some time after start-up	6-21
6.6.1c	When the message, “Beam Not Ready” appears.....	6-21
6.6.2	Concerning Electron Beam	6-21
6.6.2a	When no electron beam appears on the fluorescent screen.....	6-21
6.6.2b	When the electron beam is not generated.....	6-22
6.6.3	Concerning the Specimen Movement and Tilting.....	6-22
6.6.3a	When the specimen cannot be moved or tilted	6-22
6.6.4	Concerning Photographing.....	6-22
6.6.4a	When the Exp. Time shows *** even though the enough irradiation	6-22
6.7	INSTRUCTIONS CONCERNING NITROGEN GAS	6-23
6.7.1	Stopping and Resuming Supply of Nitrogen Gas.....	6-23

6.7.1a	Stopping supply of nitrogen gas	6-23
6.7.1b	Resuming supply of nitrogen gas	6-24
6.7.2	Replacement of Nitrogen Gas Cylinder (If Used)	6-25
6.7.3	Connection to Nitrogen Gas Supply Piping.....	6-25
6.8	CONCERNING THE LIFT AND THE LIFT POLE	6-25
6.9	CONSUMABLES AND MAINTENANCE PARTS	6-26
6.9.1	JEM-2100 Microscope Console and Column.....	6-26
6.9.2	Objective Lens Aperture.....	6-27
6.9.2a	UHR configuration.....	6-27
6.9.2b	HR and HT configurations	6-27
6.9.2c	CR configuration	6-27
6.9.2d	HC configuration.....	6-28
6.9.3	EM-23120 TMP Evacuation System	6-28

The symbols L1, L2, R1, R2, SC, KB, etc. appearing in parentheses after the names of panel controls designate the respective control panels. The windows appear on the PC monitor that is used with the TEM controller.

☞ Chapter 4, “Description of Controls” for details on the knobs and windows.

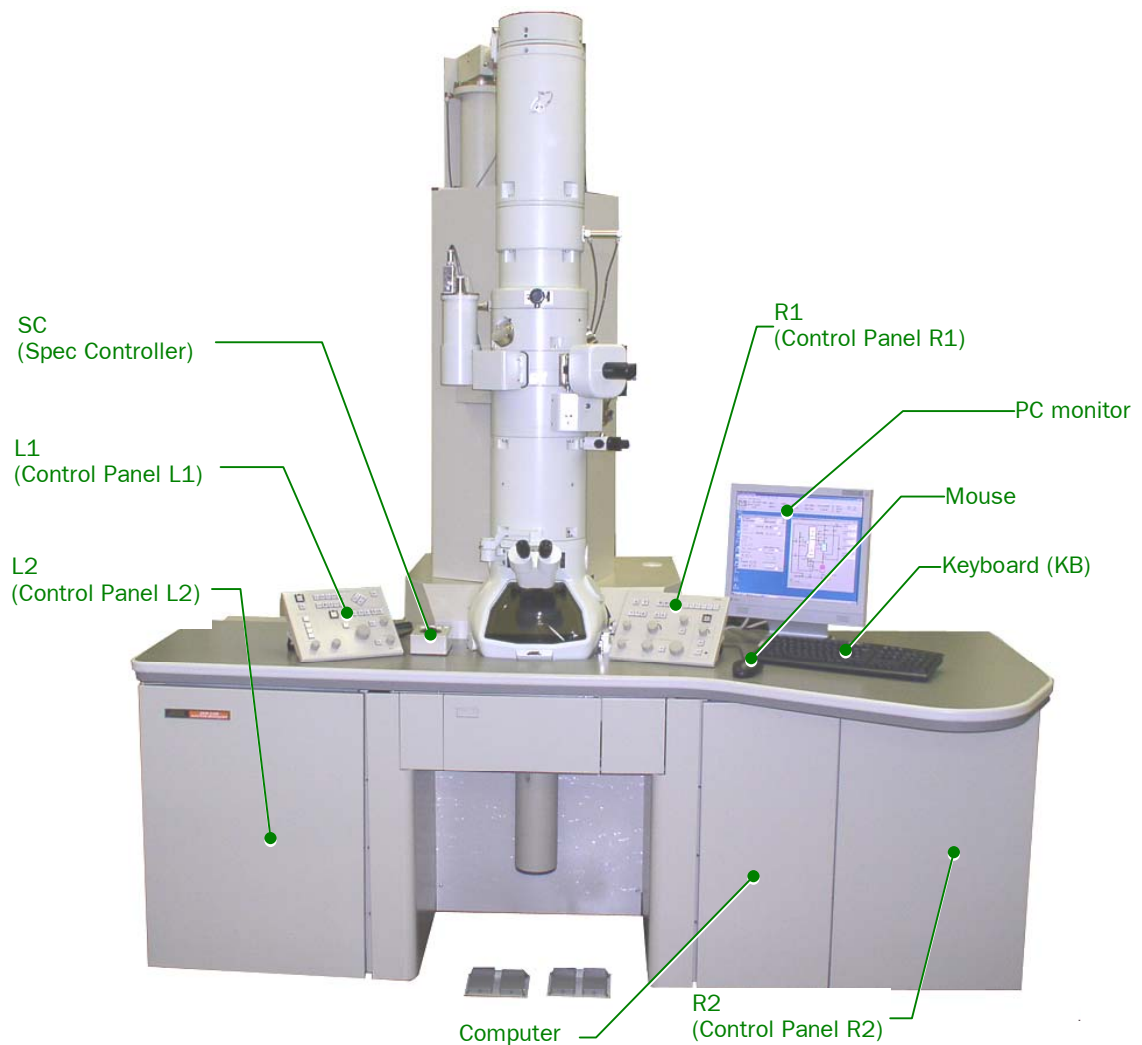


Fig. 6.1 Layout of control panels

6.1 CHANGING THE FILAMENT OF THE ELECTRON GUN

— CAUTION —

Do not stand on the chassis or the control table of the electron microscope. When you perform maintenance in a high place, be sure to use a stepstool with no wheels.

6.1.1 Checking if the Filament of the Electron Gun is Burned Out

1. Apply the accelerating voltage as follows.
 - a. Set the accelerating voltage to an appropriate value using the ▼ and ▲ buttons in the HT box in the **High Voltage Control** window.
 - b. Click on the **ON** button in the HT section in the **High Voltage Control** window.
The system starts to apply the accelerating voltage. The **Accelerating Voltage** window appears.
 - ✎ While the **Accelerating Voltage** window is on the screen, you cannot control other windows.
 - c. Wait until the **Accelerating Voltage** window disappears.
2. Start emitting the electron beam as follows
 - a. Set the value in the Filament box using the ▼ and ▲ buttons in the **High Voltage Control** window.
 - b. Click on the **ON** button in the Filament box in the **High Voltage Control** window.
The **Filament** window appears, which shows the status bar.
 - ✎ While the **Filament** window is on the screen, you cannot control other windows.
 - c. Wait until the **Filament** window disappears.
3. Set the Coarse and Fine values in the Bias box to their maximum values using the ▲ button for each (Fig. 6.2).
4. Make sure that the V1 and V2 valves are open using the **Valve Status** window (Fig. 6.3).
5. Make sure that the Beam Current does not increase even if you raise the value in the Filament box to the Filament Max Limit using the ▲ button (Fig. 6.2).
 - ✎ If the Beam Current increases, the filament is not burned out.
6. Change the Coarse and Fine values in the Bias box to their original values (5 to 6) using the ▼ button (Fig. 6.2).

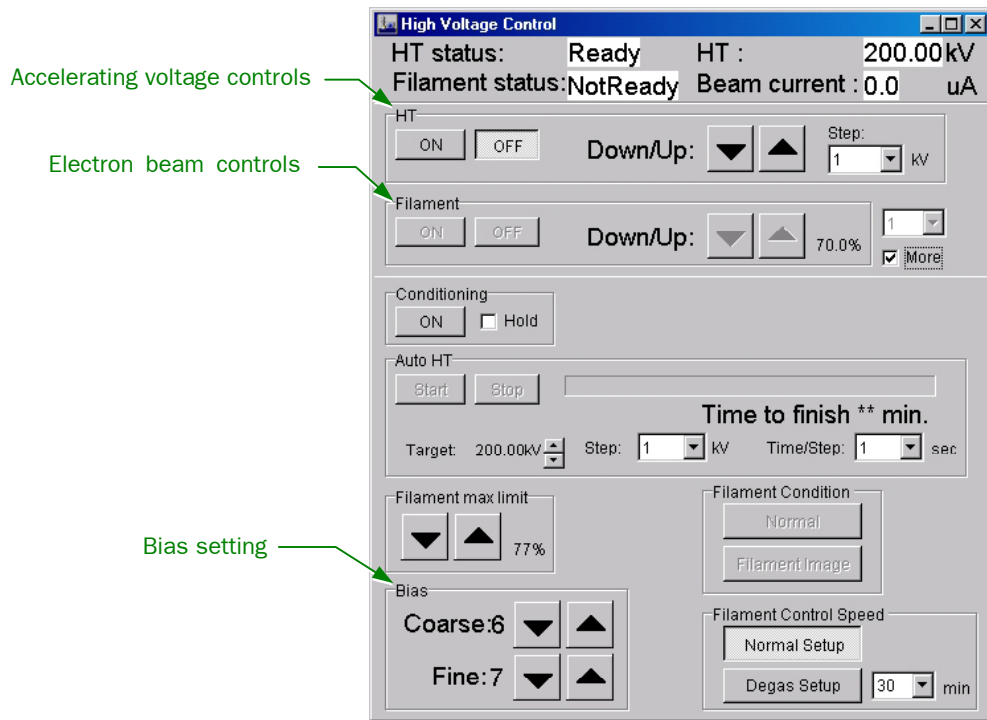


Fig. 6.2 Checking if the filament is burned out (High Voltage Control window)

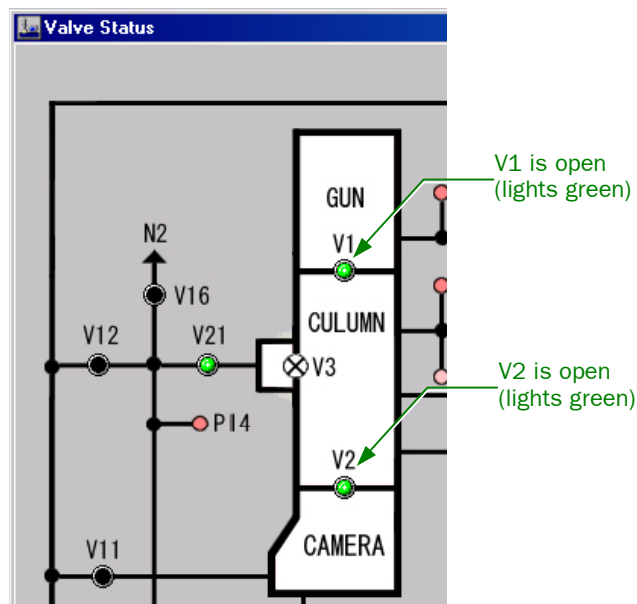




Fig. 6.3 The V1 and V2 valves are open (Valve Status window)

6.1.2 Venting the Electron Gun Chamber

1. Stop the emission of the electron beam as follows.
 - a. Click on the **OFF** button in the Filament box in the **High Voltage Control** window (Fig. 6.2).
The confirmation window appears, asking if you want to stop the emission of the electron beam.
 - b. Click on **OK** in the confirmation window.
The **Filament** window appears, which shows the status bar.
 While the **Filament** window is on the screen, you cannot control other windows.
 - c. Wait until the **Filament** window disappears.
2. After the emission of the electron beam has stopped, turn off the accelerating voltage as follows
 - a. Click on the **OFF** button in the HT box in the **High Voltage Control** window (Fig. 6.2).
The confirmation window appears, asking if you want to stop the accelerating voltage.
 - b. Click on **OK** in the confirmation window.
The **Accelerating Voltage** window appears.
 While the **Accelerating Voltage** window is on the screen, you cannot control other windows.
 - c. Wait until the **Accelerating Voltage** window disappears.
3. If there are connecting plates attached to the lift, take them off (Fig. 6.4).

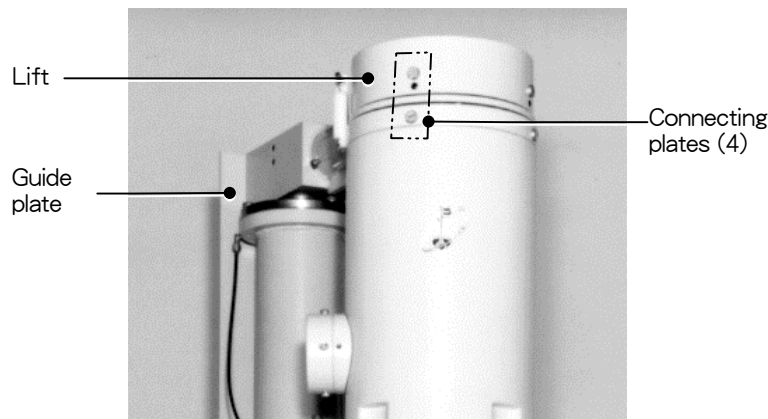


Fig. 6.4 Connecting plates attached to the lift

4. Make sure that the stop on the lift is in the A position (Fig. 6.5).

CAUTION

Do not put your hands or fingers between the upper and lower parts of the electron gun chamber while the lift is moving. You might get injured.

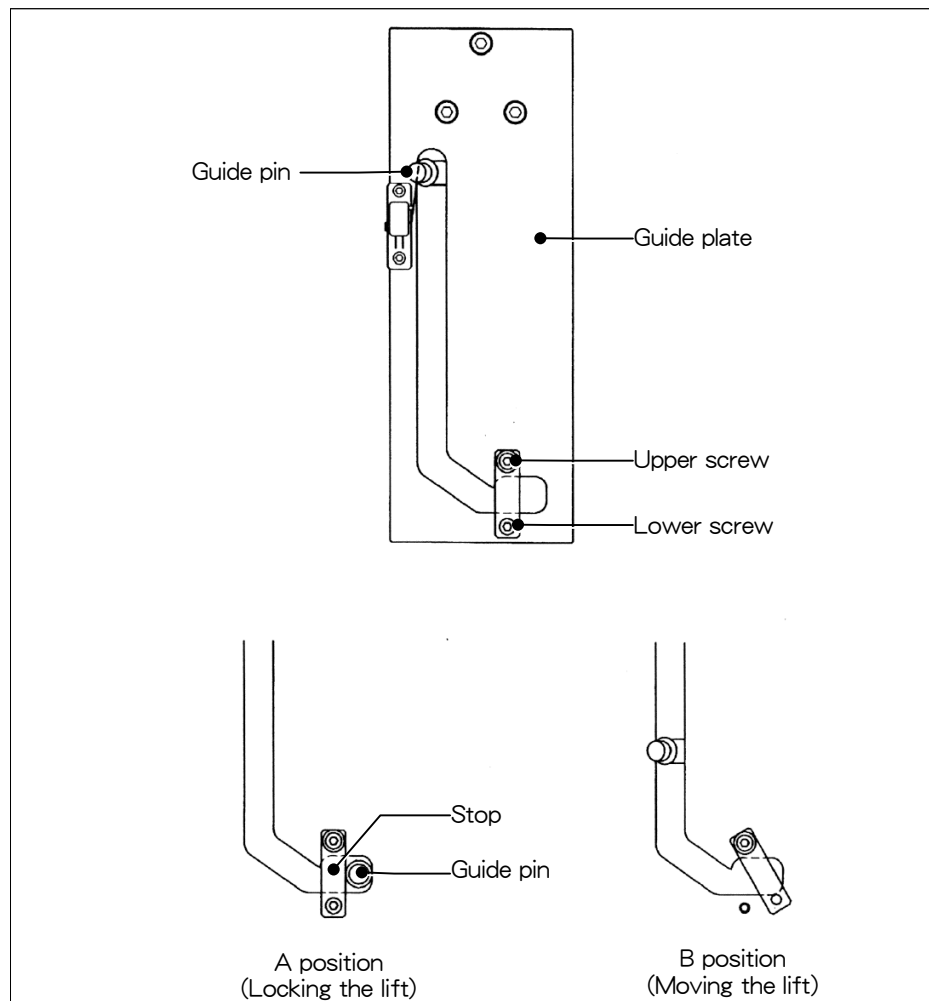


Fig. 6.5 Stop position on the lift

5. Press the GUN AIR switch (L2-⑨) (Fig. 6.6).
✂ Air enters the electron gun chamber.
6. Move the stop to the B position and fasten it with the screw.
7. Wait for 5 minutes, and press the GUN LIFT switch (L2-⑧) (Fig. 6.6).
✂ The electron gun is lifted up.
8. Cover the electron gun chamber with aluminum foil to prevent dust from entering the chamber.

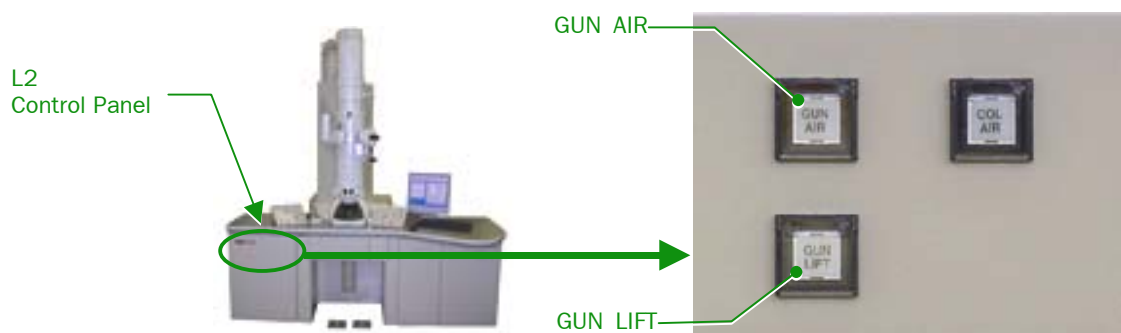


Fig. 6.6 GUN AIR and GUN LIFT switches (L2 Control Panel)

6.1.3 Changing the Filament

1. Make sure that the grounding spring is in contact with the tip of the electron gun (Wehnelt), and wait until the Wehnelt cools down.

⚠ CAUTION

If the filament has just burned out, the temperature of the Wehnelt is quite high. Wait until the Wehnelt is cool enough to touch (about an hour); then proceed to the next step.

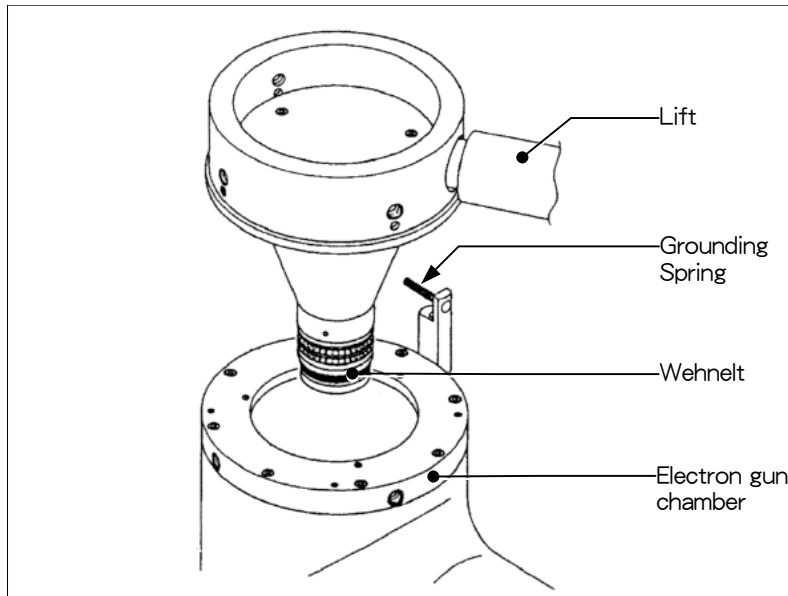


Fig. 6.7 Ground spring

2. Put on clean thin gloves of cotton or nylon, and detach the cylinder by turning it counterclockwise (Fig. 6.8).

— **CAUTION** —

Make sure that you use thin gloves. If you handle the cylinder with bare hands, the cylinder gets dirty, which might cause high-voltage discharge.

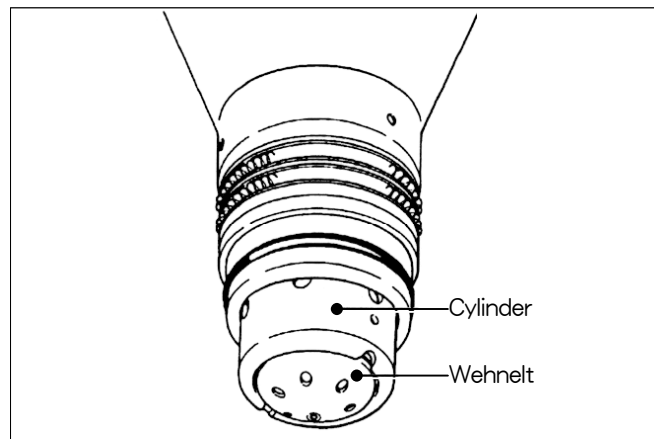


Fig. 6.8 Cylinder and Wehnelt

3. Pull down the Wehnelt and take it out of the cylinder.
4. Disassemble the Wehnelt (Fig. 6.9).
 - a. Loosen the three filament-attaching screws with an Allen wrench, and take the burned-out filament (cathode) out of the stage.
 - b. Take off the cap (grid) by turning it counterclockwise while pushing it toward the spring. The spring comes off as well.
 - ✍ If you have difficulty in taking the cap off, use the Wehnelt tool (Fig. 6.10).

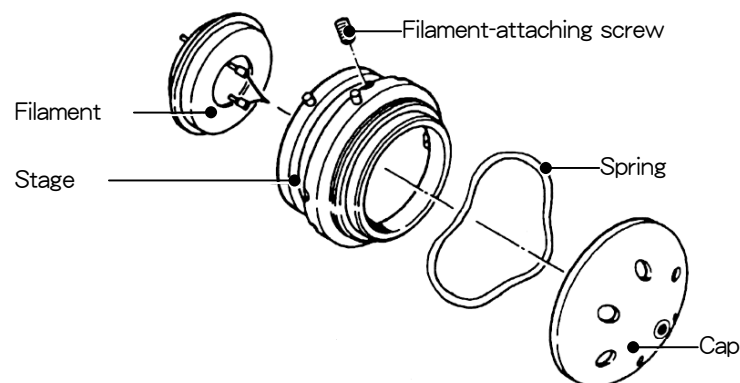



Fig. 6.9 Disassembling the Wehnelt

5. Clean the Wehnelt cap (☞ Sect. 6.4).
6. Put the spring on the filament stage and screw the cap in for 1 to 2 turns. If there is any dust on the parts, remove it using a handheld blower.
7. Attach a new filament to the filament stage so that the groove on the filament meets the pin inside the stage. Adjust the filament-attaching screws so that the tip of the filament is within $30\ \mu\text{m}$ from the center of the Wehnelt cap hole.
 - ✍ Never touch the tip of the filament.

6.1.4 Adjusting the Wehnelt Cap

1. Place the Wehnelt on the base of the Wehnelt tool as shown in Fig. 6.10, and put the cap of the tool over the Wehnelt so that the pin inside the cap of the tool meets the hole of the Wehnelt cap.
2. Follow the steps below to adjust the height of the Wehnelt (Fig. 6.10).
 - a. Turn the cap of the tool clockwise to screw the Wehnelt in until the tip of the Wehnelt cap is level with the tip of the filament.
 - b. Turn the cap of the tool counterclockwise for 1.5 turns so that the tip of the Wehnelt cap is 0.65 to 0.70 mm higher than the tip of the filament.
 -  The cap of the tool has a scale. One turn raises the height of the Wehnelt cap by 0.5 mm.
 - c. Detach the Wehnelt from the tool.

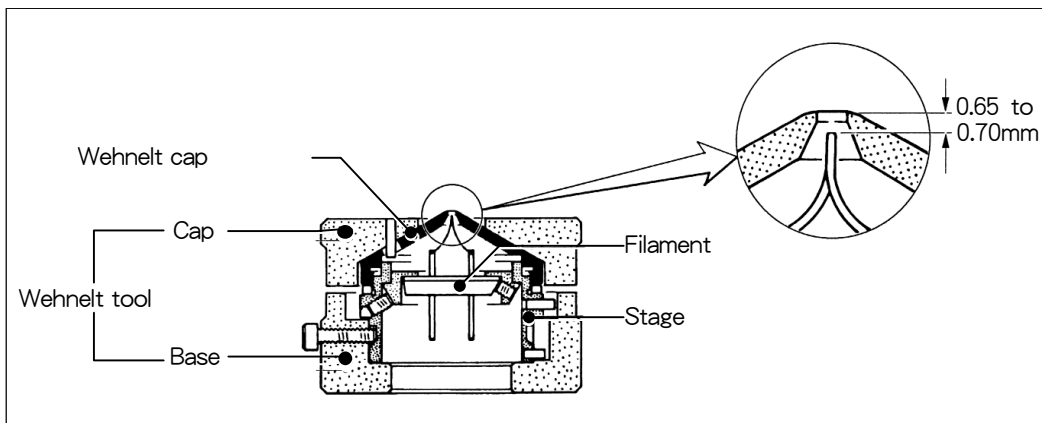


Fig. 6.10 Adjusting the Wehnelt cap

6.1.5 Re-evacuating the Electron Gun Chamber

1. Push the Wehnelt onto the electron gun while making sure that the pin on the Wehnelt meets the groove on the electron gun. Fasten it with the cylinder (Fig. 6.11).
2. Remove the dust and lint from the O-ring of the electron gun and the Wehnelt using a handheld blower. Take the aluminum foil cover off the electron gun chamber and check the inside.

— **CAUTION** —

If there is any dust or lint in the chamber, it might cause high-voltage electric discharge. Remove the dust or lint using a handheld blower. If there is any dust or lint on the O-ring, it might degrade the vacuum. Remove the dust or lint by wiping it off with your fingers.

3. Make sure that silicone grease is applied on the silicone rubber of the electron gun. Apply the provided silicone grease if necessary.
4. Remove the lower screw that fastens the stop; then move the electron gun to the right until it stops. Put the screw back on where it was, and place the stop in the B position (Fig. 6.5).

5. Press the GUN LIFT switch (L2-⑧) to turn off the lift (Fig. 6.6).
6. Press the GUN AIR switch (L2-⑨) to turn off the venting (Fig. 6.6).

The electron gun returns to the original position, and the system starts to evacuate the electron gun chamber.

- ✍ When you apply high voltage for the first time after changing the filament, make sure that the pressure in the electron gun chamber is kept under 1×10^{-4} Pa.
- ✍ After changing the filament, the saturation position of the filament might change. You should adjust the saturation position if necessary. If the filament is excessively heated, it will shorten the life of the filament.

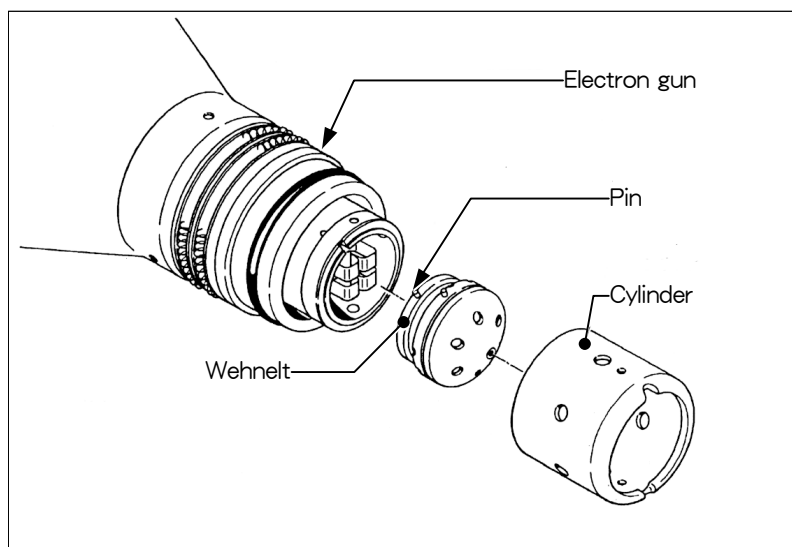


Fig. 6.11 Assembling the Wehnelt

6.1.6 Degassing the Filament

Here, it is assumed that the accelerating voltage is already being applied.

1. Set the accelerating voltage to 0 kV using the ▼ button in the HT box in the **High Voltage Control** window (Fig. 6.13).
2. Set the amount of the electron beam to 60 to 70% using the ▼ and ▲ buttons in the Filament box in the **High Voltage Control** window (Fig. 6.13).
3. Click on the **Degas Setup** button in the Filament Control Speed box in the **High Voltage Control** window to turn it on (Fig. 6.13).
4. Select the degassing time from the list box beside the **Degas Setup** button in the Filament Control Speed box in the **High Voltage Control** window (Fig. 6.13).
 - ✍ Set the time to 90 to 120 min.
5. Click on the **ON** button in the Filament box in the **High Voltage Control** window (Fig. 6.13).

The **Filament** window appears, which shows the status bar.

 - ✍ While the **Filament** window is on the screen, you cannot control other windows.
6. Make sure that the pressure in the electron gun chamber is below 1×10^{-4} Pa while the **Filament** window is on the screen.

7. After the **Filament** window disappears, leave it as is for 1 or 2 hours.
8. Click on the **OFF** button in the Filament box in the **High Voltage Control** window to turn it off (Fig. 6.13).
The **Filament** window appears, which shows the status bar.
✂ While the **Filament** window is on the screen, you cannot control other windows.
9. Generate an electron beam following the usual steps (☞ Sect. 5.2.6).
10. Set the Coarse to 9 in the Bias box in the **High Voltage Control** window (Fig. 6.13).
11. Set the magnification to $\times 40000$, and with draw all the apertures out of the electron beam path.
12. Click on the **Gun** button in the DEF Select box in the **Alignment Panel for Maintenance** to turn it on, and project the electron beam on the fluorescent screen using the SHIFT X and Y knobs (L1-⑧, R1-③).
13. Insert a condenser aperture of $70\ \mu\text{m}$ or $200\ \mu\text{m}$ diameter into the electron beam path.
14. Gradually reduce the Coarse value in the Bias box in the **High Voltage Control** window to bows the cross over so that the beam image changes like Photos 1 to 2 in Fig. 6.12.
✂ If the beam does not bows the cross over like Photos 1 to 2, reduce the amount of the electron beam using the ▼ button in the Filament box.

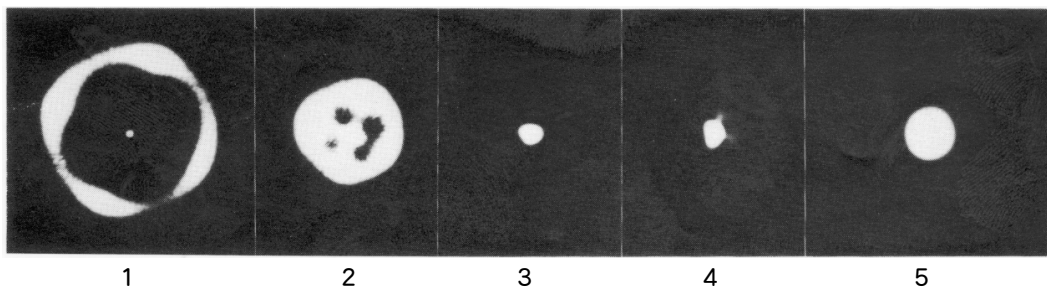



Fig. 6.12 Change of the beam image depending on the Coarse value in Bias

15. Reduce the Coarse value in the Bias box in the **High Voltage Control** window so that the beam image looks like Photo 3 in Fig. 6.12.
16. Gradually increase the amount of the electron beam using the ▲ button in the Filament box so that the beam image changes like Photos 3→4→5 or Photos 3→5 in Fig. 6.12, until it reaches the saturation position.


— **CAUTION** —

Do not raise the value in the Filament box in the High Voltage Control window higher than the saturation position. If you do, the life of the filament will be shortened.

17. Reduce the Coarse value in the Bias box in the **High Voltage Control** window gradually until the beam image disappears from the fluorescent screen, and make sure that the Coarse value was 1 to 2 when the beam image disappeared.

 If the Coarse value was 3 or more times bigger when the beam image disappeared, the tip of the filament and the top surface of the Wehnelt cap are too far apart. In this case, take out the filament again and adjust the position. If the beam image does not disappear even though the Coarse value is the lowest, the tip of the filament and the top surface of the Wehnelt cap are too close. In this case, take out the filament again and adjust the position as well.

18. When you observe using the microscope, set the value in the Bias box so that the beam current is about 10 μA .

 Normally, when the values in the **High Voltage Control** window are as follows, you will obtain the beam image like that in Photo 5 in Fig. 6.12.

- Filament: 55 to 60%
- Bias
 - Coarse: 5 to 6
 - Fine: 5 to 6

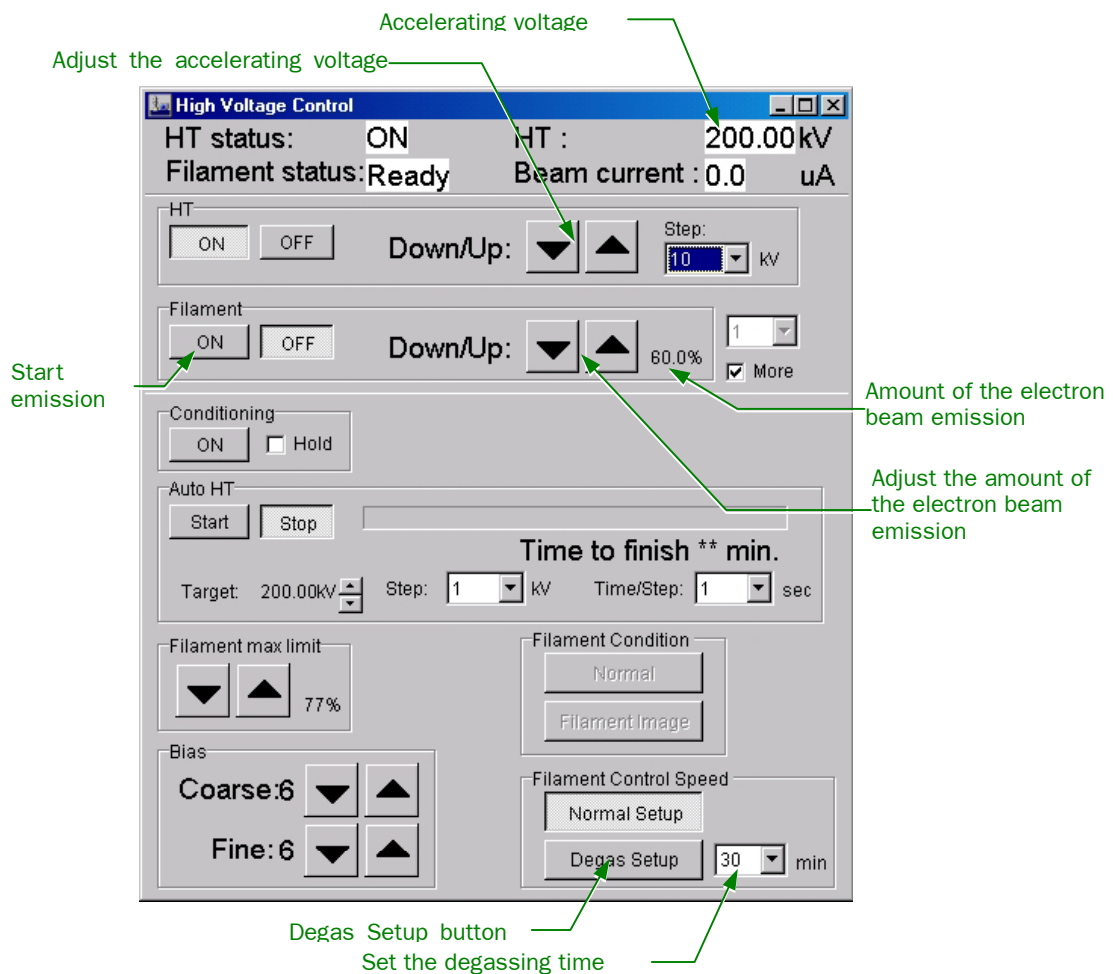






Fig. 6.13 Degassing the filament (High Voltage Control window)

6.2 CHANGING THE SMALL FLUORESCENT SCREEN

Prolonged use of the fluorescent screen deteriorates the phosphor coated on the screen, adversely affecting the brightness and sharpness of the image. If this happens, replace the worn-out small fluorescent screen with the spare one provided, and contact your nearest JEOL Service Center to have the old screen reconditioned. To replace the screen, follow the steps below:

1. Admit nitrogen gas into the viewing chamber as follows.
 - a. Open the valve of the nitrogen gas cylinder, and turn the camera chamber door handle clockwise as far as it will go.
 - b. Wait until the door opens; then close the valve of the nitrogen gas cylinder.
 -  If the valve of the nitrogen gas cylinder is closed, or if the gas cylinder is empty, the door will not open.
 -  If the door does not open after you wait for 5 minutes, turn the door handle counterclockwise all the way, turn it clockwise again as far as it will go, then wait for another 5 minutes. Repeat this until the door opens.
2. Attach the two suction disks to the viewing chamber window glass, and carefully remove the glass with both hands.

Place the removed glass in a clean spot with its inner surface facing upwards.

 -  Be careful not to touch or rub against the inner surface of the glass as it has been specially treated with conductive material.
 -  Be careful not to drop the window glass or bump its corner as it is lead glass which is brittle and breaks easily.

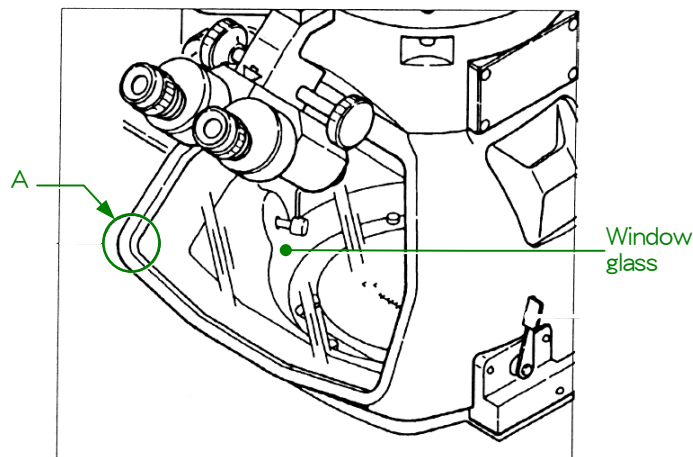



Fig. 6.14 Viewing chamber

3. While holding the small fluorescent screen bar with one hand, carefully remove the screen with the other (Fig. 6.15).
 -  Be careful when handling the screen as its fluorescent surface scratches easily.

- Carefully insert the new fluorescent screen with one hand while holding the screen bar with the other.

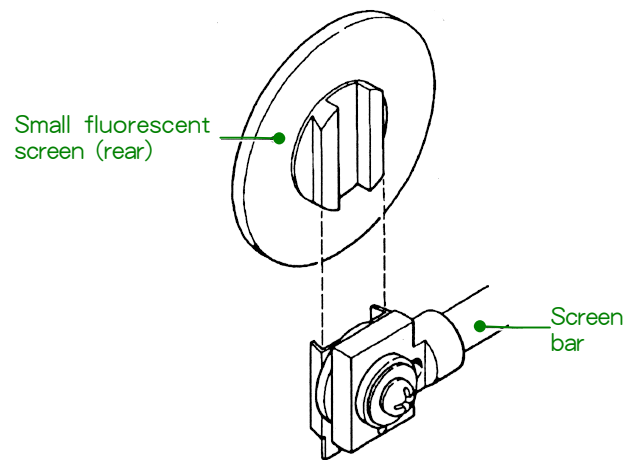


Fig. 6.15 Replacing the small fluorescent screen

- Make sure that the glass grounding spring (at A in Fig. 6.14) is properly set (Fig. 6.16), and that the O-ring and its mating surface are free from lint; then replace the glass.

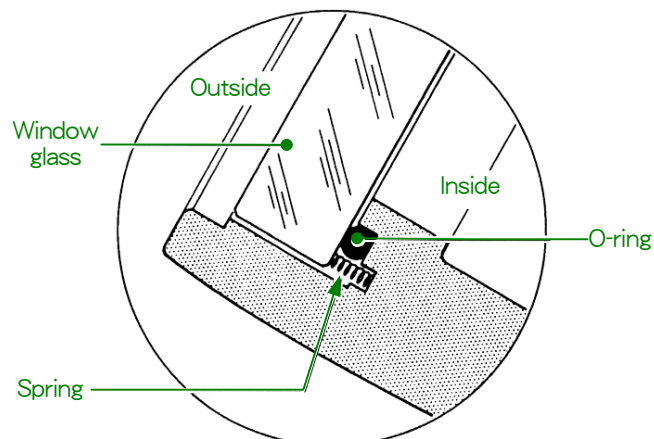


Fig. 6.16

- Close the camera chamber door, and while pressing the door, turn the door handle counterclockwise until it stops.

Evacuation of the camera chamber begins. When the evacuation ends, the valve V2 automatically opens.

 Valve statue is shown in the **Valve Status** window (**TEM Controller – Monitor**).

6.3 INSULATION GAS REPLENISHMENT

6.3.1 Characteristics of Insulation Gas (SF₆ Gas)

Color	Odor	Toxicity	Flammability	Molecular weight	Vapor pressure	Purity
None	None	None	None	146.5	2.21 MPa at 20 °C	99.99% or better



6.3.2 Precautions for Handling the Insulation Gas

WARNING

- Since the pressure inside the SF₆ gas cylinder is very high (about 3 times higher than that of Freon 12 gas at room temperature), attach a reducing valve to the mouthpiece of the cylinder to reduce the secondary pressure when you use the gas.
- When discharge occurs in the electron gun gas chamber or high voltage tank, which contains moisture, etc., poisonous gas may be generated. In order to prevent discharge, pay attention to humidity, as well as to cleaning of the chamber or tank.
- To avoid oxygen shortage, exercise care to keep the workplace well ventilated.



6.3.3 Replenishing Electron Gun Gas Chamber with SF₆ Gas

Replenish the electron gun gas chamber with SF₆ gas when the pressure gauge for electron gun (Fig. 6.17) decreases to 0.3 MPa or less.

1. Stop the emission of the electron beam as follows.
 - a. Click on the **OFF** button in the Filament box in the **High Voltage Control** window (Fig. 6.2).
The confirmation window appears, asking if you wish to turn off the emission of the electron beam.
 - b. Click on **OK** in the confirmation window.
The **Filament** window appears, which shows the status bar.
 While the **Filament** window is on the screen, you cannot control other windows.
 - c. Wait until the **Filament** window disappears.
2. After the electron beam emission has stopped, turn off the accelerating voltage as follows
 - a. Click on the **OFF** button in the HT box in the **High Voltage Control** window (Fig. 6.2).
The confirmation window appears, asking if you wish to turn off the accelerating voltage.
 - b. Click on **OK** in the confirmation window.
The **Accelerating Voltage** window appears.
 While the **Accelerating Voltage** window is on the screen, you cannot control other windows.

- c. Wait until the **Accelerating Voltage** window disappears.
- 3. Connect the SF₆ gas cylinder to the gas inlet nozzle with a hose (with a quick-coupling).
- 4. Open the gas source valve on the cylinder, and close it when the pressure gauge reading reaches 0.3 MPa. Then remove the hose from the gas inlet nozzle.
- 5. Check if the pressure gauge still reads 0.3 MPa.
If the pressure is lower than 0.3 MPa, replenish the chamber with gas.

6.3.4 Replacing the Gas in the Electron Gun Gas Chamber

1. Stop the emission of the electron beam.
 - a. Click on the **OFF** button in the Filament box in the **High Voltage Control** window (Fig. 6.2).
The confirmation window appears, asking if you wish to stop the emission of the electron beam.
 - b. Click on **OK** in the confirmation window.
The **Filament** window appears, which shows the status bar.
 While the **Filament** window is on the screen, you cannot control other windows.
 - c. Wait until the **Filament** window disappears.
2. After the emission of the electron beam has stopped, turn off the accelerating voltage as follows.
 - a. Click on the **OFF** button in the HT box in the **High Voltage Control** window (Fig. 6.2).
The confirmation window appears, asking if you wish to turn off the accelerating voltage.
 - b. Click on **OK** in the confirmation window.
The **Accelerating Voltage** window appears.
 While the **Accelerating Voltage** window is on the screen, you cannot control other windows.
 - c. Wait until the **Accelerating Voltage** window disappears.
3. Set the knob to the L position (Fig. 6.19). The gas in the chamber is released.
4. Connect the SF₆ gas cylinder to the gas inlet nozzle (Fig. 6.17) with a hose.
5. Set the knob to the P position (Fig. 6.19), and turn on the Gas Chamber Pump switch.
6. Wait until the pressure gauge (Fig. 6.17) reading reaches 0.1 MPa (760 mmHg). Wait 10 minutes more and set the knob to the C position (Fig. 6.19); then turn off the GAS CHABR PUMP switch.
7. Open the gas source valve on the gas cylinder, and close it when the pressure gauge reading reaches 0.3 MPa. Then disconnect the hose from the gas inlet nozzle.
8. Make sure that the gauge reading is still 0.3 MPa. If it is not, replenish the chamber with gas.

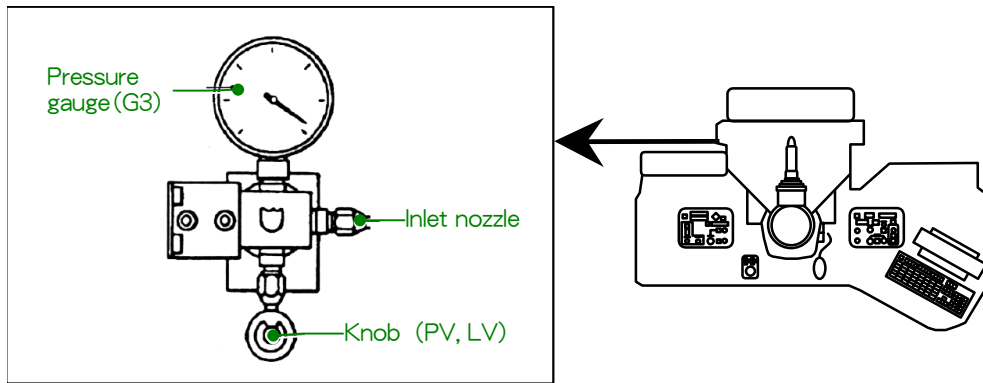


Fig. 6.17 SF₆ gas controller

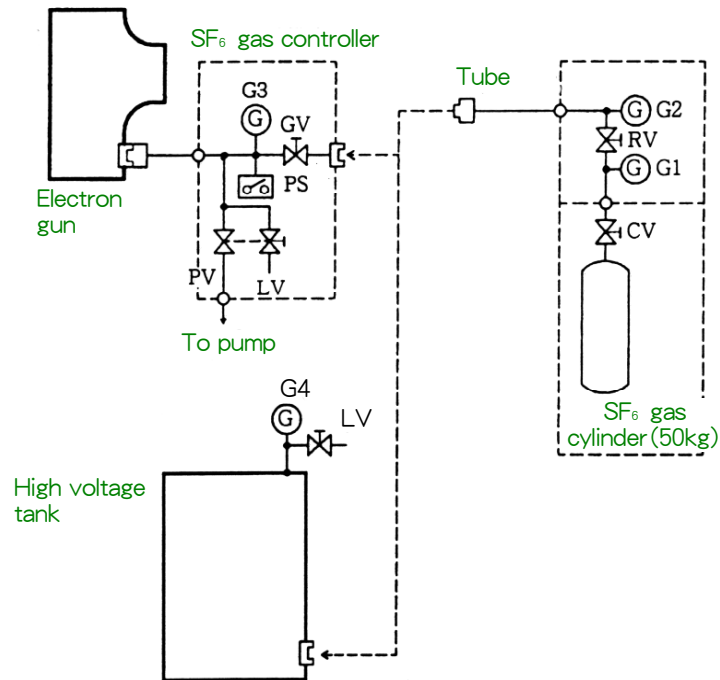


Fig. 6.18 Gas supplying tube diagram

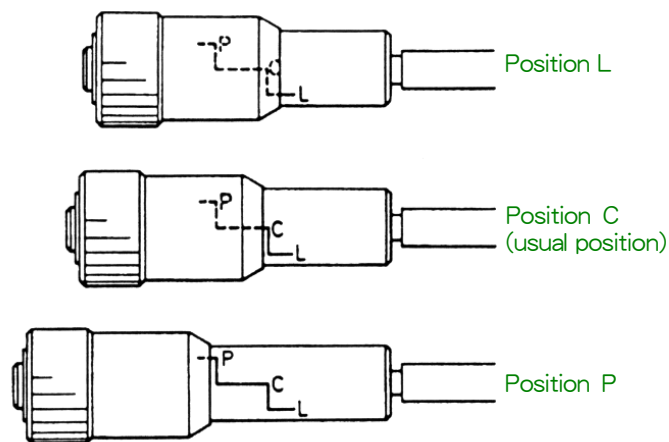




Fig. 6.19 Gas control knob settings

6.3.5 Replenishing the HT Tank with SF₆ Gas

Replenish the HT tank with SF₆ gas when the pressure gauge reading on the tank decreases to 0.1 MPa or less, as follows

1. Stop the emission of the electron beam as follows.
 - a. Click on the **OFF** button in the Filament box in the **High Voltage Control** window (Fig. 6.2).
The confirmation window appears, asking if you wish to stop the emission of the electron beam.
 - b. Click on **OK** in the confirmation window.
The **Filament** window appears, which shows the status bar.
 While the **Filament** window is on the screen, you cannot control other windows.
 - c. Wait until the **Filament** window disappears.
2. After the emission of the electron beam has stopped, turn off the accelerating voltage as follows.
 - a. Click on the **OFF** button in the HT box in the **High Voltage Control** window (Fig. 6.2).
The confirmation window appears, asking if you wish to turn off the accelerating voltage.
 - b. Click on **OK** in the confirmation window.
The **Accelerating Voltage** window appears.
 While the **Accelerating Voltage** window is on the screen, you cannot control other windows.
 - c. Wait until the **Accelerating Voltage** window disappears.
3. Connect the SF₆ gas cylinder to the small valve at the bottom of the HT tank wall with a hose.
4. Open the gas source valve on the cylinder, and close it when the gauge reading increases to 0.1 MPa.
5. Make sure that the gauge reading is still 0.1 MPa. If it is not, replenish the tank with gas. Finally, close the small valve and the gas source valve, and remove the hose.




6.4 CLEANING THE COLUMN PARTS

After prolonged operation, the column interior becomes contaminated by electron beam bombardment, adversely affecting the performance of the instrument. Accordingly, in order to ensure observation of excellent images at all times, cleaning (or replacing) the contaminated parts is required. Contact the JEOL service representative for the details.

6.5 BAKING OUT THE COLUMN

Specimen contamination can be considerably reduced by heating the column and freeing absorbed gas molecules from the column interior walls. Bakeout of the column interior is recommended if it has been exposed to air for a long time.

Open the **Bake Out/ACD Heat** window from **TEM Controller – Maintenance**, and click on the **Bake Out** tab.

1. Stop the emission of the electron beam as follows.
 - a. Click on the **OFF** button in the Filament box in the **High Voltage Control** window (Fig. 6.2).
The confirmation window appears, asking if you wish to stop the emission of the electron beam.
 - b. Click on **OK** in the confirmation window.
The **Filament** window appears, which shows the status bar.
 While the **Filament** window is on the screen, you cannot control other windows.
 - c. Wait until the **Filament** window disappears.
2. After the emission of the electron beam has stopped, turn off the accelerating voltage as follows.
 - a. Click on the **OFF** button in the HT box in the **High Voltage Control** window (Fig. 6.2).
The confirmation window appears, asking if you wish to turn off the accelerating voltage.
 - b. Click on **OK** in the confirmation window.
The **Accelerating Voltage** window appears.
 While the **Accelerating Voltage** window is on the screen, you cannot control other windows.
 - c. Wait until the **Accelerating Voltage** window disappears.
3. Select Column and Stage in the **Bake Out/ACD Heat** window if the checkmarks are off (Fig. 6.20).
 By default, both Column and Stage are checked.

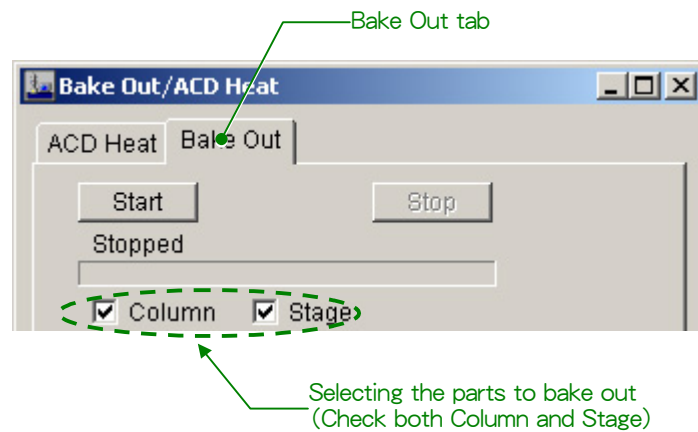


Fig. 6.20 Selecting the parts to bake out (Bake Out/ACD Heat window)

4. Set the desired bake-out time and cooling time in the Bake Out Timer box in the **Bake Out/ACD Heat** window (Fig. 6.21).
 - a. Finish Date: On the calendar, set the date to stop baking out.
 - b. Finish Time: Set the time to stop baking out using the ▼ and ▲ buttons.
 - ☞ You can set the hour, minute, second, and PM or AM individually.
 - c. Cooling Time: Set the cooling time using the ▼ and ▲ buttons. (By default, the cooling time is set to 4 hours.)
 - ☞ Total Time (include Cooling Time) shows the total time for baking out and cooling.

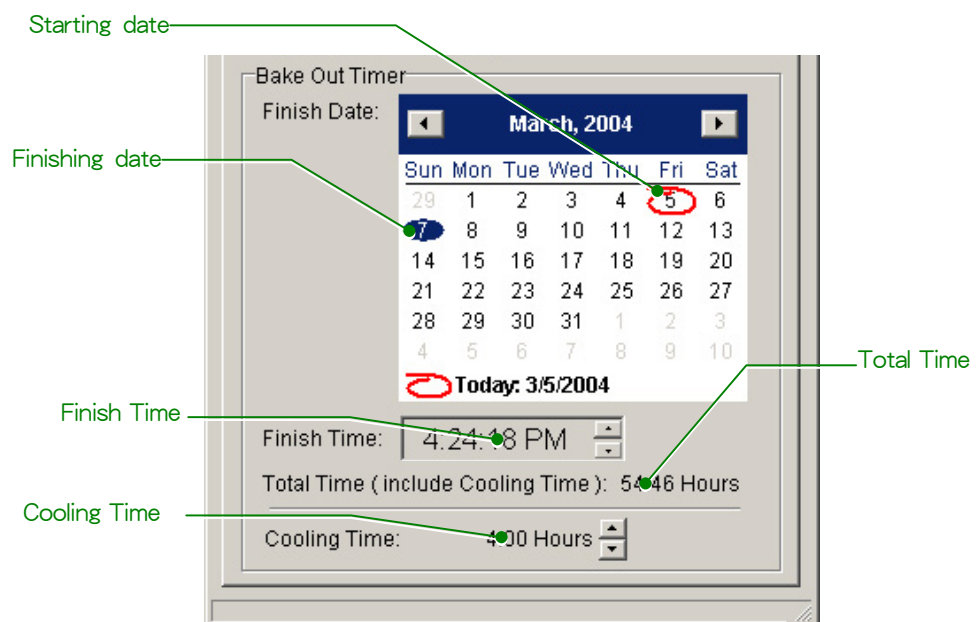


Fig. 6.21 Setting the bake-out and cooling time (Bake Out/ACD Heat window)

5. Make sure that LENS (L2-③) is on, and click on Start in the **Bake Out/ACD Heat** window to start baking out (Fig. 6.22).



Fig. 6.22 Starting baking out (Bake Out/ACD Heat window)

- ⚠* After clicking on the Start button, DO NOT close the **Bake Out/ACD Heat** window, or tamper with any switches or knobs on the control panels. If you closed the window or touched any switches or knobs, click on **Stop** in the **Bake Out/ACD Heat** window and click on **Start** again.

⚠ CAUTION

Do not touch the ion pump or its surrounding parts or TMP evacuation system since they are heated to high temperatures during baking.

6. Close the lens cooling water valve (Fig. 6.23).

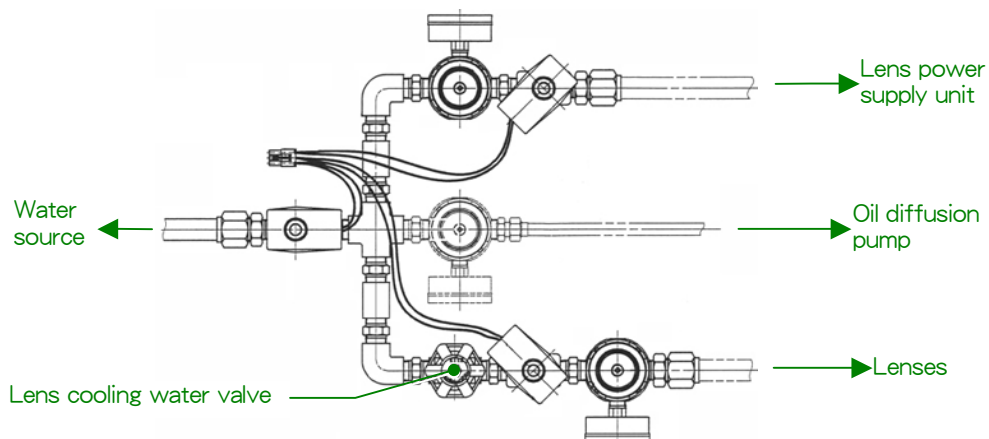


Fig. 6.23 Lens cooling water valve

7. When the bake-out time elapses and baking out finishes, the system will be in the cooling mode. Turn off the LENS (L2-③).
8. When cooling finished, a message appears on the screen. Click on **OK**.

⚠ The system will not be reset from the bake-out or cooling mode until you click on **OK**.
9. Fully open the lens cooling water valve (Fig. 6.23); then turn on the LENS switch (L2-③).

⚠ If you want to suspend the bake-out, turn off the LENS switch (L2-③) and click on **Stop** in the **Bake Out/ACD Heat** window. Then carry out Steps 8 and 9.

6.6 TROUBLESHOOTING

6.6.1 Concerning Start-up

6.6.1a When it is impossible to start up the microscope

Cause	Remedy
The circuit breaker is turned off (the breaker is in the power supply console).	Switch off the main power and set the breaker to ON. Then start up the instrument by switching on the main power. If the instrument still does not start up, consult a JEOL service office.
Broken fuse F1 on the AC PB	Consult a JEOL service office.

6.6.1b When the microscope stops automatically some time after start-up

Cause	Remedy
Insufficient water pressure (in this case, the instrument stops in 2 or 3 seconds)	Increase the pressure.

6.6.1c When the message, “Beam Not Ready” appears

Cause	Remedy
The high-voltage cable is disconnected (on the electron gun side).	Turn off the accelerating voltage and connect the cable.
No electric current in the lenses	Press the LENS switch (L2-⑧) to turn on the lens power.
The V1 valve in the electron gun chamber is not open.	Evacuate the electron gun chamber and the column and wait until the V1 valve opens.
The pressure in the electron gun chamber is 0.17 MPa or lower.	Replenish the chamber with gas.

6.6.2 Concerning Electron Beam

6.6.2a When no electron beam appears on the fluorescent screen

Cause	Remedy
No electron beam is generated.	See Section 6.2.2b.
Intercepted by the condenser aperture.	Retract the condenser aperture.
Intercepted by the specimen grid.	Move the grid and allow the beam to pass.
Intercepted by the objective lens aperture.	Retract the objective lens aperture.
Intercepted by the field limiting aperture.	Retract the field limiting aperture.

6.6.2b When the electron beam is not generated

Cause	Remedy
No electron beam is generated.	See Section 6.2.2b.
Intercepted by the condenser aperture.	Retract the condenser aperture.
Isolation valve (V2) is not open.	Evacuate the camera chamber and wait until the valve V2 opens.
The Bias value is too low in the High Voltage Control window.	Set the Coarse and Fine values to 7 to 8.
The filament of the electron gun and the Wehnelt cap are too far apart.	Adjust the distance between the filament and the Wehnelt cap (☞ Section 6.1.4).
Intercepted by the specimen grid.	Move the grid and allow the beam to pass.

6.6.3 Concerning the Specimen Movement and Tilting**6.6.3a When the specimen cannot be moved or tilted**

Cause	Remedy
The X, Y, Z, Tilt-X, and Tilt Y/Rot are set to 0 in the Speed Control box in the Specimen Property window.	Set the X, Y, Z, Tilt-X, and Tilt Y/Rot to 4 to 5 using the ▼ button in the Speed Control box in the Specimen Property window.

6.6.4 Concerning Photographing**6.6.4a When the Exp. Time shows *** even though the enough irradiation**

Cause	Remedy
Sens in the Film box in the Film Camera Property window is set to 0.	Set the Sens value to 10 to 12 using the ▼ and ▲ buttons in the Film box in the Film Camera Property window.

6.7 INSTRUCTIONS CONCERNING NITROGEN GAS

Dry nitrogen gas is contained in a compressed gas cylinder which must be handled with care. Prior to use, check the following points.

WARNING

- Although nitrogen gas is inactive and harmless, excessive nitrogen gas in a closed room lowers the oxygen concentration in the room and might cause suffocation. Be sure to ventilate the room well.
- If nitrogen gas leaks, open the windows and doors immediately and ventilate the room with fresh air.


CAUTION

- Ensure that the temperature of the place where the cylinder is installed does not exceed 40 °C.
- Make sure that there is no furnace or heating appliance near the cylinder.
- Make sure that there is no electric wiring near the cylinder.
- Be sure that the cylinder has been installed on a stand designed for the purpose or secured to a wall with chains.
- Make sure that the cylinder is never subjected to shock during usage.
- Ensure that the cylinder pressure test has been performed periodically and the cylinder safety has been assured.

6.7.1 Stopping and Resuming Supply of Nitrogen Gas

Normally, even when the instrument is not in use, the pressure regulator should be kept set at 0.02 MPa and the delivery valve (if provided) fully opened. When starting or stopping the instrument, open or close the cylinder valve (source valve). To completely stop or resume supply of nitrogen gas, when replacing the gas cylinder etc., proceed as follows.

6.7.1a Stopping supply of nitrogen gas

1. Close the pressure regulator by turning the pressure control knob fully counterclockwise.
2. If a delivery valve is provided, close the valve by turning the valve knob fully clockwise.
3. Close the cylinder valve by turning the valve control fully clockwise.
 -  To minimize hazards in an emergency situation, make sure that the valve control is kept on the cylinder in order to expedite valve closing.

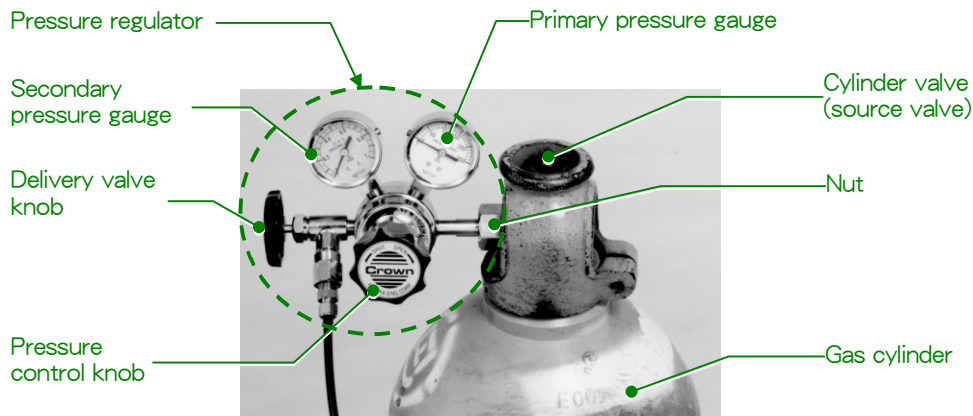





Fig. 6.24 Cylinder and pressure regulator

6.7.1b Resuming supply of nitrogen gas

1. After confirming that the pressure control knob has been turned fully counterclockwise (the pressure regulator is closed), open the cylinder valve by fully turning the valve control of the cylinder counterclockwise.
2. Slowly turn the pressure control knob clockwise to open the pressure regulator until the secondary pressure gauge registers 0.02 MPa.
 -  For safety's sake, DO NOT stand in front of the pressure regulator when manipulating the knob. Manipulate the knob from a position that is not in front of the regulator.
3. After the specified pressure has been set, leave it for a minute or two, then check to see that there is no change in the indication of the pressure gauge.
 -  If the pressure gauge indicator slowly rises, the pressure regulator is defective and must be replaced. To replace a pressure regulator, proceed as follows:
 - a. Stop the supply of nitrogen gas according to Section 6.7.1a.
 - b. Disconnect the delivery valve (or hose).
 - c. Loosen the nut to remove the pressure regulator from the cylinder.
 - d. Connect a new pressure regulator (full scale of secondary pressure gauge: about 1 MPa) to the cylinder valve and fasten it firmly with the nut. To ensure that the glass front of the pressure gauge is not directly opposite the operator's face, the gauge should be tilted 45° upward for a large size cylinder and 45° downward for a small size cylinder.
 - e. Connect the delivery valve (or hose).
4. If a delivery valve is provided, open the valve by rotating the valve knob fully counterclockwise.
 -  The secondary pressure gauge's pointer will drop temporarily. If the pointer does not return to the specified value, a gas leak at the receiving end can be suspected. Check for leaks.

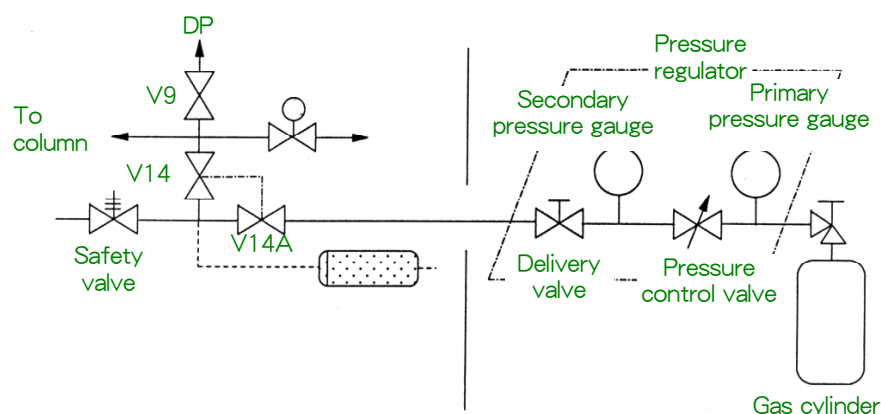


Fig. 6.25 Example of connection of nitrogen gas cylinder and peripheral units

6.7.2 Replacement of Nitrogen Gas Cylinder (If Used)

In normal operating conditions, a cylinder with a capacity of 46.7 L, and an internal pressure of 15 MPa, for example, will be adequate for about three months' use.

1. Stop the supply of nitrogen gas according to Section 6.7.1a.
2. Remove the pressure regulator from the connection to the cylinder valve by loosening the nut.
3. Remove the empty cylinder and install a cylinder filled with dry nitrogen gas in the stand (or secure it to a wall with chains).
4. Connect the pressure regulator to the cylinder valve and fasten it firmly with the nut.
 - ✍ Make sure that the nut at the connection is tightened all the way to prevent leakage of gas. Gas leaks can be easily detected by applying soap solution to the connection.
5. Resume the supply of nitrogen gas according to Section 6.7.1b.
 - ✍ A relief valve is provided to let excess gas out if nitrogen gas introduced to the column causes the internal pressure to exceed one atmosphere.

6.7.3 Connection to Nitrogen Gas Supply Piping

If the laboratory has dry nitrogen gas supply piping, connect a two-stage pressure regulator to the piping and the EM's nitrogen gas source hose (10 m) to the delivery nozzle of the regulator.

6.8 CONCERNING THE LIFT AND THE LIFT POLE

A lift and a lift pole are provided with the JEM-2100 for maintenance. These are for use by a JEOL service engineer only. Customers must not move, assemble, or use the lift or lift pole without consulting a JEOL service engineer. JEOL will not be held responsible for any accident involving a lift or a lift pole.

6.9 CONSUMABLES AND MAINTENANCE PARTS

All the parts for the JEM-2100 to be replaced periodically are listed in this chapter. Consult JEOL service personnel when any parts require replacing.

6.9.1 JEM-2100 Microscope Console and Column

Following is the list of consumables and parts for the microscope console and column.

Part name	Specifications	Part No.	Recommended replacement	Unit name
Condenser lens aperture	10 µm diam. (PT)	418000085	Every 5 years*	APERTURE
Condenser lens aperture	50 µm diam. (PT)	418000123	Every 5 years*	APERTURE
Condenser lens aperture	70 µm diam. (PT)	418000131	Every 5 years*	APERTURE
Condenser lens aperture	200 µm diam. (PT)	418000140	Every 5 years*	APERTURE
Field limiting aperture	10 µm diam. (VMP)	418000085	Every 5 years*	IL APERTURE
Field limiting aperture	20 µm diam. (VMP)	418000107	Every 5 years*	IL APERTURE
Field limiting aperture	50 µm diam. (VMP)	418000123	Every 5 years*	IL APERTURE
Field limiting aperture	100 µm diam. (VMP)	418000590	Every 5 years*	IL APERTURE
Vinyl hose for water line	TR-12 (12×18)	405000553	Every 5 years	COOLING SYSTEM
Nylon tube for water line	AS-4-50-06 (4×6)	405004087	Every 5 years	COOLING SYSTEM
Urethane tube for water line	UF-25-08 Blue (5×8)	405007761	Every 5 years	COOLING SYSTEM
Urethane tube for water line	UF-25-10 Blue	403010675	Every 5 years	COOLING SYSTEM
Water solenoid valve	AD11-10A-03A-24V	349005605	Every 5 years	WATER DISTRIB
Water regulating valve	INA-13-956-A-00	349016534	Every 5 years	WATER DISTRIB
Water pressure meter	S-130	364006561	Every 5 years	WATER DISTRIB
Oil mist filter	DT-250-25A	490020666	Every 5 years	ACCESS(R,P)
Vacuum hose	18×42×1000	405008368	Every 5 years	ACCESS(R,P)
RP oil	MR-100-1L	780001389	Every 2 years	ACCESS(R,P)
V-belt		420028188	Every 2 years	ACCESS(R,P)
DP oil	Moresco EXCELLOL 54	423010387	Every 2 years	ACCESS(4")
DP heater	RKB30V0600GB	322004535	Every 2 years	ACCESS(4")
Thermo switch	E-Z-204	344002250	Every 2 years	THERMOSTAT
Nylon tube	AS4-50-04 (2.5×4)	405004079	Every 5 years	COMP AIR SYS
Rubber hose (multi-purpose)	Excel (6.3×13.4 Black)	405012918	Every 5 years	COMP AIR SYS

*The parts marked with asterisks do not require replacement if there is no problem.

6.9.2 Objective Lens Aperture

The objective lens aperture is used in the image-forming system. The specifications of the objective lens aperture depend on the system configuration. Check your instrument's configuration before consulting a JEOL service center.

6.9.2a UHR configuration

■ High-contrast objective lens aperture (HCOA)

Part name	Specifications	Part No.	Recommended replacement	Unit name
Aperture	5-20-60-120 μm diam. (Cu)	810357089	Every 5 years*	ACCESSORIES

*The parts marked with asterisks do not require replacement if there is no problem.

■ Motor-driven URP aperture (SFOA): optional

Part name	Specifications	Part No.	Recommended replacement	Unit name
Aperture	10-25 μm diam. (Cu)	811402088	Every 5 years*	ACCESS (SFOA)

*The parts marked with asterisks do not require replacement if there is no problem.

6.9.2b HR and HT configurations

■ High-contrast objective lens aperture (HCOA)

Part name	Specifications	Part No.	Recommended replacement	Unit name
Aperture	5-20-60-120 μm diam. (Cu)	810357089	Every 5 years*	ACCESSORIES

*The parts marked with asterisks do not require replacement if there is no problem.

■ Motor-driven objective lens aperture (MDOA): optional

Part name	Specifications	Part No.	Recommended replacement	Unit name
Aperture	5-30-40-60 μm diam. (Cu)	802472516	Every 5 years*	APERTURE

*The parts marked with asterisks do not require replacement if there is no problem.

6.9.2c CR configuration

■ Motor-driven objective lens aperture (MDOA)

Part name	Specifications	Part No.	Recommended replacement	Unit name
Aperture	5-30-40-60 μm diam. (Cu)	802472516	Every 5 years*	APERTURE

*The parts marked with asterisks do not require replacement if there is no problem.

■ High-contrast objective lens aperture (HCOA): optional

Part name	Specifications	Part No.	Recommended replacement	Unit name
Aperture	5-20-60-120 μm diam. (Cu)	810357089	Every 5 years*	ACCESSORIES

*The parts marked with asterisks do not require replacement if there is no problem.

6.9.2d HC configuration

■ Motor-driven objective lens aperture (MDOA)

Part name	Specifications	Part No.	Recommended replacement	Unit name
Aperture	5-15-30-50 μm diam. (Cu)	811198669	Every 5 years*	APERTURE

*The parts marked with asterisks do not require replacement if there is no problem.

■ High-contrast objective lens aperture (HCOA): optional

Part name	Specifications	Part No.	Recommended replacement	Unit name
Aperture	5-20-60-120 μm diam. (Cu)	810357089	Every 5 years*	ACCESSORIES

*The parts marked with asterisks do not require replacement if there is no problem.

6.9.3 EM-23120 TMP Evacuation System

Following is the list of consumables and parts for the EM-23120 TMP Evacuation System. Check the configuration of the evacuation system of your instrument before consulting a JEOL service center.

Part name	Specification	Part No.	Recommended replacement	Unit name
TMP damper	DN-ISO160	460004280	Every 2 years	EVAC LINE(UPR)
Oil mist filter	FDT-250-25A	490020666	Every 1 year	ACCESS(R,P)
Vacuum hose	18×42×1000	405008368	Every 2 years	ACCESS(R,P)
RP oil	MR-100-1L	780001389	Every 2 years	ACCESS(R,P)
V-belt		420028188	Every 1 year	ACCESS(R,P)

INDEX

#

α selector knob 4-4

A

Accelerating voltage 5-43
Accelerating Voltage window 5-10
ACD Heat tab 4-42
ACD Heat window 5-41
Adjust Mode 4-25
Adjusting the wehnelt cap 6-8
After Photo Mode 4-37
AIR pressure down 4-32
Alarm tab(Status Monitor window) 4-32
Aligning the illumination system 5-20
Alignment data 5-59
Alignment Panel for Maintenance
window 4-41
Alignment Voltage tab(Status
Monitor window) 4-31
Alpha 4-22
Anticontamination device 5-39
Aperture Adjust window 4-44
Aperture angle 5-50
Aperture control 4-3
Aperture Select 4-25
Aperture selector switches 4-3
Aperture switches 4-3
Aperture tab 4-25
Apply 4-36
Arrow (\blacktriangle) switches 4-10
Auto HT 4-21
Auto HT start and stop buttons 5-15
AUTO switch 4-8
Automatic exposure 5-44
Automatic exposure mode 4-8, 4-28

B

Bake Out tab 4-43
Bake Out/ACD Heat window 4-42
Baking out the column 6-18
Basic information 4-28
Beam Blanking 4-37
Beam blanking method 4-37

Beam blanking time 4-37
Beam current 4-20
Beam current density 4-28
Beam generation 5-12
Beam generation suspension 5-14
Beam switch 4-3
Bias 4-21
BRIGHT TILT switch 4-5
Bright/Dark 4-22
Bright-field image 5-36
Bright-field image mode 4-22
BRIGHTNESS CRS switch 4-5
BRIGHTNESS knob 4-5, 4-9

C

Camera length 4-7
Caustic spot 5-18
CBD mode 3-7
Changing the filament 6-6
Changing the filament of the
electron gun 6-2
Changing the small fluorescent
screen 6-12
Characteristics of insulation gas 6-14
Checking if the filament of the
electron gun is burned out 6-2
CL deflection coil adjustment 5-21
Cleaning the column parts 6-18
COARSE knob 4-7
COL AIR switch 4-9
Compensator 4-41
COND STIG switch 4-4
Condenser aperture assembly 4-1
Condenser lens (CL) aperture 5-17
Condenser lens alignment 5-14
Condenser lens astigmatism
correction 5-21
Conditioning 4-21
Consumables 6-26
Convergent angle 4-22
Convergent beam electron
diffraction 5-33
Cooling water stoppage 5-1
CRS (Coarse) switch 4-4

CRS switch..... 4-7, 4-10
 Current axis..... 5-24

D

DARK TILT switch..... 4-5
 Dark-field image..... 5-36
 Dark-field image mode 4-22
 DEF Select 4-23, 4-41
 DEF/STIG switches 4-4
 DEF/STIG X knob 4-5
 DEF-STIG CRS switch 4-5
 DEF-STIG Y knob..... 4-7
 Degassing the filament..... 6-9
 Delay Time..... 4-37
 Delete..... 4-40
 Dialogue..... 4-19
 DIFF FOCUS..... 4-7
 Diffraction mode 3-10, 4-23
 Diffraction pattern 4-7
 Display..... 4-45
 DP1 heater failure..... 4-32
 DP1 water supply failure..... 4-32

E

EDS mode 3-7
 Electron gun lift 4-9
 EM STOP switch 4-8
 Emergency (alarms) window 4-46
 Emergency shutdown 5-1
 Etc tab (EOS Property window)..... 4-35
 EXP TIME knob 4-8
 EXP TIME/PHOTO 4-8
 Exposure time..... 4-28

F

F switches 4-8
 Faulty operation..... 5-1
 Field-limiting aperture 4-7, 5-19
 Filament 4-21
 Filament condition..... 4-21
 Filament control speed..... 4-21
 Filament max limit..... 4-21
 Filament status 4-20
 Filament window 5-11
 File 4-18
 Filling with liquid nitrogen 5-39
 Film 4-28
 Film Camera Property window 4-28

Film number5-43
 Film number and film text5-43
 Film numbering.....4-9
 Film processing.....5-48
 FINE knob4-7
 FLC (Free Lens Control) Panel
 window4-38
 Focus5-54
 Focusing5-28
 Focusing using fresnel fringes.....5-30
 Focusing using image wobbler5-28
 Focusing using point images5-31
 Free lens control (FLC)5-56
 Freq/Amp..... 4-42
 Function.....4-23
 Function switches.....4-7

G

Goniometer4-2
 Goniometer sub-system4-9
 GUN.....4-35
 GUN AIR switch.....4-9
 GUN LIFT switch4-9

H

H/W Limited indicator.....4-44
 Help.....4-45
 High magnification.....5-27
 High Voltage Control window.....4-20
 High voltage settings.....4-20
 High Voltage tab(Status Monitor
 window).....4-31
 High-dispersion electron diffraction...5-34
 History.....4-29
 Holder4-36
 Holder Exchange.....4-36
 HT4-20
 HT status4-20
 HT STOP switch4-8
 HT WOBB4-6

I

Illumination mode selector switches4-4
 Image observation5-46
 IMAGE SHIFT switch.....4-4
 IMAGE WOBB X4-6
 IMAGE WOBB Y4-6
 Image wobbler5-28

Image/Shift/Tilt 4-35
 Image-forming mode 4-7
 Imaging system mode 4-23
 Indications in the center section 4-16
 Indications in the left section 4-15
 Indications in the right section 4-17
 In-focus..... 5-30
 Inserting the specimen holder in the
 microscope column 5-7
 Inserting/removing the magazines
 into/from the camera chamber 5-3

K

Knob 4-7

L

Lamp..... 4-8
 Lens lifting tool..... 3-2
 LENS switch 4-9
 Lens Voltage tab(Status Monitor
 window) 4-30
 Lens/DEF Memory Option window 5-61
 Lens/DEF Memory window 4-39
 Lift..... 3-2
 Lift pole 6-25
 Load..... 4-40
 Load Alignment File*** 4-42
 Loading a specimen on the specimen
 holder..... 5-6
 Loading films into the dispensing
 magazine 5-3
 Loading(Saving Alignment Data)..... 5-59
 Loading(Saving Lens Alignment
 Data) 5-61
 LOW MAG switch..... 4-7
 Low magnification..... 4-7
 Low-magnification image 5-37

M

MAG 4-23
 MAG 1 switch 4-7
 MAG 2 5-58
 MAG 2 switch 4-7
 Mag mode 3-9
 MAG Select window 4-39, 5-57
 MAG/CAM L knob..... 4-7
 MAG2 4-24
 Magnification mode..... 4-23

Magnification or camera length 5-43
 MAIN 4-9
 Main system..... 4-9
 Main window 4-15
 Maintenance..... 4-40
 Maintenance parts 6-26
 Manual exposure 5-44
 Manual exposure mode..... 4-8
 MDS Focus mode 4-37
 MDS Photo set mode..... 4-37
 MDS Search mode..... 4-37
 MDS window 4-37, 5-54
 Mechanical-Limit indicator 4-44
 Medium magnification 5-26
 Microarea diffraction..... 5-33
 Microbeam electron diffraction..... 5-33
 Minimum dose exposure system
 (MDS) 5-54
 Mode 4-22, 4-37
 Monitor..... 4-29
 More 4-21
 Multiple exposure 5-45

N

Nanoarea diffraction..... 5-33
 NBD mode 3-7
 NBD/EDS/CBD mode 3-8
 Nitrogen gas..... 6-23
 No. 4-29
 Normal magnification..... 4-7, 4-23
 Normal mode 4-37
 NTRL 4-26, 4-42
 NTRL switch 4-5

O

OBJ 4-35
 OBJ FOCUS knob 4-7
 OBJ Focus Step..... 4-23
 OBJ STIG switch 4-5
 Objective aperture 5-51
 Objective lens (OL) aperture 5-18
 Objective lens aperture 6-27
 Objective lens astigmatism 5-52
 OL astigmatism correction..... 5-26
 OL Stig..... 4-23
 Operation window 4-22
 Option 4-36
 OUF 4-24

Overfocus 5-30

P

Panel sub-system 4-9
 PEG1..... 4-34
 Penning gauge 4-34
 Performing the free lens control 4-38
 Performing the minimum dose exposure system..... 4-37
 PHOTO 4-29
 Photo History window..... 4-18
 Photo set 5-54
 PHOTO switch 4-8
 Photographing history 4-18
 Piezo movement 4-26
 PIEZO switch 4-10
 PIG failure..... 4-32
 Pirani gauge status 4-34
 PLA switch..... 4-4
 Position Adjust 4-25
 Position Memory 4-27
 Power failure 5-1
 POWER switch..... 4-8
 Probe control 4-4
 Property..... 4-33
 PUMP/AIR switch 4-2

R

Recall..... 4-27
 Re-evacuating the electron gun chamber..... 6-8
 Removing the specimen holder from the goniometer..... 5-8
 RESET button..... 4-9
 Restart the microscope 5-1
 Returning the anti-contamination device to room temperature 5-40
 Room lamp switch 4-4
 RP1 failure 4-32
 RP2 failure 4-32
 RT pressure up..... 4-32

S

S/W Limited indicators 4-44
 SA DIFF switch 4-7
 SA MAG mode 5-32
 SA MAG switch..... 4-7
 Save 4-39

Save to Alignment File... 4-42
 Saving Lens Alignment Data 5-60
 Saving(Saving Alignment Data)..... 5-59
 Saving(Saving Lens Alignment Data)..... 5-60
 Scale bar 5-43
 Screen tab 4-24
 Search..... 5-54
 Selected area diffraction 5-32
 Selected area magnification 4-7
 Selecting magnifications and camera lengths 5-57
 Selecting the parts to bake out 6-19
 Setting a reference magnification..... 5-58
 Setting the bake-out and cooling time 6-19
 Settings tab 4-24
 SF₆ Gas..... 6-14
 SHIFT..... 4-26
 SHIFT CRS switch..... 4-5
 Shift X and Y adjustment..... 5-23
 SHIFT X knob..... 4-5
 SHIFT Y knob..... 4-7
 Shutting down 5-2
 Special magnification 4-23
 Specimen holder..... 4-1
 Specimen position indicator 4-27
 Specimen Position window 4-27
 Specimen Property window 4-36
 Speed Control 4-36
 Spot Size..... 4-22
 Spot size knob..... 4-4
 Stage Limit window 4-44
 Stage tab 4-26
 Standard tab 4-22
 Standard tab(Status Monitor window)..... 4-30
 Starting baking out 6-20
 Startup 5-2
 STD Focus 4-24
 STD FOCUS switch 4-8
 Stop position on the lift 6-5
 SUB..... 4-9
 Super Fine..... 4-26

T

TEM Controller..... 4-13
 TEM Controller window..... 4-14

TEM mode 3-7
 TEM Server..... 4-13
 Text 4-29
 Text (specimen name, etc.)..... 5-43
 TILT..... 4-26
 Tilt X and Y adjustment..... 5-22
 TMP failure..... 4-32
 Trackball 4-10
 Transmission electron image mode 3-7
 Turning off the accelerating voltage.... 5-15
 Turning on the accelerating voltage 5-9
 Turning on the high voltage using
 the automatic mode..... 5-15

U

Underfocus..... 5-30

V

Valve Status window..... 4-34
 Venting the electron gun chamber..... 6-4

Very low magnification mode4-23
 Voltage axis 5-25, 5-50
 Voltage center5-50

W

Wehnelt6-6
 Wire rope with hooks3-2
 Wobbler4-41
 Wobbler Freq/Amp tab (EOS
 Property window).....4-35
 Wobbler switches4-6
 Wobbler tab4-24

X

X and Y arrow switches.....4-4

Z

Z switches.....4-8