INSTRUCTIONS

JEM-2200FS

FIELD EMISSION 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.

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JEOL

JEM-2200FS

FIELD EMISSION ELECTRON MICROSCOPE

Please be sure to read this instruction manual carefully, and fully understand its contents prior to the operation or maintenance for the proper use of the instrument.

JEOL

NOTICE

- This instrument generates, uses, and can radiate the energy of radio frequency and, if not installed and used in accordance with the instruction manual, may cause harmful interference to the environment, especially radio communications.
- The following actions must be avoided without prior written permission from JEOL Ltd. or its subsidiary company responsible for the subject (hereinafter referred to as "JEOL"): modifying the instrument; attaching products other than those supplied by JEOL; repairing the instrument, components and parts that have failed, such as replacing pipes in the cooling water system, without consulting your JEOL service office; and adjusting the specified parts that only field service technicians employed or authorized by JEOL are allowed to adjust, such as bolts or regulators which need to be tightened with appropriate torque. Doing any of the above might result in instrument failure and/or a serious accident. If any such modification, attachment, replacement or adjustment is made, all the stipulated warranties and preventative maintenances and/or services contracted by JEOL or its affiliated company or authorized representative will be void.
- Replacement parts for maintenance of the instrument functionality and performance are retained and available for five years from the date of installation. Thereafter, some of those parts may be available for a certain period of time, and in this case, an extra service charge may be applied for servicing with those parts. Please contact your JEOL service office for details before the period of retention has passed.
- In order to ensure safety in the use of this instrument, the customer is advised to attend to daily maintenance and inspection. In addition, JEOL strongly recommends that the customer have the instrument thoroughly checked up by field service technicians employed or authorized by JEOL, on the occasion of replacement of expendable parts, or at the proper time and interval for preventative maintenance of the instrument. Please note that JEOL will not be held responsible for any instrument failure and/or serious accident occurred with the instrument inappropriately controlled or managed for the maintenance.
- After installation or delivery of the instrument, if the instrument is required for the relocation whether it is within the facility, transportation, resale whether it is involved with the relocation, or disposition, please be sure to contact your JEOL service office. If the instrument is disassembled, moved or transported without the supervision of the personnel authorized by JEOL, JEOL will not be held responsible for any loss, damage, accident or problem with the instrument. Operating the improperly installed instrument might cause accidents such as water leakage, fire, and electric shock.
- The information described in this manual, and the specifications and contents of the software described in this manual are subject to change without prior notice due to the ongoing improvements made in the instrument.
- Every effort has been made to ensure that the contents of this instruction manual provide all necessary information on the basic operation of the instrument and are correct. However, if you find any missing information or errors on the information described in this manual, please advise it to your JEOL service office.
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MANUFACTURER

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Note: For servicing and inquiries, please contact your JEOL service office.

Please be sure to read carefully the following Software License Agreement before using the software supplied by JEOL Ltd. If you do not agree to the terms and conditions of the Agreement, please do not use the software and contact JEOL Ltd.

Software License Agreement

This Software License Agreement is made and entered into by and between you, the end-user customer, and JEOL Ltd. (hereinafter referred to as JEOL) in witness of agreement between both parties upon licensing of the right to use the software (which is hereinafter referred to as the Licensed Software) owned by JEOL.

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"Right to Use the Licensed Software" means your right to use the Licensed Software in the country where the JEOL product you purchased is installed (hereinafter referred to as Country of Installation).

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1. JEOL grants you the non-exclusive and non-assignable right to use the Licensed Software in the Country of Installation.
2. You may install and use the Licensed Software on a single computer limiting the purpose to carrying out of your job.
3. You may not cause any third party to use the Licensed Software by establishing a sublicense or other means, and shall not disclose the Licensed Software to any third party.
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1. You may not assign, rent or lease the right to use the Licensed Software, disclose the content of the right, or transfer possession of the Licensed Software to any third party.
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You may not reproduce the whole or any part of the Licensed Software.

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1. JEOL does not guarantee proper performance of the Licensed Software if it is modified or translated.
2. JEOL does not warrant that the Licensed Software is free from defects or fit and useful for your particular purpose.

Article 7. (Exemption from Liability)

JEOL shall not be liable for any damages or losses incurred by you or any third party or for any claim of a third party against you arising out of or in relation to the use of the Licensed Software.

Article 8. (Confidentiality)

You shall keep confidential the content of the Licensed Software supplied hereunder by JEOL and the terms and conditions of this Agreement, and shall not divulge or disclose them to any third party without the prior written consent of JEOL.

Article 9. (Term of Validity)

1. This Agreement shall become effective as of the day you accept the terms hereof and so remain unless it is terminated pursuant to the next Article.
2. Notwithstanding the item above, the provisions set forth in the Article 8 (Confidentiality) shall remain effective even after the termination hereof.

Article 10. (Termination)

In any of the following event, JEOL may forthwith terminate this Agreement by so notifying you without any prior notification and may claim the damages incurred:

(1) Any breach on your part of any of the provisions hereof,

(2) Occurrence of seizure or provisional seizure or provisional injunction on your property; auctioning of your property; bankruptcy, corporate liquidation, and filing for corporate reorganization on your part; or proceedings taken against you for collection of tax delinquency.

Article 11. (Steps to Be Taken after Termination)

Upon the termination of this Agreement pursuant to the Item 1 of Article 9 and Article 10, you shall destroy the Licensed Software and notify JEOL of such destruction.

Article 12. (Discussion in Good Faith)

Matters not stipulated herein shall be discussed in good faith and settled between you and JEOL.

WARRANTY INFORMATION

1 Limited Warranty

Products manufactured by JEOL Ltd. (hereafter "JEOL products") that fail under normal use by the customer during the warranty period will be repaired or replaced, at JEOL's discretion, without charge. The components, modules and devices that are provided as replacements will be new parts or refurbished parts that provide the same performance as new parts. All components, modules and devices removed under this warranty become the property of JEOL.

1.1 Applicable Products

- This warranty applies only to hardware and software products manufactured by JEOL Ltd.
- For components that are not JEOL products, such as the computer, HDD, memory device, and the like, the warranty provisions of the respective manufacturers shall apply.

1.2 Warranty Period

- In the case of products for which the warranty period is recorded in the contract documentation, the recorded warranty period shall take precedence.
- If not specifically stated elsewhere, the warranty period is 12 months or a separately specified period from the date on which the acceptance test is completed after delivery to the customer.
- For components that are not JEOL products, like the computer, HDD, memory device, and the like, the warranty start date shall be the date on which the acceptance test is completed after delivery to the customer and the warranty periods established by the respective makers shall apply.
- In the event that parts are replaced or repaired free of charge during the warranty period, there is no change to the warranty start date or the warranty period for the product.

1.3 Scope of the Warranty

■Failure diagnosis

If a problem occurs, contact your JEOL service office and describe the conditions and content of the problem. JEOL will assess the problem based on the situation and content of the problem.

■Repair method

If it is determined that the problem is caused by a fault or defect of a JEOL product, repair or replacement will be performed free of charge. The choice of whether to repair or replace a component is entirely at the discretion of JEOL.

■Warranty exclusions

This limited warranty does not extend to products for which any of the following situations apply. Even within the warranty period, in the situations listed below, a fee will be charged to repair the product.

- Product is operated or stored in an environment or under conditions that do not satisfy the specified installation requirements.
- The installation environment has changed (temperature, humidity, magnetic fields, etc.) since the time of installation.
- There is significantly accelerated deterioration of components and/or corrosion of electrical circuitry as a result of exposure to extreme temperature, humidity, or an environment containing highly-corrosive gases or excessive dust.
- The quality of the utilities (including electricity, water, gas, air quality) has worsened.
- The customer has relocated an installed instrument.

- Even in the case of a portable or movable instrument designed to be transported to a remote location or moved around for use by the user, damage or failures caused during the instrument relocation by the customer.
- Product has not been properly maintained.
- Consumable items or parts with the specified replacement period have not been replaced as specified.
- Corrupted operating system or application software, or damaged computer used with the instrument, caused by shutting down the main power to the computer without performing the proper shutdown sequence.
- Products that have been disassembled, modified or repaired by the customer in ways other than those specified in the instruction manuals provided with the instrument.
- Products with damage or failure caused by using them in combination with hardware, software, peripheral devices, and accessories that have not been provided or approved by JEOL.
- Damage or failure resulting from a situation caused by the customer, such as failing to properly manage the instrument, for which JEOL cannot be held responsible.
- Corruption of the operating system or application software, or damage to a computer used with the instrument, caused by fluctuations in the electricity or power failure.
- Product damaged as a result of fire, earthquake, flooding, lightning or other natural disaster, or due to local conflict or war.
- Damage or malfunction of operating system, application software, or the instrument itself as a result of infection by a computer virus.
- Instruments that have been restored after being disposed of or re-sold without prior written notice to and agreement from JEOL.

1.4 Items Not Covered by Warranty

- cover losses or damage to devices made by any other manufacturer at the customer site even if they are damaged by a malfunction of the JEOL product.
- JEOL is not responsible for any loss or damage to data recorded onto storage media, or to storage units. The customer is responsible for making back-up copies of their own data.
- Replacement parts for maintenance of the instrument functionality and performance are retained and available for seven years from the date of installation. Thereafter, some of those parts may be available for a certain period of time. Please contact your JEOL service office for details before the period of retention has passed.
- For items that are frequently updated, remodeled, or disappear from the market, like the computers used with the JEOL products, it may not be possible to obtain an exact replacement.

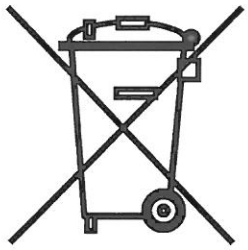
2 Repairs for a Fee

Repairs of JEOL products are available with charges after the end of the warranty period, or at anytime a customer requests. The components, modules and devices that are provided as replacements during the paid repair work will be new parts or refurbished parts that provide the same performance as new parts. All components, modules and devices removed during such repairs will become the property of JEOL.

- The warranty period for parts replaced and the service during paid repair work is a period of 3 months after the completion of the repairs; or, in the case of parts that must be periodically replaced, the warranty period is the length of the specified replacement period.
- In the event that repairs are performed again during the warranty period, there is no change to the warranty start date or the warranty period.

Notes on Disposal for Business Users

Attention:
Your product is marked with this symbol. It means that used electrical and electronic products should not be mixed with general household waste. There is a separate collection system for these products.



In the European Union

This symbol means that electrical and electronic equipment, at the end of its life, should be disposed of correctly.

In the European Union there is a separate collection system for used electrical and electronic products. Please help us to conserve the environment we live in!

Electrical and electronic appliances and machines often contain materials which, if handled or disposed of incorrectly, are potentially hazardous to human health and to the environment. They are, however, essential for the correct functioning of your appliance or machine. Therefore, please do not dispose of your old machine or appliance together with your household waste.

Your JEOL product is designed and manufactured with high-quality materials and components which can be recycled and reused. If the product is used for business purposes and you want to discard it, please contact your JEOL dealer, who will advise you about the end-of-life disposal arrangements.

Outside the European Union

If you wish to discard this product, please contact your local authorities and ask for the correct method of disposal.

NOTATIONAL CONVENTIONS AND GLOSSARY

■ Examples for general notations

– CAUTION – :	Important precautions for use, which, if not followed, may result in damage to or problems with the device itself.
IMPORTANT NOTICES :	Important notices for operating the instrument.
:	Additional points to remember regarding the operation.
:	A reference to another section, chapter or manual.
1, 2, 3 :	Numbers indicate a series of operations to achieve a task.
◆ :	A diamond indicates a single operation that achieves a task.
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.
Ctrl :	Keys on the keyboard are denoted by enclosing their names in a box.

■ Examples for mouse and touch panel 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.
Tap:	Briefly touching and then releasing a point on a touch screen.
Double-tap:	Tapping a point on a touch screen twice in rapid succession.
Swipe:	Operation for changing the screen by touching a point on a touch screen and dragging in a certain direction.
Pinch-in:	Operation to reduce the image size on the screen by touching two points on the touch screen simultaneously and dragging the two points closer together.
Pinch-out:	Operation to increase the image size on the screen by touching two points on the touch screen simultaneously and dragging the two points farther apart.

CONTENTS

6 MAINTENANCE

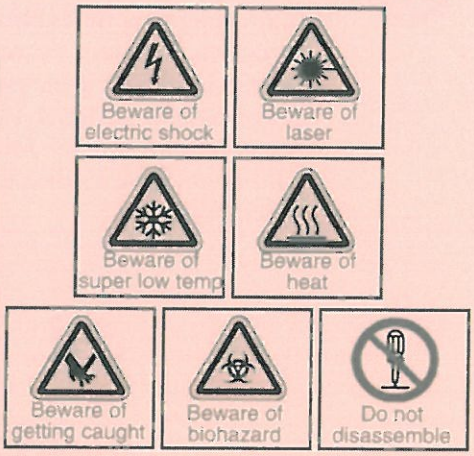
SAFETY PRECAUTIONS

Although this instrument is protected with safety device which prevents the occurrence of accident that could result in an injury, harm, and damage to the users or instrument itself, the safety feature may not work properly if you use the instrument for the purpose of use not intended or in an improper usage. For the proper use of the instrument, please be sure to read all of the instructions, descriptions, notices, and precautions contained in this manual carefully to understand them fully prior to the operation or maintenance. This section, "Safety Precautions", contains important information related to safety for using of the instrument.

The safety indications and their meanings are as follows:

DANGER	An imminently 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, may result in minor or moderate injury, or a situation that could result in serious damage to facilities or acquired data.

Labels bearing the following symbols are attached to dangerous locations on the instrument. Do not touch any of these locations with your hands or anything else.



Examples of symbols

- Use the instrument properly within the scope of the purpose and usage described in its brochures and manuals.
- Never open/remove protective parts (exterior panels) and parts that can't be opened/removed without use of tool (including key), or disconnect/ connect the cables/connectors that are not described in this manual.
- Never attempt to do any works of disassembling/assembling the instrument other than those described in this manual.
- Never make modifications that include installing substitute parts and disabling safety devices or other safety features.
- Never disconnect the grounding wire or move it from the prescribed position. Failure to follow this instruction could result in electric shock.
- The AC power cord provided with this system is supplied for the particular device so that never use it for any other equipment.
- To avoid falling, do not climb onto the operation table and console during daily operation or during maintenance or inspection.
- When you dispose of the instrument or liquid or other waste, follow all applicable laws and regulations, and dispose of it in a proper manner without polluting the environment.
- Be sure to read the "Safety Precautions" section of the manuals for the accessories attached to or built into the instrument.
- If anything is unclear, please contact your JEOL service office.

⚠ WARNING for Installation

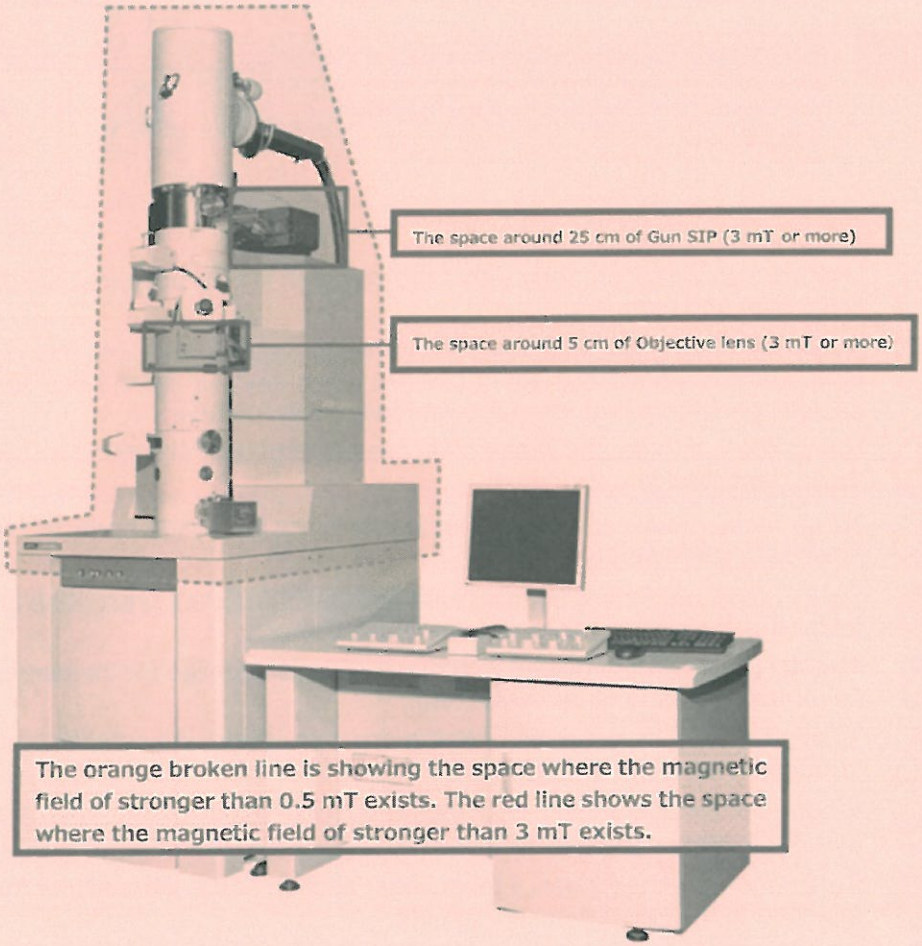
Do not attempt to install the instruments by yourself.
Installation work requires professional expertise and JEOL is responsible for the installation of the instruments and related attachments purchased from JEOL. Consult your JEOL service office.

⚠ WARNING

■ About the influence of a strong magnetic field

- **This instrument generates a strong magnetic field of more than 0.5 mT. Ferromagnetic substances or devices, which may be affected by the magnetic field such as iron, or those who are equipped with such devices cannot go near the area where the instrument is installed or the area where the magnetic field exists.**

Static magnetic fields stronger than 0.5 mT may affect the operation of some medical electronic implants, especially, cardiac pacemakers. Moreover, since some medical implants, such as aneurysm clips, surgical clips and artificial organs, include ferromagnetic material, they are strongly attracted if they are near the magnet and may cause serious injuries. Moreover, a memory device that uses a magnet such as a credit card might have its data destroyed. Problems might also occur with on a wristwatch or other devices.



■ Handling high-pressure gas

- **Even if you use only a small amount of gas, provide sufficient ventilation.**
  You run the risk of suffocation due to a low oxygen concentration.

- **Because the inner pressure of the gas supply source such as a gas cylinder is very high, mount a pressure regulator on the gas outlet to decrease the secondary side pressure for the gas being used.**

- **When you operate the gas valve do not stand directly in front of the gauge. Operate it from an off-center position.**
  If the pressure gauge is damaged, shards of glass may be scattered and cause injury.

- **When you open the primary gas valve, open the valve slowly by one quarter or half rotation and check the increase in primary pressure on the pressure gauge. After that, fully open the valve.**
  Do not open the primary gas valve rapidly. The pressure gauge may be damaged due to the applied pressure.

● Sulfur hexafluoride (SF_6)

- **SF_6 is highly stable chemically and thermally and it has good insulation characteristics, but do not inhale the high density SF_6.**
  You run the risk of suffocation due to a low oxygen concentration.

- **If you need to repair the high-voltage tank, consult the JEOL service office. Do not open the tank. Provide a low humidity work environment for handling the gas container for the electron gun and for the gas refilling work.**

● Nitrogen Gas

- **Nitrogen gas is inert and harmless. However, it is hazardous if a large amount of gas leaks into a sealed room.**
  You run the risk of suffocation due to a low oxygen concentration.

● Handling gas cylinder

- **When you install a gas cylinder, comply with the following.**
  - To prevent the gas cylinder from falling, it must be locked to the wall using a chain, or stabilize using a designated stand.

  - Ensure that the temperature of the installation room does not exceed 40 ℃.
  - Do not place a heater near the gas cylinder.
  - Do not apply any shock to the gas cylinder.

  Always keep the handle close to the gas cylinder to open/close the primary valve.

- **Always confirm the service life of the gas cylinder. In addition, do not use a gas cylinder past the recommended service life.**

⚠ CAUTION

■ General cautions for the instrument

- **When you walk behind the instrument, be aware of the cables, hoses or protruding objects.**
  There is a danger of a fall or collision. If this occurs, the instrument may be damaged and may not operate normally.

- **Do not step on the frame or table of the instrument. Use a steady footstool during daily operations or maintenance.**
  There is a danger of falling. If this occurs, the instrument may be damaged and may not operate normally.

■ Handling coolant

- **Even if you use only a small amount of gas, provide sufficient ventilation.**
  You run the risk of suffocation due to a low oxygen concentration.

- **Wear protective glasses and leather gloves to protect yourself from any cooling water splashes.**
  You run the risk of frostbite.

- **The inlet of the cooling water becomes extremely cold; so do not touch the inlet.**
  There is a risk of subsequent injury.

■ Bake out

- **During bake out operation, the part and its surroundings become hot. Do not touch or put anything flammable close to these parts.**
  Failure to observe this warning may cause fire or burn injury.

- **To prevent other people from touching or using the instrument accidentally, put up a sign or notice to the effect that the instrument is under baking.**
  Failure to observe this warning may result in fire or burn injury.

■ Cleaning using organic solvent

- **When using an organic solvent, provide sufficient ventilation and stay away from flames or sources of ignition.**
  It is harmful to human body and is flammable.

■ EDS detector

- **When installing or removing the EDS detector, consult your JEOL service office. Do not attempt installing or removing it yourself.**
  The EDS detector uses a thin beryllium window. It is dangerous if the window breaks, because liquid nitrogen boils and spouts from the Dewar. Fragments or powder of beryllium are toxic. Do not inhale them.

- **Do not touch the shaft or surrounding parts while the detector is being driven.**
  You run the risk of injury.

- **When you add liquid nitrogen to the detector, use a steady footstool. Additionally, do not touch the liquid nitrogen.**
  Unstable footing might cause injury.

■ Using the stepladder included in the configuration

- **When using the stepladder (included) in order to supply liquid nitrogen to an ACD (anti-contamination device) or an EDS (Energy Dispersive X-ray Spectrometer), there is a danger of falling. Therefore, beware of the following points and use it after the safety has been ensured.**
  - Before use, confirm that there is no damage, no loose screws, no corrosion or no other irregularity.
  - When you carry the stepladder, be aware of overhead electric wires. Electric shock causes serious damage or death.
  - Do not use it where the floor is unstable.
  - Do not use it where the floor is slippery.
  - Do not use it where the top plate of the stepladder is not level.
  - When you work on the stepladder, do not stand at the edge of stepladder, on tiptoes or on one foot. If you do, you run the risk of falling.

■ Beware of falling

- **When operating the conditioning knob, stand on a stable, unmoving footstool.**
  If you use an unstable, easy-moving footstool, you run the risk of falling.

■ Beware of pinching

- **When you insert the specimen holder into the goniometer, be careful so you do not pinch your fingers.**
  You might pinch your fingers between the specimen holder and the goniometer.

- **If there is abnormality during film transfer, contact your JEOL service office.**
  If you put your hand inside the camera mechanism unnecessarily, your finger may get caught in the transfer system.

■ Beware of low temperature

- **The outlet for helium, liquid nitrogen, or the parts surrounding become very cold. Do not touch them.**
  You run the risk of frostbite.

■ Beware of high temperature

- **The heater for the outlet pipe for helium and the heater for the outlet pipe of liquid nitrogen remain very hot during heating or immediately after the instrument is turned off. Do not touch them.**
  You may burn yourself.

- **Do not touch the coolant evaporator of the Anti-contamination device during or immediately after heating.**
  You may burn yourself.

■ Beware of water leak

- **Cooling water is used in the instrument. Turn on the cooling water system and make sure that there is no water leak. Be careful not to exceed the specified pressure and flow-rate of cooling water; otherwise, the cooling water tube might burst with pressure.**

- **Hoses and/or tubing for cooling water line require periodic replacement of once in five years for general usage and once in three years for use in the clean room. If those hoses and/or tubing are used longer than the recommended replacement time, they may crack and start leaking, causing serious damage to the installation environment.**
  Please execute replacement of the tubes by JEOL service engineer within the recommended replacement time.
- **The cooling water to be used must satisfy the criteria specified for the water chiller.**
  The use of cooling water that does not satisfy the criteria corrodes the cooling-water piping and causes leaks.

■ Handling flammable liquid

- **Oil rotary pump oil is a flammable liquid. When adding or replacing the oil rotary pump oil, read Sect. 6.8.3a "Material Safety Data Sheet / MR-200A" thoroughly. Then perform it where there is no risk of fire.**
  If it is mishandled, the oil rotary pump oil may ignite and burns may be caused by the ignition.
- **Stop the instrument before refilling the rotary pump with oil or replacing the oil.**
  If refill or replacement of the oil is performed while the oil rotary pump is operating, high temperature oil may splatter causing ignition or burns.

■ Other

- **The goniometer stage contains parts using a Class 1 laser beam. When used normally, there is no danger. However, never remove any related parts and look at the beam directly.**
  Never look at the laser beam directly or its reflection on the mirror. It could damage your eye.

- **Liquid nitrogen is used for this instrument. Therefore, when using the instrument, make sure to ventilate the room sufficiently so that the oxygen will not run out.**
  There is a risk of oxygen deficiency.

- **When filling or draining the coolant (liquid nitrogen) into/from the anti-contamination device, wear appropriate protective eyeglasses, and gloves (made of leather that liquid nitrogen will not permeate).**
  There is a risk of eye injury resulting in vision loss or frostbite

- **Use a stable workbench without rotating casters when supplying and evaporating the coolant.**
  There is a danger of falling.

- **Do not remove the evaporator while the lamp installed in the ACD HEAT is lit or immediately after it has been turned off.**
  The evaporator heater is at a high temperature when the lamp is lit or immediately after it is turned off. Therefore, you might burn yourself.

- **Gas leaks are more likely to occur in older instruments. Be sure to perform periodic inspection to prevent leaks of the high-pressure tank.**

Safety Instructions for Using JEOL Products

- **Products using materials hazardous for operators or equipment**
  When measuring, indicating, or detecting harmful or corrosive substances, or voltages or other electrical quantities that may cause electric shock, read the instruction manual carefully to assure proper operation. Ensure that all operators of the instrument receive training on the operation method.
  If there is a problem in the product, take appropriate measures in accordance with the instruction manual and contact a JEOL service office immediately.
- **Products having accessible parts that reach high temperatures**
  If an accessible part of the product reaches a high temperature while it functions, notify all the operators to exercise cautions whenever they will be near any such parts.
  It is recommended to take measures to restrict the access to the instrument by enclosing with rope or chain.
- **Using JEOL product for an integrated system with other manufacturer's product**
  Consult your JEOL office. We assume no responsibility for any damages resulting from using the product in combination with other manufacturer's product without consultation.
- **Using product in an environment that does not satisfy the installation requirements**
  Consult your JEOL office. We assume no responsibility for any damages resulting from using the product in an environment other than one specified by JEOL without consultation.
- **Attachment used for JEOL product**
  For safety reasons, only use the accessories or attachments that are supplied or designated by JEOL. We assume no responsibility for any damages resulting from using any accessory or attachment other than those specified by JEOL.
  Do not replace detachable main power supply cords with inadequately rated cords.

The following precautions are important which, if not followed, may result in damage to the instrument itself.

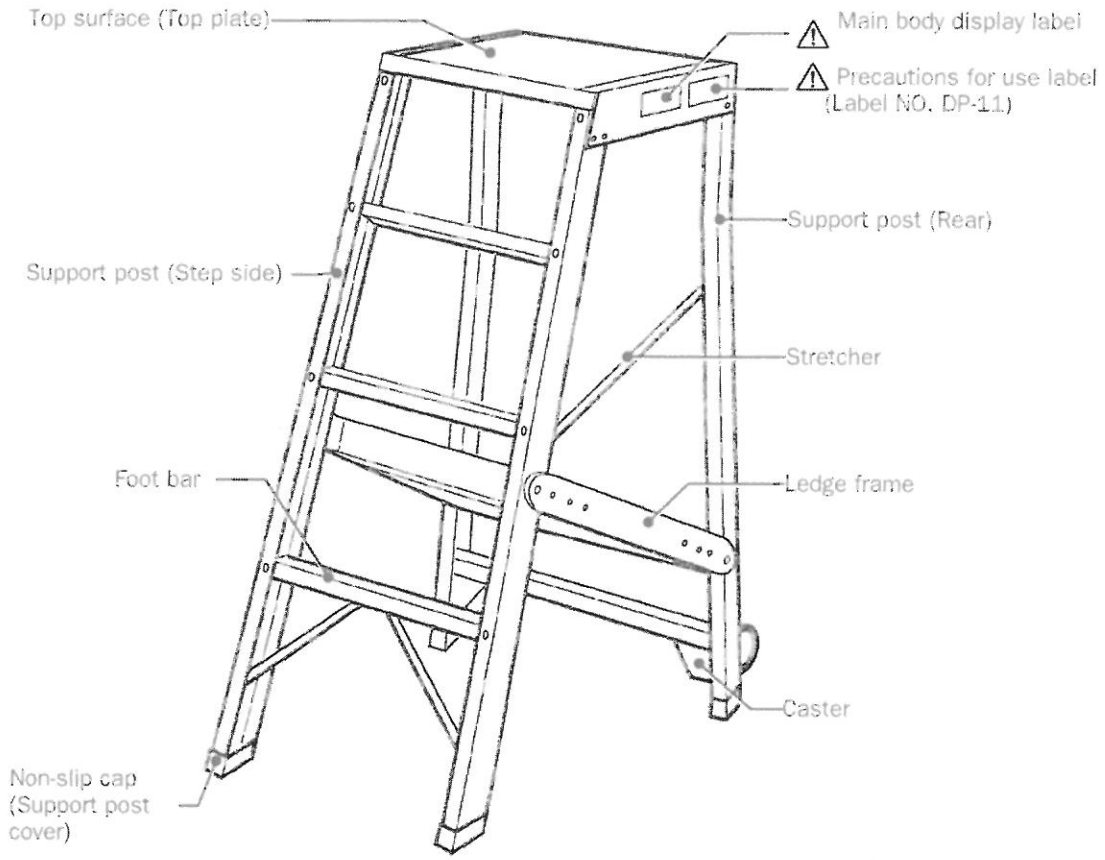
PRECAUTIONS FOR USE

- **If an abnormality occurs in the system, immediately shutdown the instrument and contact your JEOL service office.**
- **Contact your JEOL service office for disassembling and reassembling the microscope column and such. Do not disassemble or reassemble the microscope column on your own.**
- **Wear thin and lint-free gloves to handle any parts inside the column.**
  If fingerprints are left on the parts inside the column, it will oxidize and cause electric charging.
- **Complete 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 a 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 warping.**
- **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.
- **The cooling water to be used must satisfy the criteria specified for the water chiller.**
  The cooling water that does not satisfy the criteria causes the corrosion of the cooling-water piping.
- **While the electron beam is being generated, keep the following precautions in mind.**
  - Be sure to close the electron gun chamber isolation valve (V1) before inserting or removing the specimen holder.
  - Close the electron gun chamber isolation valve (V1) when microscopy is complete.
  - Do not turn off the accelerating voltage.
  - Do not touch the conditioning knob.

  Failure to follow these precautions might damage the electron gun filament.
- **Before operating the conditioning knob, make sure that the Dark Current value is set to 0 μA.**
  If you operate the knob while the value is not 0 μA, the electron gun or the high-voltage generation circuit might be damaged.
- **Do not use the electron microscope for more than one day while the electron gun power supply is not in the standard status.**
  Varying the value of the electron gun power supply may cause a problem in generating a stable electron beam.
- **When you use the ACD continuously, condensation might occur around the ACD depending on the installation environment. If condensation occurs around the ACD, be sure to wipe it away with a dry cloth.**
  If you leave it, this can cause the deterioration of the instrument or the malfunction of the water-leak detector.
- **Stop filling the liquid nitrogen (LN2) when it is fully filled.**
  If you continue, it may lower the quality of the vacuum seal part by over freezing, causing serious damage to the interior of the microscope column.
- **Do not put the cup that had liquid nitrogen in it on the table.**
  It may damage the table.

- **Always hold the specimen holder while inserting the holder into the goniometer.**
  If you release your hand from the holder, the specimen holder might hit the goniometer causing damage to the goniometer due to the force of the vacuum.
- **Stop the instrument before refilling the rotary pump with oil or replacing the oil.**
- **Use "NEOVAC MR-200A" when refilling the rotary pump with the oil.**
  If you use other oils, it might cause malfunction of the pump.
- **Be sure to fasten the white cap at the upper part of the rotary pump.**
  If the cap is loose, it might cause the leakage of oil and damage the pump.
- **Do not operate the knob of gas control section.**
  If you do, the gun insulation gas will be forcibly discharged.
- **Do not load a magnetic material into the column.**
  If you insert the specimen holder, on which a magnetic material specimen is loaded, into the microscope column, the specimen might fall off the specimen holder due to the effect of the lens magnetic field.
- **Do not install any application software or program on the system computer without permission from JEOL.**
  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 an unauthorized modification of the system.
- **Initial installation and adjustment of this product and attachments will be performed by engineers dispatched from your local JEOL service office. In general, the products we procure from suppliers must be installed by an expert from the supplier working with our service engineer.**
  Therefore, we request that the customer does not perform any of these tasks.
- **Pay attention to the replacement period of the consumable parts and the periodic replacement parts. The date of replacement or purchase is specified in the list of consumable parts and periodic replacement parts of Section 6. Contact your JEOL service office for any assistance.**
  The instrument may breakdown if you do not perform maintenance (such as replacing the oil of the oil rotary pump and oil-diffusion pump, and regular maintenance of such parts as the dry pump and turbo-molecular pump). In this situation, the cost of repair will be very expensive.
- **Supply the coolant after covering the viewing window.**
  If the coolant is supplied without covering the viewing window, the coolant comes in contact with the window glass and there is a danger of the glass cracking, causing serious damage to the interior of the microscope column.

■ About the work ladder (DWS type)



The number on the label is the label number. When ordering the label, state this number.

- **Make sure there is no support post damage, loosening of the screw, deterioration and so on before use. (Check it beforehand to ensure safety during work.)**

1

GENERAL

JEOL

The JEM-2200FS Electron Microscope makes it possible to observe high-resolution and high-contrast images in a wide range of fields, not only in material science including metallurgy and study of semiconductors, but also in medical and biological research.

● ZrO/W Schottky electron gun

With the aid of its ZrO/W Schottky electron gun, it achieves high brightness with a highly coherent electron beam. As a result, high-resolution, high quality images can readily be obtained.

● Energy filter

With an in-column Omega type energy filter as part of the image-forming lens system, it can easily acquire both energy-filtered images and energy-loss spectra with the magnification range comparable to that obtained with conventional electron microscopes. Also, the Omega type energy filter optics are designed for minimal distortion. Furthermore, any remaining distortion is eliminated in the factory before shipping the instrument.
To realize both an element mapping and an energy-loss spectroscopy system, a high-sensitivity camera system and an image-processing system are available as optional attachments.

● Introducing a new control system

A sub-system structure has been applied for individual basic functions. It includes an electron gun, electron optics system, goniometer stage, and evacuation system. This structure provides much higher performance and stability to the control system.
The use of Windows as the operating system for the system controller and user interface enables you to program a sequence of operations and offers centralized control for the optional microscope attachments.

● Introducing a new goniometer stage

A new goniometer stage is also designed as a sub-system is equipped with a piezo-drive mechanism. This significantly improves the operability of specimen movements at high magnification*.

* The piezo power supply and controller are options.

2 SPECIFICATIONS

This chapter describes the specifications and installation requirements related to the handling of the instrument.

2.1 PERFORMANCE

Configuration*1	Ultrahigh Resolution (UHR)	High Resolution (HR)	High Specimen Tilt (HT)	Cryo Stage (CR)	High Contrast (HC)
Image resolution					
Point image	0.19 nm	0.23 nm	0.25 nm	0.27 nm	0.31 nm
Lattice image	0.1 nm	0.1 nm	0.1 nm	0.14 nm	0.14 nm
Energy resolution	0.8 eV (zero loss FWHM)				
Accelerating voltage	200 kV, 160 kV (120 kV, 100 kV, and 80 kV: Option) *2				
Step size	50 V				
Energy shift	3000 V Maximum (0.2 V step)				
Electron gun					
Emitter	ZrO/W(100) Schottky emitter				
Intensity	4×10^{8}A/cm2sr				
Degree of vacuum	10^{-8}Pa				
Probe current	0.5 nA: 1 nm probe size				
Power stability					
Acc. voltage	2×10^{-6}/min				
OL current	1×10^{-6}/min				
Filter lens current	1×10^{-6}/min				
Objective Lens					
Focal length	1.9 mm	2.3 mm	2.7 mm	2.8 mm	3.9 mm
Spherical aberration	0.5 mm	1.0 mm	1.4 mm	2.0 mm	3.3 mm
Chromatic aberration	1.1 mm	1.4 mm	1.8 mm	2.1 mm	3.0 mm
Minimum step	1.0 nm	1.4 nm	1.8 nm	2.6 nm	5.2 nm
Spot size					
TEM mode		2 to 5 nm		2 to 5 nm	7 to 30 nm
EDS mode		0.5 to 2.4 nm		–	4 to 20 nm
NBD mode		0.5 to 2.4 nm		–	–
CBD mode		0.5 to 2.4 nm		1.5 to 2.4 nm	–
CB Diffraction					
Convergent angle	1.5 to 20 mrad or more				–
(2α)	±10°				–
Acceptance angle					
Magnification					
MAG mode	×2 k to 1500 k	×2 k to 1200 k	×1.5 k to 1000 k	×1.5 k to 1000 k	×1.2 k to 600 k
	×50 to 1.5 k	×50 to 1.5 k	×50 to 1.5 k	×50 to 1.5 k	×50 to 1.5 k
LOW MAG mode	×10 k to 800 k	×8 k to 600 k	×8 k to 600 k	×8 k to 500 k	×5 k to 400 k
SA MAG mode					
Energy-selected image	When 10 eV is selected, 80 mm in diameter on the final window (film).				
Effective field of view size	When 2 eV is selected, 25 mm in diameter on the final window (film).				
Camera Length					
SA diffraction	150 to 1500 mm	200 to 2000 mm	200 to 2000 mm	250 to 2500 mm	300 to 3000 mm

*1 Specify a configuration when ordering this model.
*2 80 kV, 100 kV and 120 kV are possible using the optional accelerating tube electrode short-circuit unit.

Configuration*1	Ultrahigh Resolution (UHR)	High Resolution (HR)	High Specimen Tilt (HT)	Cryo Stage (CR)	High Contrast (HC)
EELS Dispersion On energy-selection slit On the film	1.2 μm/eV at 200 kV 50 to 300 μm/eV at 200 kV				
Specimen Chamber Specimen shift (XY/Z) Specimen tilt (X/Y)	2 mm/0.2 mm ±25°/±25° *3	2 mm/0.4 mm ±35°/±30° *3	2 mm/0.4 mm ±42°/±30° *3	2 mm/0.4 mm ±60°/ – *4	2 mm/0.4 mm ±38°/±30° *3
EDS (Option) *5 Solid angle Take-off angle		0.13 sr 25°		– –	0.09 sr 20°

2.2 Electron optical system

2.2.1 Illumination System

■ Electron gun (Thermal field emission)

Emitter: ZrO/W (100)
Electron gun lens: Electrostatic lens
Axis alignment: Electromagnetic 2-stage interlocking system (SHIFT, TILT)
Anode chamber airlock valve: Built-in, pneumatic

■ Condenser Lens

Lens configuration
·For UHR, HR, HT, CR configuration:
3-stage (1st and 2nd CL lenses and condenser mini lens)
·For HC configuration: 2-stage (1st and 2nd CL lenses)
Variable aperture: Platinum disk aperture with 4 holes (200, 100, 40, 10 μm in diameter)
Motor-driven aperture drive shaft with metal bellows, provided with aperture-position memory
Astigmatism correction: Electromagnetic (with centering circuit)
Axis alignment: Electromagnetic 2-stage interlocking system (SHIFT, TILT), 4 modes (TEM, EDS, NBD, and CBD) independent electromagnetic deflection memory built-in
Deflection sensitivity linked to magnification
Link correction wobbler built-in
Quick beam selector:
·For UHR, HR, HT configuration:
Instantaneous switching between TEM, EDS, NBD and CBD modes

*3 The value when using the specimen tilting holder (EM-31630).
*4 The value when using the attached high tilt retainer or Gatan 626.
*5 EDS system is optional. It is the value when using the EDS detector with specification of 30mm^2.

·For CR configuration: Instantaneous switching between TEM and CBD modes
·For HC configuration: Instantaneous switching between TEM and EDS modes
α-selector
·For UHR, HR, HT, CR configuration:
Built-in (TEM mode: 3 steps, EDS mode: 5 steps, NBD mode: 5 steps, CBD mode: 9 steps)
Dark-field image: Instantaneous switching between bright and dark field
Dark field electromagnetic beam deflector condition memory: 5 sets built-in
Electron beam tilting angle
·For UHR, HR, HT, CR configuration:
$\pm 5^\circ$ to all direction (maximum)
·For HC configuration: $\pm 2^\circ$ to all direction (maximum)
Hard X-ray aperture for EDS: Optional motor-driven aperture for EDS analysis

2.2.2 Imaging System

■ Objective lens

Lens configuration: 2-stages (objective lens, objective mini-lens) Wobbler for axis alignment built-in
Polepiece: Ultrahigh-resolution polepiece (UHR configuration)
High-resolution polepiece (HR configuration)
Specimen high-tilt polepiece (HT configuration)
Cryo polepiece (CR configuration)
High contrast polepiece (HC configuration)
Variable aperture:
·For UHR, HR, HT configuration:
High contrast aperture (Within the polepiece lower pole) Built-in
4 Pt film apertures (120, 60, 40, 20 μm in diameter)
Motor-driven aperture drive shaft with metal bellows, provided with aperture-position memory
Optional OL aperture within the gap (HR, HT configuration only)
·For HC, CR configuration Optional OL aperture built-in within the gap
4 Pt film apertures (50, 30, 15, 5 μm in diameter)
Motor-driven aperture drive shaft with metal bellows, provided with aperture-position memory
Astigmatism correction: Electromagnetic (with centering circuit)
Independent stigmator memory: 5 sets built-in
Focusing: Digital control, coarse/fine controls
Focus zoom
Image wobbler (X, Y cycle / amplitude: 5 stage variable) provided

■ Intermediate lens

Lens configuration:	4-stage (1st, 2nd, 3rd and 4th Intermediate lenses) Distortion free Image rotation free (Selected-field image mode and selected area diffraction mode)
Selected-area aperture:	4 Pt disc apertures (100, 50, 20, 10 μm in diameter) Motor-driven aperture drive shaft with metal bellows, provided with aperture-position memory
Axis alignment:	Mechanical and electromagnetic
Astigmatism correction:	Electromagnetic (with centering circuit)
Port for biprism:	One port provided (biprism is optional)

■ Energy filter

Method:	Omega (Ω) type, four sector magnets
Entrance aperture:	4 Pt film apertures Motor-driven aperture drive shaft with metal bellows, provided with aperture-position memory
Axis alignment:	Mechanical and electromagnetic
Astigmatism correction:	Electromagnetic (with centering circuit) Incident correction and exit correction
Distortion correction:	Magnetic-field compensation method
Slit:	1 μm to 0.5 mm, open (double-bladed sliding slit) Pneumatic drive, Motor-driven used in combination
Demagnetization circuit:	Built-in
Bake-out heater:	Built-in

Dark-field scanning transmission electron image.

Detection port:	Built-in (Scanning Image Observation Device (ASID) and STEM DFI (Dark Field Image) detector are optional)

■ Projector lens

Lens system:	2-stage (1st and 2nd Projector Lenses) Distortion-free
Axis alignment:	Mechanical and electromagnetic

2.3 SPECIMEN CHAMBER

■ Specimen stage

Specimen stage:	Side entry eucentric 5-axis goniometer stage
Specimen Exchange:	Automatic airlock method, automatic 2-stage pre-evacuation system
Specimen holder:	Common specimen holder (with quick-change specimen retainer), standard attachments
Specimen movement:	
·For X/Y axes:	Motor drive (controlled by both trackball and push buttons) Movement range ±1 mm Piezo drive is available (movement range ±1.2 μm: option)
·For Z axis:	Motor drive (push button switch) Movement range ±0.4 mm (depends on the basic unit configuration)
Specimen tilting	
·X axis tilt:	Motor drive (push button switch)
·Y axis tilt:	Motor drive (push button switch)* *only with the optional specimen-tilting holder.
Stage bakeout heater:	Built-in

■ Specimen position display function

Specimen position display	Digital display (X, Y and Z movements, X and Y tilt angles). Graphical display (X and Y movements)
Specimen position registration:	Up to 100 arbitrary specimen positions can be stored and recalled

■ Electromagnetic image shift function:

Image shift:	Electromagnetic image shift standard built-in Movement range of ±2 μm (X, Y) / MAG mode

■ Specimen anti-contamination device (ACD)

Anti-contamination device:	Built-in

■ Ports for options

Ports for options:	One port each for EDS detector, Backscattered Electron (BEI) detector and Hard X-ray shield aperture

2.4 IMAGE VIEWING AND CAMERA CHAMBERS

2.4.1 Image Detector

Observation window:	50 mm in diameter (for maintenance)
Fluorescent screen:	Large fluorescent screen: 110 mm × 80 mm, maintenance / light interception Small fluorescent screen: 25 mm diameter, for exposure metering
Beam stopper:	Option Pneumatic drive
Wide angle digital CCD camera:	
Fluorescent screen:	43 × 24 mm Pneumatic drive retractable
Field of view size:	70 × 70 mm or more at the film position
Camera head:	Air-cooled head
Image sensor:	2/3 all element read out interline CCD Peltier cooling and natural cooling
Effective number of pixels:	1344 (H) × 1024 (V) maximum
Loading speed:	8.3 frames/s (loading all element) 16 frames/s (2 × 2 binning, loading all elements)
AD converter:	12 bit
Computer:	Windows PC
Beam stopper:	Option
Faraday cage port:	One port provided (optional Faraday cage)
Ports for STEM detectors:	For bright field and dark field (HAADF) (Scanning Image Observation Device (ASID) and detector are optional)

2.4.2 Photographing Device

■ Camera

Sheet (cut) film, magazine type

■ Film

Size:	Select one from the following 82 × 59 mm (for Japan) (J) 90 × 65 mm (for Europe) (E) 100 × 83 mm (for U.S.A.) (A) 118 × 82 mm (large size) (S)
Number of loadable films:	Max. 50 sheets
Exchange method:	Automatic airlock Light shielding magazine method 2 magazine feed 2 magazine feed attached

Film feeding:	Automatic (single / continuous film feed selectable) With double-exposure protection mechanism Multiple-exposure capability built-in Photographing method: Fully automatic or by manual is possible Exposure range: $5 \times 10^{-13} \sim 5 \times 10^{-10}$ A/cm^2 Current density is digitally displayed
Shutter speed:	0.1 to 900 s, valve
Unused-film counter:	Digital display
Data registration:	Operator code Film number Accelerating voltage Magnification or Camera length Micron scale bar Text (Comment)

■ Exposure history record

Recorded in text file and displayed

■ Film desiccator

Stand-alone unit (optional)

2.5 EVACUATION SYSTEM

■ Evacuation System

Differential pumping system

■ Vacuum system control

Fully automatic control, schematic diagram of vacuum system displayed with vacuum gauge display.

■ Bakeout system

Built-in, automatic control

■ Electron gun

Ultimate pressure:	10^{-8} Pa order
Evacuation pumps:	15 L/s SIP (5 L/s SIP × 3)

■ Accelerating tube

Evacuation pumps:	60 L/s SIP ×1
Vacuum gauge:	Ion pump current display

■ Intermediate chamber

Evacuation pumps:	20 L/s SIP ×1
Vacuum gauges:	Ion pump current display

■ Lens and Specimen Chamber

Ultimate pressure:	$\sim 2 \times 10^{-5}$ Pa
Vacuum pumps:	150 L/s SIP (when SIP vacuum system is configured) 400 L/s TMP (when TMP vacuum system is configured)
Vacuum gauges:	Ion pump current display (when SIP vacuum system is configured) Penning gauge for TMP configuration

■ Filter Lens

Evacuation pump:	420 L/s DP

■ Image Observation Chamber / Camera Chamber:

Evacuation pump:	420 L/s DP
Rough evacuation pump:	100 L/min RP ×2
Vacuum gauge	Five Pirani gauges and one Penning gauge

2.6 INSTALLATION REQUIREMENTS

2.6.1 Power Supply and Cooling Water

■ Power

Basic system:	Single-phase 240/220/200 V, 10 kVA
Air compressor (optional):	Single-phase 100 V, 5 A (12.5 A at peak)
Film desiccator (optional)	Single-phase 100 V, 0.5 kVA (3.0 kVA at peak)
Power fluctuations:	±10% or less (Moderate voltage variation)

■ Grounding terminal

100 Ω or less ×1

A stable power source, which does not have voltage surges or voltage dips, should be supplied to the AC power supply of this system. We strongly recommend that you provide an uninterruptible power supply (UPS) between the power distribution board and the AC power supply input device of the microscope.

■ Cooling Water

Flow rate:	7.5 L/min
Water pressure:	0.2 to 0.3 MPa
Water temperature:	18 to 23 ℃, variation 0.1 ℃ or less
Inlet:	TH-12-1/2 (18 mm (OD) × 12 mm (ID) in diameter 1 hose) to be supplied by customer.
Outlet:	One, Natural drainage (18 mm (OD) × 12 mm (ID) in diameter 4 hose)

We recommend the use of the Water Chiller. To avoid any vibration and noise, it is necessary to place the water chiller in the peripheral equipment room that is separately located from the microscope room.

If the water circulator is necessary, please consult JEOL service personnel.

—CAUTION—

The cooling water to be used must satisfy the criteria specified for the water chiller.

The use of cooling water that does not satisfy the criteria corrodes the cooling-water piping and causes leaks.

- As an example, The following table shows the standards used in Japan.

	Item	Standard value
Standard value item	pH (25 °C)	6.5 to 8.2
	Electric conductivity (25 °C) [mS/m]	80 or less
	Chloride ion Cl^-[mg Cl^-/L]	200 or less
	Sulfate ion SO_4^{2-}[mg SO_4^{2-}/L]	200 or less
	Acid consumption rate (pH4.8) [mg Ca CO_3/L]	100 or less
	Total hardness[mg Ca CO_3/L]	200 or less
	Calcium hardness[mg Ca CO_3/L]	150 or less

	Item	Standard value
Reference Value	Ionized silica[mg Si O_2/L]	50 or less
	Iron Fe [mg Fe/L]	1.0 or less
	Copper Cu [mg Cu/L]	0.3 or less
	Sulfide ion S^{2-} [mg S^{2-}/L]	No detection
	Ammonium ion NH^{4+}[mg NH^{4+}/L]	1.0 or less
	Residual chlorine [mg Cl/L]	0.3 or less
	Free carbon [mg CO_2/L]	4.0 or less

■ Dry Nitrogen Gas

✍ The customer must provide dry nitrogen gas.

Pressure: 0.01 to 0.02 MPa Gauge
Hose joint on device side: ISO 7/1 Rc 1/4

■ SF_6 Gas

Pressure: 0.1 to 0.3 MPa Gauge
Hose joint: ISO 7/1 Rc 1/4

■ Compressed air (for driving air mount and valves for basic unit)

Pressure: 0.5 MPa Gauge
Hose joint: 1/4, 9 mm in diameter female, for rubber hose

✍ Compressed air pressure at 0.5 MPa (gauge) is necessary.
If it is difficult to use the EM-08010 Air Compressor, pay attention to the inlet pressure of a different air compressor.
You can use dry nitrogen gas as a substitute for compressed air.

■ Installation room

Floor Area: 5000 (W) × 5400 (D) mm or more
Ceiling height: 3200 mm or more
Entrance for delivery: 1000 (W) × 2200 (H) mm or more
Room temperature: 15 to 25℃, variation1 ℃/h or less
Humidity: 60% or less
Pressure fluctuations: 1 Pa or less
Allowable noise level: 60 dB (C) or less
Floor Vibration Tolerance: Measure the floor vibration in advance.
The method of vibration isolation used will be determined from the measurement results.

Floor Vibration Tolerance: Maximum effective value of the velocity amplitude of the 1/3 octave-band (measurement time: 1 minute)

Horizontal direction: Less than 3.1 μm/s
1 Hz band to 80 Hz band
(For other frequency range, contact us.)

Vertical direction: Less than 3.1 μm/s
1 Hz band to 80 Hz band
(For other frequency range, contact us.)

- The values described above are the criteria of vibration when the installation room is prepared. If you use an optional vibration isolator designated by JEOL, the resolution satisfying the specifications may be obtained even when the actual vibration values do not satisfy the above criteria.
- Be sure to measure the floor vibration in advance. To determine the vibration level for whether the resolution satisfies the specifications, the measurement of the installation room environment, which is carried out by JEOL, is needed.

External magnetic field tolerance:
0.1 μT or less

Air current tolerance: 150 mm/s

2.7 DIMENSIONS AND WEIGHT

	Height (mm)	Width (mm)	Depth (mm)	Weight (kg)
Main console	2800	894[*6]	1135	1300
(Maintenance Parts)	(3110)[*7]	–	–	–
Operation console	720	1400	828	200
EOS console	1550	840	1082	280
Power supply console	1750	570	800	400
High voltage tank	1650	972	1200	450
Pump box[*8]	410	215	275	33
Air compressor	510	430	210	16

[*6] With angle plates attached to the base of the console.
[*7] The height during maintenance when the gun lift is raised. (3110 mm) indicates the height of the tip of the lift.
[*8] Two RPs in the SIP vacuum system configuration and 3 RPs in the TMP vacuum system configuration.

3

CONFIGURATION AND CONSTRUCTION

3.1 CONSTRUCTION

3.1.1 General View of Microscope

The exterior view of the microscope installed at your site may be different from this.

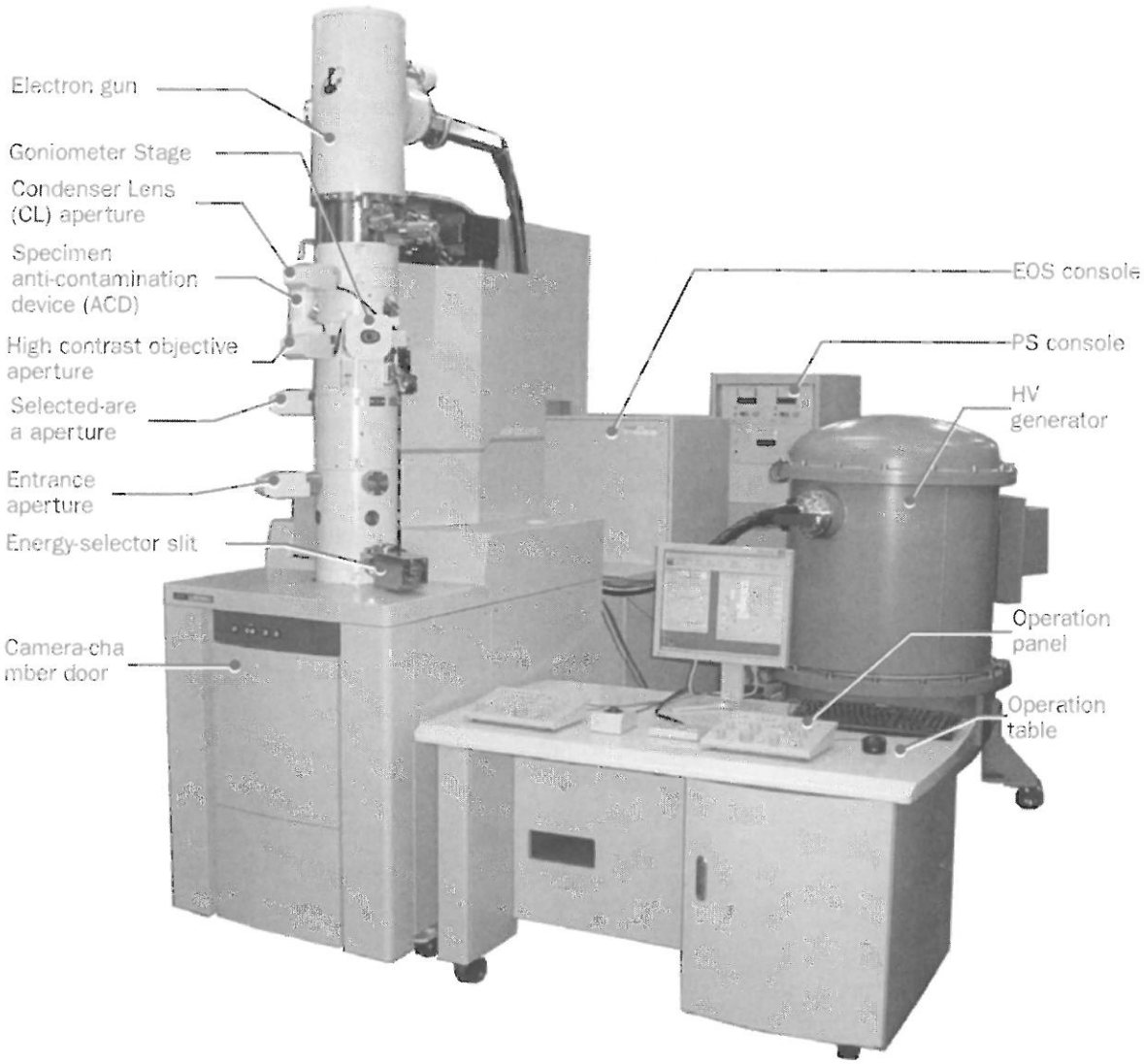
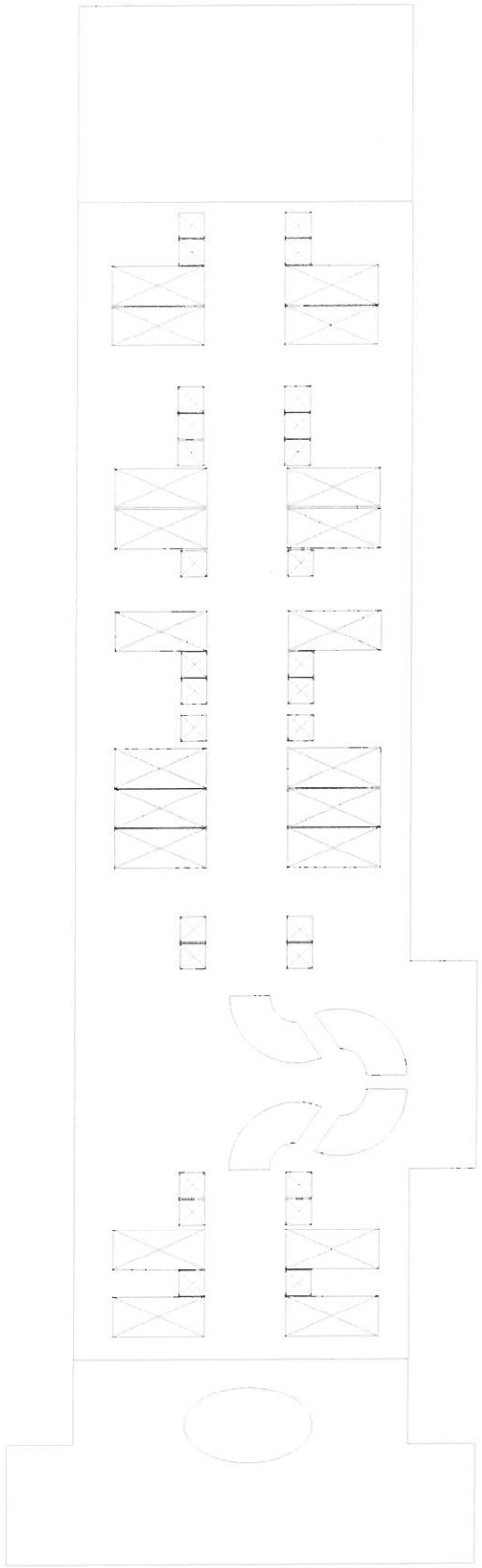


Fig. 3.1 Appearance

3.1.2 Layout of Lenses and Deflection Coils in The Column



GUN-A1	Electron gun 1st beam deflector coil
GUN-A2	Electron gun 1st beam deflector coil
CL1	1st condenser lens
CL2	2nd condenser lens
CL-STIG	CL stigmator coil
CL-A1	CL 1st deflector coil
CL-A2	CL 2nd deflector coil
CM	Condenser mini-lens
OL	Objective lens
OL-STIG	OL stigmator coil
OM	Objective mini-lens
IS1	1st image shift coil
IS2	2nd image shift coil
IL-STIG	IL stigmator coil
IL1	1st intermediate lens
IL2	2nd intermediate lens
IL3	3rd intermediate lens
	4th intermediate lens
FL-STIG	Filter lens 1st stigmator coil
FL-A1	Filter lens 1st deflector coil
FL	Filter lens
FL-A2	Filter lens 2nd deflector coil
FL-STIG	Filter lens 2nd stigmator coil
PL1	1st projector lens
PL-A	Projector lens deflector coil
PL2	2nd Projector lens

Fig. 3.2 Layout of lens and coils

3.1.3 Layout of Operation Panels

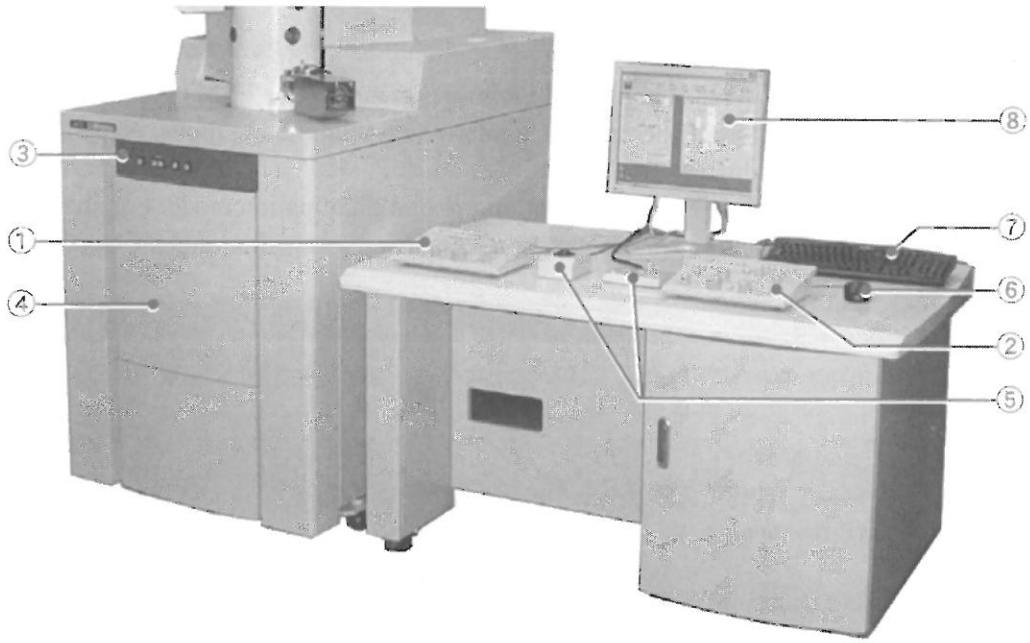


Fig. 3.3 Layout of operation panels

① Operation panel L1
② Operation panel R1
③ Operation panel R2
④ Operation panels GC, TR
⑤ Operation panel R3
⑥ Mouse
⑦ Keyboard
⑧ Monitor

3.2 RAY DIAGRAM

3.2.1 Illumination System

TEM mode: Wide area parallel illumination mode. For TEM observation.
NBD mode: Small aperture angle micro-area illumination mode. Nano beam diffraction (NBD).
EDS mode: Large probe current micro-area illumination mode. For analysis.
CBD mode: Large aperture angle micro-area illumination mode. Convergent beam diffraction.

Illumination mode	TEM	NBD	EDS	CBD
Low Mag image observation	○	×	×	×
High Mag image observation	○	△	△	△
Selected area diffraction (SAD)	○	△	△	△
Nano beam diffraction (NBD)	△	○	△	△
Convergent beam diffraction	△	○	○	○
EDS analysis	△	○	○	○
EELS analysis	○	○	○	○

○: Applicable, △: Not recommended but usable, ×: Not attainable

- Ray diagrams of TEM mode

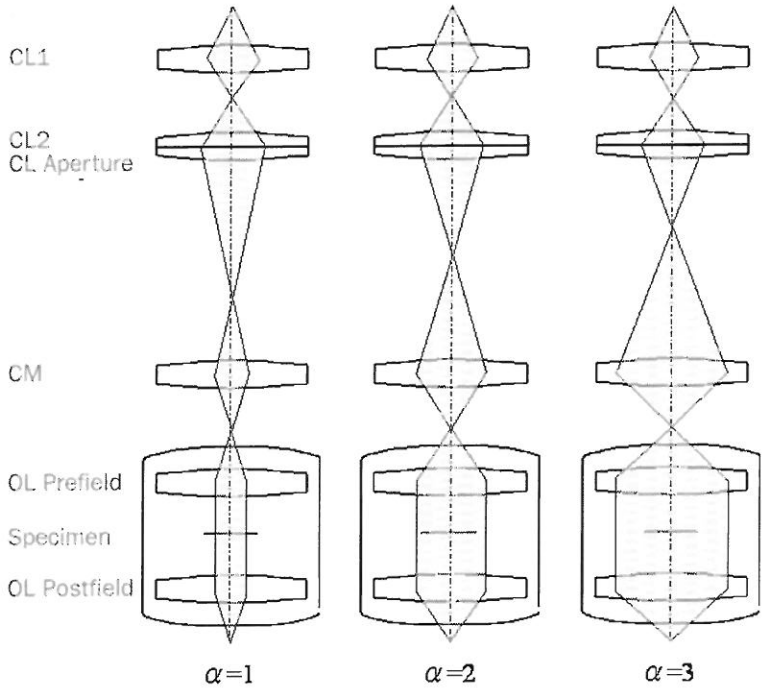


Fig. 3.4 Ray diagrams of TEM mode

The size of the parallel-beam illumination area can be changed using the alpha (α) selector while keeping the size of the aperture constant.

α = 1: Suitable for a magnification of approximately 200,000 and above.
α = 2: Suitable for a magnification of approximately 50,000 to 200,000.
α = 3: Suitable for a magnification of approximately 50,000 and below.

- Ray diagrams of NBD/EDS/CBD mode

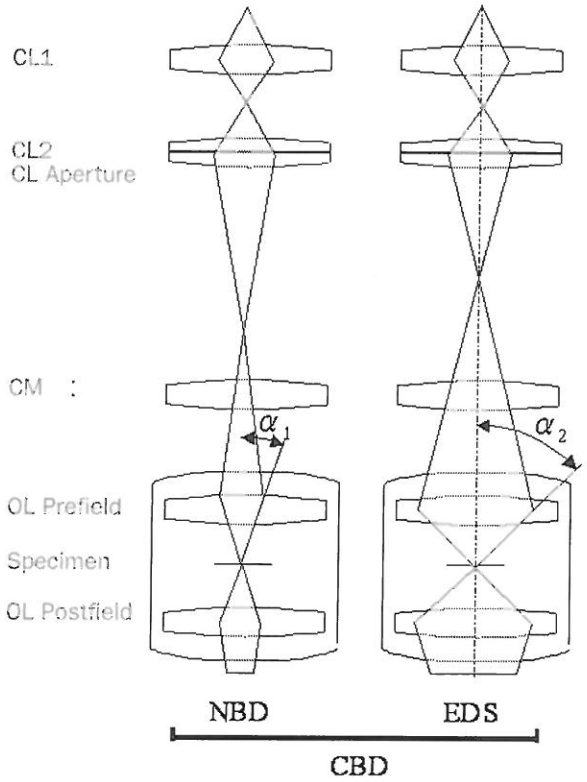


Fig. 3.5 Ray diagrams of NBD/EDS/CBD mode

3.2.2 Ω Filter

3.2.2a X orbit (Plane perpendicular to the magnetic field of Filter lens)

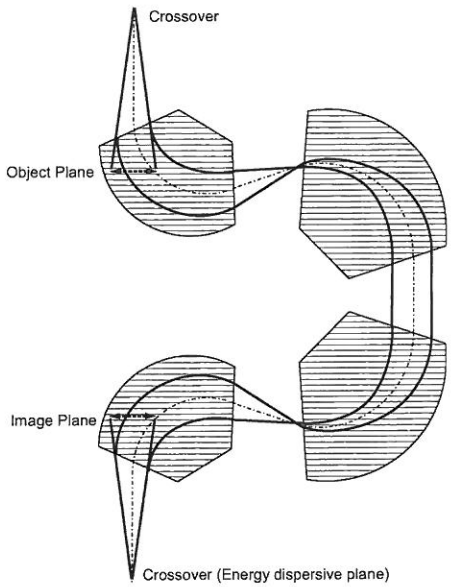


Fig. 3.6 Ray diagram of filter (X orbit)

3.2.2b Y orbit (Parallel direction to the magnetic field of Filter lens)

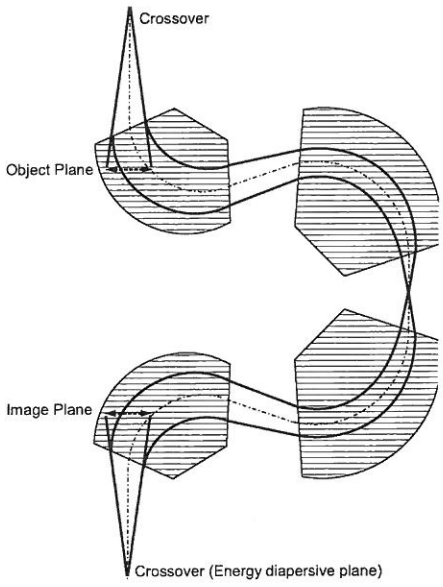


Fig. 3.7 Ray diagram of Ω filter (Y orbit)

3.2.2c Direction of energy dispersion

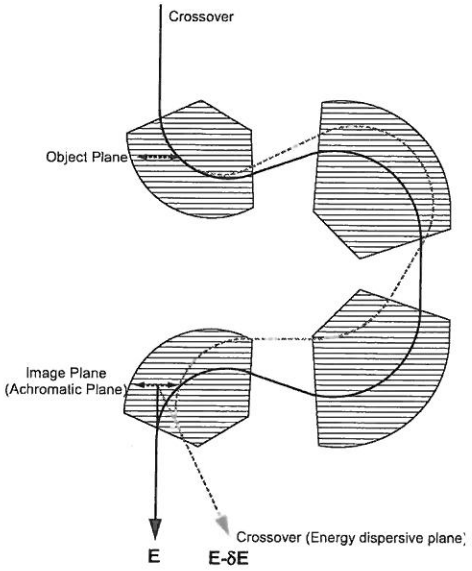


Fig. 3.8 Ray diagram of Ω filter energy dispersion

3.2.3 RAY DIAGRAM

3.2.3a MAG mode

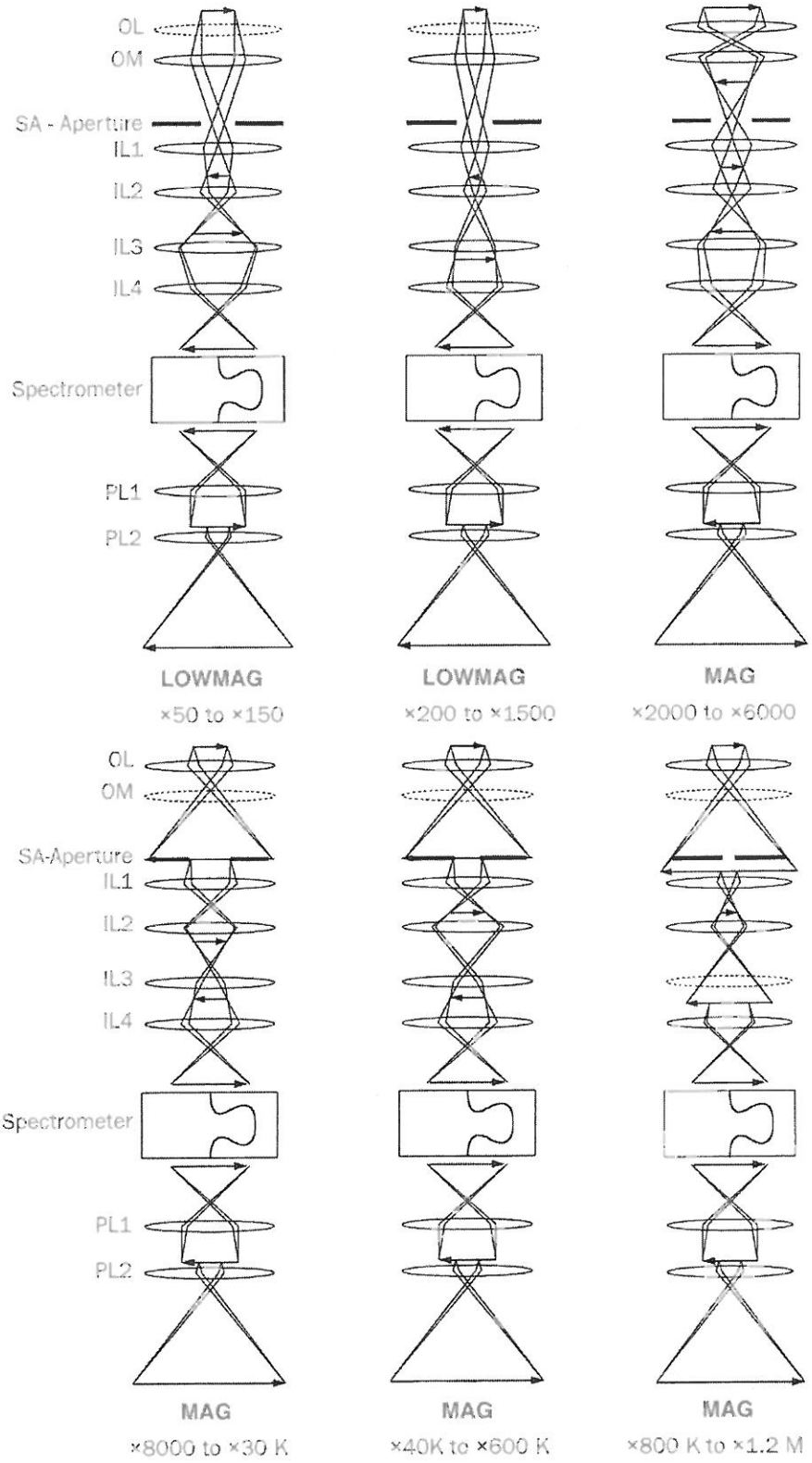


Fig. 3.9 Ray diagrams of image-forming system (MAG mode)

3.2.3b DIFF, SPCTR mode

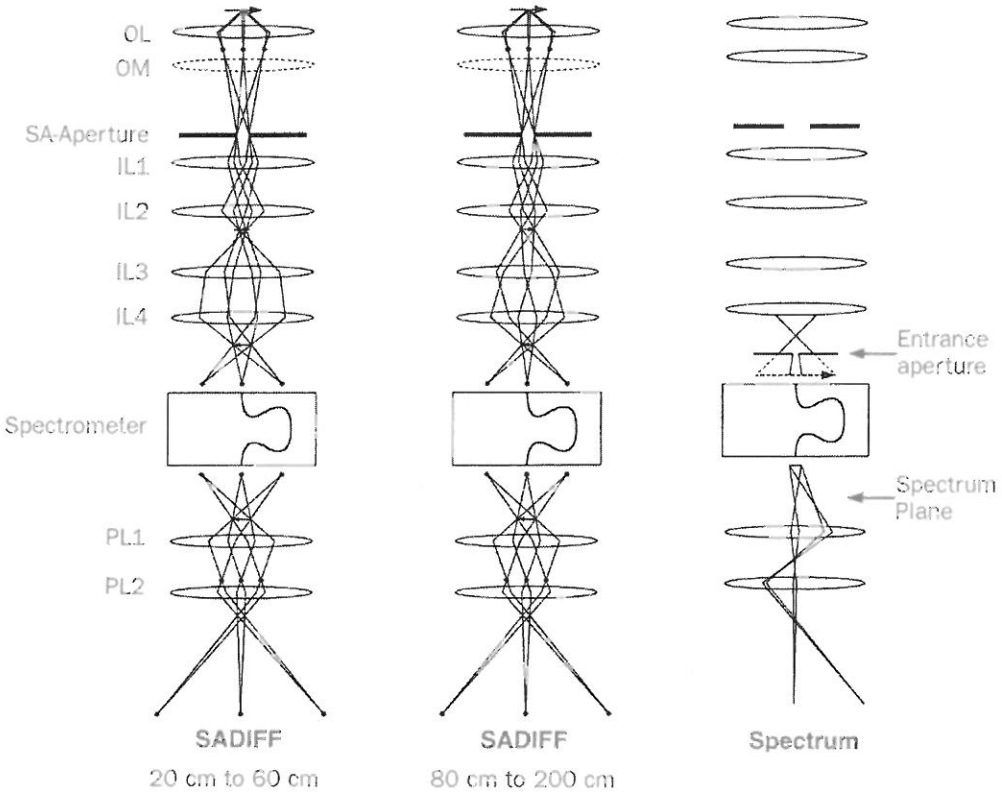


Fig. 3.10 Ray diagrams of image-forming system (DIFF, SPCTR mode)

4

EXPLANATION ON KNOBS

4.1 COLUMN

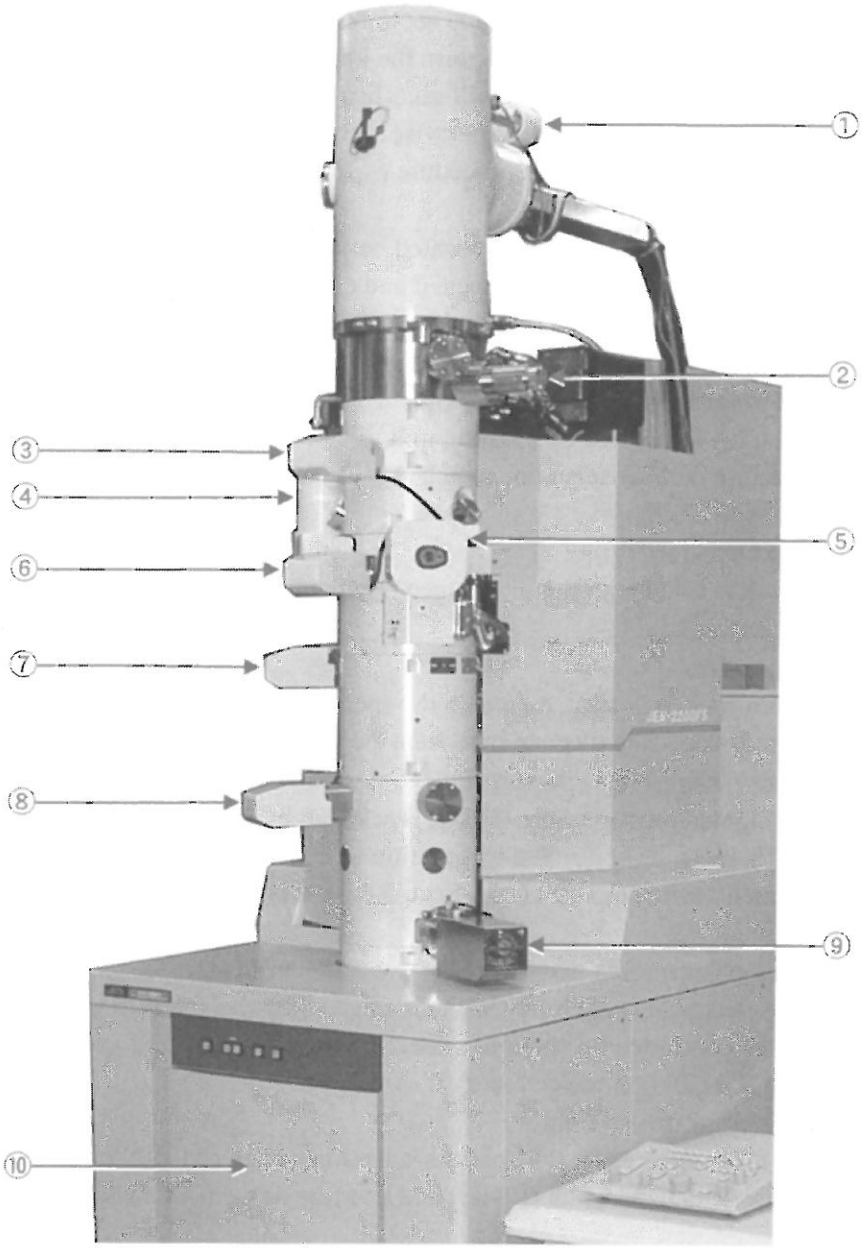


Fig. 4.1 Exterior view of the column

① Conditioning knob

HV conditioning is performed with the high voltage conditioning knob set to COND; general microscopy, with the knob set to "OPERATE". To change the knob setting from "COND" to "OPERATE", turn the knob fully clockwise and push the knob toward the column as far as it will go. Then turn the knob fully clockwise, pull it out until it stops and turn it fully clockwise. To change the knob from "OPERATE" to "COND", reverse the above procedure (☞ Sect. 5.5.2).

② Isolation valve

This is an isolation valve (V1), located between the electron gun chamber and the microscope column, which is opened and closed by manipulating the BEAM VALVE switch (L1-①), or by clicking on Valve Open or Close in the High Voltage Control window (☞ Sect. 4.4.7b).

③ Condenser lens (CL) aperture unit

When CLA is selected by aperture unit selection switch (L1-②), bit can be controlled by aperture number selection switch (L1-②) and aperture movement switch (L1-②) (☞ Sect. 5.6.2).

④ Liquid Nitrogen Tank

The tank is filled with liquid nitrogen as a coolant for the anti-contamination device (☞ Sect. 5.13).

⑤ Goniometer

This is a specimen stage on which the specimen holder, which holds the specimen, is mounted. The stage tilts and translates the specimen with built-in motors.

⑥ High-contrast (HC) aperture unit

If the high contrast aperture (HCA) is selected by the aperture selection switch (L1-②), it can be controlled by aperture selection switch (L1-②) and aperture movement switch (L1-②) (☞ Sect. 5.6.3). It is optional in the CR and HC configurations.

⑦ Selected area (SA) aperture unit

If the selected area aperture (SAA) is selected by the aperture selection switch (L1-②), it can be controlled by aperture selection switch (L1-②) and aperture movement switch (L1-②) (☞ Sect. 5.6.4).

⑧ Entrance aperture unit

If ENTR is selected by the aperture selection switch (L1-②), it can be controlled by aperture selection switch (L1-②) and aperture movement switch (L1-②) (☞ Sect. 5.6.5).

⑨ Slit

It is controlled by the Energy Filter (L1-④) or by SLIT in the Filter Tuning window of the PC (☞ Sect. 4.4.7e).

⑩ Camera chamber door

Open the camera chamber console door by pressing the right corner of the door to find the camera door handle is found. To close the console door, press the door toward the camera chamber again.

✍ The objective aperture unit is located at the back of the device and it cannot be seen directly because it is behind the cover panel.

4.2 CONTROL PANELS

4.2.1 Control Panel L1

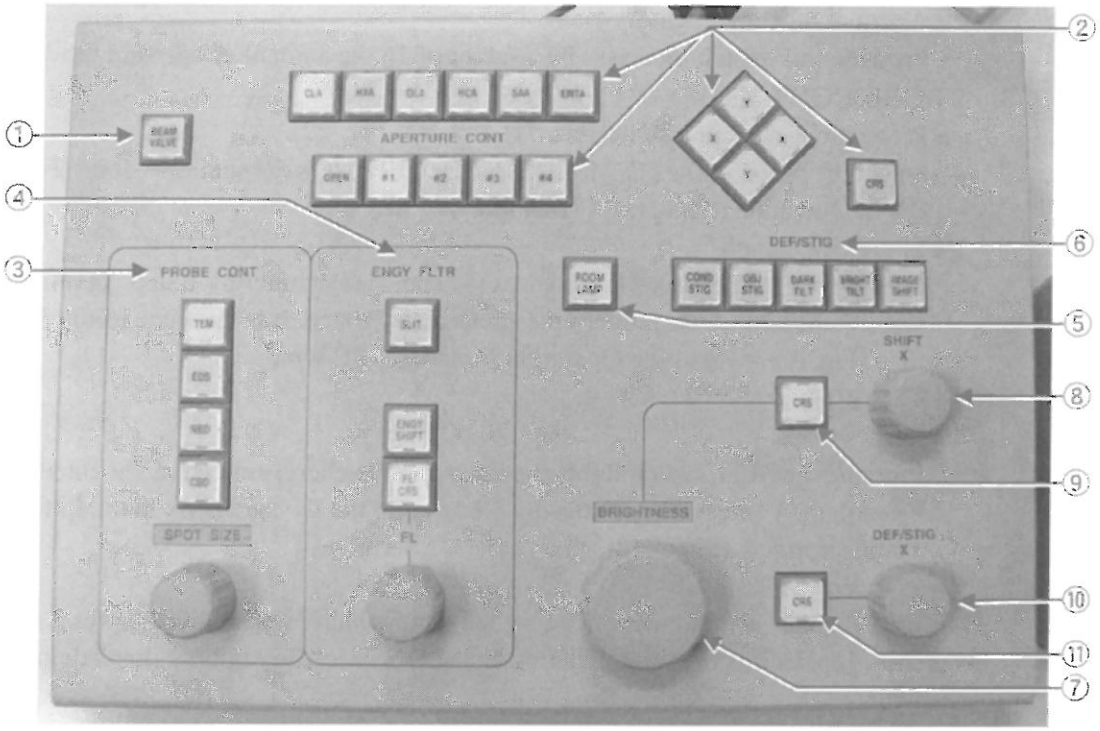


Fig. 4.2 Control panel L1

① BEAM VALVE switch

Pressing the switch opens the isolation valve (V1) between the electron gun and the column. The function of this switch is the same as that of the Valve button in the High Voltage Control window in the PC monitor screen (Fig. 4.29).

② APERTURE CONT

Pressing an APERTURE CONT switch lights the lamp and aperture unit is selected. You can control the selected aperture using the aperture number selection switch and the aperture movement switch. Aperture unit that are not configured cannot be selected.

- Aperture unit selection switches:
  - CLA: Selects the CL aperture unit
  - HXA: Selects the hard x-ray aperture unit
  - OLA: Selects the OL aperture unit
  - HCA: Selects the HC OL aperture unit
  - SAA: Selects the SA aperture unit
  - ENTA: Selects the entrance aperture unit
- Aperture number selection switch:

  Select the desired aperture number of the selected aperture unit from these switches.
  - OPEN: The aperture opens.
  - #1: Aperture number 1 is selected.
  - #2: Aperture number 2 is selected.
  - #3: Aperture number 3 is selected.
  - #4: Aperture number 4 is selected.

- Aperture movement switch:
  Adjust the position of the aperture of the selected aperture unit of the selected aperture number using these shift switches.
- Aperture movement CRS switch:
  Pressing this switch increases by a factor of 16 the amount of aperture movement.

③ PROBE CONT

- Probe mode selection switch
  Select the probe mode (TEM, EDS, NBD, CBD). It is the same as Mode (Fig. 4.33-①) in Operation (Standard) PC window.
- SPOT SIZE knob
  Turning it 1 step clockwise increases the spot size number by 1 step. Turning it 1 step counterclockwise reduces the spot size by 1 step. It is the same as the Spot Size (Fig. 4.33-②) of the Operation (Standard) PC window.

④ ENGY FLTR

- SLIT switch
  Pressing the SLIT switch lights the lamp and the energy-selection slit enters the beam path. You can also do this by clicking on the IN check box in the Filter Tuning window (Fig. 4.42-⑩).
- ENGY SHIFT switch
  Pressing this switch turns on the switch lamp which implements the preset energy shift. It performs the same function as the ON check box in the Filter Tuning window (Fig. 4.42-①).
- FL CRS switch
  When the FL knob is turned, the change per notch increases by 16 times.
- FL knob
  This knob adjusts the FL FOCUS value.

⑤ ROOM LAMP switch

It is a switch for a room lamp.

⑥ DEF/STIG switch

Pressing the DEF/STIG switch lights up the lamp and enables you to change the coil current of the lens described on the switch using the SHIFT knobs (L1-⑧ and R1-④) or the DEG/STIG knobs (L1-⑩ and R1-⑤). Pressing the switch again dims the lamp and the coil current is held.

- COND STIG
  Pressing this switch enables you to change the current of the condenser lens stigmator coil. It is the same as DEF Select — **CL STIG** (Fig. 4.61-①) of the Alignment Panel PC window.
- OBJ STIG
  The electric current recorded in the number memory can be changed and it is supplied to the objective lens stigmator coil (Fig. 4.33-⑦).
- DARK TILT
  This switch is used mainly to tilt the beam. The electric current recorded in the number memory can be changed and it is supplied to the condenser lens deflector coil. It is mainly used when observing the dark-field image.
- BRIGHT TILT
  It is used to tilt the electron beam and to adjust the optical axis. It is mainly used when observing the bright-field image.

- IMAGE SHIFT
  It is used when moving the field of view at high magnification. It is the same as DEF Select — **Image** (Fig. 4.33-⑦) of the Operation (Standard) PC window.

⑦ BRIGHTNESS knob
Converge and diverge the electron beam.

⑧ SHIFT X knob
This knob shifts the electron beam in the X direction by varying the CL deflection coil. If the DEF Select — **Gun** from Alignment Panel for Maintenance PC window (Fig. 4.61-①), or DEF Select — **FLA** of the Filter Tuning PC window (Fig. 4.42-⑱)is selected, change the electron gun 1st deflection coil or the X current of the filter lens 1st deflector coil.

⑨ SHIFT CRS switch
When SHIFT X knob (L1-⑧), SHIFT Y knob (R1-④) and BRIGHTNESS knob (L1-⑦) are turned, the change per notch increases by 16 times.

⑩ DEF/STIG X knob
It changes the X current for the coil chosen from DEF/STIG switch or Alignment Panel for Maintenance (Fig. 4.61-①) PC window.

⑪ DEF/STIG CRS switch
The change in current per notch increases by 16 times when DEF/STIG X knob (L1-⑩) and DEF/STIG Y knob (R1-⑤) are turned.

4.2.2 Control Panel R1

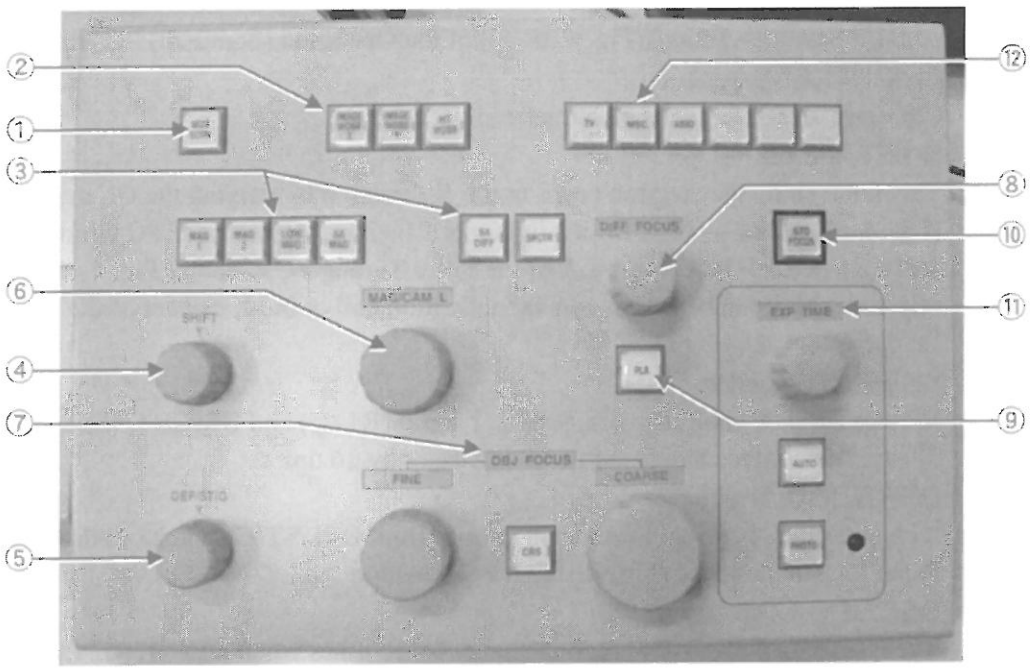


Fig. 4.3 Control panel R1

① MON SCRN switch

Moves the fluorescent screen for the wide angle CCD camera. Pressing the switch inserts the screen into the beam path and the switch lamp lights). It is the same as F-Screen (Fig. 4.35-③) in PC window Screen.

② WOBBLER

- IMAGEWOBB X

  Turning this switch on by pressing it makes the CL 1st and 2nd deflection coil currents oscillate. If the image is out of focus, the image oscillates in the X direction. Clicking on the **Image X** in the Wobbler window (Fig. 4.34-③) performs the same operation.

- IMAGEWOBB Y

  Turning this switch on by pressing it makes the CL 1st and 2nd deflection coil currents oscillate. If the image is out of focus, the image oscillates in the Y direction. Clicking on the **Image Y** in the Wobbler window (Fig. 4.34-④) performs the same operation.

- HT WOBB

  Turning this switch on by pressing it makes the accelerating voltage oscillate. This switch is used to align the voltage axis with the optical axis. Clicking the **HT** button in the Wobbler window (Fig. 4.34-①) performs the same operation.

③ FUNCTION

Set the system to imaging mode. It is the same as Function (Fig. 4.33-⑤) PC window Operation (Standard) The magnification, camera length or energy dispersion of the selected mode can be changed in MAG/CAM L (R1-⑥ or Fig. 4.33-⑥). The magnification, camera length and energy dispersion will be recorded. Therefore, when it is returned to its original mode after changing it to other mode, it will be set to the recorded magnification, camera length or the energy dispersion (except for MAG2).

MAG1: Normal magnification mode

MAG2:	Sets the instrument to the specific magnification. The system does not record the magnification in this mode.
LOWMAG:	Ultra low magnification mode.
SAMAG:	Selected-area magnification mode.
SA DIFF:	Selected area diffraction mode.
SPCTR:	Spectrum mode, spectra to be obtained under present image-forming system conditions.

④ SHIFT Y knob

This knob shifts the electron beam in the Y direction by changing the condenser lens alignment coil current. When DEF Select — **Gun** is selected from PC window Alignment Panel for Maintenance (Fig. 4.61-①), or if DEF Select — **FLA** (Fig. 4.42-⑱) is selected from PC window Filter Tuning, change the electron gun first deflection coil or the Y electric current of filter lens first deflection coil.

⑤ DEF/STIG Y knob

This knob controls the Y current of the coil selected by the DEF/STIG switch or the DEF Select switches in the Alignment Panel for Maintenance window (Fig. 4.61-①).

⑥ MAG/CAM L knob

When the FUNCTION (R1-③ or Fig. 4.33-⑥) is MAG1, MAG2, this knob changes the magnification. When it is LOWMAG, it changes the low magnification. When SA MAG is selected, it changes the selected area-magnification. When DIFF is selected, it changes the camera length and when SPCTR (R1-③ or Fig. 4.42-⑮) is selected, it changes the energy dispersion.

If it rotated to the right, it increases. When it is rotated to the left, it decreases.

⑦ OBJ FOCUS

This knob adjusts the focus of the image. When you select MAG1, MAG2 or SAMAG for FUNCTION (R1-③,Fig. 4.33-⑤), objective lens current is changed, and when you select LOWMAG, you can change the objective mini lens current.

- FINE knob
  Smallest focus change can change the step size.
- COARSE knob
  Step size is 16 times larger than that of the FINE knob.
- CRS switch
  Increases/decreases the focus change step sizes of the FINE and COARSE knobs by a factor of 16 compared to their initial amounts.

⑧ FOCUS knob

When you select SA M for FUNCTION (R1-③, Fig. 4.33-⑤), this knob is used to focus the selected area aperture image. When you select DIFF, this knob is used to focus the diffraction image. When SPCTR (R1-③ or Fig. 4.42-⑮), this knob is used for FL FOCUS alignment.

⑨ PLA switch

The lamp becomes brighter when it is pressed and the projector lens alignment can be changed with DEF/STIG knob. (L1-⑩, R1-⑤)

⑩ STD FOCUS switch

When you press this switch, the objective lens current becomes the specific standard lens current.

⑪ EXP TIME/PHOTO

- EXP TIME knob
  Adjusts the manual exposure time. The exposure time increases when it is rotated to the right and shorter when it is turned to the left.
- AUTO switch
  Press the switch (the switch lamp lights) to set the exposure time automatically. When the switch lamp is off, the exposure should be set manually.
- PHOTO switch
  Press this switch when the switch lamp is off. A film moves into position for taking photographs and the switch lamp goes on. Press the switch again while the switch lamp is on. Photographing starts. After the set exposure time passes, the film is unloaded and the switch lamp goes off.
- Lamp
  The lamp lights while the shutter is open.

⑫ TV/MSC switch
Raises and lowers the fluorescent screen. Pressing it turns on the lamp and raises the screen.

4.2.3 Control Panel C1

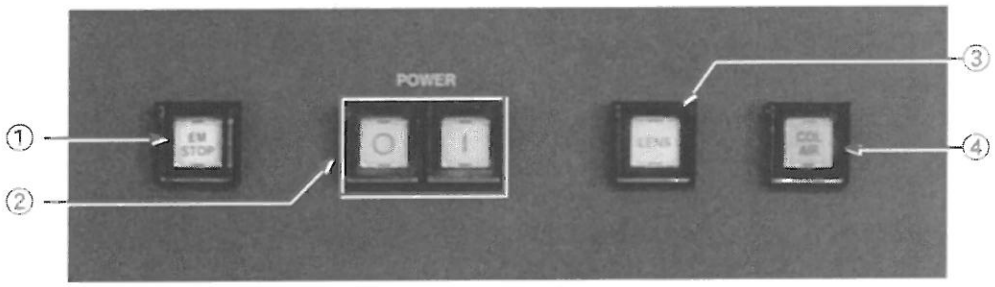


Fig. 4.4 Control Panel C1

① EM STOP switch
Used for emergency shutdown.

② POWER switches
These are for starting and stopping the instrument.

- ○ switch: Stop button
- | switch: Start button

③ LENS switch
When this switch is turned ON, the powers of all lense deflection coils and stigmator coils turn on.

High voltage and electron gun system cannot be turned ON/OFF.

④ COL AIR switch
When it is turned ON, nitrogen gas will enter the column and vents the microscope column to atmospheric pressure. When it is turned OFF, the column is evacuated.

4.2.4 Control Panel C2

It is installed near the bottom right of the operation panel C1.

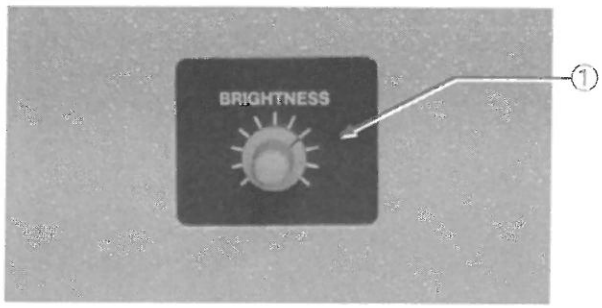


Fig. 4.5 Control Panel C2

① BRIGHTNESS knob

Adjusts the black-level of the film numbering.

Turning the knob clockwise lengthens the numbering exposure time and the characters printed on the film will be darker.

4.2.5 Control Panel GC

This control panel has the same function as the Specimen Position window.

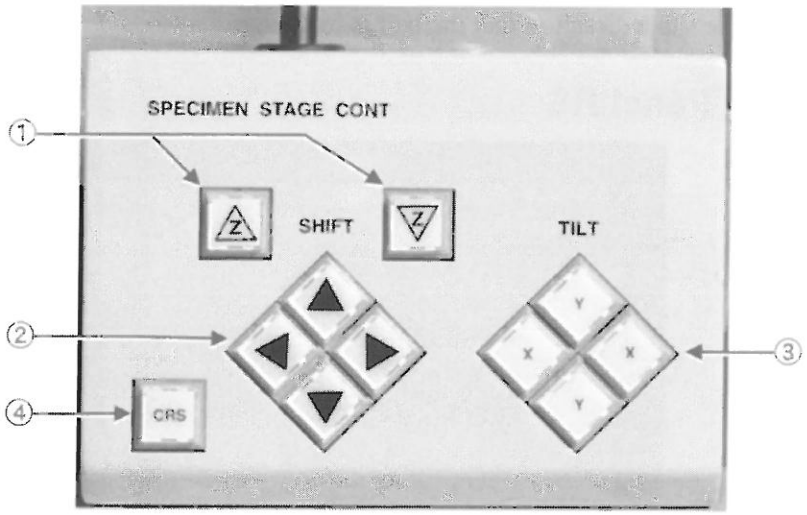


Fig. 4.6 Control Panel GC

① Moving the Z position (vertical) of the specimen.

It is used to move the Z position of the specimen.

② Moving the XY position (horizontal)

It is used to move the XY position of the specimen.

③ Tilting the specimen.

X is tilted by the goniometer, Y is effective if double tilt specimen holder is used and it adjusts the tilt inside the holder.

④ Switching coarse/fine movement for specimen movement

When it is turned ON (built-in lamp lights up green), specimen movement is coarse. When it is turned OFF (built-in lamp is off), specimen movement is fine. This function is effective for all specimen movement X, Y, Z, tilt X and tilt Y.

4.2.6 Control Panel TR

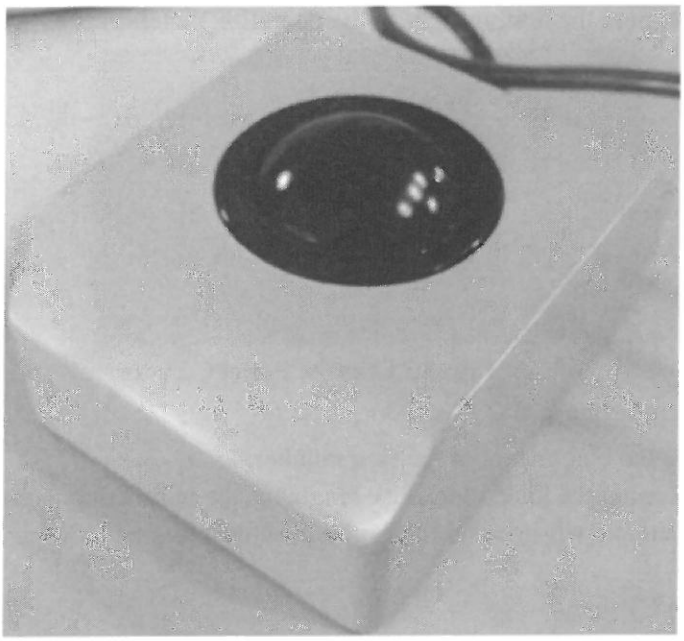


Fig. 4.7 Control Panel TR

It moves in the same direction that the ball is rotated.

4.2.7 Control Panel RS

Fig. 4.8 Control Panel RS

There is a VEM reset switch under the operation table. If the system freezes, press this switch to restart the electron microscope system.

It takes several minutes to complete the restart. The evacuation system and the electron gun power supply are not reset, so the system is restored safely.

4.3 POWER SUPPLY CONSOLE PS

■ SIP Evacuation System Configuration

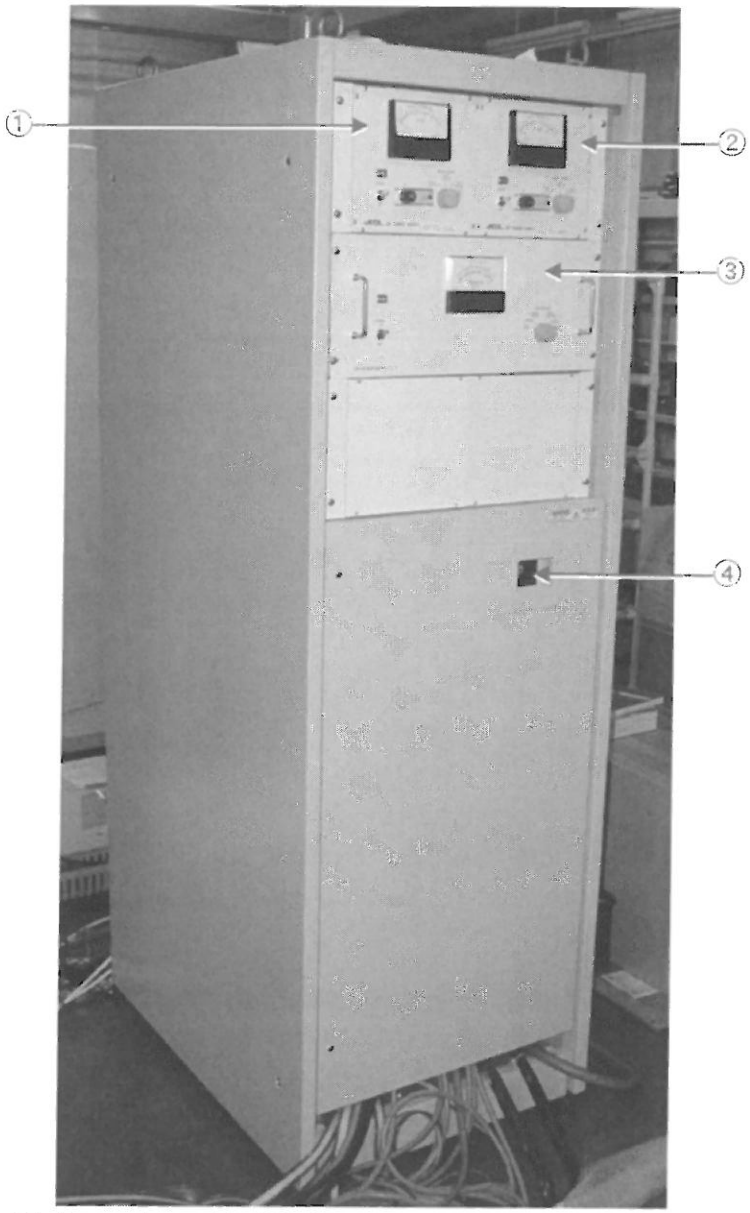


Fig. 4.9 Operation table PS (SIP evacuation system configuration)

① PS−1
② PS−2
③ PS−SIP
④ Circuit breaker

■ TMP Evacuation System Configuration

Fig. 4.10 shows how the upper part of the power supply console should be.

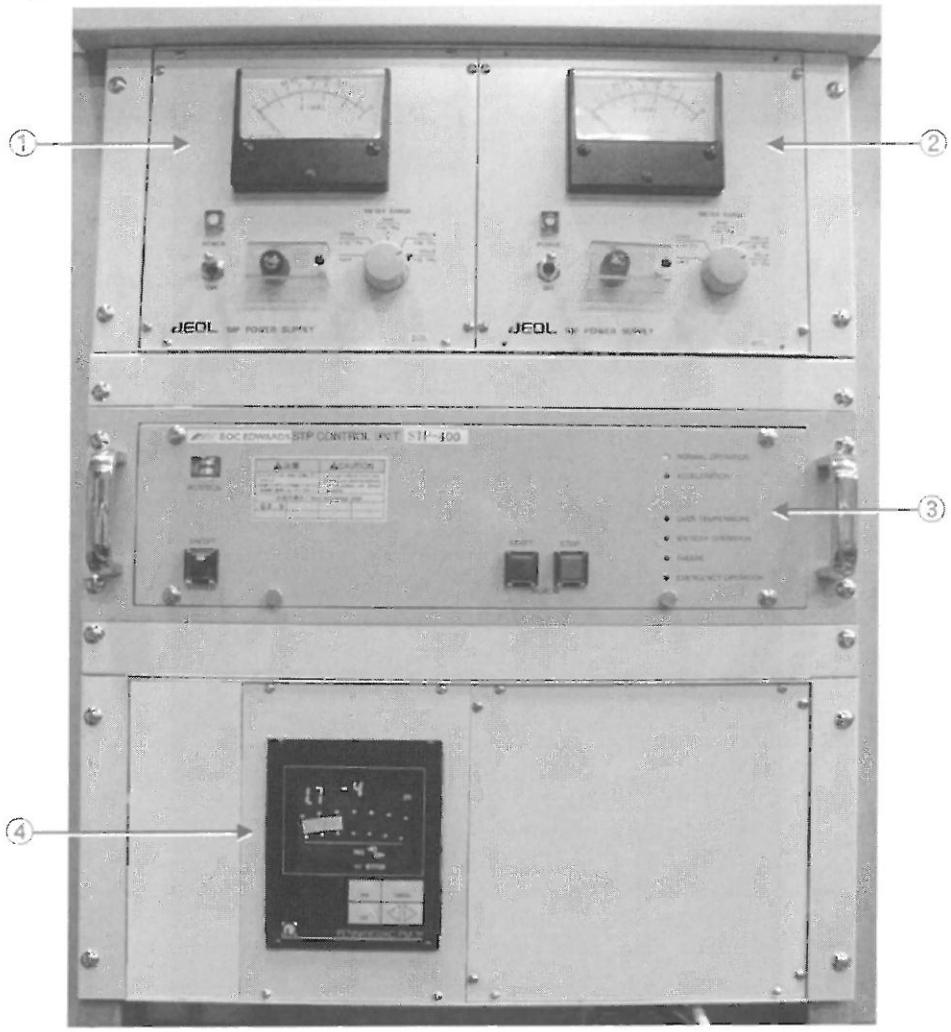


Fig. 4.10 Operation table PS (TMP evacuation system configuration)

① PS–1
② PS–2
③ PS–TMP
④ Penning Gauge

4.3.1 PS-1

This is the power supply of the 20 L/s ion pump connected to the electron gun.

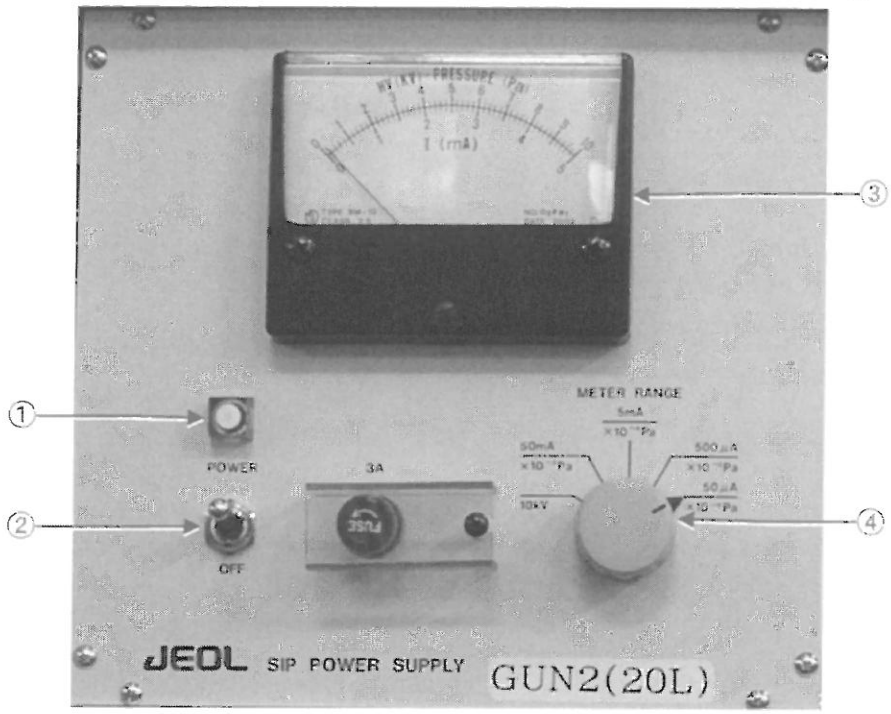


Fig. 4.11 PS-1

① POWER lamp
This lamp lights up when you turn ON the POWER switch (PS-1-②).

② POWER switches
This is the power supply switch for the electron gun ion pump.

③ Meter
This meter indicates the value based on the range selected by the METER RANGE knob (PS-1-④).

④ METER RANGE knob
Selects the item to measure and display in the meter (PS-1-③).

4.3.2 PS-2

This is the power supply of the 60 L/s ion pump connected to the electron gun.

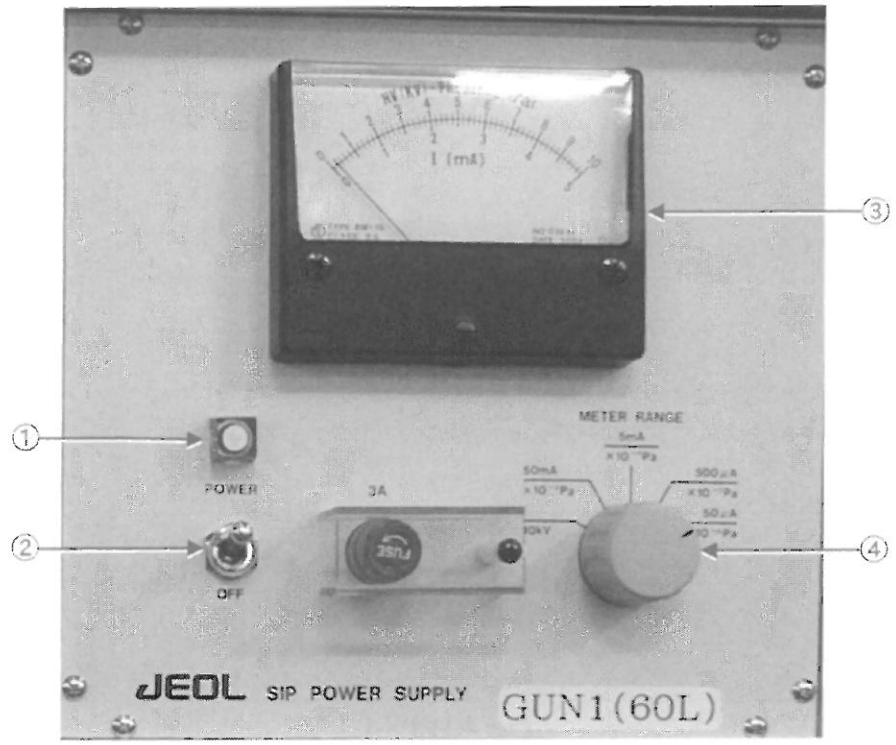


Fig. 4.12 PS-2

① POWER lamp
This lamp lights up when you turn on the POWER switch (PS-2-②).

② POWER switches
This is a power supply switch for electron gun ion pump.

③ Meter
It displays the value selected by the METER RANGE knob (PS-2-④).

④ METER RANGE knob
Selects the item to display in the meter (PS-2-③).

4.3.3 PS-SIP (during SIP evacuation configuration only)

This is the power supply of the 150 L/s ion pump connected to the column.

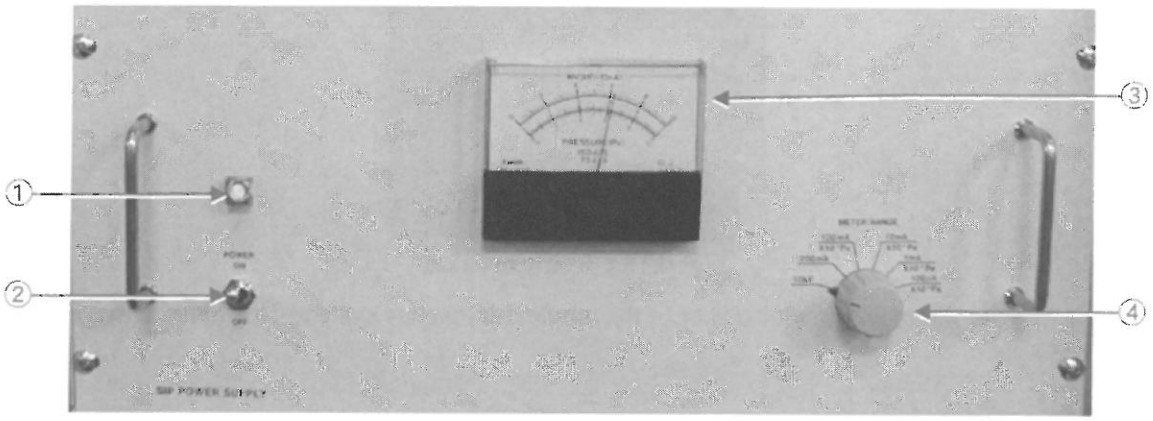


Fig. 4.13 PS-SIP

① POWER lamp
It lights when the POWER switch (PS-SIP-②) is turned ON

② POWER switch
This is a power switch for the ion pump.

③ Meter
It displays the value selected by the METER RANGE knob (PS-SIP-④).

④ METER RANGE knob
Selects the item to display in the meter (PS-SIP-③).

4.3.4 PS-TMP (during TMP evacuation configuration only)

This is the power supply of the 400 L turbo molecular pump connected to the column.

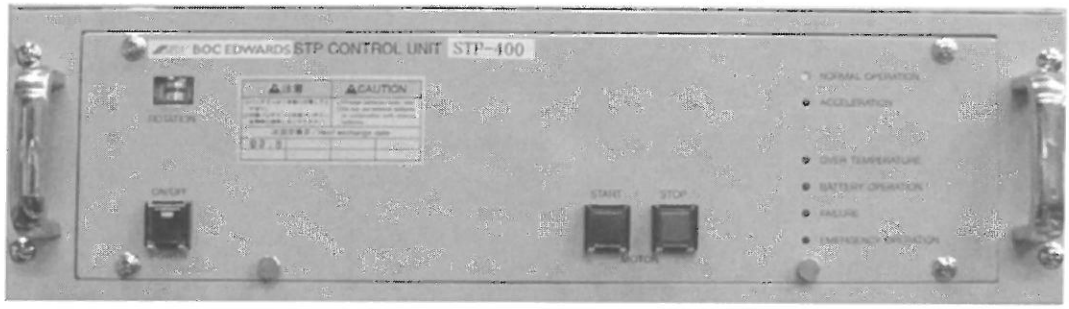


Fig. 4.14 PS-TMP

Normally there is no need to operate this unit.

☞ Refer to the turbo molecular pump instruction manual.

4.3.5 Circuit Breaker

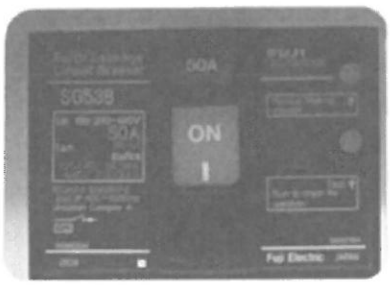


Fig. 4.15 Circuit breaker

This is the main circuit breaker of the whole microscope system. Normally, leave it ON.

4.4 PC WINDOW

4.4.1 Starting the Application

4.4.1a TEM SERVER

Double click on the **TEM Server** icon (Fig. 4.16) on the PC monitor screen (Fig. 3.3-⑧) to start the TEM Server. The icon will be displayed in the task tray (Fig. 4.17).

Fig. 4.16 TEM Server icon

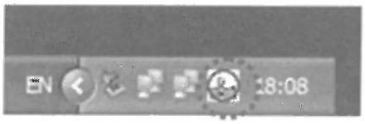


Fig. 4.17 Task tray

4.4.1b TEM Controller

The TEM Controller window (Fig. 4.20) appears when the TEM Controller icon (Fig. 4.18) on the PC monitor (Fig. 3.3-⑧) is double-clicked.

Fig. 4.18 TEM Controller icon

4.4.1c SightX

This application software displays a wide-field CCD camera image. Double-clicking the **SightX** icon (Fig. 4.19) displays the monitor window.

☞ For the operation method, refer to a separate manual "Image Display Software".

Fig. 4.19 SightX icon

4.4.2 TEM Controller Window

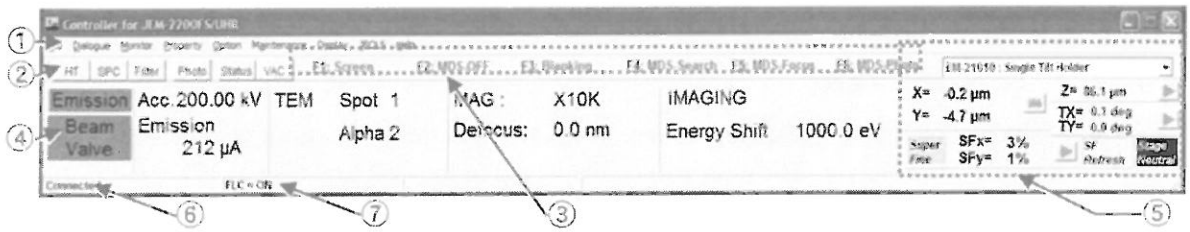


Fig. 4.20 TEM Controller window

① Menu bar

The menu bar enables you to select and set a function by displaying each window (☞ Sect. 4.4.3).

② Toolbar

These buttons do the following common tasks.

- HT: Opens the High Voltage Control window (☞ Sect. 4.4.7b).
- SPC: Opens the Specimen Position window (☞ Sect. 4.4.7d).
- Filter: Opens the Filter Tuning window (☞ Sect. 4.4.7e).
- Photo: Opens the Film Camera Property window (☞ Sect. 4.4.7f).
- Status: Opens the Status Monitor window (☞ Sect. 4.4.7g).
- VAC: Opens the Valve Status window (☞ Sect. 4.4.7h).

③ Display and Settings of Function keys

Displays and sets the functions that are set to the Function switches on the control panel R1.

④ Main Window

Information appears in this window (☞ Sect. 4.4.4).

⑤ Right Main Window

Sets and displays the selection of holder, specimen position and tilt.

⑥ Connection display, ON/OFF of free lens control, and displaying a target window at the top position.

Displays the connection status with the TEM Server. If it is connected, **Connect** will be displayed.

If the free lens control is ON, FLC=ON will be displayed here (☞ Sect. 4.4.7k).

This function is used when window displays are overlapped (☞ Sect. 4.4.6).

4.4.3 Menu Bar

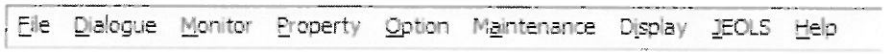


Fig. 4.21 Menu bar

- File:
  - Photo History: Opens the Photo History window (☞ Sect. 4.4.7a).
  - Exit: Terminates the TEM Controller.
- Dialogue:
  - High Voltage Control: Opens the High Voltage Control window (☞ Sect. 4.4.7b).
  - Operation: Opens the Operation window (☞ Sect. 4.4.7c).
  - Specimen Position: Opens the Specimen Position window (☞ Sect. 4.4.7d).
  - ASID Control: Opens the optional ASID Control Panel window.
  - Filter Control: Opens the Filter Tuning window (☞ Sect. 4.4.7e).
  - Photo Set: Opens the Film Camera Property window (☞ Sect. 4.4.7f).
- Monitor:
  - Status: Open the Status Monitor window (☞ Sect. 4.4.7g).
  - Vac Sys: Opens the Valve Status window (☞ Sect. 4.4.7h).
  - Dark Window: Dims the monitor screen.
- Property:
  - EOS: Opens the EOS Property window (☞ Sect. 4.4.7i).
  - Others: Not used.
- Option:
  - MDS: Opens the MDS window (☞ Sect. 4.4.7j).
  - Free Lens Control: Opens the FLC Panel window (☞ Sect. 4.4.7k).
  - Hollow Cone: Optional. Normally shaded gray and not enabled.
  - Auto Through Focus: Optional. Normally shaded gray and not enabled.
  - Gun Electrode Short: Optional
  - Interface for 20XXFEF Enabled: Specifies whether to authorize the external computer control or not
- Maintenance:
  - Alignment: Opens the Alignment Panel for Maintenance window (☞ Sect. 4.4.7l).
  - ACD & Bake: Opens the Bake Out/ACD Heat window (☞ Sect. 4.4.7m).
  - Aperture: Opens the Aperture Adjust window (☞ Sect. 4.4.7n).
  - Stage Limit: Opens the Stage Limit window (☞ Sect. 4.4.7p).
  - Network: Connect: Connects the TEM Server. Disconnect: Disconnects the TEM Server.
- Display:
  - PutInOrder: Rearranges the contents of the screen.
  - StayOnTop: Places the TEM Control window on top of the others.
  - SHORTCUT: Displays the Short Cut window.

<Active Windows>

Displays a list of windows that are presently open. Selecting a window from the list opens the corresponding window.

- JEOLS: This is a display for menu items only. Enter a password to use it. When the password is entered, maintenance command shown below will be displayed.

  HexDisplay: Displays the Lens/Def Monitor window.
  Alignment: Displays the Alignment Panel for Maintenance window.
  Scan/Focus: Displays the Scan/Focus window.
  FEG Setup: Displays the FEG Set up (JEOL) window.
  Filter: Displays the Filter Maintenance window.
  GONIO: Displays the Gonio Adjust window.
  Network:
  Connect: Connects the TEM server.
  Disconnect: Disconnects the TEM server.
  Property: Displays the Network Property window.
  I/O Panel: Displays the I/O Panel window.
  Configuration: Displays the Configuration window.
- Help

  Instruction: Displays operating instructions.
  Version: Displays the version information (Fig. 4.22).

Fig. 4.22 Main window

4.4.4 Main Window

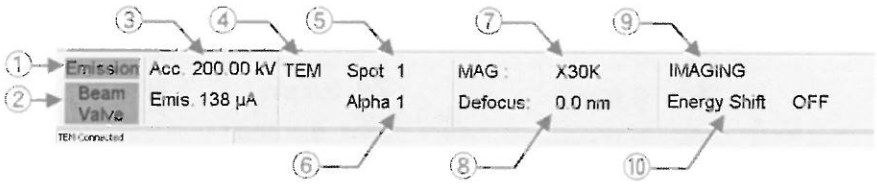


Fig. 4.23 Main window

① Simple display of the current status
When HV is on: "HT" background will be green.
When HV is off: "HT" background will be gray.
When the beam is emitted: "EMISSION" appears on a green background.

② Status display of V1 (Fig. 4.1-②)
When the valve is open: the background will be green.
When the valve cannot be opened: the background will be gray.

③ Accelerating voltage and emission current

④ Selected illumination mode

⑤ Selected spot size

⑥ Selected alpha selector number

⑦ Selected magnification, camera length, and size of the spectrum.

⑧ Displays the amount of focus current change.
It is reset to 0.0 nm each time the magnification is changed.

⑨ Filter mode
For image or diffraction mode, IMAGING will be displayed. When it is SPCTR mode, Spectroscopy is displayed along with the variance (defined on the film).

⑩ Energy shift value.

4.4.5 Right Main Window

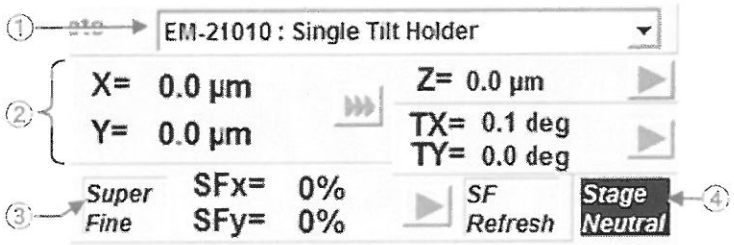


Fig. 4.24 Right main window

① Selecting the specimen holder

The presently selected specimen holder name appears here. When the tab control is clicked, a list of registered specimen holder will be displayed. Selecting a specimen holder you want to use from the list automatically sets the limits of the tilt angle of the specimen holder.

② Specimen position display and the stage drive speed selection button

X: Displays the present specimen position (X direction).
Y: Displays the present specimen position (Y direction).
Z: Displays the present specimen position (Z direction).
TX: Displays the specimen tilt angle (X tilt).
TY: Displays the specimen tilt angle (Y tilt).
Right arrow button: Clicking this button displays three kinds of arrow marks by rotation, thereby enabling you to change the moving speed of the specimen stage at the same time (Fig. 4.25).

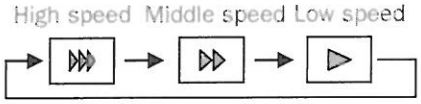


Fig. 4.25 Drive-speed selection buttons of the specimen stage

③ Super Fine drive button and position display

Super Fine: Clicking this button changes the drive system of the specimen stage from Motor drive to Super Fine drive (piezoelectric element drive).
The button turns green during the Super Fine drive.
SFx: Displays the present value (X direction) of Super Fine.
SFy: Displays the present value (Y direction) of Super Fine.
You can perform the Super Fine drive between –100% to 100% of the drive range.
Right arrow button: Clicking this button displays three kinds of arrow marks by rotation as shown in the figure above, thereby enabling you to change the moving speed of the Super Fine specimen-stage drive mechanism at the same time.
SF Refresh: When you double-click this button, the Super Fine drive system returns to the neutral point.

④ Stage Neutral

Double-clicking this button returns all the coordinates of the specimen stage to the neutral points (including the Super Fine drive system). This function is used when you exchange the specimen holder.

4.4.5a Function Key Status window

This screen displays the functions assigned to the Function Key switch (Fig. 4.20-③) on the control panel R1, and allows you to save and load the settings from files.

Fig. 4.26 Function Key Status window

① Function Key Status

Displays the function assigned to the Function key switch (Fig. 4.20-③) on control panel R1.

② Setting File

Save: It saves the switch shown in the Function Key Status and its function settings and save after giving a file name. (F1 to F6 saved all at once)

Load: It loads the saved file. The functions saved in that file can be applied to the Function Key switch. (F1 to F6 applied all at once)

To assign a function to a single Function Key switch

Click on the F number in the Function Key display (Fig. 4.20-③) of the TEM Controller. → a list of functions that can be applied will be displayed → select the desired function (☞ Sect. 5.14.6a or Sect. 5.14.6d).

To delete a saved file, right click on the file name to delete in the window displayed by **Save** or **Load** and then select **delete**.

4.4.6 Function of Displaying a Target Window at the Top Position

When you click an area below the TEM Controller window, a list of currently displayed windows appears. When you select a target window, the window appears at the top position (Fig. 4.27). This function is used when window displays are overlapped.

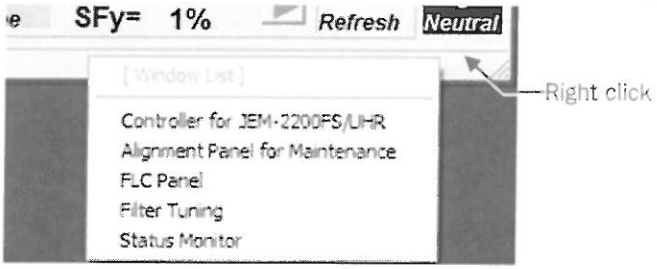


Fig. 4.27 Function of displaying a target window at the top position

4.4.7 Windows Opened from the Menu Bar

4.4.7a Photo History File

You can open this window either by clicking File (Fig. 4.20-①) in the TEM Controller menu bar or by clicking on the **History** button in the Film Camera Property (Fig. 4.44-④). Data obtained during photography and displayed in the main window are listed in the Photo History window. To save or print this data, copy the data to a text editor, such as the Memo Pad included in Windows, and then save. In the Photo History Window, use the mouse to select data, and simultaneously press CTRL + C (press C while pressing down on the control key) keys to copy the selection and press CTRL + V on the text editor.

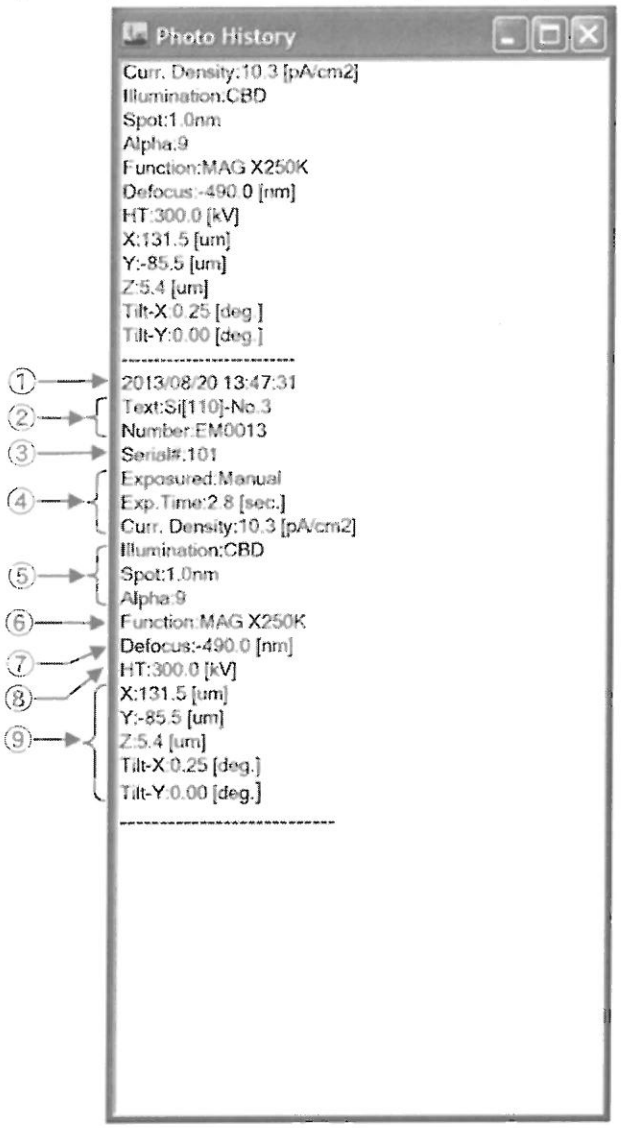


Fig. 4.28 Date and Time of acquiring the Photo History Window.

① Date and time of the photo

② Film information

- Text: Printed text on the film
- Number: Printed film number

③ Total number of films exposed until 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 and camera length

⑦ Amount of defocus

⑧ Accelerating voltage

⑨ Specimen position

4.4.7b High Voltage Control window

This is a window is used to perform settings for the voltage (accelerating voltage) and electron beam.

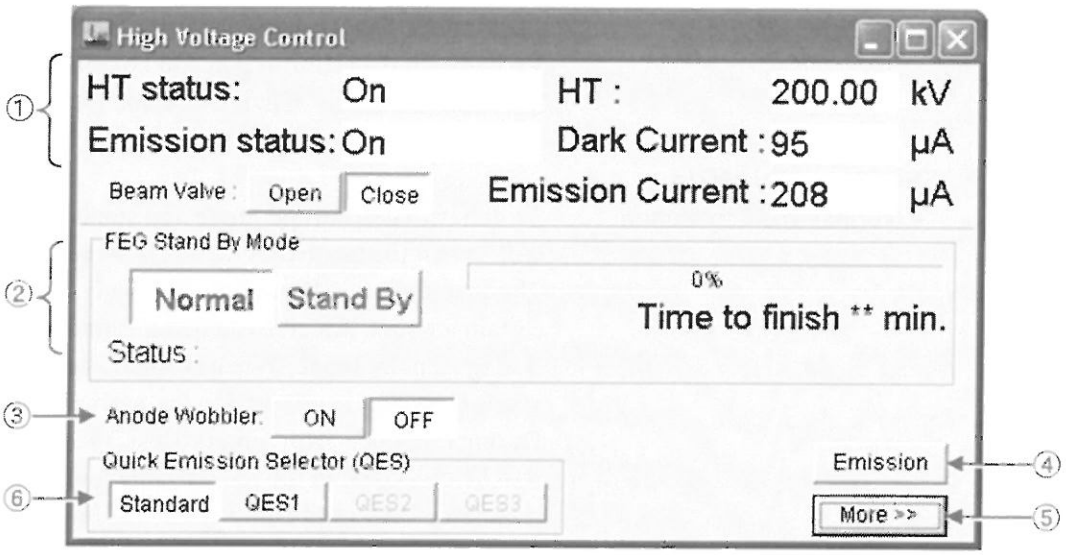


Fig. 4.29 High Voltage Control window 1

① Electron Gun Status Display Area
- HT status: Status of the high voltage application is displayed here. The display changes according to the status as follows.

On:	High voltage is being applied
Ready:	High voltage is off although it can be applied
Not Ready:	High voltage cannot be applied because some conditions are not met (☞ Sect. 6.5.4).

- Emission Status: Status of the electron beam emission is displayed here. Depending on the status, the indication changes as follows.
  - On: Electrons are being emitted
  - Ready: Electron beam emission is off although electrons can be emitted
  - Not Ready: Electron beam emission is not possible because some conditions are not met (☞ Sect. 6.5.4).
- HT: It displays the voltage value currently applied.
- Dark Current: It displays the dark current.

✍ Dark current is the current that depends on the accelerating voltage that is applied to the accelerating tube, and it is not the electron beam current.

- Emission Current: It shows the total electron beam emitted.

✍ The Emission Current is the total amount of current of the electron beam that is emitted from the electron source and it is not the probe current.

- Beam Valve Open/Close button: Clicking the Open button opens the isolation valve V1 between the electron gun and column, and emits the electron beam. Click Close and close V1. If V1 does not open, see (☞ Sect. 6.5.6).

② FEG Stand By Mode

- Normal/Stand by button: Switch between normal mode and standby mode. It will switch to standby mode when Standby is clicked. The accelerating voltage will be slowly lowered by a certain amount. An electron beam cannot be emitted during standby mode. When Normal is clicked, the status is gradually restored to the normal mode. During the mode switching process, the progress will be displayed in the progress bar and the remaining time until completion will be displayed.

③ Anode Wobbler

Use this button to align the electron gun axis.

④ Emission

Display the FEG and QES Setting window. This is used when displaying and setting the FEG status at this point.

✍ When changing the electric current value, follow the instructions from the JEOL service office.

✍ Normally, there are no electron gun power supply value data in the QES. Therefore, an orange colored line will be displayed.

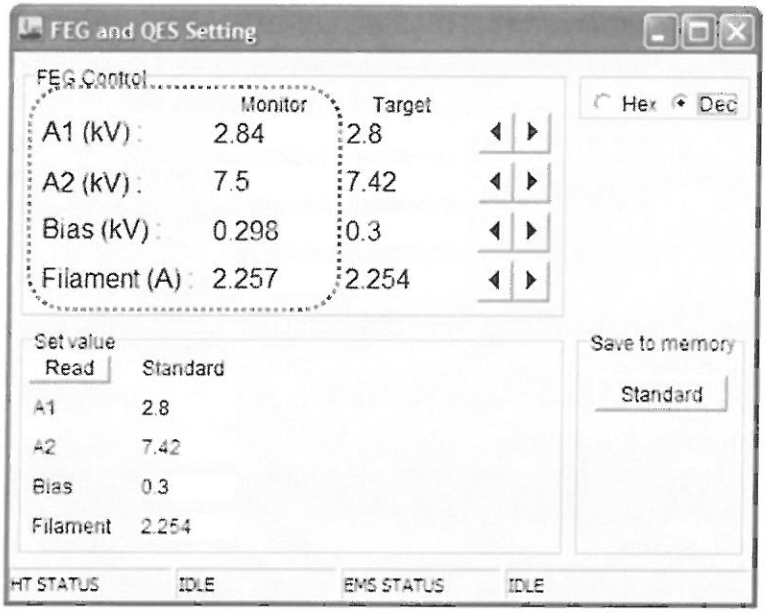


Fig. 4.30 FEG and QES Setting window

⑤ QES (Quick Emission Selector) selection button

This is a button to select the electron gun power supply value other than the standard setting. (Standard)

Normally, it cannot be selected. If you want to record the electron gun power supply value other than the standard setting, contact the JEOL service office (☞ Sect. 5.14.5).

⑥ More button

When it is clicked, this High Voltage Control window will spread downwards and it will display ⑥ onwards.

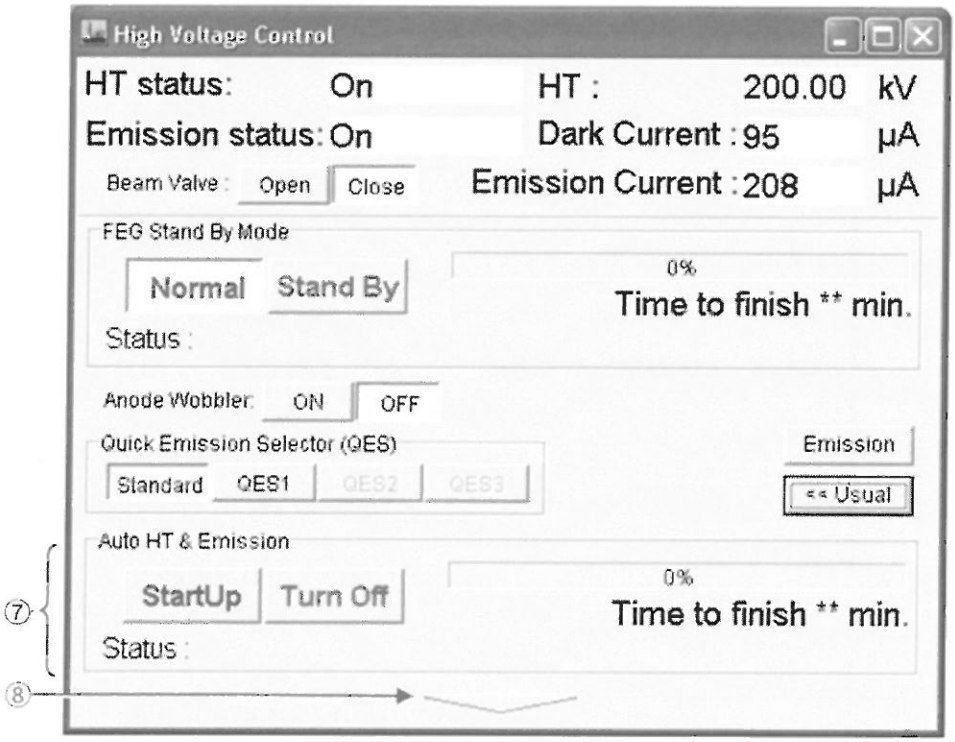


Fig. 4.31 High Voltage Control window2

⑦ Auto HT and Emission

- Start Up/Turn Off button: The **StartUp** button automatically raises the accelerating voltage and the electron beam emission. The **Turn Off** button automatically lowers the accelerating voltage and the electron beam emission. During the process, the progress will be displayed in the progress bar and the remaining time until completion will be displayed.
  If the **StartUp** button is not active (☞ Sect. 6.5.5).

⑧ Expand button

Clicking this button will spread the High Voltage Control window downwards and it will display ⑧ onwards.

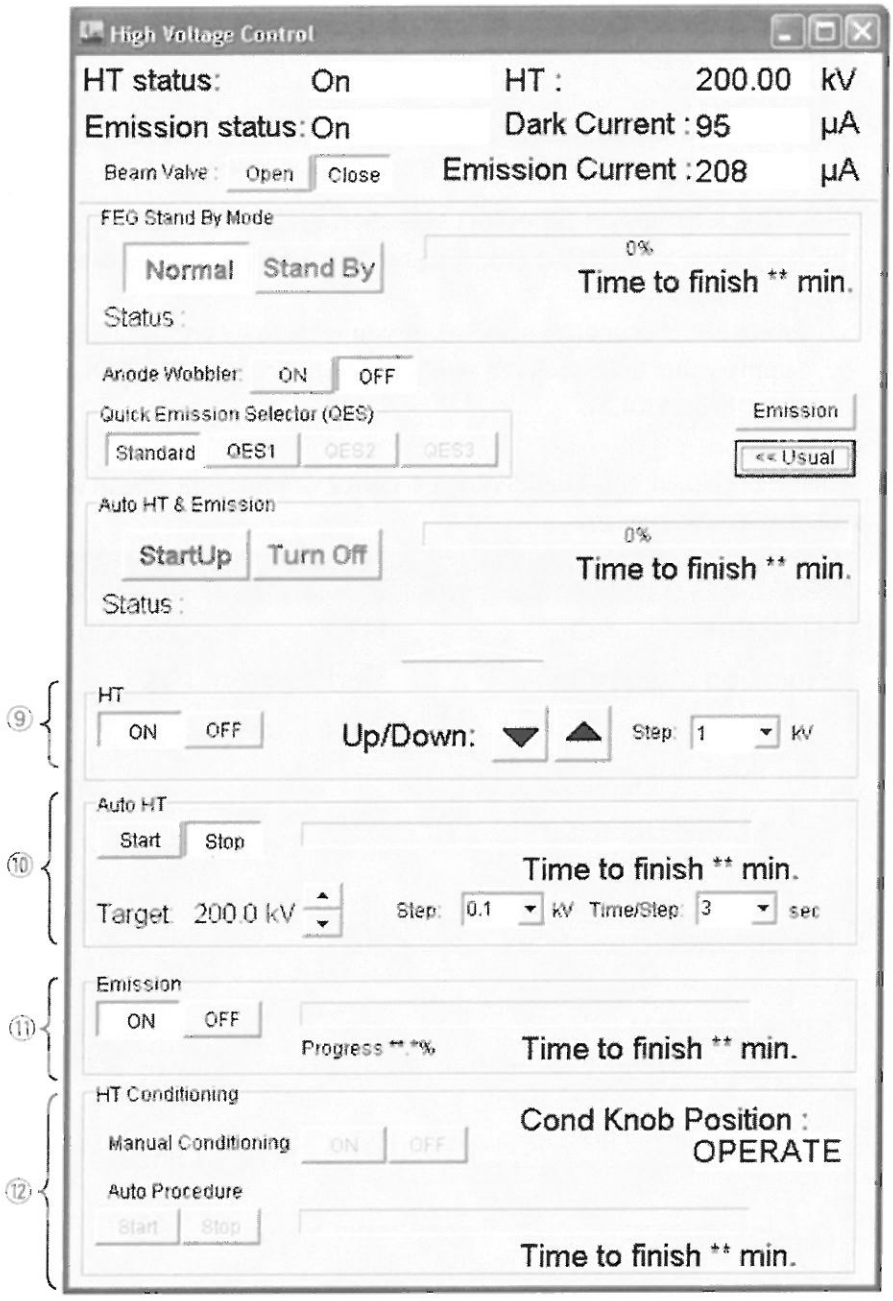


Fig. 4.32 High Voltage Control window 3

⑨ HT

- ON/OFF button: It applies and stops the acceleration voltage application.
- Up/Down button: It raises and lowers the set value of the acceleration voltage.
- Step: Select the amount of change in the set value of the acceleration voltage.

When operating the Up/Down, the reach value at that point will be displayed on the TEM Controller. However, the real application status will be displayed in ① HT.

⑩ Auto HT

- Start/Stop button: By following the conditions set in Target, Step, Time/Step as shown below, perform start and stop of automatic change of the acceleration voltage. During the automatic change process, the progress will be displayed in the progress bar and the remaining time until completion will be displayed.
- Target: This is a setting to automatically change the target acceleration voltage. Use the arrow buttons to increase/decrease the setting.
- Step: Select the amount of change for 1 step of the automatic change.
- Time/Step Select the hold time per step for automatic change.

⑪ Emission

- ON/OFF button: Generating and stopping the electron beam. If it is turned ON or OFF, everything including the preset electron beam emission condition will be set automatically. During the automatic process, the progress will be displayed in the progress bar and the remaining time until completion will be displayed. The setting for electron beam emission condition can be performed using the ④ **Emission** button.

The operation of electron gun power supply should be performed only if you are instructed by the JEOL service office.

⑫ HT Conditioning

- Manual Conditioning ON/OFF button: It is used when performing acceleration voltage variable manually. When ON is clicked, the acceleration voltage is increased by 20 kV. It is operable only when the conditioning knob (Fig. 4.1-①) is set to the COND position. If the knob is set to the OPERATE position, the button will be displayed in gray and it cannot be operated.
- Cond. Knob Position: It displays the setting position of the conditioning knob. (Fig. 4.1- ①)
- Auto Procedure: This is a function to perform the accelerating voltage variable of the HT Conditioning automatically. Auto Procedure will start by clicking the **Start** button. It

can only be operated if the (Fig. 4.1-①) is set to the COND position. If the knob is set to the OPERATE position, the button will be displayed in gray and it cannot be operated.

4.4.7c Operation window

Clicking on Operation in the Dialogue menu in the TEM Controller menu bar (Fig. 4.20-①) opens this window.

■ Standard tab window

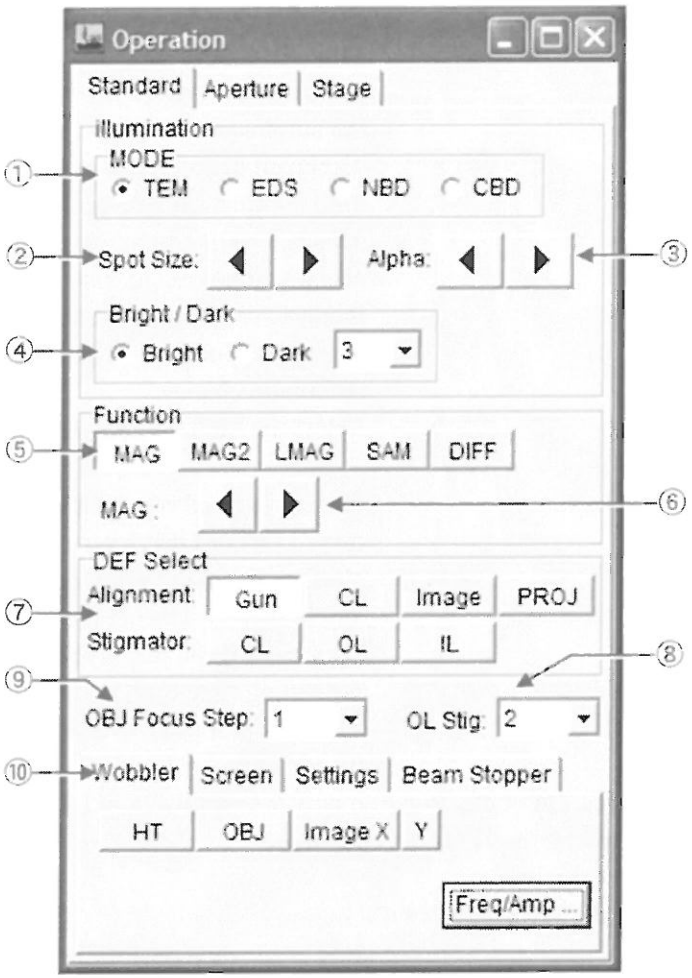


Fig. 4.33 Operation (Standard) window

① Mode
This switch selects the illumination mode (TEM, EDS, NBD, CBD). It is the same as (L1-③).

② Spot Size
Use "◀" and "▶" button to change the beam spot size. When "▶" button is clicked once, the spot size (the size of the electron beam is focused to its smallest by BRIGHTNESS) increases by one step. It will be 1 step smaller when "◀" button is clicked once. It is the same as L1-③.

③ Alpha
Changes the convergent angle using the "◀" and "▶" buttons.

④ Bright/Dark

Select either bright field observation (Bright) or dark field observation (Dark).

⑤ FUNCTION

Select an image forming mode from these buttons. The magnification, camera length and energy dispersion of the selected mode can be changed using MAG/CAM L (R1-⑥ or Fig. 4.33-⑥). The magnification, camera length and energy dispersion will be recorded. Therefore, when it is returned to the previous mode after changing it to other mode, it will be set to the recorded magnification, camera length or the energy dispersion (except for MAG2).

- MAG: Normal magnification mode
- MAG2: The magnification was set beforehand. The magnification can be changed using the MAG/CAM L knob.

The MAG/CAM L setting will be set in ⑪ Settings tab.

- LMAG: Ultra low magnification mode.
- SAM: Selected-area magnification mode. When the scanning image observation device (sold separately) is used, it will be in locking mode.
- DIFF: Selects the diffraction mode. By operating the MAG/CAM L knob, the camera length can be selected from selected area diffraction, high-dispersion diffraction and high-resolution diffraction.

In MAG Select, if a particular camera length is set to non display setting, that camera length will not be displayed.

⑥ MAG

This switch enables you to change the normal magnification when you select MAG1 or MAG2 for FUNCTION (R1-②,Fig. 4.33-⑤), the ultra low magnification when you select LOWMAG, the selected area magnification when you select SAM, and the camera length when you select DIFF. When the "▶" button is pressed once, the spot size becomes 1 step larger. It will be 1 step smaller when the "◀" button is pressed once. (It is the same as R1-⑥)

⑦ DEF Select

Assigns functions to the SHIFT knobs (L1-⑧ and R1-④) and the DEF/STIG knobs (L1-⑩ and R1-⑤) on the control panel L1 and control panel R1. If the selected coil can be assigned to the DEF/STIG knobs, the SHIFT knobs can be assigned to Beam Shift.

- Alignment
  - GUN: Assigns the SHIFT knobs to Gun Shift, and the DEF/STIG knobs to Gun Tilt.
  - CL: Assigns the SHIFT knobs to Beam Shift, and the DEF/STIG knobs to Beam Tilt.
  - Image: Assigns the DEF/STIG knobs to image shift (like L1-⑥).
  - PROJ: Assigns the DEF/STIG knobs to PL alignment (like L1-⑥).
- Stigmator
  - CL: Assigns the DEF/STIG knobs to CL astigmatism correction to the DEF/STIG knobs.
  - OL: Assigns the DEF/STIG knobs to OL astigmatism correction to the DEF/STIG knobs.
  - IL: Assigns the DEF/STIG knobs to IL astigmatism correction to the DEF/STIG knobs.

⑧ OBJ Focus Step
Changes the step size for objective lens focus.

⑨ OL Stig
Up to 5 sets of data for the OL astigmatism-correction coil can be recorded using this instrument. You can restore a desired set of OL astigmatism-correction coil data by selecting its memory number from this box.

⑩ Window selection tabs
Open the Wobbler, Screen, Settings and Beam Stopper windows (Fig. 4.34, Fig. 4.35, Fig. 4.36, Fig. 4.37).

● Wobbler tab

Display it with the **Wobbler** tab (Fig. 4.34) in the PC window Operation (Standard).

Fig. 4.34 Wobbler window

① HT
Turning on this switch makes the accelerating voltage oscillate. It is used for voltage-axis alignment (☞ Sect. 5.9.2).

② OBJ
Turning on this switch makes the OL current oscillate. It is used for current-axis alignment (☞ Sect. 5.9.1).

③ Image X
It oscillates the image wobbler in the X direction.

④ Y
It oscillates the image wobbler in the Y direction.

⑤ Freq/Amp•••
Opens the EOS Property window (☞ Sect. 4.4.7i).

● Screen tab

Click on the **Screen** tab (Fig. 4.35) in the PC window Operation (Standard).

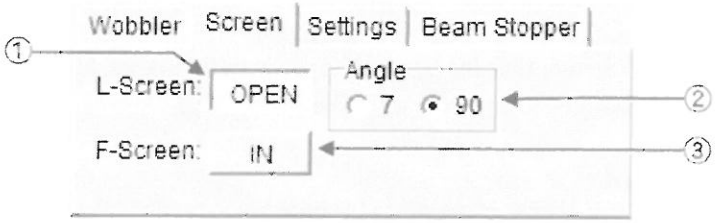


Fig. 4.35 Screen window

① Open
Raises the large fluorescent screen to the angle selected in ②.

② Angle
Select the tilting angle in ①.

③ F-Screen
It performs inserting and removing of the wide field of view CCD camera. (It is the same as control panel R1-①)

● Settings tab

Click on the **Settings** tab (Fig. 4.36) in the PC window Operation (Standard).

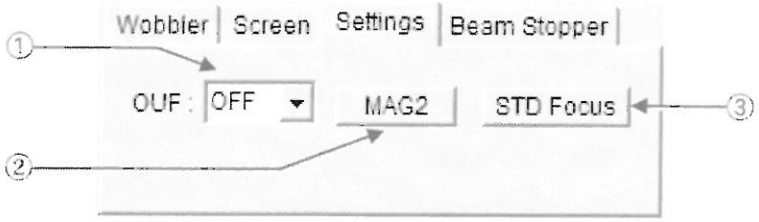


Fig. 4.36 Setting window

① OUF
Perform settings for Optical Under Focus. OFF, 1: small, 2: medium, and 3: large can be selected.

② MAG2
Clicking Store when FUNCTION (R1-③ or Fig. 4.33-⑤) is MAG2, sets the present magnification as the default magnification of MAG2.

③ STD Focus
It will change to (the focus value specified by JEOL engineer) Standard Focus.

● Beam Stopper tab

Click on the **Beam Stopper** tab (Fig. 4.37) in the PC window Operation (Standard). It will operate only when the beam stopper (optional) is configured.

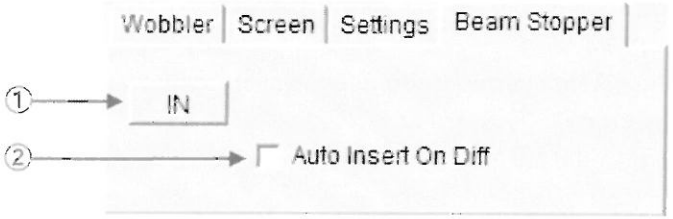


Fig. 4.37 Beam Stopper window

① IN
Clicking this button inserts the beam stopper into the optical axis. Clicking on it again retracts the beam stop from the optical axis.

② Auto Insert On Diff
You can decide whether the beam stopper is to be inserted automatically or not when the system changes to the diffraction mode (DIFF).

■ Aperture tab window

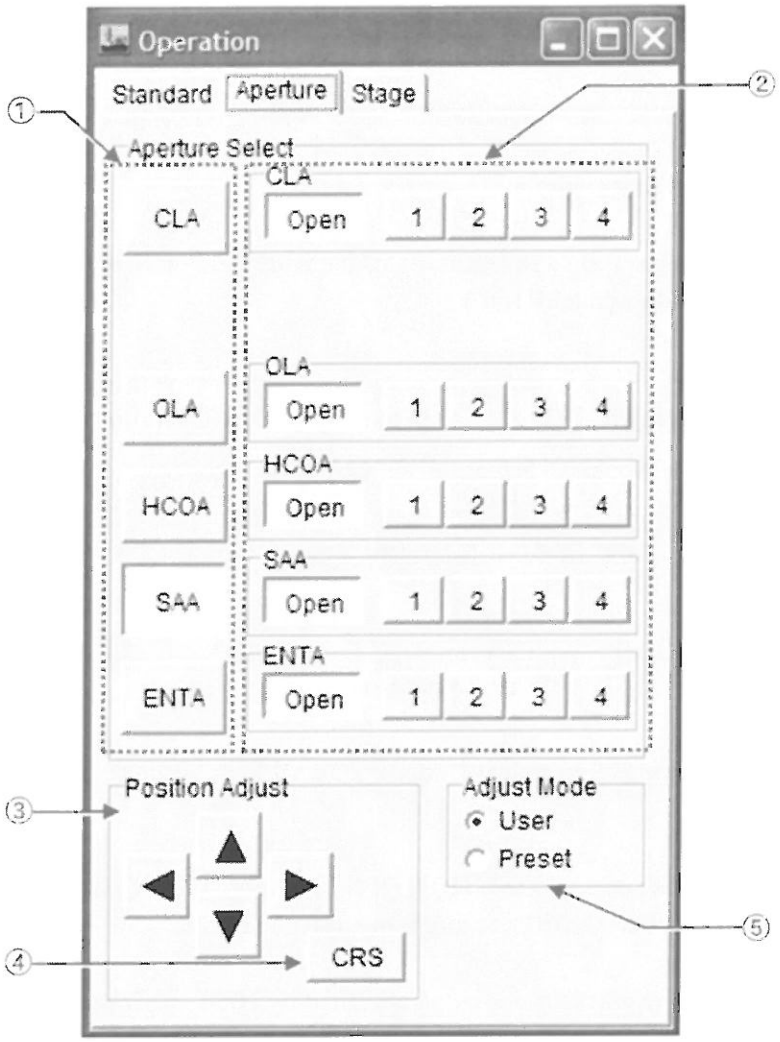


Fig. 4.38 Operation (Aperture) window

① Aperture Select
Select the aperture that you want to operate. This applies only to the motor-drive apertures, so only they appear on the display.

② Open/1/2/3/4
Select the number corresponding to the aperture to insert.

③ Position Adjust
Finely adjust the position of the aperture selected by ①.

④ CRS
Changes the speed of fine adjustment of the aperture position.

⑤ Adjust Mode

Changes the aperture fine adjustment mode:

User: Adjusts the position of the aperture.

Preset: Records the information on the position specific to the aperture number.

■ Stage tab window

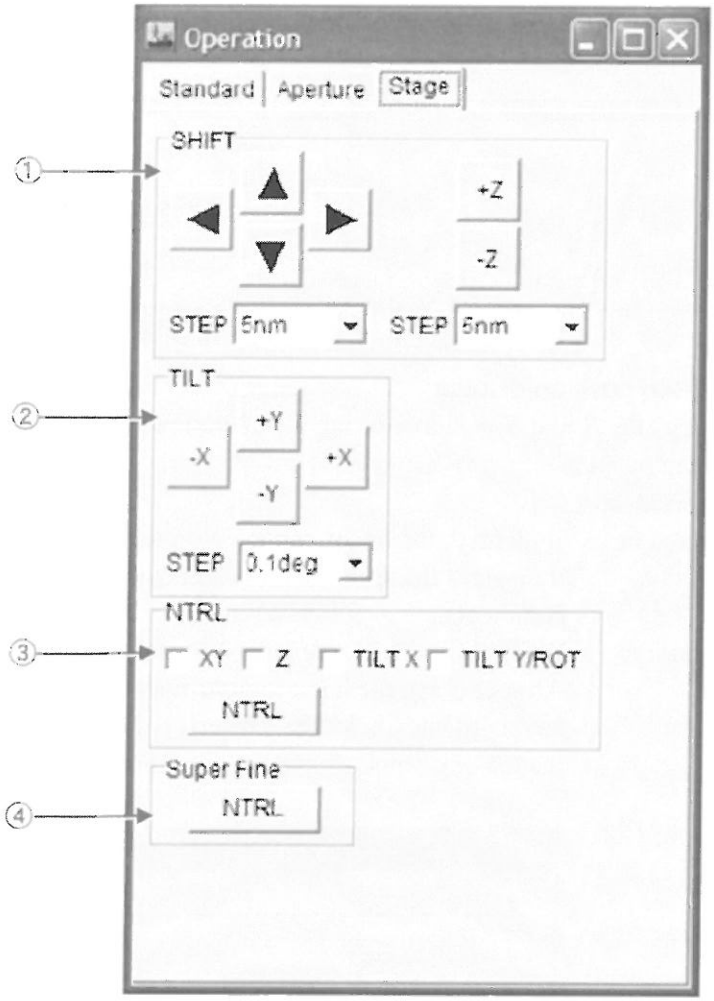


Fig. 4.39 Operation (Stage) window

① SHIFT

Pressing the button moves the specimen. Use the "◀" and "▶" buttons to move in the X direction. Use the "▲" and "▼" buttons to move in the Y direction. Use +Z and −Z buttons to move in the Z direction. The minimum movement can be set in the STEP below.

② TILT

Rotate the specimen in the X or Y direction (when using the single-axis tilt holder, it cannot be rotated in the Y direction). The minimum tilt amount can be set in the STEP below.

③ NTRL

Move the items selected in the check box on the upper part to the neutral point.

④ Super Fine

Move the Piezo drive SFx and SFy to the neutral point.

4.4.7d Specimen Position Window

It can be displayed by selecting the menu bar: Dialogue (Fig. 4.20-①) or by pressing the shortcut switch (Fig. 4.20-②) in the PC window TEM Controller.

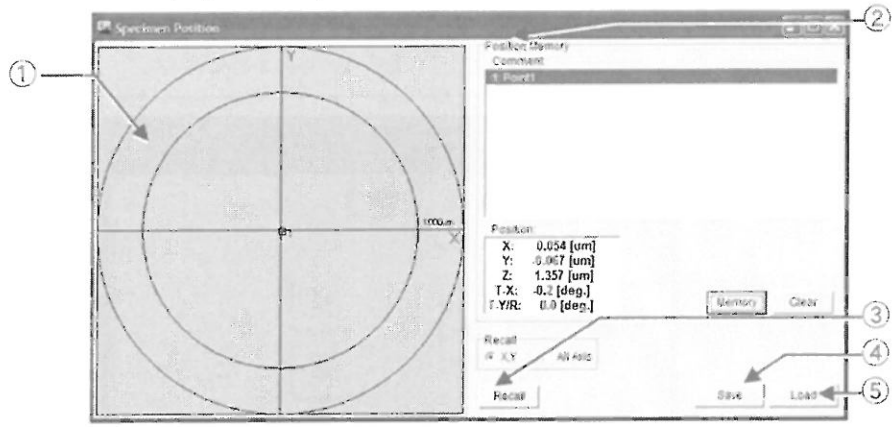


Fig. 4.40 Specimen Position window

① Specimen position display

It displays the X and Y position during the operation and it also displays the recorded specimen position.

② Position Memory

- Comment: It displays the list of comment on recorded specimen position.
- Position: It displays the specimen position that was selected in the list of comments.
- Memory: When it is clicked, the comment entry window will be displayed. After clicking the input region, enter the comment using the keyboard and click **OK**. The entered comment will be displayed in the list of comments and the specimen position at that point will be recorded.

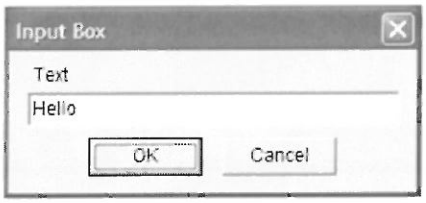


Fig. 4.41 Comment Entry Window

- Clear: When the recorded specimen position is selected and **Clear** button is clicked from the displayed list of comments, it will delete the specimen position record.

③ Recall

When the recorded specimen position is selected from the list of comments and **Recall** is clicked, the specimen will automatically reproduce that specimen position.

✍ The position reproducibility depends on the usage.

④ Save

Give a Comment name and save all the specimen positions in the Comment field.

⑤ Load

Load the specimen position of all the saved Comment name.

✍ If you want to delete the Comment name, right click on the Comment name in the GUI displayed with Save or Load, and select **delete**.

4.4.7e Filter Tuning

It can be displayed by selecting the menu bar: Dialogue (Fig. 4.20-①) or by pressing the shortcut switch (Fig. 4.20-②) in the PC window TEM Controller.

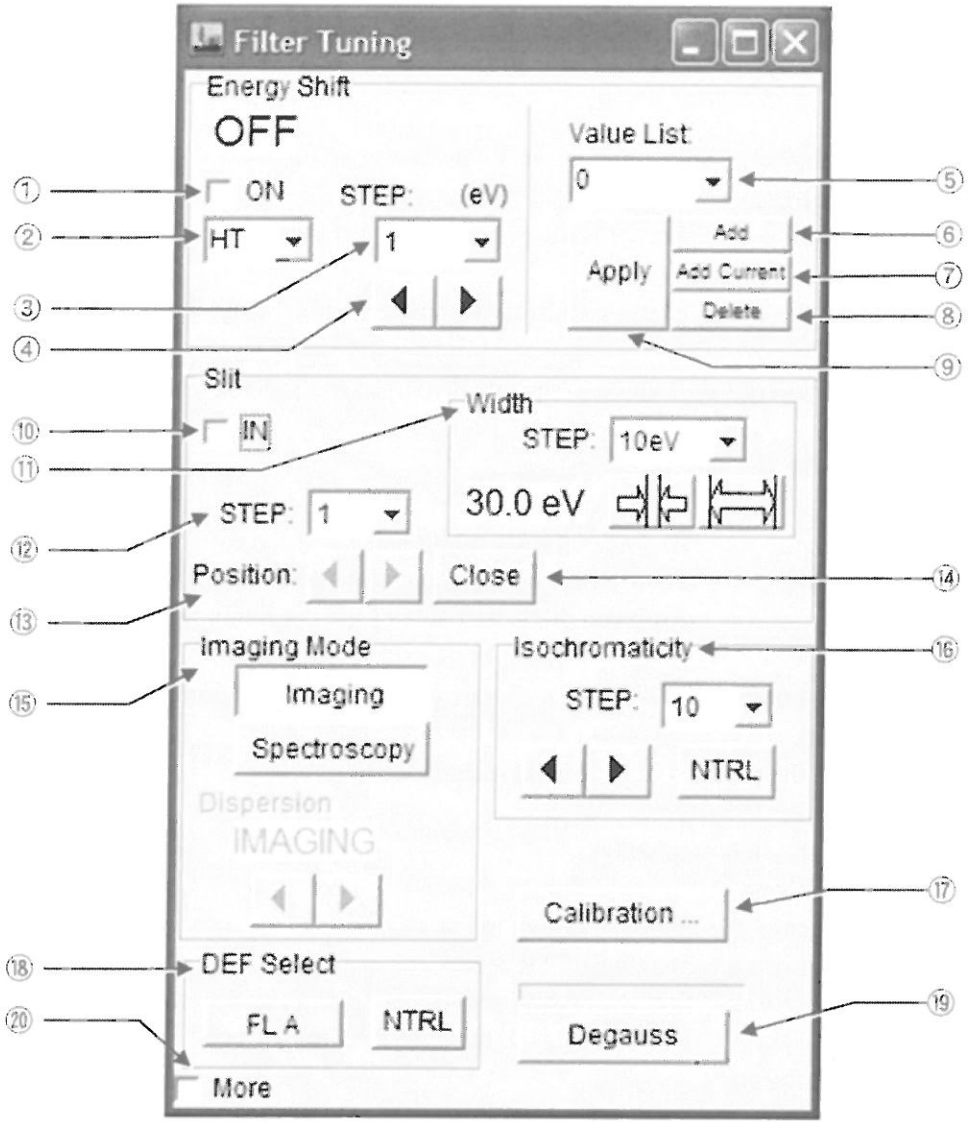


Fig. 4.42 Filter Tuning window

① ON

Clicking this button performs the energy shift. Energy shift is performed when the check box is selected and energy shift will stop when the check box is cleared.

② Combo box for selecting the energy shift method

The energy shift method can be selected from this box.

- HT

  When performing the energy shift by change the high voltage (HT), select HT.

- FL

  When using the Filter Lens (FL), select FL.

③ Step

Sets the variation amount of energy shift per click when changing it with "◀" "▶" button.

④ ◀ ,▶ button
Changes the energy shift value. The energy shift value increases and decreases within the amount set in Step (Fig. 4.42-③) .

⑤ Value List
The recorded energy shift values are displayed. Keyboard can be used to enter the value.

⑥ Add
Saves an energy shift input in the Value List box (Fig. 4.42-⑤).

⑦ Add Current
Clicking this button records the present energy shift value.

⑧ Delete
Deletes the energy shift input from the Value List box (Fig. 4.42-⑤).

⑨ Apply
Sets the energy shift value to the one displayed in the Shift Value List (Fig. 4.42-⑤).

⑩ IN
Inserts the slit into the optical axis.

⑪ Width
- Step: Set the slit width using
- : It is used for opening and closing the slit (The current slit width is displayed on the left side of the operation button.) .

⑫ Step
Sets the amount of slit position change adjusted with position (Fig. 4.42-⑬).

⑬ Position
Adjusts the position of the energy-selection slit.

⑭ Close
Closes the slit completely.

⑮ Image Mode
- Imaging: Sets to imaging mode
- Spectroscopy: Sets to SPCTR mode
- Dispersion: Sets the display length per 1eV of the Spectrum using the ◀, ▶. This length is defined on the film surface.

⑯ Isochromaticity
☞ Refer to the Section 5.12.7c.

⑰ Calibration
Calibrates the energy shift, energy selection slit (zero point adjustment), and energy shift feedback (☞ Sect. 5.12.10).

⑱ DEF Select
- FLA: Assigns the SHIFT knobs to the filter lens 1st deflection coil and the DEF/STIG knobs to the filter lens 2nd deflection coil.
- NTRL: Resets the filter lens 1st and 2nd deflection coil to their neutral positions.

⑲ Degauss
Degausses the filter lens.

⑳ More
Checking this opens the Filter Tuning (More) window (Fig. 4.43).

● Filter Tuning (More) window

Check More (Fig. 4.42-⑳) in the Filter Tuning window to open the Filter Tuning (More) window.

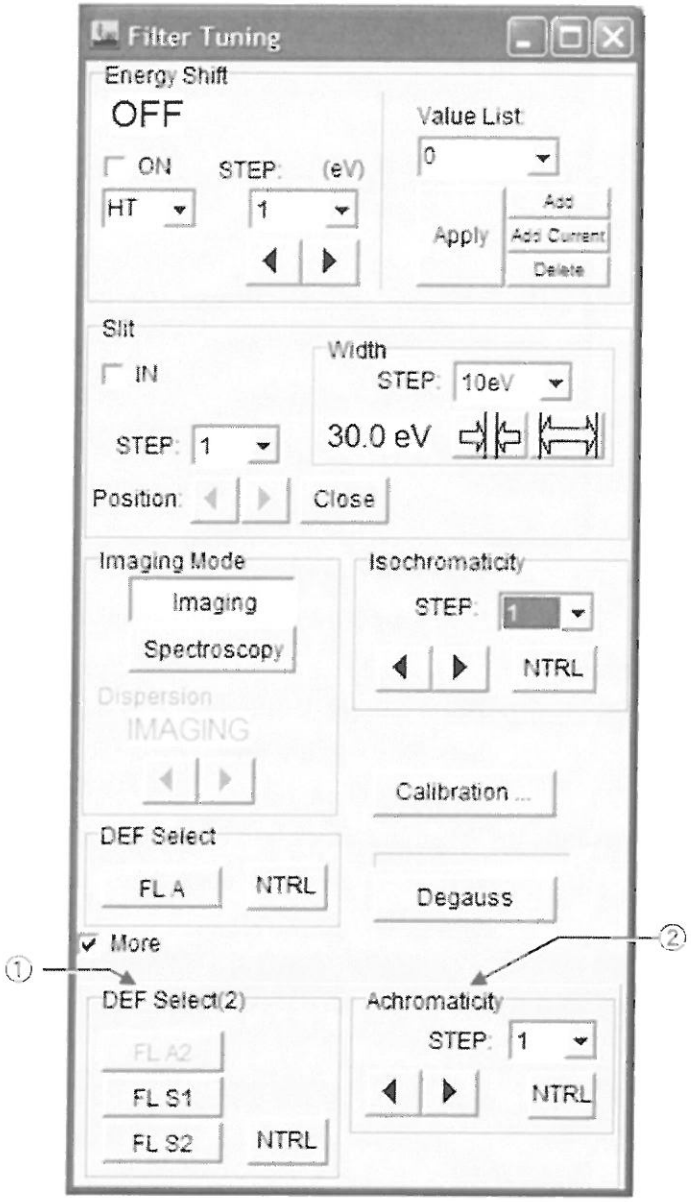


Fig. 4.43 Filter Tuning (More) window

① DEF Select (2)

- FL S1: Assigns the DEF/STIG knobs to the filter lens 1st stigmator coil.
- FL S2: Assigns the DEF/STIG knobs to the filter lens 2nd stigmator coil.
- NTRL: Resets the 1st and 2nd stigmator coil control settings to their neutral positions.

② Achromaticity

Adjusts the alignment of the lens focus and the filter lens achromatic plane. (☞ Sect. 5.12.7d)

4.4.7f Film Camera Property window

It is displayed when you select from menu bar: Dialogue in the TEM Controller menu bar (Fig. 4.20-①) or when you click on the shortcut switch button in the PC screen TEM Controller window (Fig. 4.20-②).

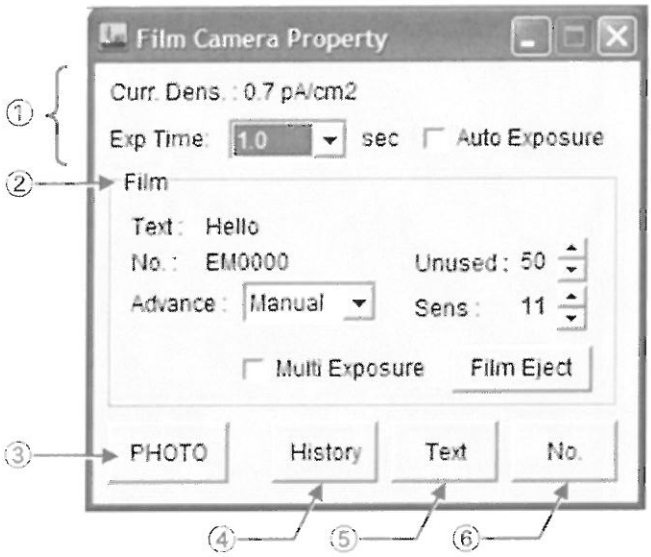


Fig. 4.44 Film Camera Property window

① Basic Information

- Curr. Dens.: Beam current density (pA/cm^2) on the fluorescent screen.
- Exp Time: Sets the exposure time. Select the desired exposure time from the combo box.
- Auto Exposure: When the check box is selected, it will be automatic exposure (Fig. 4.45), and the combo box for Exp Time selection will disappear.

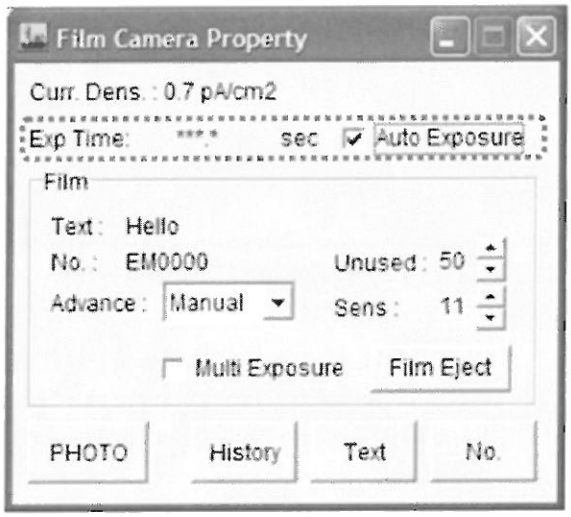


Fig. 4.45 Film Camera Property window (Auto Exposure)

② Film

- Text: Text to print on the film will be displayed.
- No.: Film number to print on the film will be displayed.
- Advance It switches the film advance method.

Manual: It will be manual.
Auto 1: It will be automatic. After acquiring the image, the non-photographed film will be advanced to the camera position.
Auto 2: It will be automatic 2. Advance the film cassette to the camera position and start photographing.

- Unused: It displays the number of films in the magazine feed. It can be changed using the "▲" and "▼" buttons.

Sens: It displays the film sensitivity of the exposure meter. Sensitivity can be changed using the "▲" and "▼" buttons. The sensitivity increases as the value is increased and the exposure time becomes shorter.

- Multi Exposure: When it is selected, multiple exposure is possible.

When canceling the Multi Exposure, either remove the check from the check box before acquiring the last image, or advance the film using Film Eject.

Instead of selecting the Multi Exposure check box, Multi Exposure is also possible by pressing the Photo switch again before the film is advanced after an image has been acquired.

- Film Eject: Receive the film that is in the current camera position and advance it to magazine.

③ Photo

It is the same as the Photo (R1-⑪) (Fig. 4.3-⑪).

④ History

Opens the Photo History window (Fig. 4.28).

⑤ Text

Displays the (Text) Input Box (Fig. 4.46). Enter a film text (up to 18 alphanumeric characters) for annotating the film. Enter the text and click on the **OK** button.

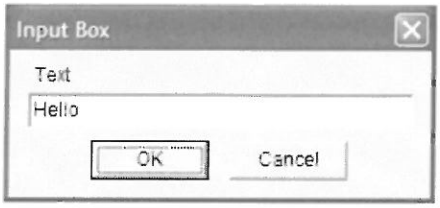


Fig. 4.46 Input Box (Text) window

⑥ No.

Displays the Input Box (No.) (Fig. 4.47). Enter a film number that will be printed on the film inside the box. Then, click on the **OK** button.

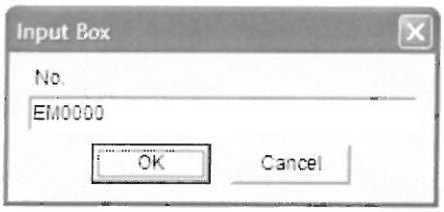


Fig. 4.47 Input Box (No.) window

4.4.7g Status Monitor window

This window is displayed when you select the menu bar: Monitor menu (Fig. 4.20-①) or by clicking on the Status shortcut switch in the PC TEM Controller window (Fig. 4.20-②).

■ Standard tab

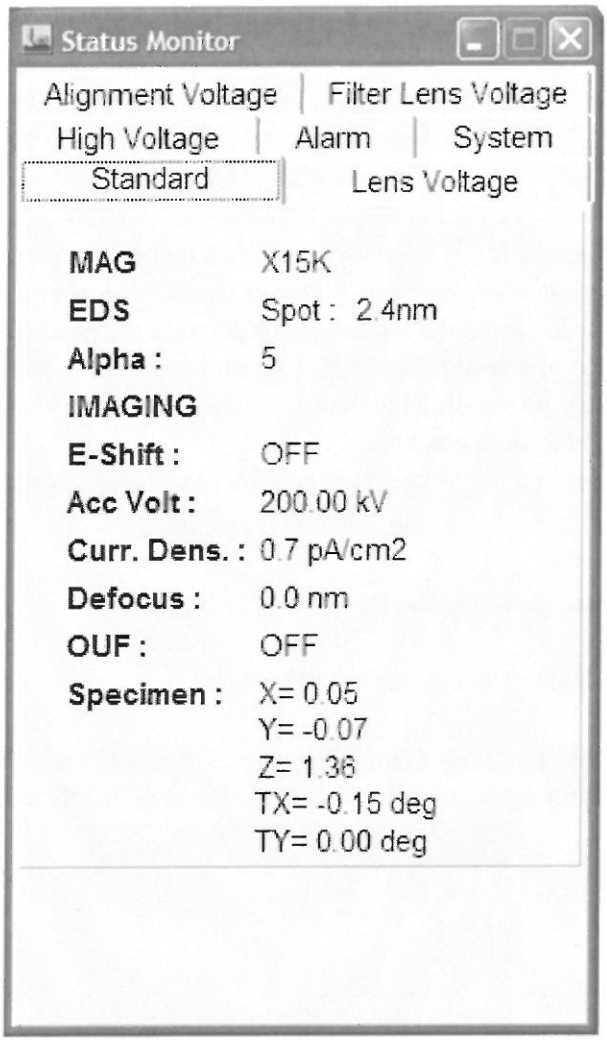


Fig. 4.48 Status Monitor (Standard) window

Displays information identical to that in the Main window of the TEM Controller window (Fig. 4.20).

■ Lens Voltage tab

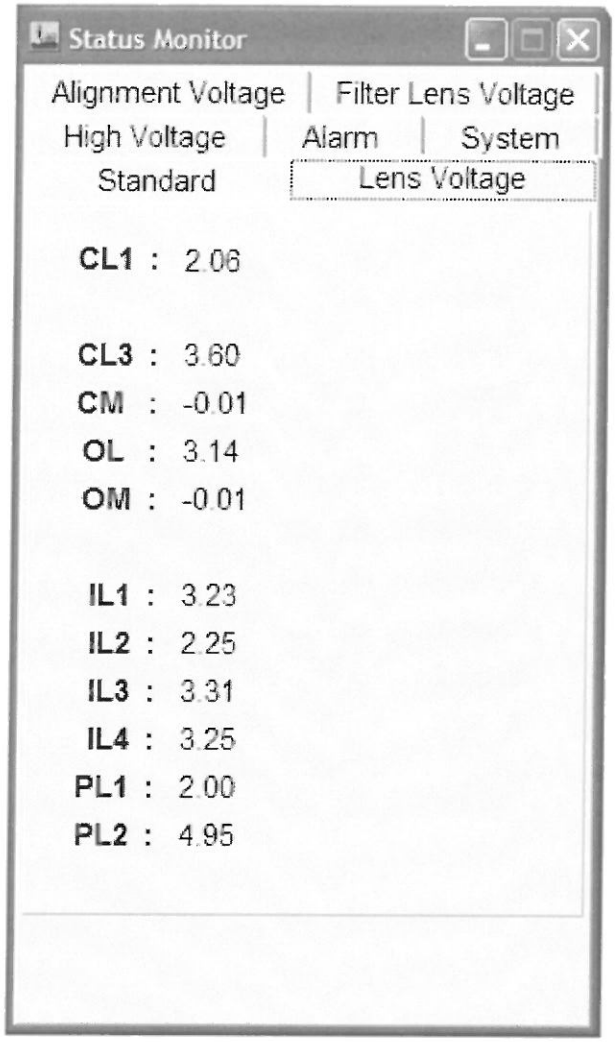


Fig. 4.49 Status Monitor (Lens Voltage) window

Displays the lens current values.

■ Alignment Voltage tab

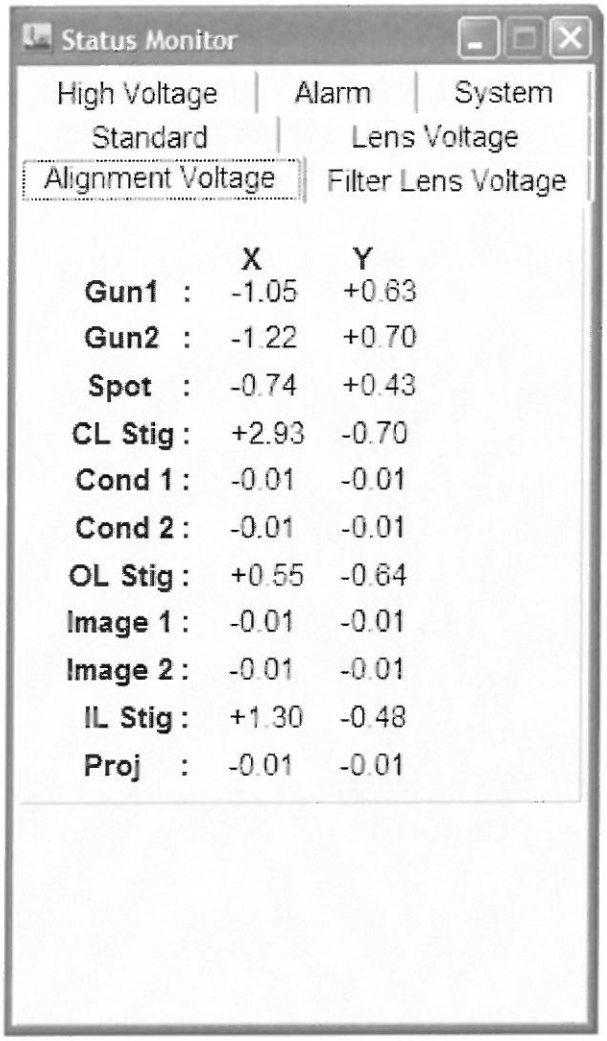


Fig. 4.50 Status Monitor (Alignment Voltage) window

Displays the deflection coil currents values.

■ Filter Lens Voltage tab

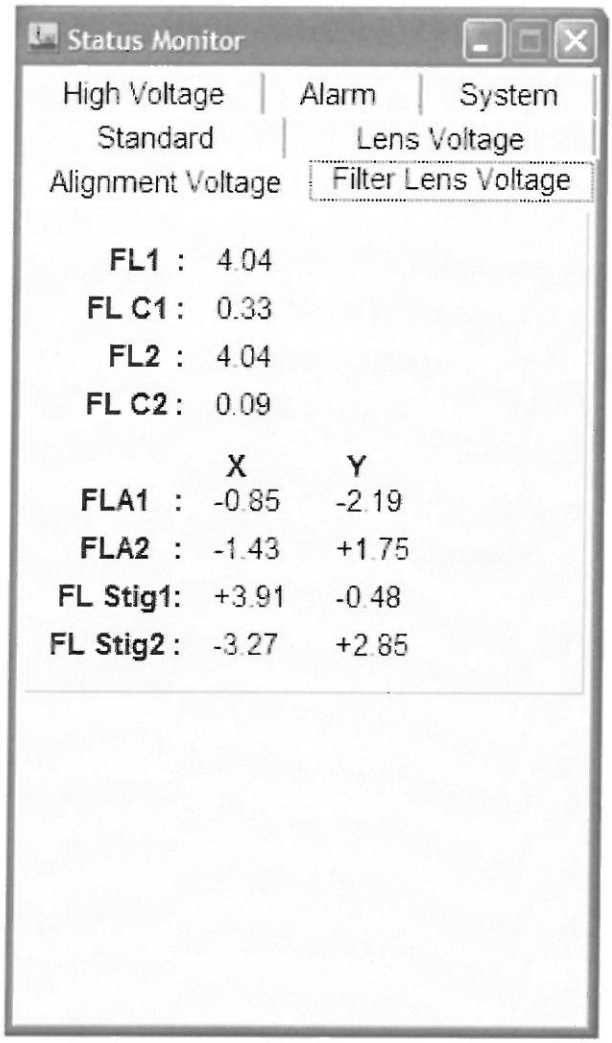


Fig. 4.51 Status Monitor (Filter Lens Voltage) window

Displays the filter lens and filter deflection coil current values.

■ High Voltage tab

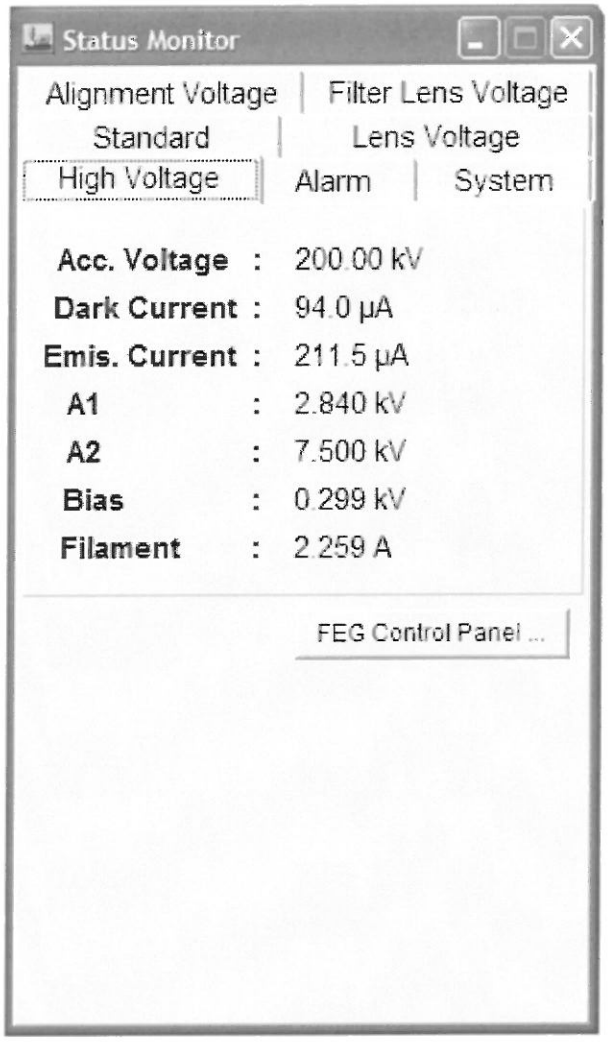


Fig. 4.52 Status Monitor (High Voltage) window

Displays the beam accelerating voltage, beam currents, and electron gun anode voltages. Clicking on the FEG Control Panel displays the High Voltage Control window (Fig. 4.21).

● Alarm tab

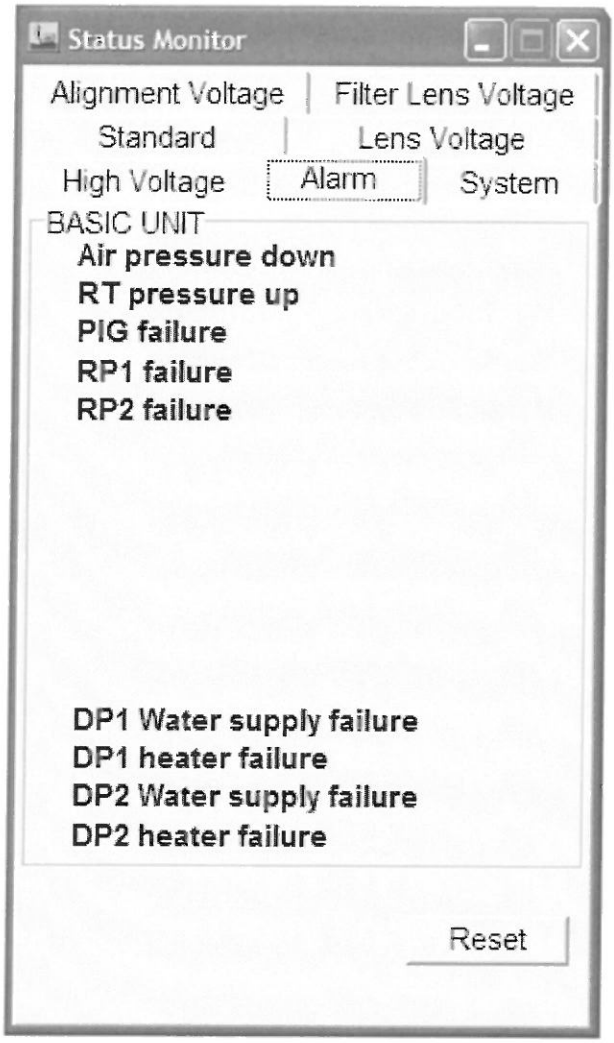


Fig. 4.53 Status Monitor (Alarm) window

An indicator lamp turns red when an abnormality occurs in the corresponding system.

- AIR: Abnormality in the compressed air supplied to the microscope.
- RT: Abnormality in the vacuum reservoir
- PIC: Abnormality in the Pirani vacuum gauge
- RP1: Abnormality in rotary pump 1.
- RP2: Abnormality in rotary pump 2.
- DP1-Water: Abnormality in the diffusion pump cooling water system.
- DP1-Heater: Abnormality in the diffusion pump heater circuit.

■ System tab

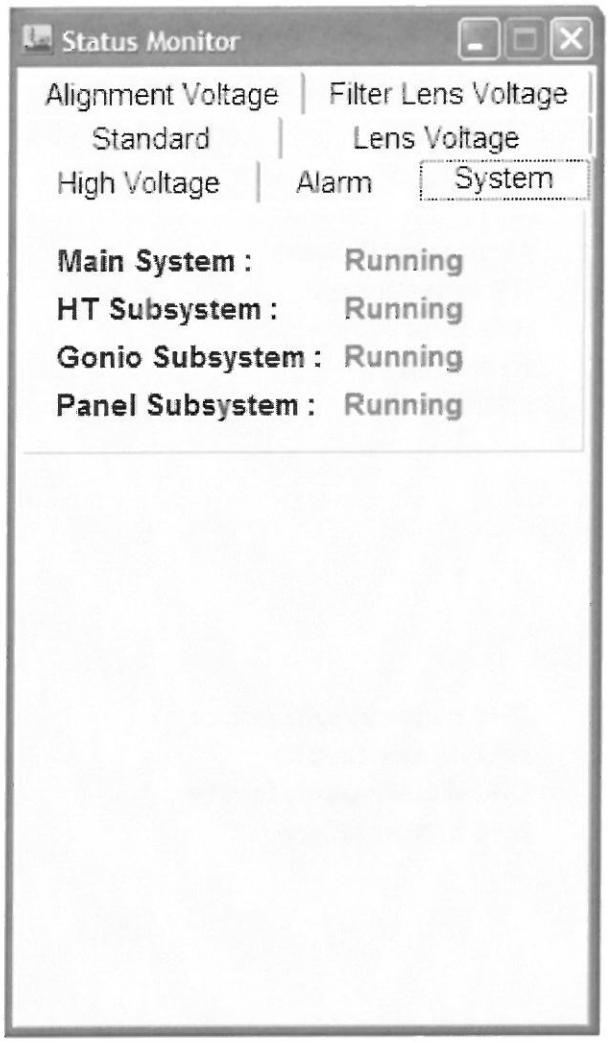


Fig. 4.54 Status Monitor (System) window

Displays the communication status of each system.

Running: Normal communication status.

———: If the red line is displayed, it means that the communication with that system has been disconnected.

4.4.7h Valve Status window

It is displayed when Monitor in the TEM Controller menu bar (Fig. 4.20-①) is selected. (Fig. 4.55) The vacuum system diagram in the display might differ from that shown below, depending on the system configuration.

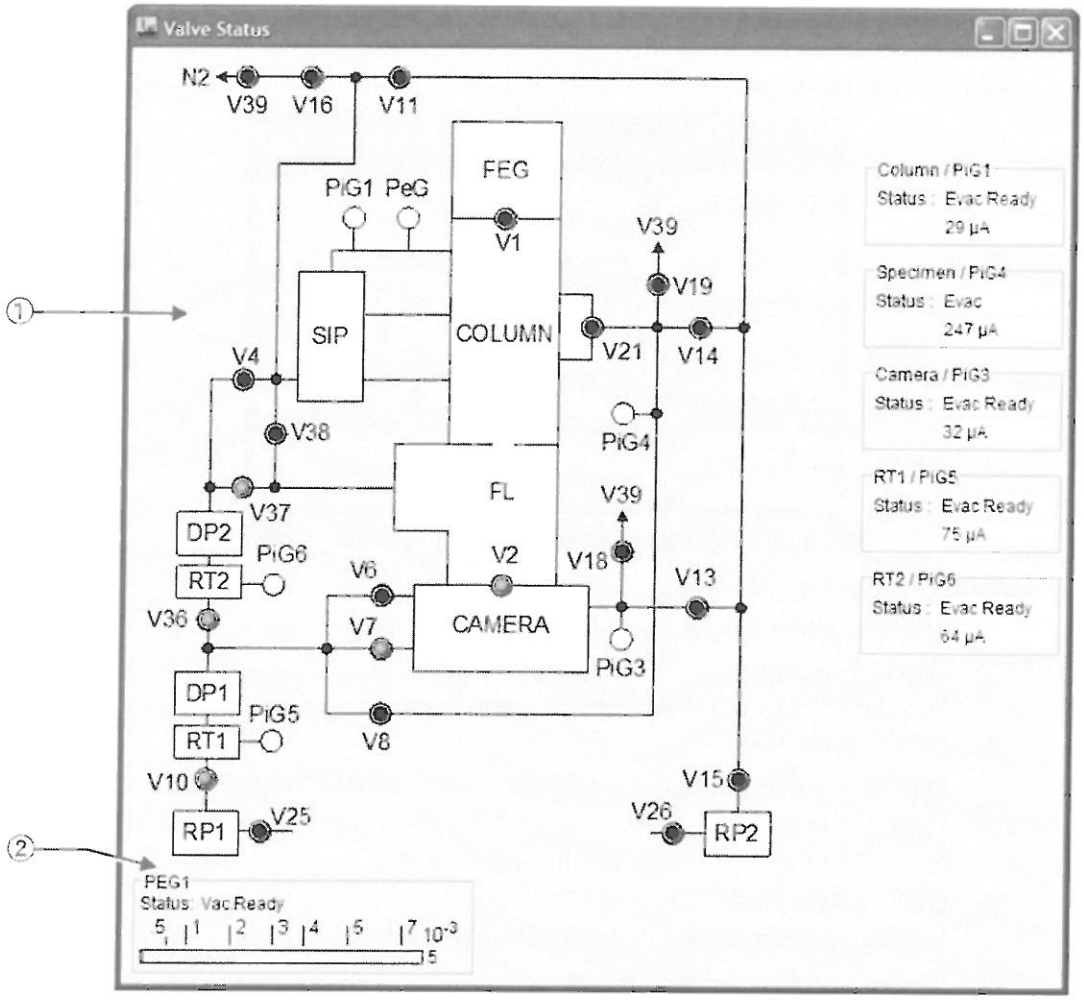


Fig. 4.55 Valve Status window

① Vacuum system (system diagram)

Displays electromagnetic and pneumatic valve conditions, Pirani gauge status and its reading. Each of the valve lamps lights (green) when the corresponding valve is open and goes out (black) when the valve is closed.

- Column/PIG1: Column (PI1) status and Pirani gauge reading is displayed.
- Specimen/PIG4: Specimen chamber (PI4) status and Pirani gauge reading is displayed.
- Camera/PIG3: Camera chamber (PI3) status and Pirani gauge reading is displayed.
- RT1/PIG5: Reservoir 1 (PI5) status and Pirani gauge reading is displayed.
- RT2/PIG6: Reservoir 2 (PI6) status and Pirani gauge reading is displayed.

② PEG1

Displays the status of the Penning gauge. As the pressure decreases, the status changes from OFF to Evac. Low to Evac. High to Vac. Ready.

4.4.7i EOS Property window

■ Wobbler Freq/Amp

This is displayed when Property in the menu bar (Fig. 4.20-①) is selected, or by pressing the shortcut switch button in the TEM Controller window (Fig. 4.20-②) (Fig. 4.56). Also, the window opens when you click on either **Freq/Amp...** in the Wobbler window (Fig. 4.34⑤) or **Freq/Amp...** in the Alignment Panel for Maintenance window (Fig. 4.61⑥).

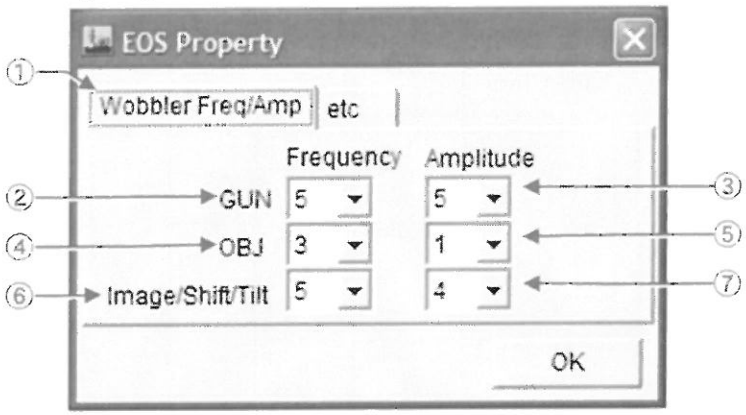


Fig. 4.56 EOS Property (Wobbler Freq/Amp) window

① Wobbler Freq/Amp tab
Select Wobbler Freq/Amp tab from the EOS Property, etc.

② GUN : Frequency
Sets the wobbler frequency for the electron gun 1st deflection coil.

③ GUN : Amplitude
Sets the wobbler amplitude for the electron gun 1st deflection coil.

④ OBJ : Frequency
Sets the wobbler frequency for the objective lens.

⑤ OBJ : Amplitude
Sets the wobbler amplitude for the objective lens.

⑥ Image Wobbler : Frequency
Sets the image wobbler frequency.

⑦ Image Wobbler : Amplitude
Sets the image wobbler amplitude.

■ etc

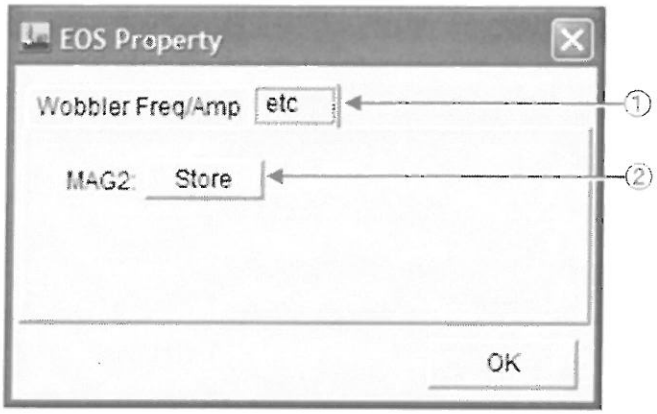


Fig. 4.57 EOS Property (etc) window

① etc tab
Select the etc tab in EOS Propertyetc.

② Store
Clicking on **Store** when FUNCTION (R1-③ or Fig. 4.33-⑤) is MAG2, the present magnification will be set as MAG2 default magnification.

4.4.7j MDS window

It is displayed when Option in the TEM Controller menu bar is selected (Fig. 4.20-①) (Fig. 4.58).

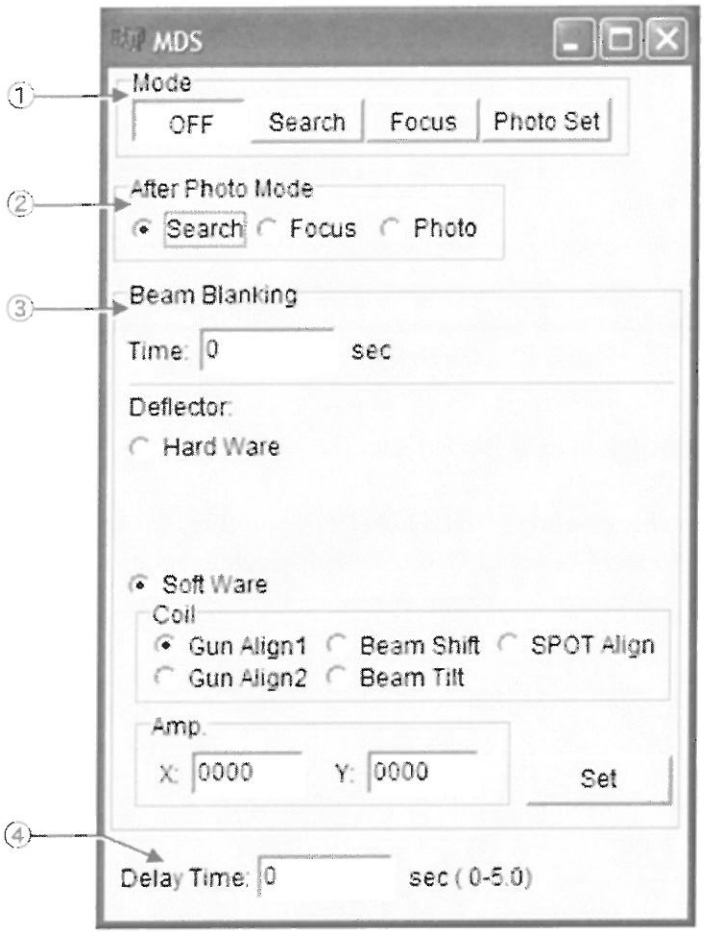


Fig. 4.58 MDS window

① Mode

- OFF: Turns off the MDS mode and returns to the normal photographing 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

Selects the mode (Search, Focus, Photo) after completion of photography.

③ Beam Blanking

- Time: Sets the beam blanking time.
- Deflector: Sets the beam blanking method.
- Delay Time: Sets the delay time.

④ Delay Time

It sets the delay time.

4.4.7k FLC Panel window

■ FLC Panel (Column tab)

This window opens selecting the Free Lens Control in the Option menu in the TEM Controller menu bar (Fig. 4.20-①) (Fig. 4.59).

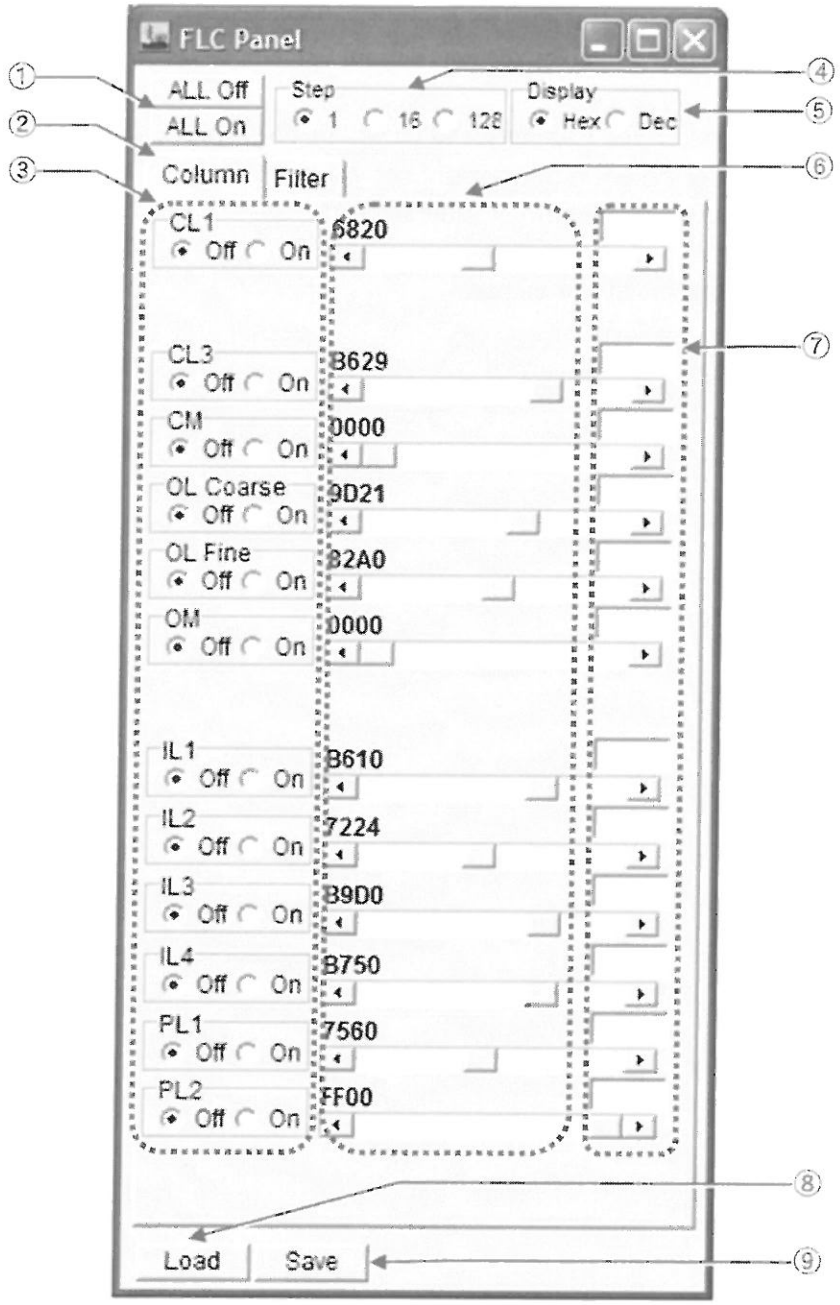


Fig. 4.59 FLC Panel window (Column tab)

① ALL Off button/ ALL On button

Each button in this field lets you turn on or off the free lens control function of each lens (or coil).

② Column tab

In terms of column lens, it is selected when free lens control is applied.

③ OFF/ON
Turns on and off the free (manual) lens controls. While the manual lens control is on, the status of options (Fig. 4.20-⑦) indicates FLC=ON.

④ Step
Sets the step size for lens current.

⑤ Hex/Dec
Selects whether to display the lens current value in hexadecimal or decimal.

⑥ Slider
Set the lens current. Current set value will be displayed at the top left.

⑦ Text box for entering the current set value.
Enter the desired lens current value for each lens.

⑧ Load
Loads the recorded lens current.

⑨ Save
Saves the present lens current.

■ FLC Panel (Filter tab)

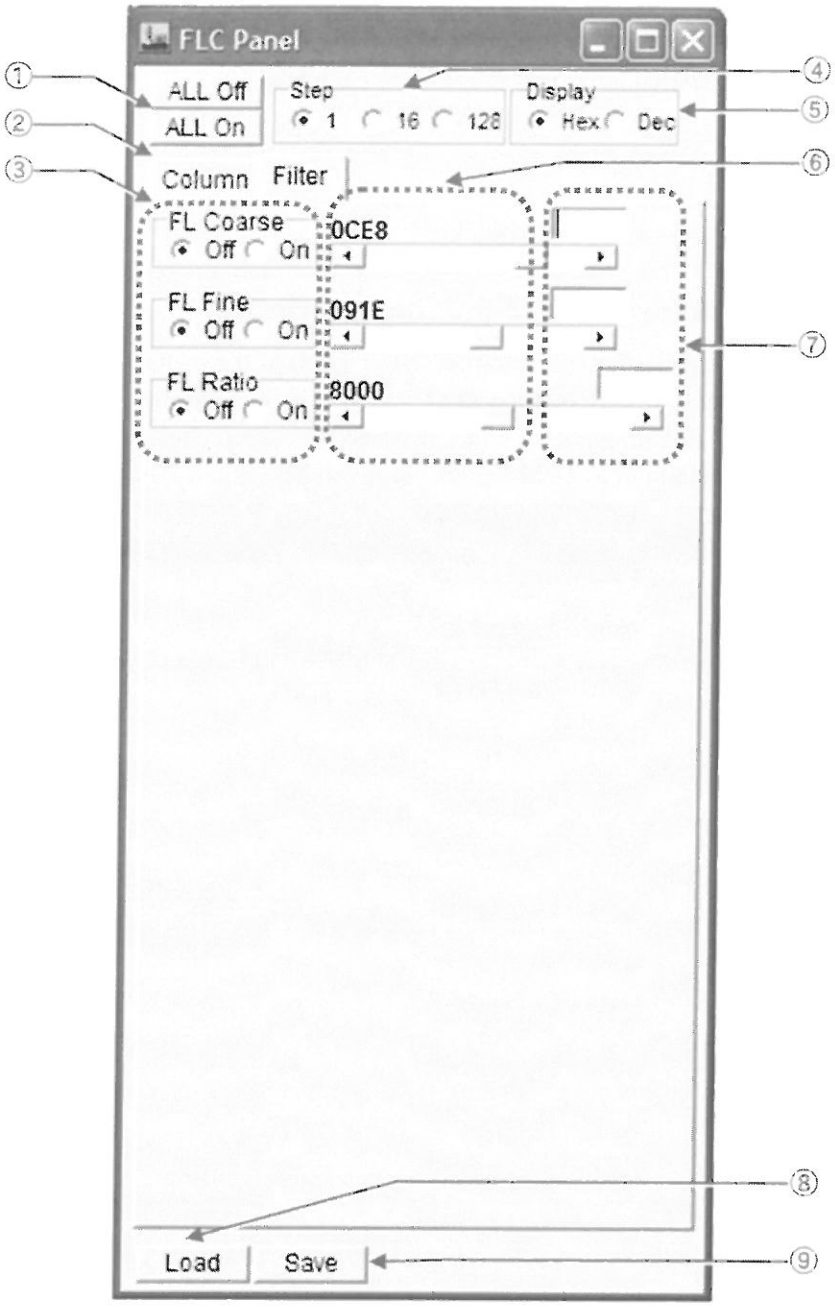


Fig. 4.60 FLC Panel window (Filter tab)

① ALL Off button/ ALL On button
Clicking this button turns off the free lens control function of all lenses.

② Filter tab
It is selected when free lens control is applied to the Filter Lens.

③ OFF/ON
Sets the ON/OFF of free lens control function for each lens.

④ STEP
This combo box enables you to set the variation amount for setting the lens current.

⑤ Hex/Dec
Selects whether to display the lens current value in hexadecimal or decimal.

⑥ Slider
Set the lens current. Current set value will be displayed at the top left.

⑦ Text box for entering the current set value
Enter the desired lens current value for each lens.

⑧ Load
Loads the recorded lens current.

⑨ Save
Saves the present lens current.

4.4.7l Alignment Panel for Maintenance window

This is used to assign functions to the SHIFT knob of the control panel and the DEF/STIG knobs, and select the deflection system, and to turn the wobbler ON and OFF as required for optical axis alignment. This window opens when you click on Alignment in the Maintenance menu in the TEM Controller menu bar (Fig. 4.20-①) (Fig. 4.61).

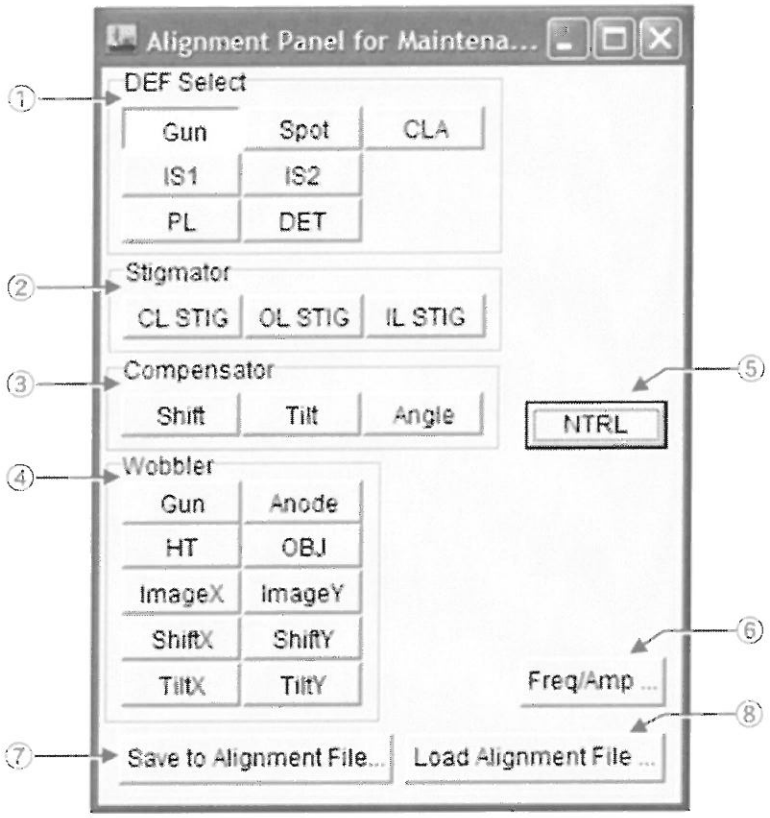


Fig. 4.61 Alignment Panel for Maintenance window

① DEF Select
Assigns functions to the SHIFT knobs (L1-⑧ and R1-④) and the DEF/STIG knobs (L1-⑩ and R1-⑤). If the selected coils can be assigned to DEF/STIG knobs, the SHIFT knobs can be assigned to Beam Shift.

- Gun: Assigns the gun shift function to the SHIFT knob and the gun tilt function to the DEF/STIG knobs.
- Spot: Assigns the spot alignment to the DEF/STIG knobs.
- CLA: Beam Shift is assigned to the SHIFT knobs, and Beam Tilt is assigned to the DEF/STIG knobs.
- IS1: Clicking this button assigns the Image Shift 1 to the DEF/STIG knobs.

- IS2: Clicking this button assigns the Image Shift 2 to the DEF/STIG knobs.
- PL: Clicking this button assigns the PL alignment to the DEF/STIG knobs.
- CL STIG: Clicking this button assigns the CL stigmator coils to the DEF/STIG knobs.
- OL STIG: Clicking this button assigns the OL stigmator coils to the DEF/STIG knobs.
- IL STIG: Clicking this button assigns the IL stigmator coils to the DEF/STIG knobs.
- DET: Used for alignment when an additional detector is attached.

② Stigmator

- CL STIG: Clicking this button assigns the CL stigmator coils to the DEF/STIG knobs.
- OL STIG: Clicking this button assigns the OL stigmator coils to the DEF/STIG knobs.
- IL STIG: Clicking this button assigns the IL stigmator coils to the DEF/STIG knobs.

③ Compensator

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

④ Wobbler

- HT: Clicking this button oscillates the high voltage periodically. Use this button when you align the electron gun axis. (☞ Sect. 5.9.2).
- GUN: Clicking this button oscillates the first deflector coil X currents of the electron gun periodically. Use this button when you search for the electron beam. (☞ Sect. 5.8).
- OBJ: Clicking this button oscillates the current value of the objective lens periodically. This switch is used when centering the current axis (☞ Sect. 5.9.1).
- Image X/Y: Clicking on this switch oscillates the condenser lens deflector coil Tilt. This switch is used for focusing (☞ Sect. 5.11.1).
- Anode: Clicking this button oscillates the second anode voltage periodically. This switch is used in aligning the gun axis (☞ Sect. 5.8.1).
- Shift X/Y: Clicking this button oscillates the condenser lens deflector coil periodically. This switch is used in adjusting Shift Balance.
- Tilt X/Y: Clicking this button oscillates the second deflector coil X and Y currents of the condenser lens periodically. This switch is used when you adjust Tilt Balance.

⑤ NTRL

Sets the selected DEFLECTOR to the center.

⑥ Freq/Amp...

Opens the EOS Property window (Fig. 4.56).

⑦ Save to Alignment File...

Saves data on the lens and deflection coil currents.

⑧ Load Alignment File...

Loads the saved alignment status. Current alignment will be lost.

4.4.7m Bake Out/ACD Heat window

PC window TEM Controller menu bar: Select from Maintenance (Fig. 4.20-①) to display (Fig. 4.62, Fig. 4.63).

■ ACD Heat

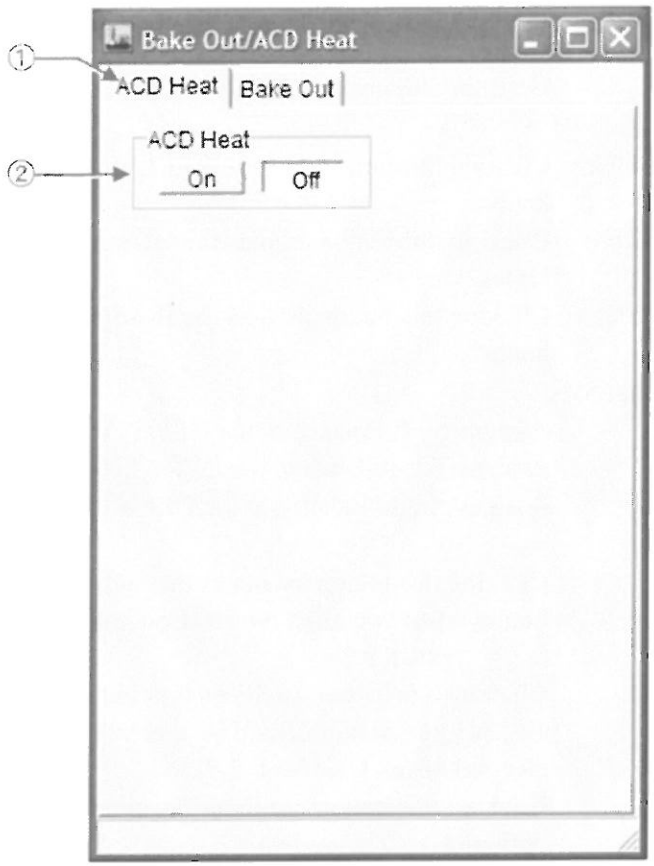


Fig. 4.62 Bake Out/ACD (ACD Heat) window

① ACD Heat tab
Displays the ACD Heat window.

② ACD Heat
Turns ACD Heat on/off.

■ Bake Out

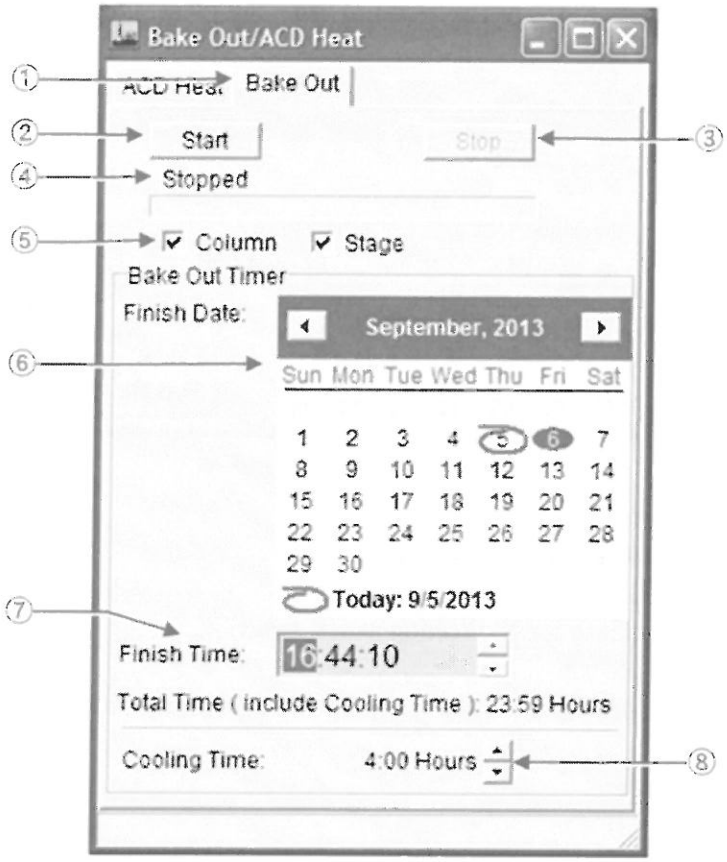


Fig. 4.63 Bake Out/ACD (Bake Out) window

① Bake Out tab
Displays the Bake Out window.

② Start
Starts the bake out.

③ Stop
Stops the bake out.

④ Displaying the status of baking
Indicates the status of baking—"Baking→Cooling→Stopped". Additionally, the status of the progress is displayed on the progress bar.

⑤ Selecting bake out target
Perform bake out on the selected target.

⑥ Calendar buttons
Sets the date to stop the baking. Select the date.

⑦ Finish Time
Sets the time to stop the baking. Change by using the spin control button.

⑧ Cooling Time
Set the cooling time. The default time is 4 hours. Change by using the spin control button.

4.4.7n Aperture Adjust window

It will be displayed (Fig. 4.64) by selecting from the PC window TEM Controller menu bar: Maintenance (Fig. 4.20-①).

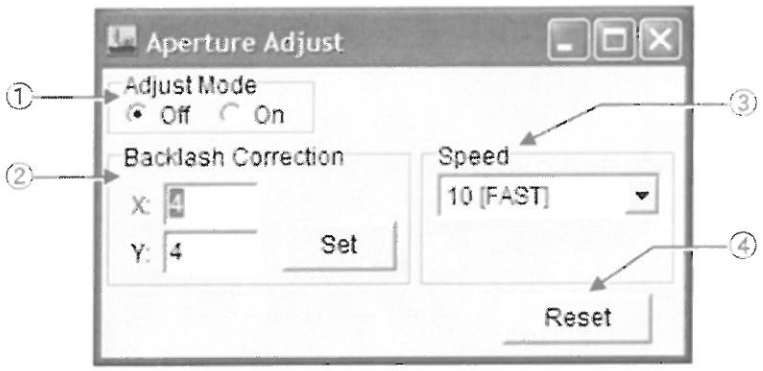


Fig. 4.64 Aperture window

① Adjust Mode
Turns Adjust Mode On/Off.

② Backlash Correction
Sets the Backlash for X direction and Y direction.

③ Speed
Adjusts the drive pulse cycle. The larger the value, the slower the speed.

④ Reset
Clears the input.

4.4.7o Brightness Zoom window

When the irradiation mode is TEM (Control panel L1-③), it maintains the size of the electron beam automatically when the magnification is changed (Fig. 4.65). Additionally, in order to use this function, irradiation state of α-selector and spot size has to be initialized beforehand.

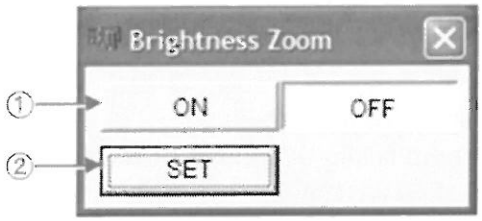


Fig. 4.65 Brightness Zoom window

① ON button/OFF button
- If the **ON** button is clicked, the Brightness Zoom function will operate.
- If the **OFF** button is clicked, the Brightness Zoom function will be canceled.

② SET button
If the button is clicked after setting the electron beam to spot status with the BRIGHTNESS knob (Control panel L1-⑦), the initial state of the irradiation condition (α selector and spot size) at that point will be recorded.

It will not function in an irradiation mode other than TEM. Additionally, during magnification change, the shift of the electron beam will be larger as the magnification change is larger from the initial state setting. It is recommended to set the initial setting near the desired magnification.

4.4.7p Stage Limit window

It is displayed when you select Stage Limit from the Maintenance menu in the TEM Controller menu bar (Fig. 4.20-①) (Fig. 4.66).

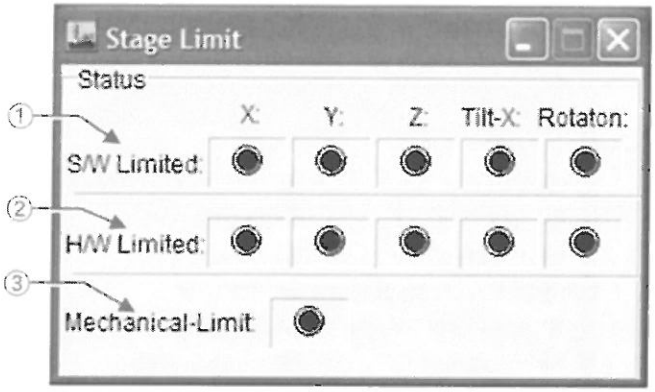


Fig. 4.66 Stage Limit window

① S/W Limited
When the current specimen position and the tilt angle is compared with the acceptable range of tilting table in 3D space, it indicates that the specimen movement or tilting has reached its limit value.

② H/W Limited
It indicates that the movement of each axis or tilt limit detector is operating.

③ Mechanical-Limit
It indicates that the specimen holder came in contact mechanically with aperture and such.

4.4.7q Photo Error window

The Photo Error window will be displayed (Fig. 4.67) when there is no film during image acquisition or when there is abnormality during film transfer. In Fig. 4.67, the Photo Error window was displayed because the film magazine was empty.

Fig. 4.67 Photo Error window

Film Empty:	It lights when there is no film when acquiring images. Load the film and set it in magazine.
Dispenser:	It lights when there is abnormality during film transfer. Contact your JEOL service office.
Receiver:	It lights when there is abnormality during film transfer. Contact your JEOL service office.

⚠ CAUTION

If there is abnormality during film transfer, contact your JEOL service office.
If you put your hand inside the camera mechanism unnecessarily, your finger may get caught in the transfer system.

4.4.8 Emergency Window

This window is displayed when abnormality occurs in the electron microscope. The abnormal item is underlined, and a red lamp lights next to it to indicate the abnormality. If an abnormal item is not fixed, it will appear repeatedly even if the **OK** button is pressed. (The window will disappear when the abnormal item is fixed.)

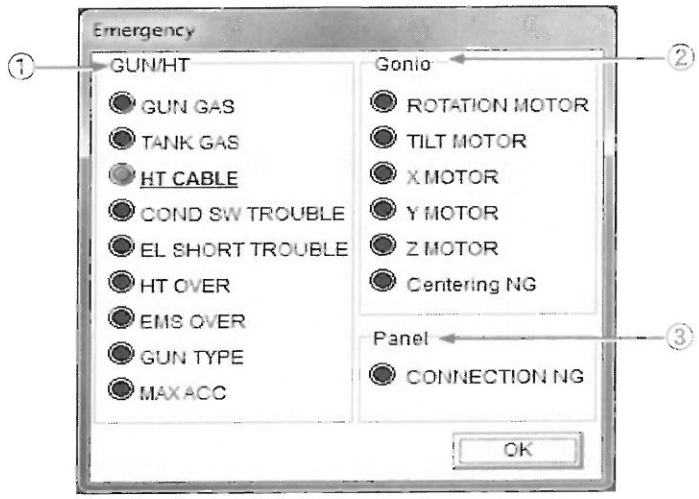


Fig. 4.68 Emergency window

① GUN/HT
It indicates abnormalities in high voltage and electron beam generator.

② Gonio
It indicates abnormalities in the goniometer.

③ Panel
It indicates the communication abnormality for the control panel.

5 OPERATION

5.1 EMERGENCY MEASURES

5.1.1 Power Failure

The microscope automatically shuts down safely when the power fails. Restart the microscope by following the normal startup procedure (☞ Sect. 5.2.1).

5.1.2 Water Supply Interruption

If the water supply interruption continues for a long time, the high voltage power and lens power supplies turn off and the evacuation system goes into a safe condition. Restart the microscope by following the normal startup procedure (☞ Sect. 5.2.1, 5.2.4).

5.1.3 Water Leakage

When the safety device detects leakage of water, power to the instrument shuts down immediately. Remove the cause of the leakage, confirm that the problem has been solved completely, and then restart the instrument.

5.1.4 Faulty Operation

The microscope is protected by various safety devices.

5.2 STARTING AND STOPPING THE INSTRUMENT

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 TEM POWER switch [I] (on switch: C1-②) to turn on the microscope.
   ✍ If it does not start, press the EM STOP switch (C1-①) once and press the POWER switch again.
4. Turn on the computer (PC).
5. Start up the TEM Server program (☞ Sect. 4.4.1a).
   ✍ Normally, when the PC starts, TEM Server will start automatically. If it does not start, double click the **TEM Server** icon on the desktop.
6. Start up the TEM Controller program (☞ Sect. 4.4.1b).
   ✍ When TEM starts, each subsystem will start. However, it will take few minutes for all the subsystems to start. Start the TEM Controller a few minutes after the TEM instrument has started.
7. Generate the electron beam (☞ Sect. 5.5).
8. As required, fill the anti-contamination device with liquid nitrogen (☞ Sect. 5.13.1).
   ✍ After confirming that the pressure inside the column is 5×10^{-5} Pa or lower, fill the liquid nitrogen.
9. Insert the specimen holder into the microscope column (☞ Sect. 5.4.2).
   ✍ It is recommended that you first insert the specimen holder without a specimen into the column, check the electron beam emission on the fluorescent screen, and then load the specimen for axis alignment or microscopy.

5.2.2 Standby Operation

When no microscopy will be performed for some time, such as at night, you can keep the instrument in a standby state without shutting down.

✍ When you do not plan to use the instrument for a long time, or a power interruption is expected, shut down the instrument.

1. Press the BEAM switch (L1-①) to close the isolation valve (V1).
2. Pull out the specimen holder from the microscope column (☞ Sect. 5.4.3).

a. Double click the **Stage Neutral** button on the right main window of the TEM Controller.

b. Pull out the specimen holder from the microscope column.

3. Set the electron gun to the standby mode and keep the instrument running all night.
   ✍ Normally, even if you will not perform microscopy, you do not need to stop the electron beam. It is recommended that you keep the instrument in standby mode at night.

a. Select **TEM Controller — Dialogue — High Voltage Control** and click the **Stand By** button from the FEG Stand By Mode field in the window.
The electron gun HT lowers to the standby mode value and electron gun will be maintained in a safe state.

4. If an anti-contamination device is used, set the heater in the liquid nitrogen tank, drain the LN_2, click the ACD HEAT **On** button and return it to room temperature (☞ Sect.5.13.2).

5.2.3 Restoration from the standby operation

1. Restore the electron gun from the standby mode.
   a. Select **TEM Controller — Dialogue — High Voltage Control**, and click the **Normal** button in the FEG Stand By Mode field in the window.
   The HT will rise automatically and it will return to a normal usage state in approximately 20 minutes.
2. As required, fill the anti-contamination device with liquid nitrogen (☞ Sect. 5.13.1).

5.2.4 Shutting Down

When you do not plan to use the instrument for a long time, or a power interruption is expected, shut down the instrument.

✍ When no microscopy will be performed for some time, such as at night, you can keep the instrument in a standby state without shutting down.

1. Press the BEAM switch (L1-①) to close the isolation valve (V1).
2. Pull out the specimen holder from the microscope column (☞ Sect. 5.4.3).
   a. Double click the **Stage Neutral** button on the right main window of TEM Controller.
   b. Pull out the specimen holder from the microscope column.
3. Remove all apertures from the electron-beam path (set to open).
4. Select **TEM Controller — Dialogue — High Voltage Control**, click the **Turn Off** button in the HT & Emission field on the screen and turn off the electron gun.
   Lowering of acceleration voltage and shutting down of the electron beam is executed automatically.
5. If an anti-contamination device is used, set the heater in the liquid nitrogen tank, drain the LN_2, click the ACD HEAT **On** button and return it to room temperature (☞ Sect.5.13.2) .
   When the ACD HEAT is turned **On**, the evacuation system sequence will be switched and then, automatic control will start. This control finishes in about 30 mins to 2 hours, and the system returns to the normal state.
6. Shut down the TEM Controller application and shut down the PC.
7. Press the POWER (C1-②) ⏻ **OFF** switch.
   The instrument will stop after a shut down process of approximately 10 minutes.
8. Close the cooling water supply valve.
9. Turn off the power of the power distribution board.
10. Close the nitrogen gas supply valve.

5.3 PREPARING FILMS

5.3.1 Loading Films into the Dispensing Magazine

1. Insert an unexposed film into each cassette with the emulsion side facing up under a safe light (red light) in the darkroom (Fig. 5.1).
2. Remove the lid from the dispensing magazine (Fig. 5.2) and fully depress the bottom plate and hold it.
3. Place the loaded cassettes in the dispensing magazine and insert the magazine lid. Up to 50 cassettes can be loaded in one magazine.

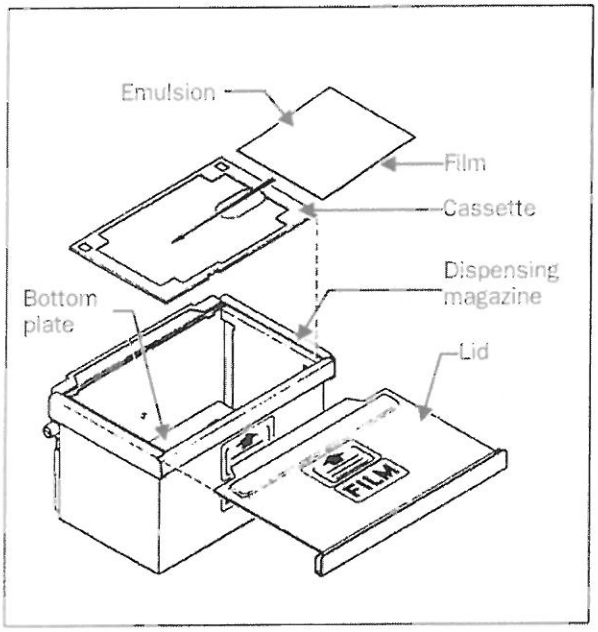


Fig. 5.1 Film loading

Fig. 5.2 Magazines

✍ Do not confuse the dispensing magazine for the receiving magazine.

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

1. Make sure that the isolation valve (V1 valve: Fig. 4.1-②) is closed (Fig. 4.29-①).
2. Open the nitrogen gas supply valve and turn the handle of the camera chamber door (the camera chamber can be seen when the Fig. 4.1-⑩ door is opened) clockwise until it stops.
3. The door will open after a while. Therefore, open the camera chamber and close the nitrogen gas supply valve. If the door does not open after 5 minutes, turn the door handle fully in the counterclockwise direction and then, turn it fully in the clockwise direction. Then wait 5 minutes. Repeat this procedure until the door opens.

   ✍ If the nitrogen-gas valve is not open or if the nitrogen-gas cylinder is empty, the door will not open no matter how long you wait.

4. Draw out the magazine drawer by pulling the handle (Fig. 5.3).

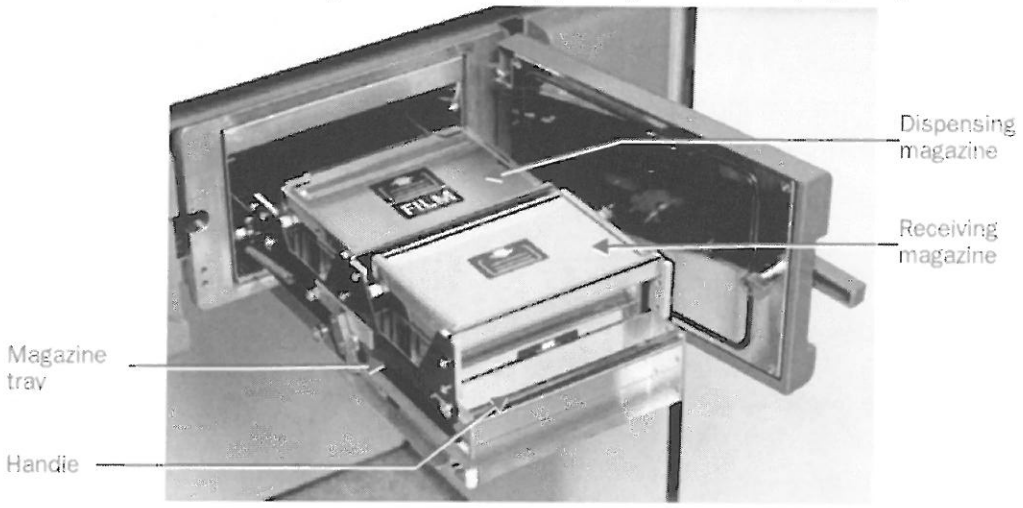


Fig. 5.3 Magazine tray

5. If there is an empty dispensing magazine in the magazine tray, remove it by lifting it up. Then place the dispensing magazine, loaded with unexposed films, in the magazine drawer.
   - If the magazine is not inserted properly, it will get caught when inserting the magazine tray and cause malfunction.
   - There are two pairs of dispensing magazine and receiving magazine. For the dispensing magazine, insert one in the camera chamber and store the other in the vacuum drying chamber (separate order) with films inside. For the receiving magazine, insert one in the camera chamber and keep the other nearby so that it can be replaced anytime.
   - Make sure the lid does not open when carrying the magazine.
6. If there are exposed film inside the receiving magazine in the magazine tray, remove it by lifting it up and place the empty receiving magazine inside.
7. Push in the magazine tray handle until it stops.
8. Close the camera chamber door; press the door handle toward the door and turn the handle counterclockwise as far as it will go.
   - If there is lint or debris on the O-ring or the contact surface of the camera chamber, it could cause insufficient vacuum.
9. Set the number of unexposed films (films inside the dispensing magazine) (Fig. 5.4, ☞ Sect. 4.4.7f)

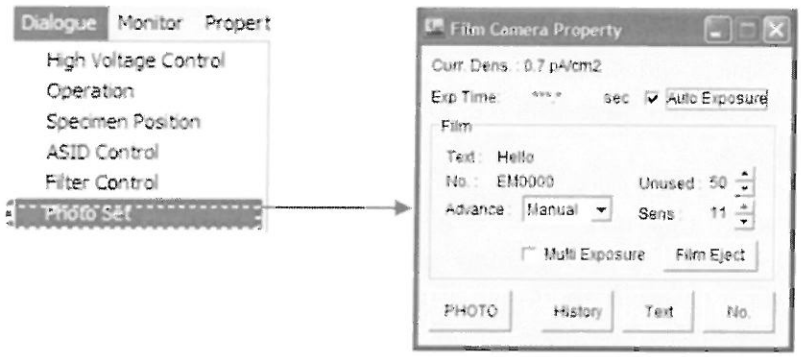


Fig. 5.4 Film Camera Property window

5.4 SPECIMEN EXCHANGE

5.4.1 Loading a Specimen on the Specimen Holder

1. Insert the cartridge removal tool to the cartridge-fixing bracket on the tip of the specimen holder and remove the cartridge (Fig. 5.5).

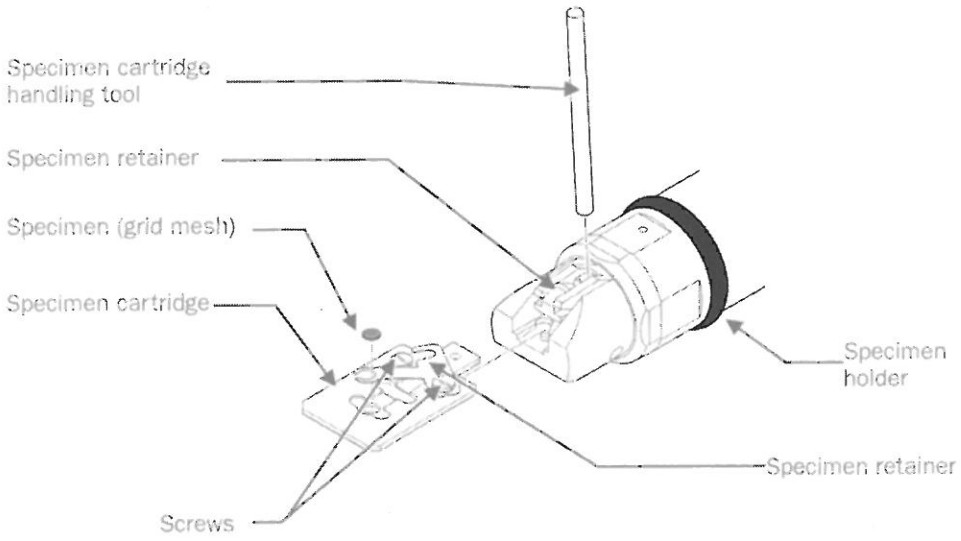


Fig. 5.5 Removing the specimen cartridge

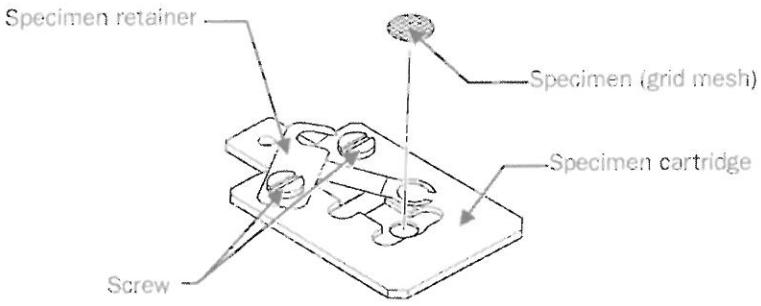


Fig. 5.6 Removing the specimen

2. Loosen the specimen retainer screws; rotate the specimen retainer; then remove the specimen (Fig. 5.6).
3. Place a specimen (grid mesh) with the specimen surface facing upward in the specimen cartridge.
4. Return the specimen retainer to the original position and secure it with the specimen retainer screws.
   The specimen is fastened.
5. Insert the cartridge removal tool in the cartridge-fixing bracket and raise the bracket.
6. Insert the cartridge into the tip of specimen holder, align the cartridge guide hole to the guide pin and return the specimen fixing bracket to its original position. Make sure that the specimen cartridge is fixed with the bracket (that there is no gap between the bracket and the cartridge).
   Ensure that the specimen cartridge is fixed with the fixing bracket (No gap between the bracket and the cartridge).

5.4.2 Inserting the Specimen Holder in the Microscope Column

1. Turn off the BEAM VALVE switch (L1-① or Fig. 4.29-④).
   The electron gun isolation valve V1 closes.
2. Make sure that there is no dust and/or lint on the specimen holder O-ring.
3. Align the specimen holder guide pin with the guide groove, push the holder into the goniometer until it stops without rotating and set the goniometer PUMP/AIR switch to PUMP (Fig. 5.7). The orange LED lamp lights up and the evacuation of the goniometer starts.

   Do not turn the specimen holder while evacuating the goniometer, because the evacuation stops if you turn the holder.

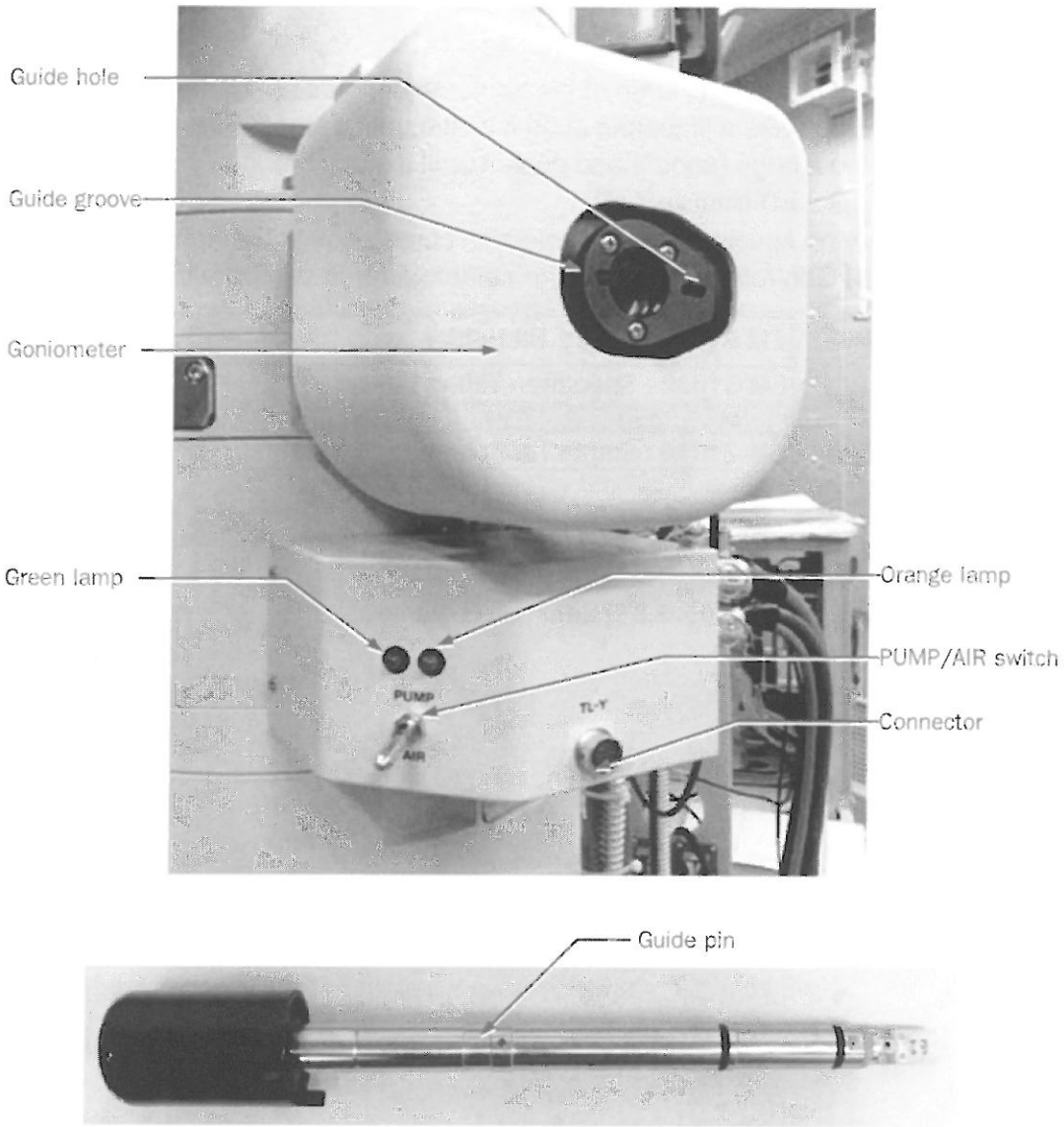


Fig. 5.7 Inserting the specimen holder in the column

⚠ CAUTION

- **When you insert the specimen holder into the goniometer, be careful so you do not pinch your fingers.**
  You might pinch your fingers between the specimen holder and the goniometer.

—CAUTION—

Always hold the specimen holder while inserting the holder into the goniometer.
If you release your hand from the holder, the specimen holder might hit the goniometer causing damage to the goniometer due to the force of the vacuum.

4. When the green LED lamp of the goniometer lights up, rotate the specimen holder clockwise a little, and push it a little until it stops. Further, rotate it clockwise a large amount and push it until it stops.
   The orange LED lamp goes off.
5. Click on the specimen holder selection combo box at the right main window of the TEM Controller and select the holder name to use from the list (Fig. 5.8).

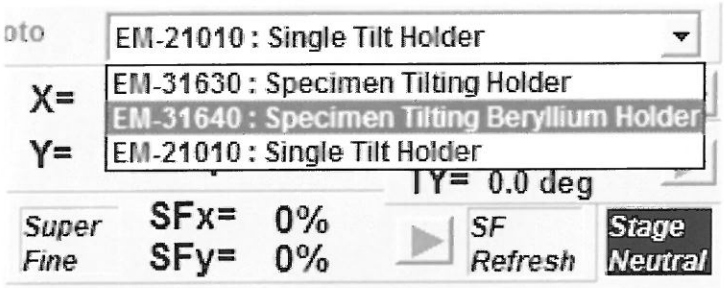


Fig. 5.8 Holder Select window

5.4.3 Removing the Specimen Holder from the Column

1. Turn OFF the BEAM VALVE switch (L1-①).
   The electron gun isolation valve V1 closes.
2. Double click on the **Stage Neutral** button on the right main window of the TEM Controller (Fig. 5.9).
   The specimen position moves to the origin.

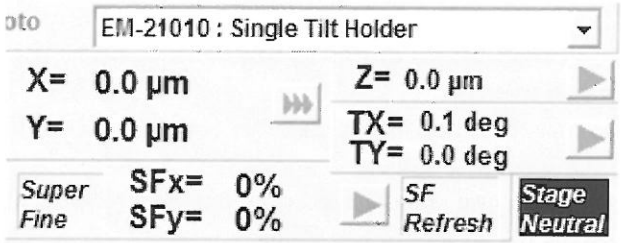


Fig. 5.9 Holder Select window

For dual axis tilt specimen holder, double-click the **Stage Neutral** button again.

3. Open the nitrogen gas supply valve.
4. Pull the specimen holder until it stops, turn it fully counterclockwise, pull it a bit until it stops, and then turn it fully counterclockwise until it stops.
5. Set the PUMP/AIR switch on the goniometer to AIR, wait 30 seconds, and then pull out the specimen holder.

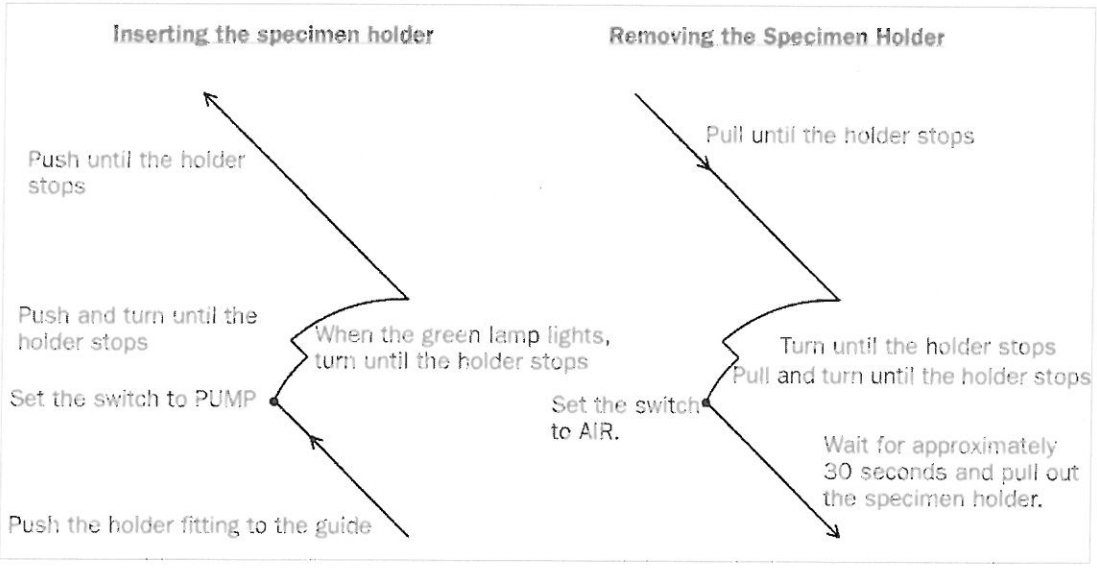


Fig. 5.10 Inserting the specimen holder

⚠ CAUTION

The goniometer stage contains parts using a Class 1 laser beam. When used normally, there is no danger. However, never remove any related parts and look at the beam directly.
Never look at the laser beam directly or its reflection on the mirror. It could damage your eye.

5.5 GENERATING THE ELECTRON BEAM

The High Voltage Control window (☞ Sect. 4.4.7b) is used for generating the electron beam. Even when the electron beam is generated automatically, the electron gun setting values can be changed in the High Voltage Control window. The new conditions are saved and used the next time he electron beam is generated automatically.

—CAUTION—

While the electron beam is being generated, keep the following precautions in mind.

- Be sure to close the electron gun chamber isolation valve (V1) before inserting or removing the specimen holder.
- Close the electron gun chamber isolation valve (V1) when microscopy is complete.
- Do not turn off the accelerating voltage.
- Do not touch the conditioning knob.

Failure to follow these precautions might damage the electron gun filament.

5.5.1 Outline for Generating the (200 kV) Electron Beam

The illustration shown below is the flowchart of operation necessary for microscopy using the 200 kV accelerating voltage (Fig. 5.11). HT conditioning is required before generating the electron beam. After generating the electron beam, or if there are plans to vent the column to atmospheric pressure, or a power interruption is expected, turn OFF the electron beam and accelerating voltage.

HT conditioning:	About 50 minutes
Beam generation (automatic):	1 hour and half to 2 hours
HV increment to 200 kV:	About 3 minutes
Stopping beam generation (automatic):	About 1 minute

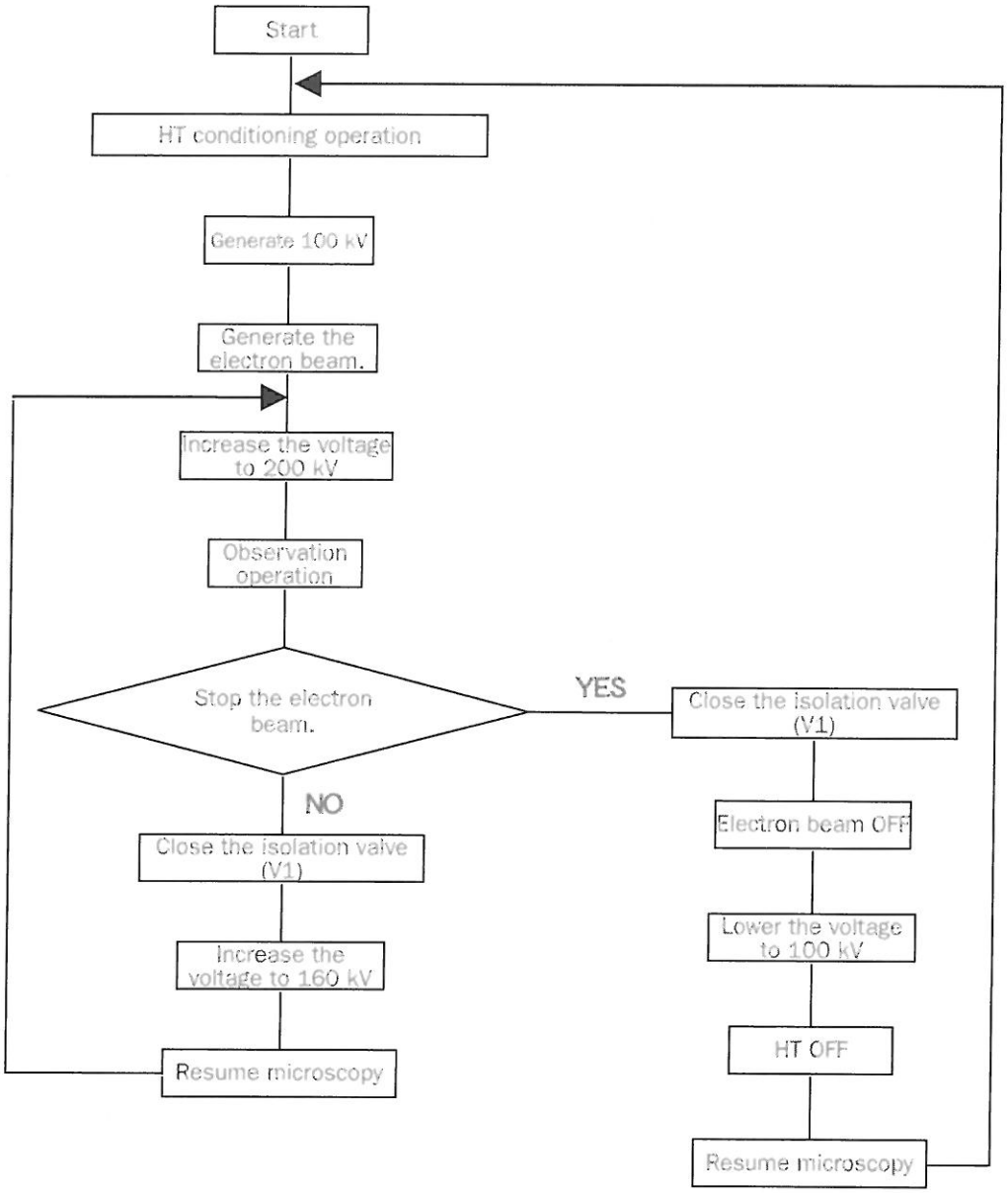


Fig. 5.11 Required operation to perform microscopy with acceleration voltage of 200 kV

5.5.2 HT Conditioning

The HT conditioning is required before turning on the high voltage. Open the High Voltage Control window (Fig. 4.29) (☞ Sect. 4.4.7b), select Usual (⑤ and ⑧ in High Voltage Control window) and display the High Voltage Control window in full screen (Fig. 5.12).

⚠ CAUTION

When operating the conditioning knob, stand on a stable, unmoving footstool.

If you use an unstable, easy-moving footstool, you run the risk of falling.

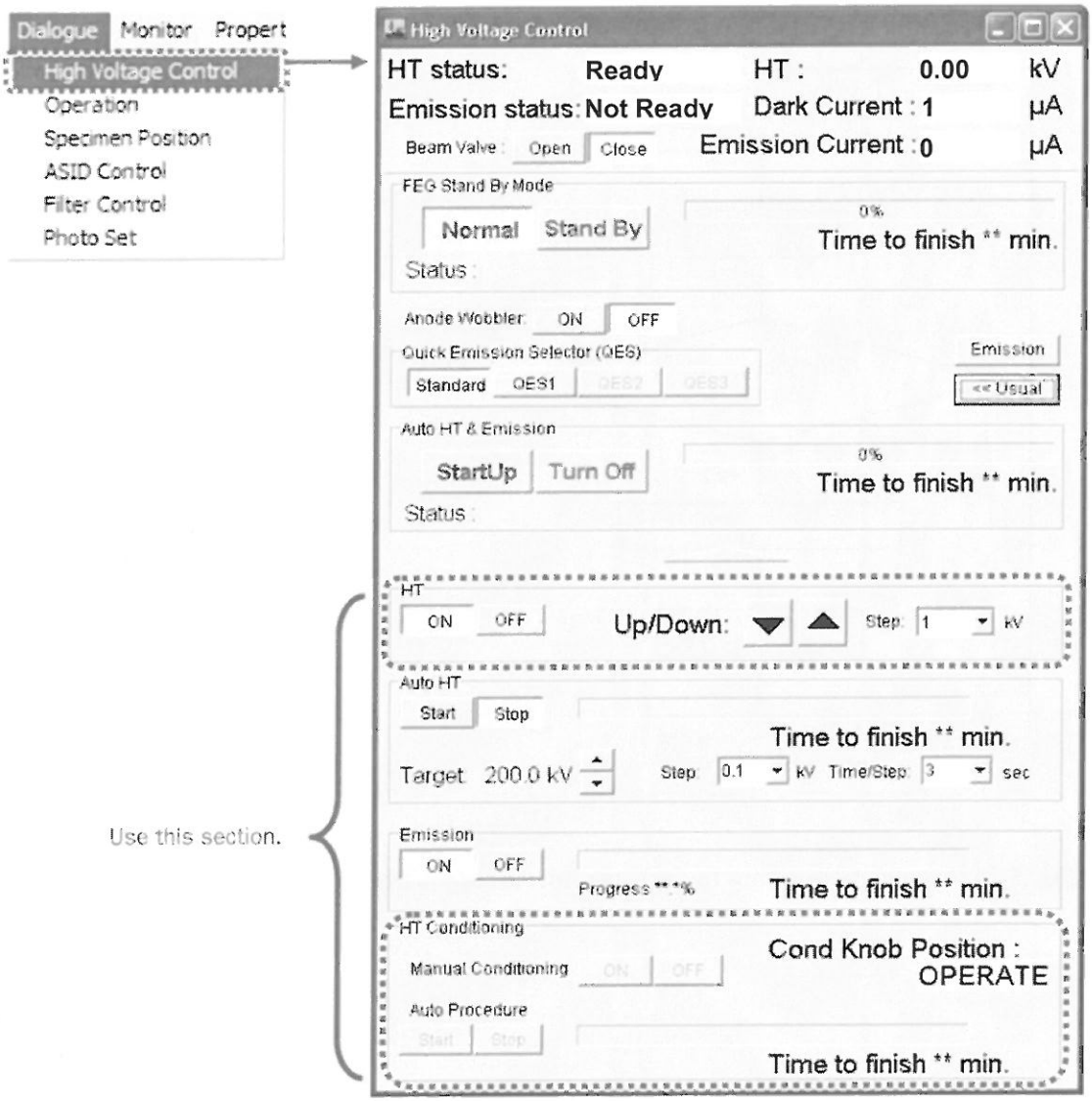


Fig. 5.12 High Voltage Control window

1. Click the HT **OFF** button, and set the "HT status:" to Ready.
2. Stand on a stable, unmoving footstool and set the conditioning knob to "COND".
   "COND" will be displayed in "Cond Knob Position:".

—CAUTION—

Before operating the conditioning knob, make sure that the Dark Current value is set to 0 μA.

If you operate the knob while the value is not 0 μA, the electron gun or the high-voltage generation circuit might be damaged.

a. Turn the knob fully clockwise (Fig. 5.13-a).
b. Push it in toward the gun chamber until it stops (Fig. 5.13-b).
c. Turn it fully counterclockwise (Fig. 5.13-c).
d. Pull it out until it stops (Fig. 5.13-d).
e. Turn it fully clockwise (Fig. 5.13-e).

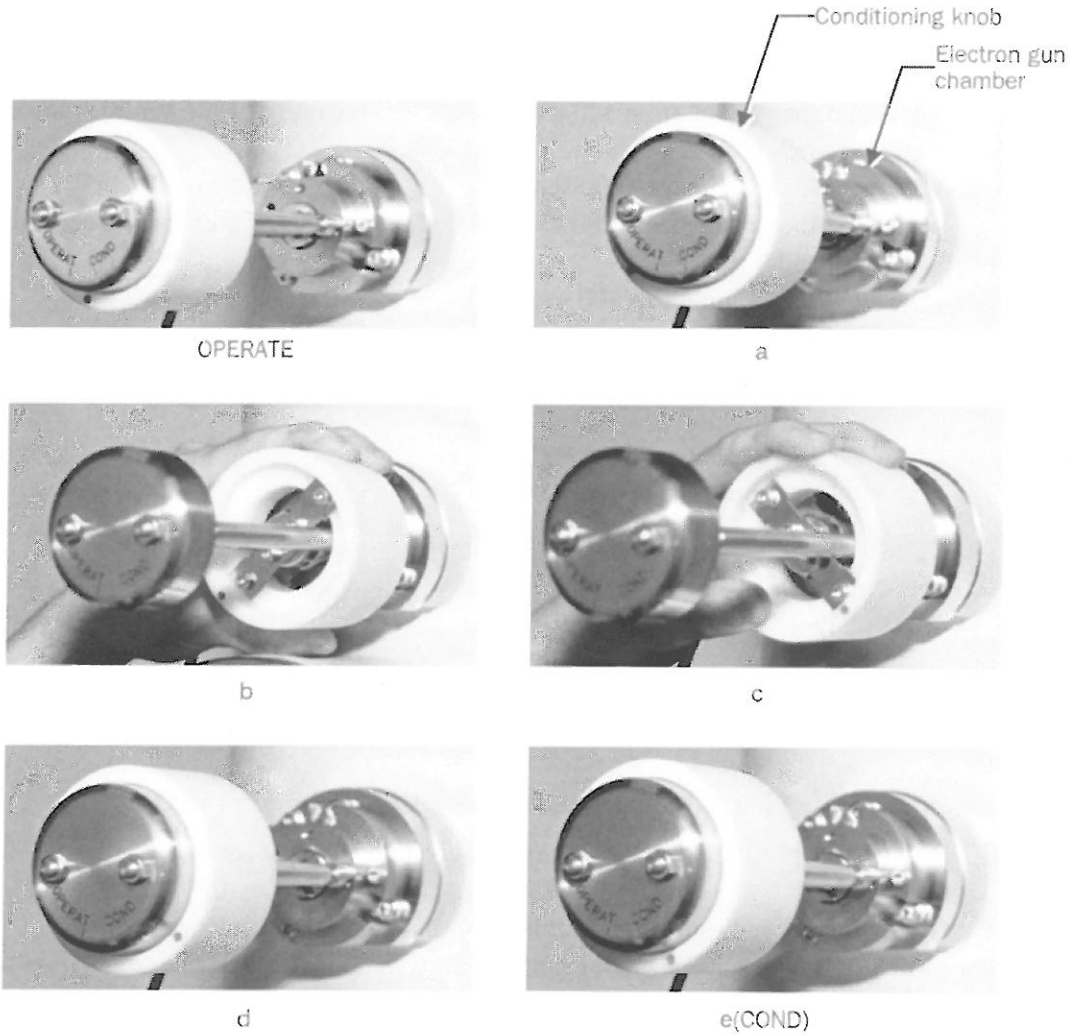


Fig. 5.13 Conditioning knob

"COND" will be displayed for "Cond. Knob Position" at the bottom part of the "High Voltage Control" window (Fig. 5.14).

Fig. 5.14 COND display

3. Set the HT: to 100 kV using the UP/DOWN buttons for the accelerating voltage (High Voltage Control window (Fig. 4.29-⑩)) and generate 100 kV of accelerating voltage.
4. Press the Manual Conditioning (High Voltage Control window (Fig. 4.29-⑩)) **ON** button.
   The value for HT: will be displayed as 100 kV in the window (High Voltage Control window (Fig. 4.29-①) or TEM Controller main window). However, 20 kV of conditioning voltage will be added and the acceleration voltage will increase to 120 kV.
5. Follow the schedule below to increase the acceleration voltage using the **UP/DOWN** buttons (High Voltage Control window (Fig. 4.29-④)) (Fig. 5.15).
   - Increase the voltage from 100 kV to 140 kV at the rate of 1 kV per second. (40 seconds)
   - Increase the voltage from 140 kV to 180 kV at the rate of 1 kV per 20 seconds. (800 seconds)
   - Leave it for 10 minutes. (600 seconds)
   - Increase the voltage from 180 kV to 200 kV at the rate of 1 kV per 30 seconds. (600 seconds)
   - Leave it for 15 minutes. (900 seconds)

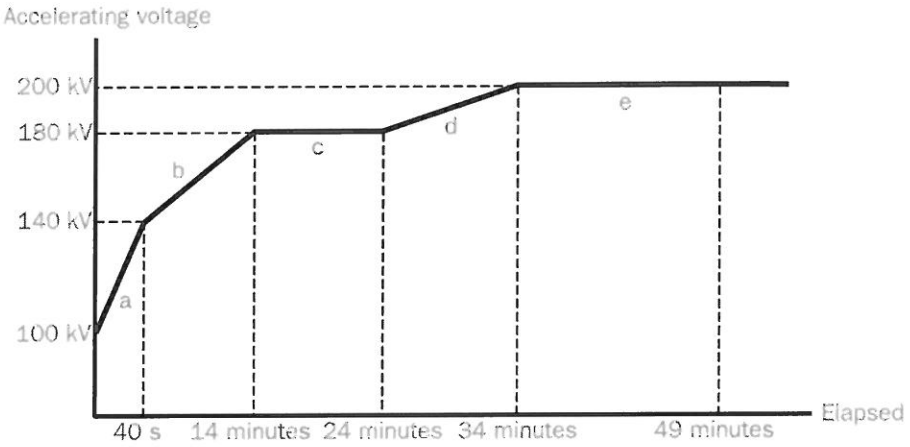


Fig. 5.15 Schedule for voltage increase

6. Press the Manual Conditioning (High Voltage Control window (Fig. 4.29-⑫)) **OFF** button.
   High voltage conditioning is complete. At this point, the accelerating voltage displayed on the screen is being generated.
7. Lower the value for HT: from 200 kV to 100 KV using the UP/DOWN buttons (High Voltage Control window (Fig. 4.32-⑨)).
8. When the value for HT: becomes 100 kV, press the HT (High Voltage Control window (Fig. 4.32-⑨)) **OFF** button.
9. Check that the value displayed for HT: is "0.00". Then set the conditioning knob to OPERATE.
   OPERATE will be displayed for the "Cond Knob Position:".

5.5.3 Generating the Accelerating Voltage

1. Confirm that the value of the pressure gauge at the lower part of the HT tank is 1.0 or more, and the value of the pressure gauge (electron gun insulation gas pressure) at the lower right side of the column is 3.0 or more (check several times a year).
   If the value does not reach the above values, supply SF_6 gas.
2. Confirm that the column pressure is 4×10^{-5}Pa or lower.
3. Make sure that the dispensing and receiving magazines are in the camera chamber, and the specimen holder is in the goniometer.
   If the specimen holder is not inserted in the goniometer, the electron gun chamber isolation valve (V1) cannot be opened.
4. Make sure that the Cond Knob Position indicator is set to OPERATE. OPERATE is displayed for "Cond Knob Position:".
5. Make sure that "HT status:" is Ready.
6. Set thevalue for "HT:" to 100 kV using the Up/Down buttons (High Voltage Control window (Fig. 4.32-⑨)).
7. Press the HT (High Voltage Control window (Fig 4.32-⑨)) **ON** button.

5.5.4 Generating the Electron Beam using the Automatic Mode

High Voltage Control window is used (Fig. 5.16).

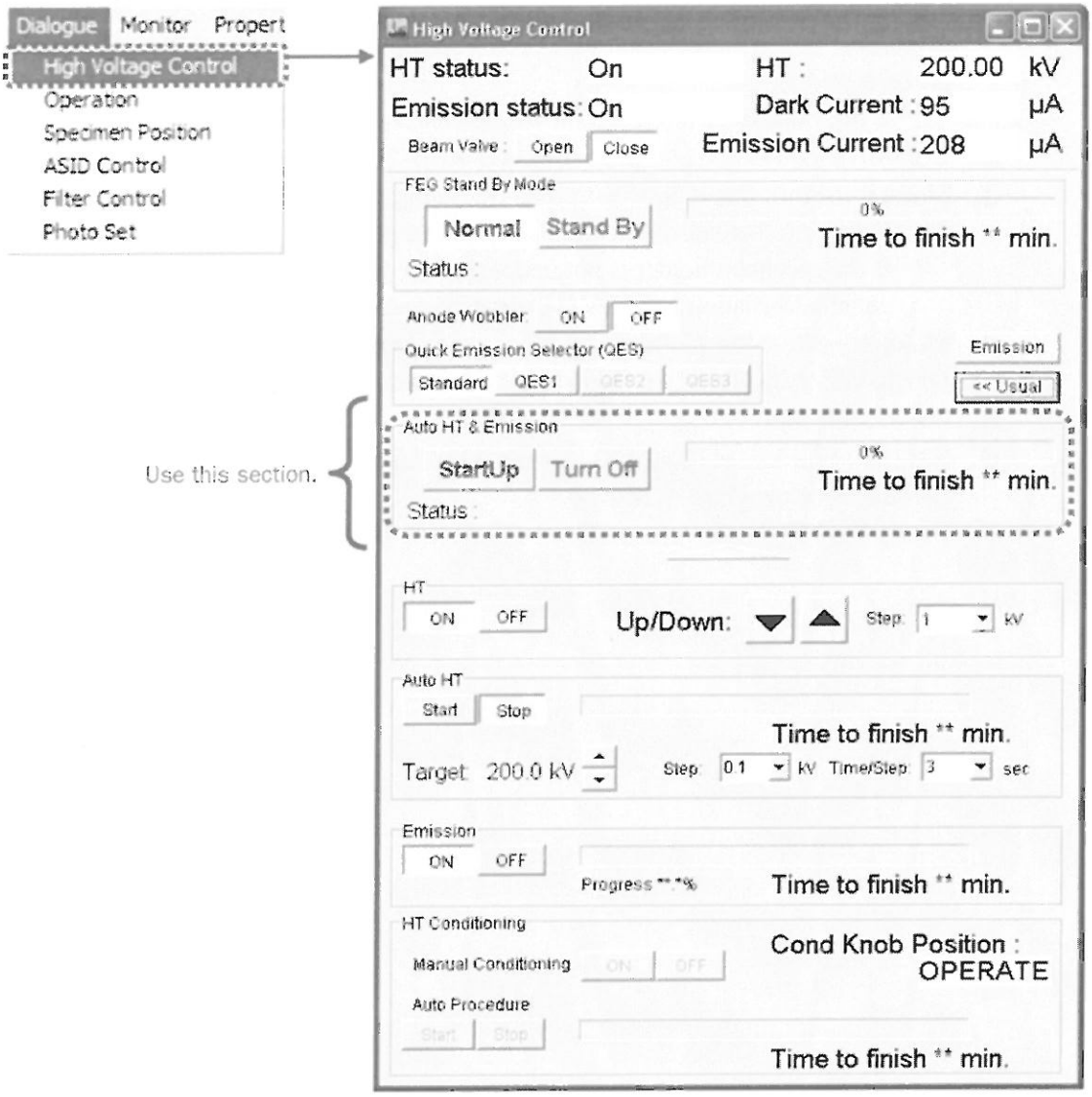


Fig. 5.16 High Voltage Control window

1. Check the following points.
   - 100 kV of acceleration voltage is being generated (displayed as "HT:"100 kV).
   - "Emission Status:" is Ready.
2. Click the Auto HT and Emission **Startup** button.
   The electron beam will be generated automatically in 90 to 120 minutes.
3. Make sure that "Emission Current:" reads the specified value (specified at installation) or less.

   If the difference between the specified value is 20 µA or more, contact your nearest JEOL service center. Clicking **Emission** will display the electron gun power supply value (Fig. 5.16). Additionally, do not change the power supply value until you are instructed by JEOL service office.

4. If the value of "Emission Current:" is not specified, click **Emission**, display the FEG and QES setting window (Fig. 5.17), read the display value for "A1", "A2", "Bias", "Filament" (Monitor) and contact the JEOL service office.

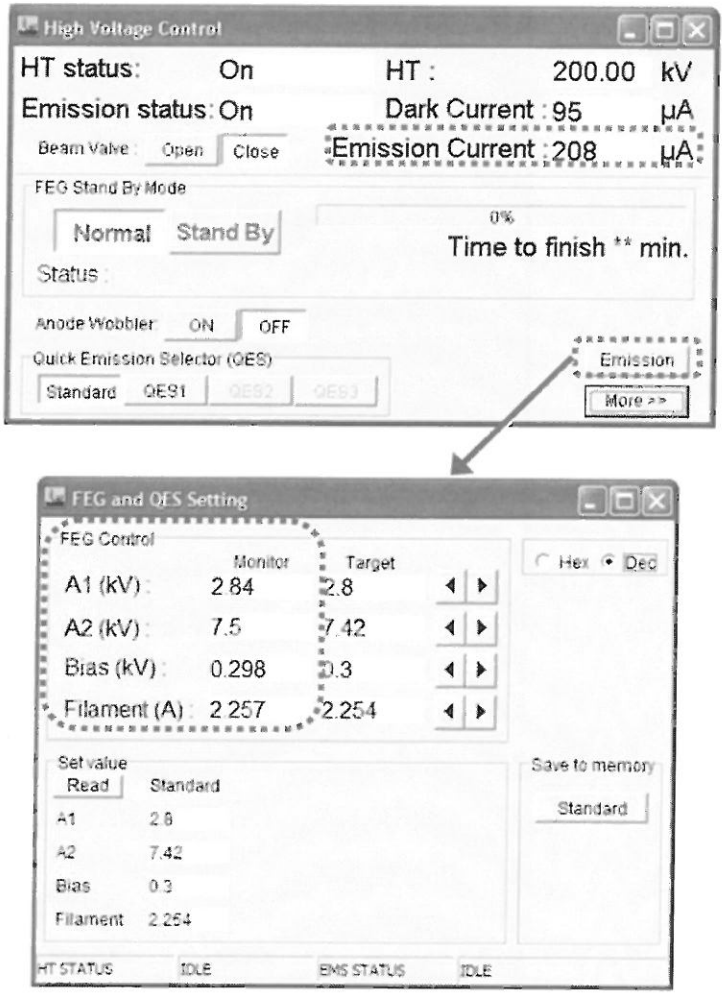


Fig. 5.17 FEG and QES Setting window

5.5.5 Turning off the Electron Beam using the Automatic Mode

Use the High Voltage Control window (Fig. 5.18).

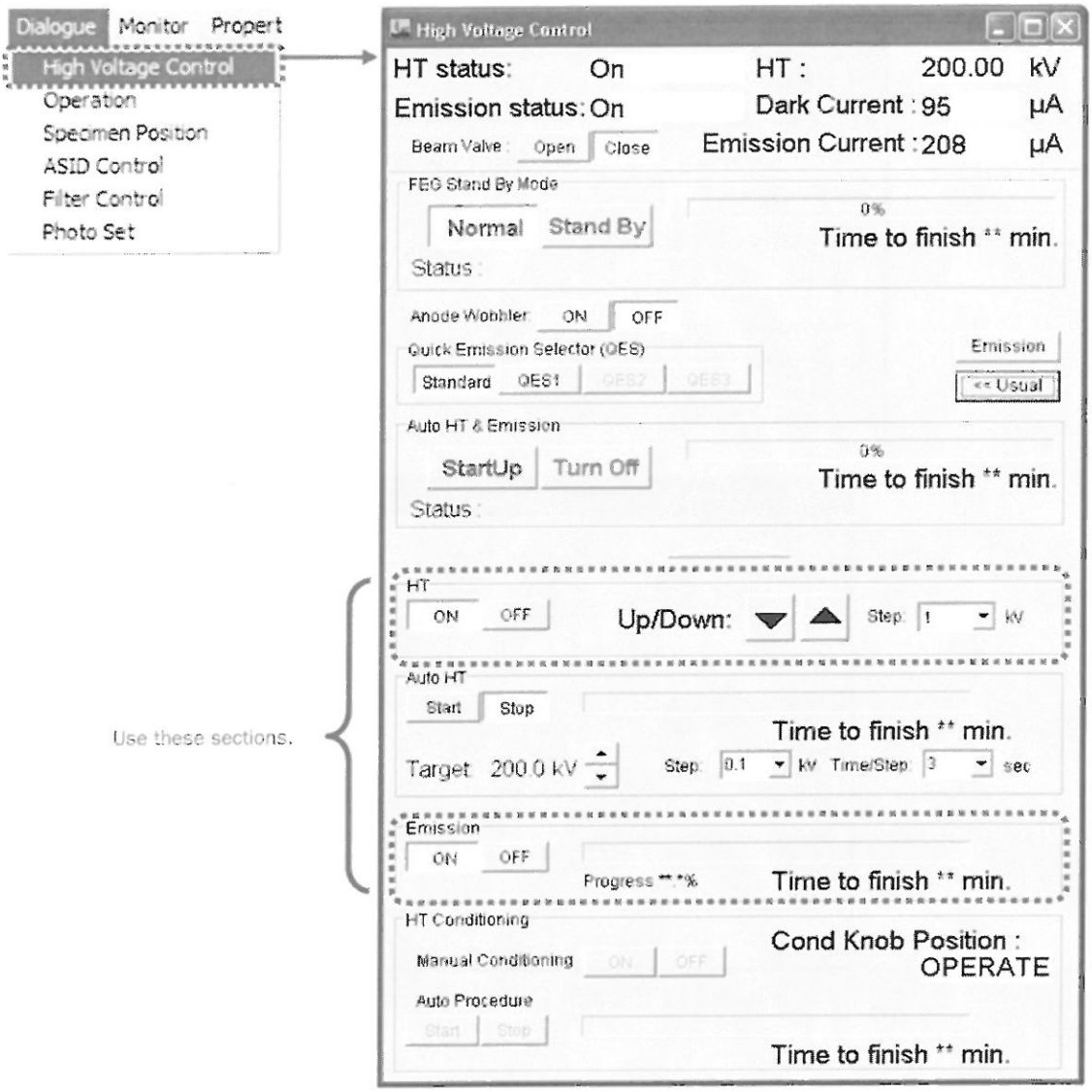


Fig. 5.18 High Voltage Control window

1. Click the **OFF** button in "Emission".
2. Set Auto HT-**Step** to 1 kV.
3. Set it to100 kV using the **Up/Down** buttons.
4. Click the **OFF** button in "HT".

5.5.6 Generating the Electron Beam using the Manual Mode

When the electron beam is turned on or off in automatic mode, the electron beam cannot be turned on manually. Execute this operation only when instructed by service personnel. Users are requested to refrain from executing this procedure. The High Voltage Control window and FEG and QES Setting window (Fig. 5.19) will be used (Fig. 5.17).

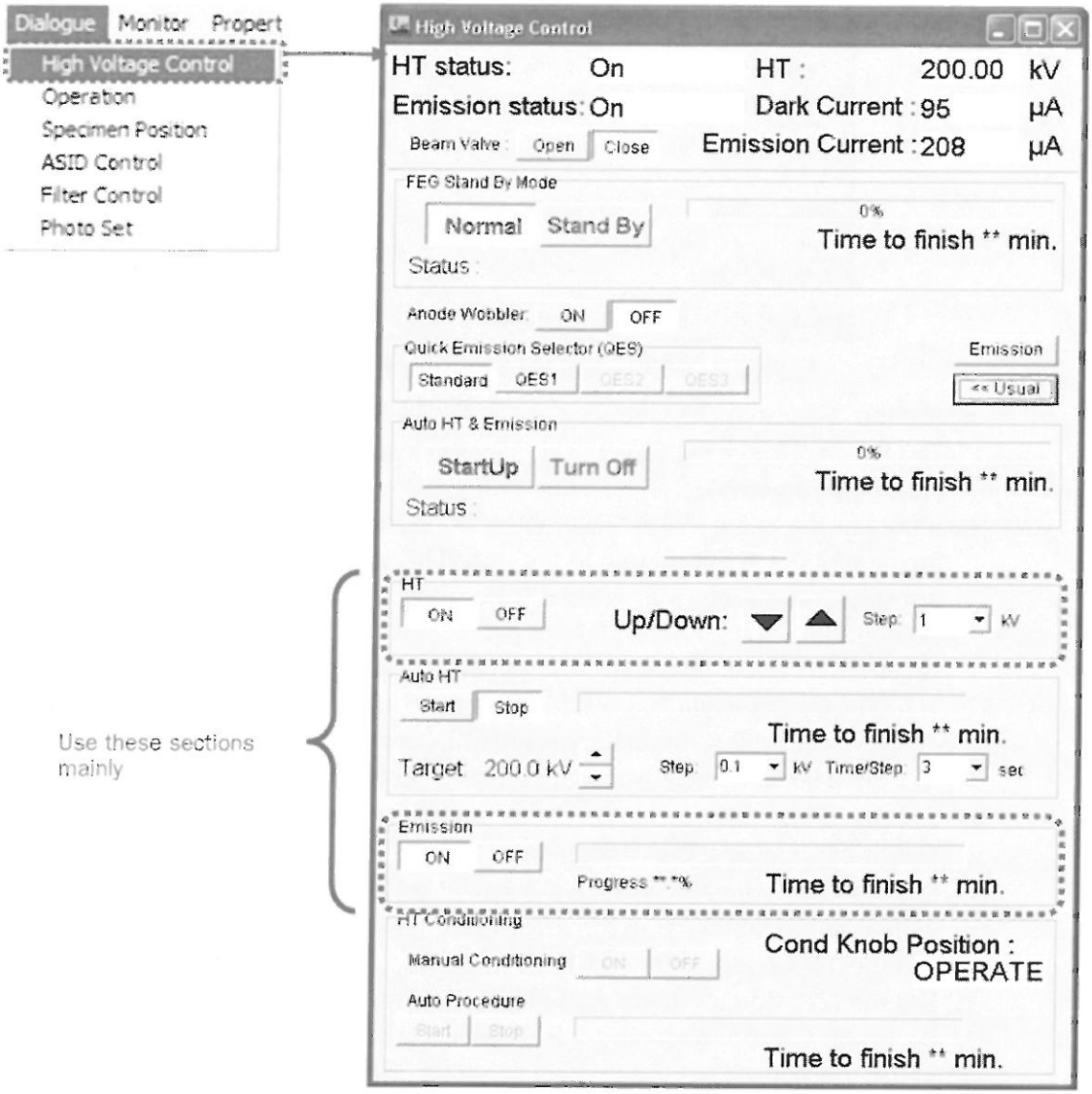


Fig. 5.19 High Voltage Control window

1. Check the following points.
   - 100 kV of acceleration voltage is being generated (displayed as "HT:"100 kV).
   - "Emission Current:" should be set to Ready.
   - "Cond Knob Position:" should be set to OPERATE.
2. Click the "Emission" **ON** button.
   "Emission Current:" becomes ON and starts blinking.

3. Set the emitter (filament) temperature to 1800 K (Fig. 5.20).

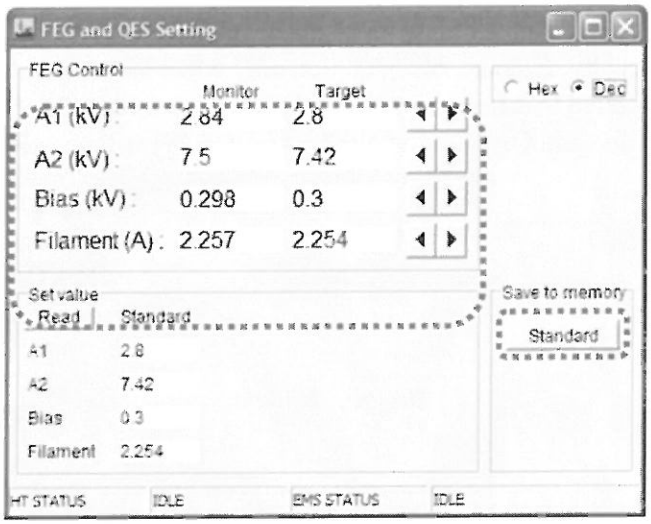


Fig. 5.20 FEG and QES Setting window

a. Set the "Filament (A):" monitor to 1.0 A with buttons.
The buttons change the Target value. The value in the Monitor column increases to match the Target value.

b. Increase the value in the "Filament:" Monitor column using the arrow buttons at the rate of 0.1 A per minute to the specified value that corresponds to the emission temperature of 1800 K (refer to setting value table); then leave it for 20 minutes.
An electron current (about 10 μA) will be generated (when no bias is applied).

The emitter might become damaged if the emitter temperature exceeds 1800 K. Even at 1800 K, the emitter might also become damaged if the emitter is left on for 2 hours or more without generating the electron beam.

4. Set the "Bias:" Monitor value to the specified value (displayed in the electron gun setting value table) using the buttons.
5. Set the "A2:" Monitor value to the specified value (displayed in the electron gun setting value table) using the arrow buttons.
a. Set the 1st anode voltage (A1) as follows.
b. Set the A1: Monitor value with the buttons so that the display value for Emission Current becomes 1.0. Then wait for 5 minutes.
c. In the same way, set the display value for "Emission Currents:" to 5.0 and wait for 5 minutes.
d. In the same way, set the display value for "Emission Currents:" to 10.0 and wait for 5 minutes.
e. Increase the display value to the specified value at the rate of 10 µA per 5 minutes.
6. Make sure that the filament current is the the same as the current value corresponding to 1 800 K (☞ electron gun setting value table). If it is not the same, follow the above 3 steps to adjust.
By pressing the Save to memory **Standard** button, the currently set values will be saved in each memory. Therefore, it can be used when generating the electron beam automatically next time.

5.5.7 Turning off the Electron Beam using the Manual Mode

Execute this operation only when instructed by JEOL service personnel. Users are requested to refrain from carrying out the procedure.

1. Close the gun isolation valve (V1).
2. Set the "A1:" Monitor value to the minimum value using the buttons.
   The first anode voltage becomes 0.
3. Set the "A2:" Monitor value to the minimum value using the buttons.
   The second anode voltage becomes 0.
4. Set the "Bias:" Monitor value to the minimum value using the buttons.
   The bias voltage becomes 0.
5. Set the "Filament:" Monitor value to the minimum value using the buttons.
   The filament acceleration voltage becomes 0.
6. Click the "Emission" **OFF** button.
7. Set **Step** to 1 kV in HT.
8. Set to 100 kV using the **Up/Down** buttons.
9. Click "HT" **OFF**.

5.6 INSERTING THE APERTURE

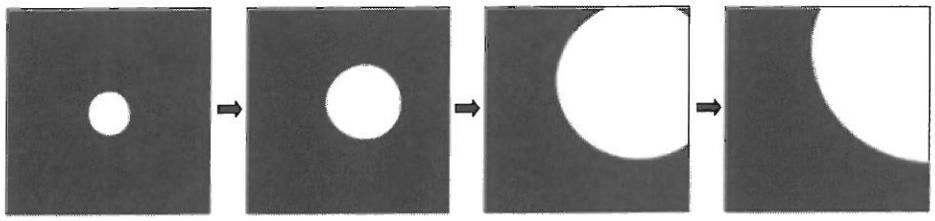
5.6.1 Aperture Operations

1. Perform all aperture operations with APERTURE CONT (L1-②).
2. Select the aperture to operate with aperture unit selection switch.
3. Select the hole number to use with aperture number selection switch.
4. Adjust the position with aperture shift switch.

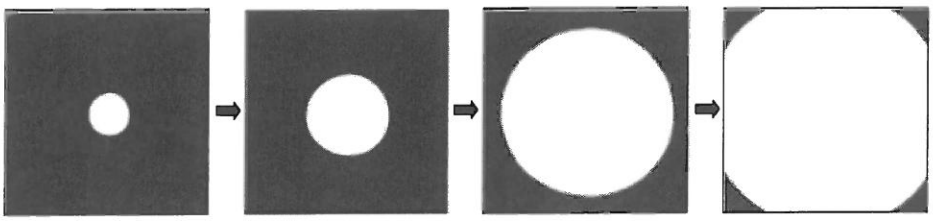
5.6.2 Condenser Lens (CL) Apertures

The CL aperture is used to control the illumination angle and brightness on the specimen. Larger apertures give larger illumination angles and brighter illumination.

1. Set it to MAG mode and focus the electron beam to its minimum using the BRIGHTNESS (L1-⑦) knob and move it to the center of fluorescent screen with SHIFT (L1-⑧, R1-④).
2. Select CLA using the APERTURE CONT (L1-②) aperture unit selection switch and select the desired aperture number to use with the aperture number selection switch.
3. Slowly turn the BRIGHTNESS knob clockwise. If the electron beam moves off the fluorescent screen center, center the beam with aperture shift switch.
4. Adjust the position of the aperture with the aperture shift switch so that the beam expands and contracts coaxially when the BRIGHTNESS knob is turned in the clockwise direction and counter clockwise direction around the focus position(Fig. 5.21).



(a) Aperture is not correctly inserted.



(b) Aperture is correctly inserted.

Fig. 5.21 Adjusting the CL aperture position

5.6.3 OL Aperture

The OL aperture is used to control the angle of beam scattering caused by the specimen. It affects the image contrast and the resolution.

1. Select DIFF from FUNCTION (R1-③ or Fig. 4.33-⑤). Then, select the desired camera length using the MAG/CAM L knob (R1-⑥, Fig. 4.33-⑥).
2. Select OLA using the APERTURE CONT (L1-②) aperture unit selection switch and then select the desired aperture number to use with the aperture number selection switch.
3. Focus the aperture using the FOCUS knob (L1-⑧).
4. Move the aperture to the desired location on the diffraction image with aperture shift switch.

5.6.4 Selected-area Aperture

The selected area (SA) aperture is used to select a region from the specimen to observe diffraction patterns.

1. Select SAM, MAG1 or MAG2 from FUNCTION (R1-③ or Fig.4.33-⑤), and set the desired magnification with the MAG/CAM L knob (R1-⑥ or Fig. 4.33-⑥)
2. Select SAA using the APERTURE CONT (L1-②) aperture unit selection switch and then select the desired aperture number to use with the aperture number selection switch.
3. Focus the aperture using the FOCUS knob (L1-⑧).
   It cannot be operated in MAG mode.
4. Select the area to observe by moving the specimen (control panel SC, control panel TR) or by using the aperture shift switch.

5.6.5 Incident Aperture

The incidence aperture limits the paraxial electron beam that enters the filter lens. The smaller the aperture size, the higher the energy resolution. If a small filter aperture is chosen, energy resolution will be high. However, the images will be dim. To limit the electron beam entering the filter lens, you could use either the field-limiting aperture in MAG mode or the OL aperture in DIFF mode. However, an incident beam size independent of magnification or camera length can be obtained by using the incident aperture.

1. Choose the desired magnification or the camera length (R1-⑥ or Fig. 4.33-⑥).
2. Select ENTR using the APERTURE CONT aperture selection switch (L1-②) and select the aperture number to use using the aperture-number selecting switch.
3. Adjust the aperture position using the aperture shift switches.

5.7 OPERATING THE FILTER LENS

5.7.1 Adjusting the Filter Lens

Screws for adjusting the position of the filter lens are provided on the microscope column. Be careful not to turn these screws. The filter lens should be adjusted only for the following electrical items. Normally, there is no need to adjust the items other than FL-FOCUS. Adjust the other items only when it is absolutely necessary to do so.

- FL-FOCUS:
  Vary with FL knob (Fig. 4.2 L1-④) on the panel. By adjusting the filter lens electric current, the position of the electron beam on the slit surface will be determined. Set the energy shift (Fig. 4.42-④) to zero and then set to SPCTR mode (R1-③ or Fig. 4.42-⑮). Adjust so that the zero-loss electrons will be positioned nearest to the center of the field of view.
- FLA1 (X/Y):
  When DEF Select - FLA (Fig. 4.42-⑱) is selected from the PC window Filter Tuning, this can be varied with the SHIFT knobs (L1-⑧, R1-④) of control panel L1 and control panel R1. This is used to return the shifted field of view when the observation magnification has been changed. It can also be used to perform electromagnetic image shift.
- FLA2 (X/Y):
  When DEF Select - FLA (Fig. 4.42-⑱) is selected from the PC window Filter Tuning, this can be varied with the DEF/STIG knobs (L1-⑩, R1-⑤) of control panel L1 and control panel R1. This is used when aligning the shadow, which appears when the slit is inserted, to the center.
- FLS1(X/Y):
  When DEF Select (2) - FLS1 (Fig. 4.43-①) is selected from the PC window Filter Tuning (more), this can be varied with the DEF/STIG knobs (L1-⑩, R1-⑤) of control panel L1 and control panel R1. Use it for astigmatism correction for low magnification images if astigmatism appears in the low magnification image even when OL stigmator in the high magnification image was executed.
- FLS2(X/Y):
  When DEF Select (2) - FLS1 (Fig. 4.43-①) is selected from the PC window Filter Tuning (more), this can be varied with the DEF/STIG knobs (L1-⑩, R1-⑤) of control panel L1 and control panel R1. The operation is the same as FLS1. Either one can be used.

5.7.2 Inserting the Slit

1. Set the desired image forming mode and magnification for observation.
2. Select SPCTR for FUNCTION (R1-③). Or select Spectroscopy (Fig. 4.42-⑮) from the PC window Filter Tuning.
3. Bring the edge of the spectrum to the center of the large fluorescent screen using the FOCUS knob (R1-⑧).
   Before changing to SPCTR mode, focus the electron beam irradiation area to a diameter of less than a few centimeters on the fluorescent screen using the BRIGHTNESS knob (L1-⑦). It may be easier to adjust by inserting the SA aperture (☞ Sect. 5.6.4).
4. Select the SLIT switch (L1-④) or IN (Fig. 4.42-⑩) from the PC window Filter Tuning and insert the slit into the optical axis.
5. Set the slit width using the Tuning width (Fig. 4.42-⑪) of Filter Tuning.
   The slit width is normally set to 10 to 20 eV. If it is set smaller than this, the field of view may become limited.
6. Pass through the edge of the spectrum using the FL knob (Panel L1-④).
7. Press SPCTR from FUNCTION (R1-③) and turn OFF the SPCTR mode. Or select Imaging (Fig. 4.42-⑮) from the PC window Filter Tuning.
   You can now observe an image (known as a zero-loss image) that is formed by only the electrons that undergo no energy loss by the specimen (zero-loss electrons).

5.7.3 Setting the Energy Shift

Energy Shift refers to slightly increasing the accelerating voltage of the electron gun (superposition of accelerating voltage).

- Use the **ENGY SHIFT** button (L1-④) or the **ON** check box (Fig. 4.42-①) from Filter Tuning window to switch ON/OFF. Or change the accelerating voltage using the [◀], [▶] (Fig. 4.42-④) buttons in the Filter Tuning window.

5.8 ALIGNING THE ILLUMINATION SYSTEM

5.8.1 Axis Alignment

1. Set the magnification to ×5,000 in MAG mode.
2. Set the spot size to 1 using the SPOT SIZE knob (L1-③ or Fig. 4.33-②), and focus the electron beam using the BRIGHTNESS knob (L1-⑦).
3. Select Alignment — **Gun** (Fig. 4.33-⑦) from the Operation (Standard) screen or DEF Select — **Gun** (Fig. 4.61-①) from the Alignment Panel for Maintenance.
4. Adjust the electron beam to the center of the fluorescent screen using the SHIFT X and Y knobs (L1-⑧, R1-④) or the DEF/STIG knobs (L1-⑩, R1-⑤).
5. Click on Anode Wobbler: **ON** (Fig. 4.29-③) in the High Voltage Control window. Use the SHIFT knobs or DEF/STIG knobs to adjust so that the electron beam expands and contracts symmetrically around the center of the image display window.
6. Click the Wobbler — **Anode** (Fig. 4.29-③) **OFF** button and set the spot size number to 5 (L1-② or Fig. 4.33-②).
7. Press the BRIGHT TILT switch (L1-⑥). Select Alignment — **CL** (Fig. 4.33-⑦) from the Operation (Standard) window or DEF Select — **CLA** (Fig. 4.61-①) from the the Alignment Panel for Maintenance.
8. Adjust the electron beam to the center of the fluorescent screen using the SHIFT knobs (L1-⑧, R1-④).
9. Repeat steps 2 to 8 until the electron beam stays at the center of the fluorescent screen.

5.8.2 Correcting the CL Astigmatism

If astigmatism is present in the condenser lens, the electron beam, when it is brought to a focus on the fluorescent screen, is elongated and the brightness is insufficient. Astigmatism correction is performed to change the shape of the electron beam spot to become round.

1. Insert the CL aperture (☞ Sect. 5.6.2).
2. Focus the beam using the BRIGHTNESS knob (L1-⑦) so that the electron beam becomes smallest.
3. Press the COND STIG switch (L1-⑥). Or select Stigmator — **CL** (Fig. 4.33-⑦) from the Operation (Standard) screen or Stigmator — **CL STIG** (Fig. 4.61-②) from the Alignment Panel for Maintenance.
4. Slowly turn the BRIGHTNESS knob back and forth around the focus position and adjust the DEF/STIG knobs (L1-⑩, R1-⑤) so that the shape of the electron beam spot becomes round immediately before and after focusing the electron beam to the minimum.

5.8.3 Adjusting the CL Deflector Coil

5.8.3a Adjusting shift

Adjust the ratio of the currents in the 1st and 2nd CL deflection coils so that the electron beam spot remains stationary when the electron beam is tilted.

1. Focus the electron beam at ×10,000 in MAG mode using the BRIGHTNESS knob (L1-⑦).
2. Center the electron beam on the fluorescent screen using the SHIFT knobs (L1-⑧, R1-④).
3. If Wobbler — **TiltX** (Fig. 4.61-④) is selected from the Alignment Panel for Maintenance window, the electron beam is split into 2.
4. Select Compensator — **Tilt** (Fig. 4.61-③) from the Alignment Panel for Maintenance window.
5. Unify the split electron-beam spot using the DEF/STIG X knob (L1-⑩).
6. Click the Wobbler — **TiltX** button (Fig. 4.61-④) again to turn it OFF.
7. Center the electron beam on the fluorescent screen using the SHIFT knobs.
8. Click the Wobbler — **Tilt Y** button (Fig. 4.61-④).
9. Unify the split electron-beam spot using the DEF/STIG Y knob (L1-⑤).
10. Click the Wobbler — **Tilt Y** button (Fig. 4.61-④) again to turn it OFF.

5.8.3b Adjusting tilt

Shift adjustment consists of adjusting the ratio of the currents in the 1st and 2nd CL deflection coils so that the electron beam does not tilt when the electron beam is shifted.

1. Set to DIFF mode (R1-③ or Fig. 4.33-⑤)
2. Turn the BRIGHTNESS knob (L1-⑦) fully counterclockwise.
3. Adjust the FOCUS knob (R1-⑧) to obtain a caustic spot.
4. Select Wobbler — **Shift X** (Fig. 4.61-④) from the Alignment Panel for Maintenance window. The caustic spot is split into two parts.
5. Select Compensator — **Shift** (Fig. 4.61-③) from the Alignment Panel for Maintenance window.
6. Unify the split caustic spot using the DEF/STIG X knob (L1-⑩).
7. Press the Wobbler — **Shift X** (Fig. 4.61-④) and turn it OFF.
8. Select Wobbler — **Shift Y** (Fig. 4.61-④).
9. Unify the split caustic spot using the DEF/STIG Y knob (L1-⑤).
10. Press the Wobbler — **Shift Y** (Fig. 4.61-④) and turn it OFF.

5.9 AXIS ALIGNMENT

5.9.1 Centering the Current Axis

1. Set MAG mode and set an appropriate magnification (R1-③ or Fig. 4.33-⑤).
2. Focus with OBJ FOCUS (R1-⑦).
3. Spread the electron beam fully on the fluorescent screen and move a target image to the center of the screen.
4. The image will expand and contract when Wobbler — **OBJ** (Fig. 4.61-④) from the Alignment Panel for Maintenance window or OBJ (Fig. 4.34-②) from Wobbler is selected.
5. Press the BRIGHT TILT switch (L1-⑥). Or, select Alignment — **CL** (Fig. 4.33-⑦) from the Operation (Standard) screen or DEF Select — **CLA** (Fig. 4.61-①) from the Alignment Panel for Maintenance.
6. Adjust the DEF/STIG knobs (L1-⑩, R1-⑤) so that the image expands and contracts around the center of the fluorescent screen.
7. Click on Wobbler — **OBJ** (Fig. 4.61-④) again to turn it off.

5.9.2 Centering the Voltage Axis

1. Set MAG mode (R1-③ or Fig. 4.33-⑤) and set an appropriate magnification.
2. Focus the image using OBJ FOCUS (R1-⑦).
3. Spread the electron beam fully on the fluorescent screen and move a target image to the center of the screen.
4. Press the HT WOBB switch (R1-②). Or select HT from Wobbler window (Fig. 4.34-①) or Wobbler — **HT** (Fig. 4.61-④) from the Alignment Panel for Maintenance. The image expands and contracts.
5. Press the BRIGHT TILT switch (L1-⑥). Or, select Alignment — **CL** (Fig. 4.33-⑦) from the Operation (Standard) screen or DEF Select — **CLA** (Fig. 4.61-①) from the Alignment Panel for Maintenance.
6. Adjust the DEF/STIG knobs (L1-⑩, R1-⑤) so that the image expands and contracts around the center of the fluorescent screen.
7. Turn OFF the HT WOBB switch (R1-②).

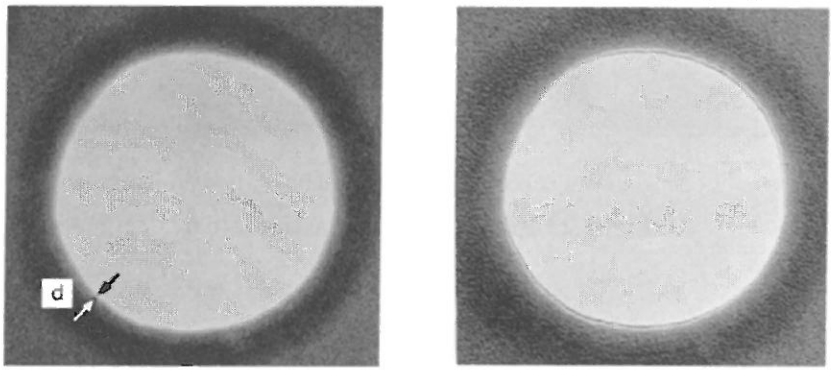
5.10 CORRECTING THE OL ASTIGMATISM

5.10.1 Correcting the OL astigmatism at medium magnifications

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

1. Set to MAG mode and set the magnification to 20,000 or more. Adjust the brightness of the image with the BRIGHTNES knob (L1-⑦) and the electron beam position with the SHIFT knob (L1-⑧, R1-④).
2. Focus with OBJ FOCUS (R1-⑦).
3. Find an appropriate film hole by moving the specimen (control panel GC, control panel TR).
4. Press the OBJ STIG switch (L1-⑥). Or, select Stigmator — **OL** (Fig. 4.33-⑦) from the Operation (Standard) screen or Stigmator — **OL STIG** (Fig. 4.61-②) from the Alignment Panel for Maintenance.
5. Adjust the OBJ FOCUS knob (R1-⑥) so that the image of the film hole is overfocused, and Fresnel fringes appear along the edges of the hole (Fig. 5.22-b).
6. Adjust the DEF/STIG knobs (L1-⑩, R1-⑤) so that Fresnel fringes appear to have equal contrast (Fig. 5.22-a) in all directions around the circumference of the hole.

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



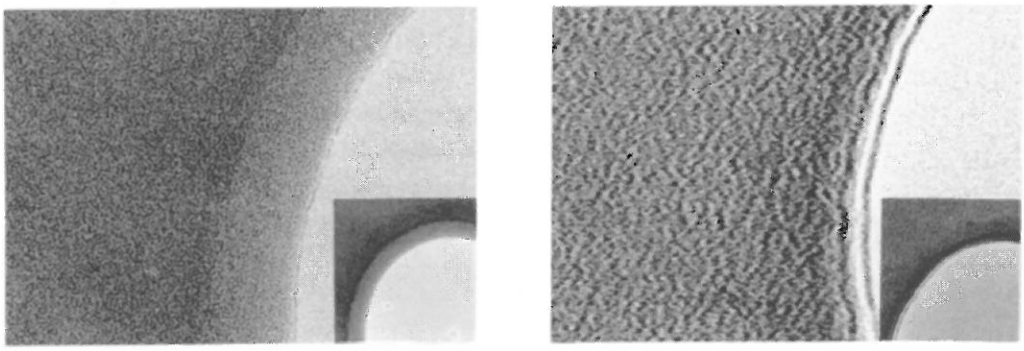
a. Astigmatism is not present b. Astigmatism is present

Fig. 5.22 Correcting the OL Astigmatism

5.10.2 Correcting the OL astigmatism at high magnifications

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

1. Set to MAG mode and set the magnification to 100,000 or more. Adjust the brightness of the image with the BRIGHTNESS (L1-⑦) knob and adjust the beam position using the SHIFT knobs (L1-⑧, R1-④).
2. Focus with OBJ FOCUS (R1-⑦).
3. Look for an amorphous part by moving the specimen (control panel GC, control panel TR).
4. Press the OBJ STIG switch (L1-⑥). Or, select Stigmator — **OL** (Fig. 4.33-⑦) from the Operation (Standard) screen or Stigmator — **OL STIG** (Fig. 4.61-②) from the Alignment Panel for Maintenance.
5. Adjust the OBJ FOCUS so that the image of the amorphous part is overfocused or underfocused, and observe the variations of its phase contrast image (Fig. 5.23-b).
6. Adjust the DEF/STIG knobs (L1-⑩, R1-⑤) so that there are resolved small spots on the phase contrast image (Fig. 5.23-a).



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

Fig. 5.23 Effect of the OL astigmatism

5.11 FOCUSING

Focusing images at low magnifications can readily be performed using the image wobbler. However, at high magnifications; focusing using Fresnel fringes is more useful. Furthermore, focusing using micro point images is more suitable for very high magnifications.

5.11.1 Focusing Using Image Wobbler

1. Change to MAG mode.
2. Press the IMAGE WOBB X switch or Y switch (R1-②). Or Image X or Y from the Wobbler window (Fig. 4.34-③, ④) or Wobbler — **Image X** or **Image Y** (Fig. 4.61-④) from the Alignment Panel for Maintenance.
   The image looks like a double image (Underfocus and Overfocus in Fig. 5.24).
   If you use the Image Wobbler with the OL aperture or slit, the field of view may be largely obstructed. Set the OL aperture to a larger size or OPEN and set the slit to OUT.
3. Adjust the OBJ FOCUS (R1-⑦) knobs so that the double image is unified and looks stationary (In focus in Fig. 5.24).
4. Turn OFF the X switch or Y switch of the IMAGE WOBB.

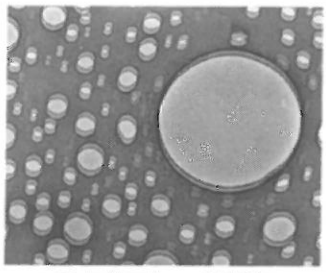
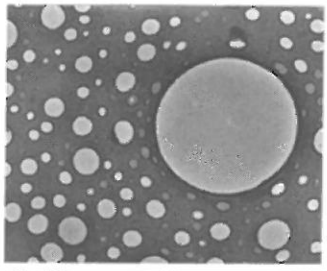
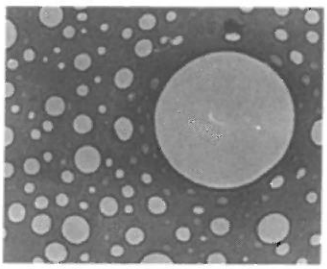
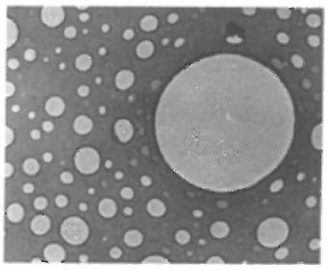
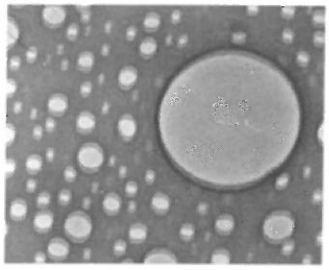
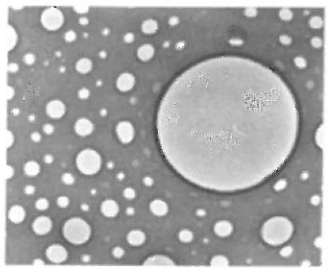
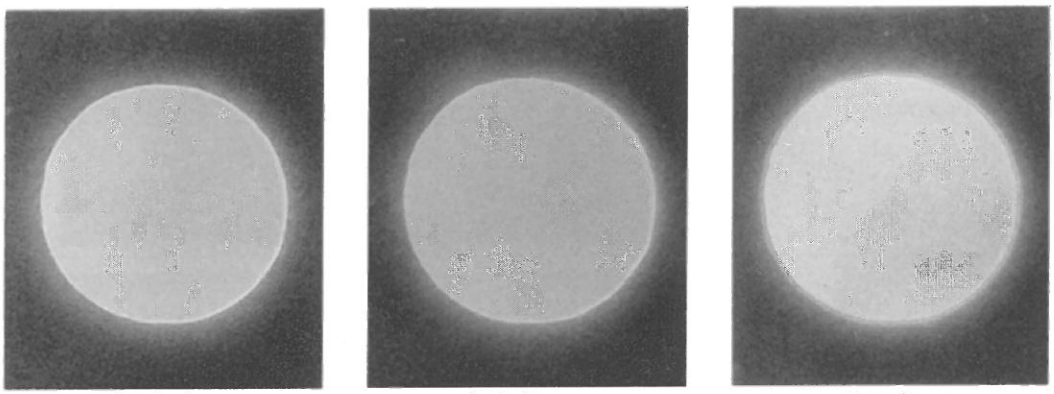
	WOBBLER-IMAGE X switch	
	ON	OFF
Underfocus		
In Focus (Just focus)		
Over Focus		

Fig. 5.24 Focusing using image wobbler

5.11.2 Focusing Using Fresnel Fringes

1. Obtain the sharpest image (rough focus adjustment) by adjusting the OBJ FOCUS COARSE knob (R1-⑦).
2. While observing the part of the object where the contrast is highest (For practice, a hole in the specimen supporting film or foreign particles such as dust on the specimen is suitable), slightly turn the FOCUS knob clockwise and counterclockwise and check the position for exact focus.
   - If the specimen is a film hole, turning the FINE knob counterclockwise makes a high-contrast fringe (Fresnel fringe) appear inside of the hole along the contour, as shown in Fig. 5.25 - a. Such defocusing is called "under focus". As the defocusing increases, the Fresnel fringe becomes wider.
   - On the other hand, as shown in Fig. 5.25-c, when the FINE knob is turned clockwise from a focused condition, a bright fringe (Fresnel fringe) appears outside the boundary. Such defocusing is called "over focus". As the defocusing increases, the distance between the contour of the hole and the fringe becomes larger.
3. Gradually turn the FINE knob clockwise from an underfocus condition.
   - The width of the fringe with a strong brightness that follows the shape of the hole becomes thinner. The state where the contrast has decreased the most and the fringe has disappeared as in Fig. 5.25-b is called "Just focus".
   - As the knob is turned clockwise, an unclear focus condition continues in an extremely small range (in photography, the overfocus fringe is already appearing), and then the bright fringe appears inside the boundary, indicating overfocus.



a: Underfocus b: In-focus c: Overfocus

Fig. 5.25 Focusing using Fresnel fringes

4. Use the OBJ FOCUS knob to set to the exact-focus position or the underfocus position where the knob is slightly turned counterclockwise.

   When observing a specimen with a low contrast (such as a biological ultra-thin section), the most useful focus frequently lies at a slightly underfocus condition. The most suitable focus to take a photo is called optimum-focus, in distinction from just-focus.

5.11.3 Focusing Using Micro Point Images

To focus at ×100,000 magnification or higher, use of Fresnel fringes (underfocus and overfocus) together with micro point images in the background greatly enhances the accuracy of focusing. First, focus on an image using the Fresnel fringe in underfocus, as accurately as possible; then focus using the micro point image in such a way that each point has the minimum contrast (in-focus).
Fig. 5.26 shows images of the film hole obtained while varying the focus. It is possible to see the correspondence of the changes in the background micro-point images and the changes in the Fresnel fringe.

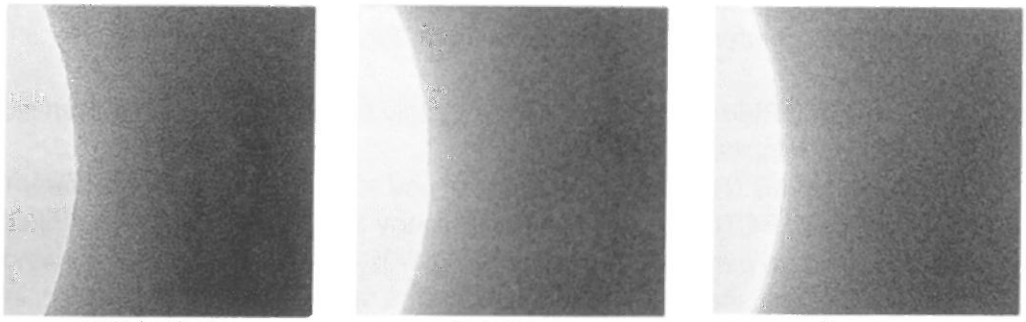


Fig. 5.26 Focusing with Fresnel fringe

5.12 IMAGE OBSERVATION

5.12.1 Observing TEM Images

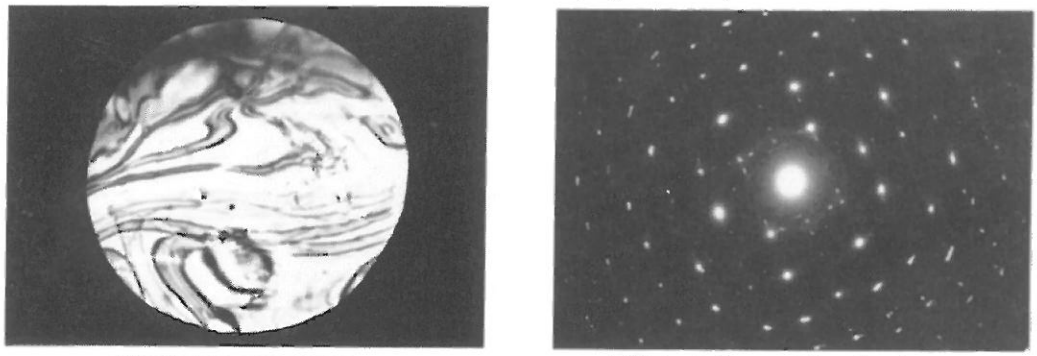
Procedure for obtaining ordinary TEM images.

1. Prepare the specimen (☞ Sect. 5.4).
2. Generate an electron beam (☞ Sect. 5.5).
3. Check that the energy shift (L1-④ or Fig. 4.42-①) is turned OFF.
4. The electron beam should reach the fluorescent screen. If you cannot observe the electron beam, carry out the following operations.
   a. Use a larger condenser aperture, and decrease the magnification (☞ Sect. 5.6.2).
   b. Turn the BRIGHTNESS knob (L1-⑦) fully clockwise once, and then slowly turn it counterclockwise.
   c. Set to LMAG (R1-③ or Fig. 4.33-⑤) and search for the electron beam.
   d. Turn ON SPCTR (R1-③) or Spectroscopy (Fig. 4.42-⑮) from the Filter Tuning window and perform Degauss (Fig.4.42-⑲) from the Filter Tuning window.
   e. Remove the specimen holder; unload the specimen from the holder; insert the holder into the column; then search for the beam again by following the above operation (☞ Sect. 5.4).
      ✍ The electron beam cannot be generated unless the holder is inserted into the column.
5. Adjust the image brightness using the BRIGHTNESS knob (L1-⑦), and center the beam using the SHIFT knobs (L1-⑧ and R1-④).
6. Move the desired field of view to the center of the fluorescent screen by moving the specimen (control panel GC, control panel TR).
7. Perform the axis alignment (☞ Sect. 5.8, 5.9).
8. Select the magnification using the MAG/CAM L knob (R1-⑥ or Fig. 4.33-⑥).
9. Turn ON SPCTR (R1-③) or Spectroscopy (Fig. 4.42-⑮) from the Filter Tuning window. Turn OFF the SPCTR after moving the edge of the spectrum as near as possible to the center of the fluorescent screen using the FOCUS knob (R1-⑧).
10. Perform focus (☞ Sect. 5.11).

5.12.2 Selected Area Diffraction

This is the procedure to form the diffraction pattern with the electron beam that passes through the micro specimen area selected by the selected area aperture.

1. Adjust the TEM image (☞ Sect. 5.12.1).
2. Set SAM for FUNCTION (R1-③ or Fig. 4.33-⑤) and select the magnification with the MAG/CAM L knob (R1-⑥ or Fig. 4.33-⑥).
3. Move the desired field of view to the center of the fluorescent screen by moving the specimen (control panel GC, control panel TR).
4. Insert the selected-area aperture (☞ Sect. 5.6.4).
5. Turn the BRIGHTNESS (L1-⑦) knob clockwise and darken the image sufficiently.
6. Set the FUNCTION to DIFF (R1-③ or Fig. 4.33-⑤) and select the camera length with MAG/CAM L (R1-⑥ or Fig. 4.33-⑥).
7. Adjust the FOCUS knob (R1-⑧) to obtain the sharpest diffraction pattern. A diffraction pattern like that shown in (Fig. 5.27-b) can be obtained.



a : Selected area image　　b : Selected area diffraction image

Fig. 5.27 Selected area diffraction (SAD)

5.12.3 Nano - beam Diffraction

The diffraction image electron beam irradiation area of the specimen is limited to a nano area by finely focusing the electron beam, and the diffraction image of that area is obtained. This is called micro area diffraction, nano area diffraction or convergent beam electron diffraction (Fig. 5.28).

✍ Nano-beam diffraction cannot be performed with the JEM-2200FS (HC).

1. Obtain an ordinary TEM image.
2. Press the NBD switch or the CBD switch (L1-③) on the control panel L1.
   ✍ To obtain a large convergence angle, the CBD mode is suitable. If not, the NBD mode is suitable.
3. Adjust the probe size of the electron beam to minimize the size at the center of the field of view, using the BRIGHTNESS knob (L1-⑦) and the SHIFT knobs (L1-⑧, R1-④).
4. Insert a condenser lens aperture with an appropriate hole size and center the aperture (☞ Sect. 5.6.2).
5. Press the BRIGHT TILT switch (L1-⑧).

6. Turn on the HT-Wobbler switch (R1-②); then adjust the DEF/STIG knobs (L1-⑩, R1-⑤) and the SHIFT knobs (L1-⑧, R1-④) so that the convergence of the electron beam becomes isotropic.
7. Press the TEM switch and set it to TEM mode. Then press the NBD switch or CBD switch again and center the shifted electron beam using the SHIFT X and Y knobs (L1-④, R1-③).
8. Repeat Step 7 several times to make the shift of the electron beam small.
9. Switch to the TEM mode; then align the field of view for microscopy to the center of the fluorescent screen.
10. Switch to the NBD or CBD mode.
11. Move the electron beam to the field of view you want to observe using the SHIFT knobs.
12. Press the SA DIFF switch and choose the camera length.
13. Note that you can select the sizes of the diffraction spots by using the size of the condenser lens aperture and α-SELECTOR (Fig. 4.33-③). When you change α-SELECTOR, you need to perform steps 6 to 12 again.

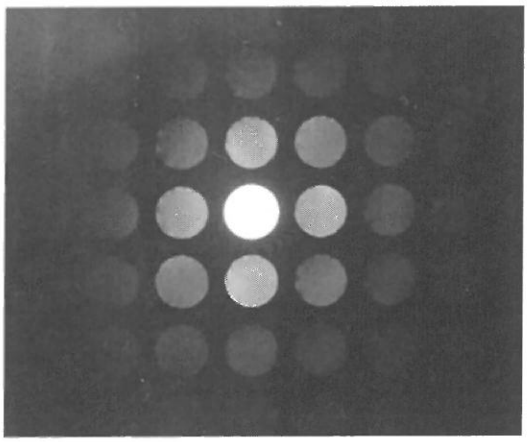


Fig. 5.28 Nano-area diffraction pattern

5.12.4 Bright-Field (BF) Image

When the electron beams pass through the specimen, they are mainly split into transmitted electrons and scattered (diffracted) electrons. The image formed by the transmitted electrons is generally called a bright-field image.

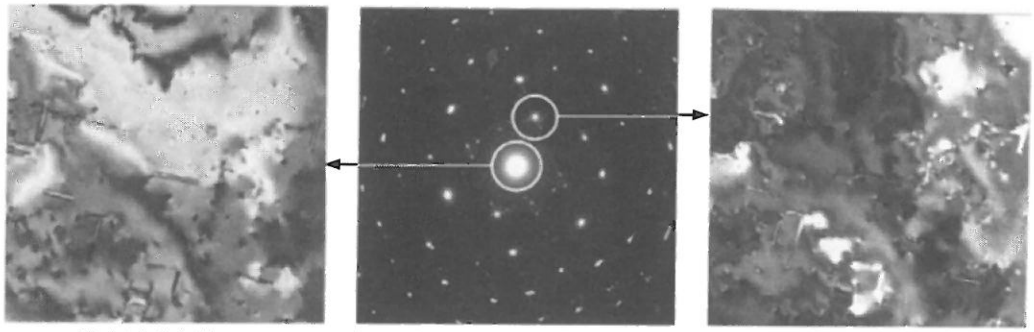
1. Adjust the selected-area diffraction image (☞ Sect. 5.12.2).
2. Insert an OL aperture into the electron beam path (☞ Sect. 5.6.3).
3. Adjust the aperture position (L1-②) so that only the direct spot passes through the aperture.

   ✍ The center spot in the diffraction pattern is called the direct spot and other spots are called diffraction spots.
4. Set SAM for FUNCTION (R1-③ or Fig. 4.33-⑤) and select the magnification with MAG/CAM L (R1-⑥ or Fig. 4.33-⑥).
5. A bright-field image (Fig. 5.29-a) is obtained.

5.12.5 Dark-Field (DF) Image

When the electron beams pass through the specimen, they are mainly split into transmitted electrons and scattered (diffracted) electrons. The image formed by the diffracted electrons is generally called a dark-field image. The dark-field images are dimmer than bright-field images but the contrast of the dark-field images is characteristically high.

1. Adjust the selected-area diffraction image (☞ Sect. 5.12.2)
2. Insert an OL aperture (☞ Sect. 5.6.3).
3. Adjust the aperture position using the aperture shift switch (L1-②), so that only the direct spot passes through the aperture.
4. Press the DARK TILT switch (L1-⑥).
5. Adjust the OL aperture position using the DEF/STIG knobs (L1-⑩, R1-⑤) so that the desired diffraction spot passes through the aperture.
6. Set SAM for FUNCTION (R1-③ or Fig. 4.33-⑤) and select the magnification with MAG/CAM L (R1-⑥ or Fig. 4.33-⑥).
7. Adjust the brightness of the image with the BRIGHTNESS knob (L1-⑦). Adjust the electron beam position with the SHIFT knobs (L1-⑧, R1-④) if the position of the electron beam shifts from the center of the fluorescent screen. A dark-field image (Fig. 5.29-c) is obtained.



a: Bright-field image
b: Diffraction pattern (aperture position)
c: Dark-field image

Fig. 5.29 Comparison of bright-field image and dark-field image

5.12.6 Low-Magnification Images

You can use the LOWMAG mode for searching the field of view over a wide area of the specimen and observing images at low magnification. The OL aperture cannot be used since the objective lens current is turned off in LOWMAG mode. The selected area aperture is used to enhance the image contrast.

1. Perform the normal alignment procedure (☞ Sect. 5.8, 5.9).
2. OPEN the objective and field-limiting apertures (☞ Sections 5.6.3 and 5.6.4).
3. Set to LMAG in FUNCTION (R1-③ or Fig. 4.33-⑤) or click and select the magnification with the MAG/CAM L knob (R1-⑥ or Fig. 4.33-⑥).
4. Adjust the image brightness using the BRIGHTNESS knob (L1-⑦) and adjust the electron beam position using the SHIFT knobs (L1-⑧, R1-④).
5. Adjust the voltage axis (Sect. ☞ 5.9.2).
   a. Select Wobbler — **OBJ** (Fig. 4.34-②, or Fig. 4.61-④) from the PC window.
   b. Press the BRIGHT TILT switch (L1-⑥). Or select the Alignment — **CL** (Fig. 4.33-⑦) from the Operation (Standard) window, or DEF Select — **CLA** (Fig. 4.61-①) from the Alignment Panel fro Maintenance.
   c. Adjust the DEF/STIG knobs (L1-⑩, R1-⑤) so that the image expands and contracts around the center of the fluorescent screen.
   d. Turn off the Wobbler — **OBJ** (Fig. 4.3.4-② or Fig. 4.61-④) .
6. Correct astigmatism.
   a. Press the OBJ STIG switch (L1-⑥). Or select the Stigmator — **OL** (Fig. 4.33-⑦) from the Operation (Standard) window, or Stigmator — **OL STIG** (Fig. 4.61-①) from the Alignment Panel fro Maintenance.
   b. Press the IMAGE WOBB X switch (R1-②). Or select **Image X** (Fig. 4.34-③) from Wobbler window or Wobbler — **Image X** (Fig. 4.61-④) from the Alignment Panel for Maintenance.
   c. Adjust the DEF/STIG Y knob (L1-⑩) to unify the image.
   d. Turn OFF the IMAGE WOBB X switch and turn ON the Y switch (R1-②). Or select Image Y (Fig. 4.34-④) from Wobbler window or Wobbler — **Image Y** (Fig. 4.61-④) from the Alignment Panel for Maintenance.
   The image will appear doubled.
   e. Adjust the DEF STIG Y knob (R1-⑤) to unify the image.
   f. Repeat steps 6c to 6e until there is no double image.
   g. Turn off the IMAGE WOBB switch.
7. Focus the image using the Image Wobbler (☞ Sect. 5.11.1).
   ✍ If you turn on the image wobbler with the field-limiting aperture inserted, the image might not appear. Therefore, it is recommended to set the field-limiting aperture to the OPEN position when you use the image wobbler.
8. Insert the selected-area aperture (☞ Sect. 5.6.4).
   ✍ Insert the field-limiting aperture with MAG mode and center it in advance.

5.12.7 Energy Filter Image

5.12.7a Zero-loss image

1. Adjust the image that you want to observe. (☞ Sections 5.12.1 to 5.12.6)
2. Insert the field-limiting aperture or incident aperture, and adjust the aperture position (☞ Sections 5.6.4 or 5.6.5).
   ✍ The field-limiting aperture is dependent on the magnification and needs to be changed. However, the incident aperture is independent of the magnification.
3. Press the SPCTR switch (R1-③) in FUNCTION, or click on Spectroscopy (Fig. 4.42-⑮) in the Filter Tuning window.
4. Move the the brightest part of the edge of the spectrum as close as possible to the center of the image display window using the FOCUS knob (R1-⑧).
   ✍ The brightest part of the edge of the spectrum is called the zero-loss spot.
5. Press the SLIT switch (L1-④) or check the IN box (Fig. 4.42-⑩) in the Filter Tuning window to insert the slit.
6. Set the width of the slit using Width (Fig. 4.42-⑪) in the Filter Tuning window.
7. Adjust the FL knob (L1-④) so that the zero-loss spot passes through the selection slit.
8. Press the SPCTR switch (R1-③) in FUNCTION, or click on Imaging (Fig. 4.42-⑮) in the Filter Tuning window to switch from SPCTR mode to Image mode.
9. Set the field-limiting aperture or incident aperture to OPEN.

5.12.7b Energy-loss image

1. Complete the procedure in Section 5.12.7 and adjust the zero-loss image.
2. Press the ENGY SHIFT switch (L1-④), or check the ON box (Fig. 4.42-①) in the Filter Tuning window and turn ON the energy shift.
3. Set the energy shift value using the ENGY SHIFT knob (L1-④), or with ◀ ▶(Fig. 4.42-④) in the Filter Tuning window.
   ✍ The energy-loss image has extremely low intensity compared to the zero-loss image. This makes in-situ observation difficult. Especially in the case of images with energy losses higher than 100 eV, you must expose the image for a long time using a high-sensitivity detector such as a slow-scan CCD camera or imaging plate.

5.12.7c Adjusting isochromaticity

To observe an energy-filter image with the slit inserted, first obtain the zero-loss image. The field of view might be restricted by the slit as shown in Fig. 5.30. If the image changes as shown in Fig. 5.31 when you move the slit slightly, the slit is cutting the image. If this happens, you must adjust the isochromaticity not only because you cannot obtain the zero-loss image by inserting a narrow slit, but also because the selected energy does not remain constant within the field of view even while observing a moderate-energy-loss image.

The image cutting by a slit is characterized by an arc whose center does not move even though the radius changes when the slit moves. The same effect as moving the slit can be observed by changing the current of the filter lens or the Energy Shift control.

If the image does not change in the way shown in Fig. 5.32, the cause of the cutting is something other than the slit. Take the necessary steps, for instance, by adjusting other apertures or changing the beam position.

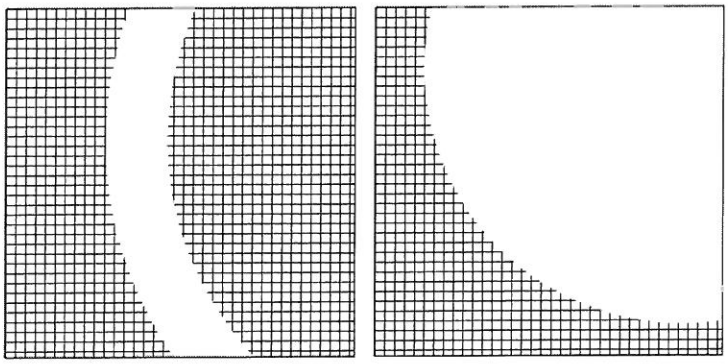


Fig. 5.30 Example of the image cut by a slit

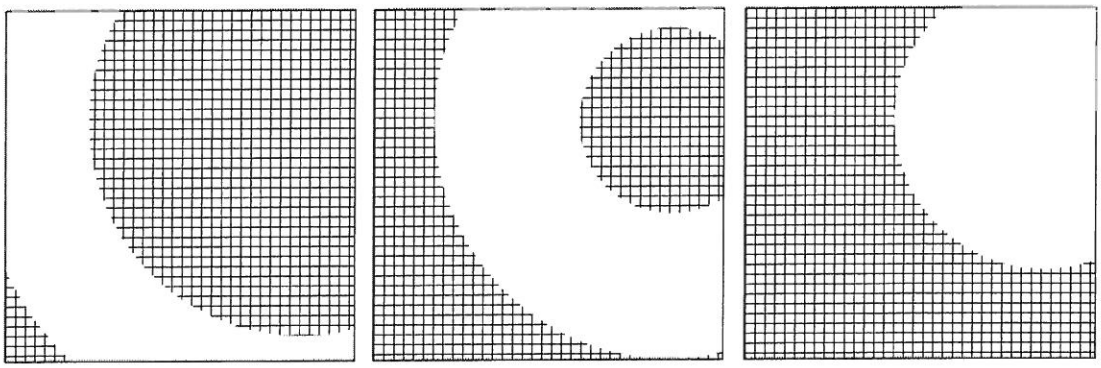


Fig. 5.31 Changes in the image cutting when changing the filter lens or moving slit position

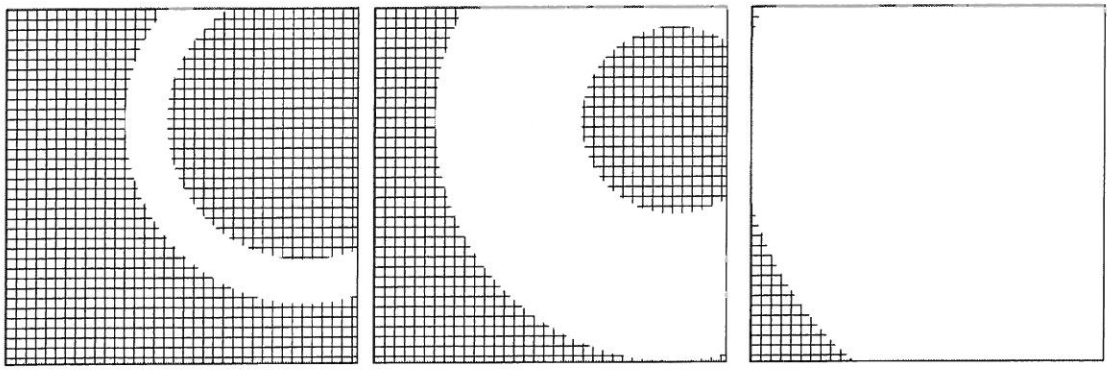


Fig. 5.32 Changes in the image cutting when changing slit width

1. Choose the observation mode and magnification that you want and obtain an image with adequate brightness.
2. Select SPCTR from FUNCTION (R1-③). Or select Spectroscopy (Fig. 4.42-⑮) from the Filter Tuning window.
3. Move the zero-loss spot as close as possible to the center of the image display window using the FOCUS knob (R1-⑧).
4. Insert the slit either by pressing the SLIT switch (L1-④) or by clicking on the IN check box (Fig. 4.42-⑨⑩) in the Filter Tuning window.
5. Set the slit width with Width (Fig. 4.42-⑪) in the Filter Tuning window.
6. Shift the spectrum with FL knob (Panel L1-④) and adjust so that the zero-loss spot will pass through the slit.
7. Press the SPCTR of FUNCTION (R1-③) and turn OFF the SPCTR mode. Select Imaging Mode (Fig. 4.42-⑮) in the Filter Tuning window and switch to Imaging mode.
8. Move the spectrum to the position where you obtain a shape as shown in Fig. 5.33.
   A bright band passes through the center.

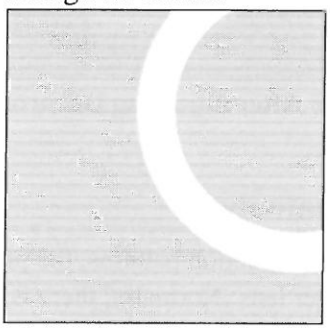


Fig. 5.33 Condition at the beginning of the IL FOCUS adjustment

9. Observe how the size and position of the bright part of the image change when you click on Isochromaticity (Fig. 4.42-⑯) in the Filter Tuning window and confirm that the image changes as shown in Fig. 5.34.

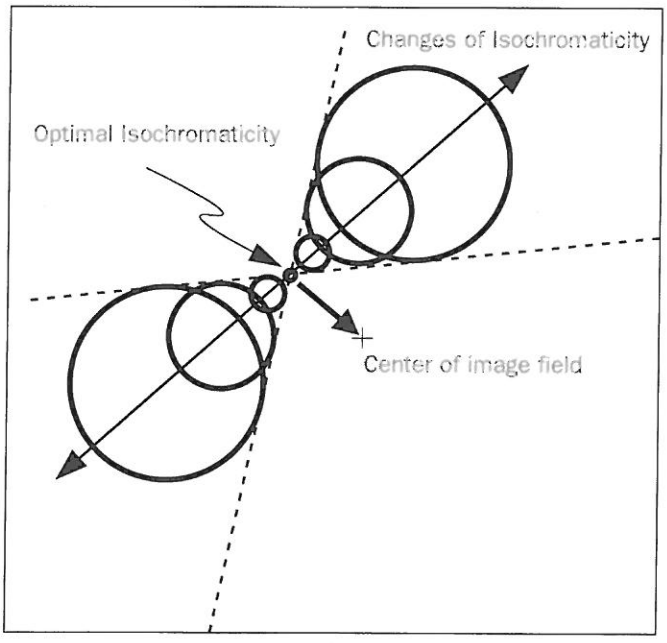


Fig. 5.34 Diagram of image cutting change in Isochromaticity adjustment

10. Adjust to make the arc radius of the image cut as small as possible.
11. Select DEF Select — **FLA** (Fig. 4.42-⑱) in the Filter Tuning window.
12. Move the center of the arc to the center of the image display window using the DEF/STIG knobs (L1-⑩ and R1-⑤).
13. Set the slit width.
14. Adjust with the FL knob (Panel L1-④) to make the bright part of the image as large as possible (Fig. 5.35).

    When the magnification is×50 000 or less, the optimum isochromaticity position moves whenever you change the image brightness using the BRIGHTNESS knob. Readjust the position every time you change the brightness.

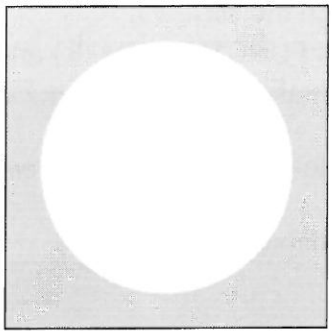


Fig. 5.35 After adjusting isochromaticity

5.12.7d Adjusting Achromaticity

When observing images or diffraction patterns, the projection lens is focused on the achromatic plane of the filter lens. Normally, there is no need to adjust this because it has been done during instrument installation.
However, when the projection lens is defocused, the image might appear elongated in one direction. In such a case, readjust the focusing.

1. Perform ordinary axis alignment and focusing (☞ Sections 5.8, 5.9, 5.10 and 5.11).
2. Select the desired mode for observation with FUNCTION (R1-③ or Fig. 4.33-⑤) and adjust the MAG/CAM L knob (R1-⑥ or Fig. 4.33-⑥) to change the magnification or camera length.
3. During MAG mode, search for a small and clear field of view that could be used as a target. During DIFF mode, clear the diffraction spot with the FOCUS knob (R1-⑧).
4. Press the ENGY SHIFT switch (L1-④) or check the ON box (Fig. 4.42-①) in the Filter Tuning window to turn ON the energy shift.
5. Set the ENGY SHIFT value to 50 to 100 eV using the ENGY SHIFT knob (L1-④) or the ◀ ▶ (Fig. 4.42-②) buttons in the Filter Tuning window.
6. Adjust with the Achromaticity (Fig. 4.43-②) in the Filter Tuning window to minimize the movement of the image when the ENGY SHIFT switch (L1-④ or Fig. 4.42-①) is turned ON and OFF.

   You cannot completely stop the image movement that occurs when you turn the energy shift ON or OFF.
7. Press the ENGY SHIFT switch (L1-④) or select the ON check box (Fig. 4.42-①) in the Filter Tuning window and turn OFF the energy shift.

5.12.7e Adjusting OBJ FOCUS (Focusing)

The best zero-loss image observation condition lies in a slightly underfocused image exhibiting Fresnel fringes, as in the case of ordinary electron microscopy. Focus the image using the ordinary procedure (☞ Sect. 5.11). For energy-loss images, however, you must choose the exact focus condition.
A defocus condition causes the image to blur. Find the exact focus energy-loss image with the highest possible resolution.

5.12.8 Energy Filtered Diffraction

5.12.8a Zero-loss diffraction image

1. Adjust the selected-area diffraction image (☞ Sect. 5.12.2).
2. Press the SPCTR (R1-③) in FUNCTION. Or select Spectroscopy (Fig. 4.42-⑭) in the Filter Tuning window.
3. Adjust the zero-loss spot as close as possible to the center of the image display window using the DIFF FOCUS knob (R1-⑧).
4. Insert the slit with the SLIT switch (L1-④) or check the IN box (Fig. 4.42-⑩) in the Filter Tuning window.
5. Set the slit width using the Width (Fig. 4.42-⑪) in the Filter Tuning window.
6. Move the spectrum with the FL knob (Panel L1-④) so that the zero-loss spot passes through the slit.
7. Press the SPCTR in FUNCTION (R1-③) and turn OFF the SPCTR mode. Or select the Imaging (Fig. 4.42-⑮) in the Filter Tuning window and return to DIFF mode.

5.12.8b Energy-loss diffraction image

1. Adjust a zero-loss diffraction image (☞ Sect. 5.12.8a).
2. Press the ENGY SHIFT switch (L1-④) or select the ON check box (Fig. 4.42-①) in the Filter Tuning window and turn ON the energy shift.
3. Set the energy shift value with ENGY SHIFT knob (L1—④), or ◀ ▶(Fig. 4.42-④) in the Filter Tuning window.

5.12.9 Energy-Loss Spectrum

1. Adjusting a zero-loss image (☞ Sect. 5.12.8a).
2. Search for the region on the specimen from which you want to obtain spectra by moving the specimencontrol panel GC, control panel TR).
3. Insert the field-limiting aperture or incident aperture and select the specimen region from which you want obtain the spectrum (☞ Sections 5.6.4 and 5.6.5).
   ✍ Set the magnification to more than roughly ×50 000. You can obtain a higher-resolution image if you use a smaller field-limiting aperture or incident aperture.
4. Select SPCTR in FUNCTION (R1-③), or select Spectroscopy in the Filter Tuning window (Fig. 4.42-⑮).
5. Move the zero-loss spot as close as possible to the center of the image display window using the FL knob (L1-④).
6. Select the PLA switch (R1-⑨) or click on Alignment - PROJ (Fig. 4.33-⑦) in the Operation (Standard) window.
7. Move the zero-loss spot to the center of the image display window using the DEF/STIG knobs (L1-⑩ and R1-⑤).
8. Press the ENGY SHIFT switch (L1-④) or select the ON check box (Fig. 4.42-①) in the Filter Tuning window and turn ON the energy shift.
9. Set the energy shift value with ENGY SHIFT knob (L1-④), or ◀ ▶ buttons (Fig. 4.42-④) in the Filter Tuning window.
10. Photograph the spectrum using a CCD camera or imaging plate.
    ✍ You need not perform focusing for the spectrum.
    ✍ The zero-loss spot might cause serious damage to the CCD camera or other devices because of its high intensity. Decrease the electron-beam intensity before the beam irradiates the camera or other devices.

5.12.10 Calibration

The microscope has the following three calibration programs that improve the accuracy of the data acquired by the energy filter. Calibration data can readily be updated by following the instructions displayed on the respective windows.

- Energy shift value
  Adjusts the display of the energy shift accurately. A specimen with a known absorption edge is used. For example, Si with a 99 eV absorption edge (L shell), or C with 284 eV absorption edge (L shell) is suitable.
- Illumination system compensation
  Sets the compensation coefficient for electron irradiation conditions when the energy-shift function is activated.
- Slit width zero
  Displays 0 when the width of the slit is zero.

✍ Calibration is not implemented automatically. It needs to be operated manually by the user.

5.12.10a Calibration of Energy Filter window

Clicking on **Calibration** (Fig. 4.42-⑰) in the Filter Tuning window will display the calibration window (Fig. 5.36).

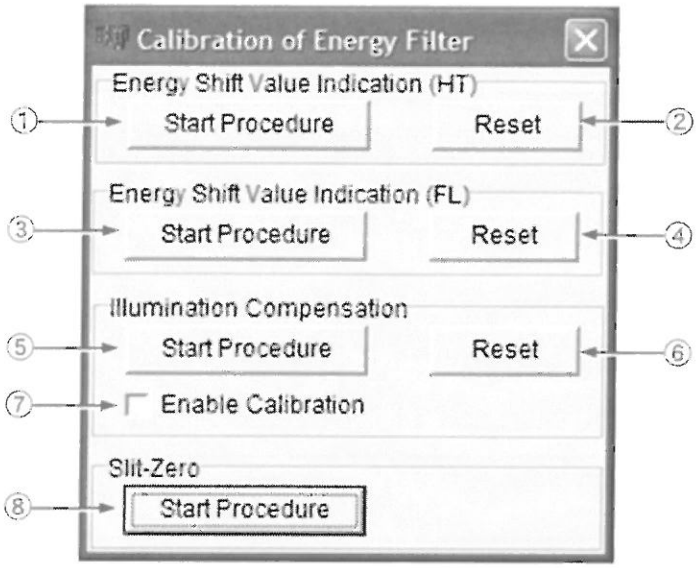


Fig. 5.36 Calibration of Energy Filter window

① Start Procedure
Clicking this button starts the calibration of energy shift by HT.

② Reset
Clicking this button resets the calibration of energy shift value by HT.

③ Start Procedure
Clicking this button starts the calibration of energy shift value by FL.

④ Reset
Clicking this button resets the calibration of energy shift value by FL.

⑤ Start Procedure
Clicking this button starts the calibration of Illumination Compensation.

⑥ Reset
Clicking this button resets the calibration of Illumination Compensation.

⑦ Enable Calibration
It switches the ON and OFF of the calibration of illumination compensation temporarily.

⑧ Start Procedure
Clicking this button starts the calibration of the zero-point of slit width.

5.12.10b Calibration of Energy Shift Value (HT)

Clicking this button starts the calibration of energy shift by HT. Follow the wizard instructions and continue the process (Fig. 5.37 through Fig. 5.43).

1. Follow "Instruction – 1. Set Spectroscopy Mode" and press the **Spectroscopy** button and select the SPCTRE mode (Fig. 5.37). When the selection is complete, press the **next** button and proceed to the next window.

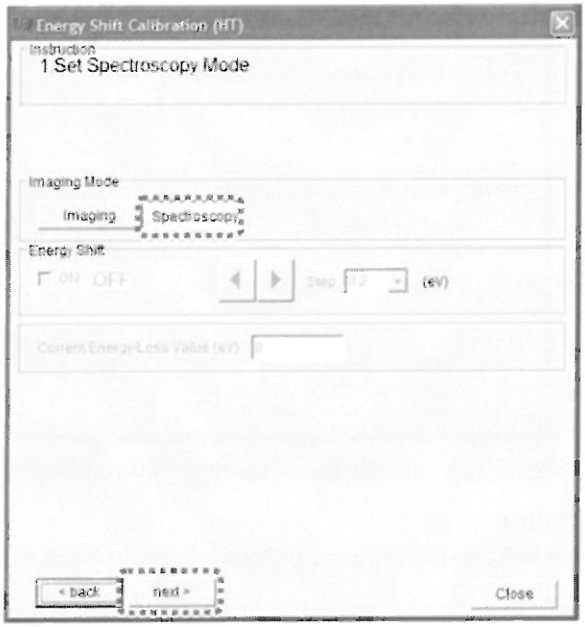


Fig. 5.37 Energy Shift Calibration (HT) - 1. Set Spectroscopy Mode

2. Follow "Instruction – 2. ON the Energy Shift" and select the check box to turn ON the Energy Shift (Fig. 5.38). After checking that the Energy Shift is **ON**, press the **next** button and proceed to the next window.

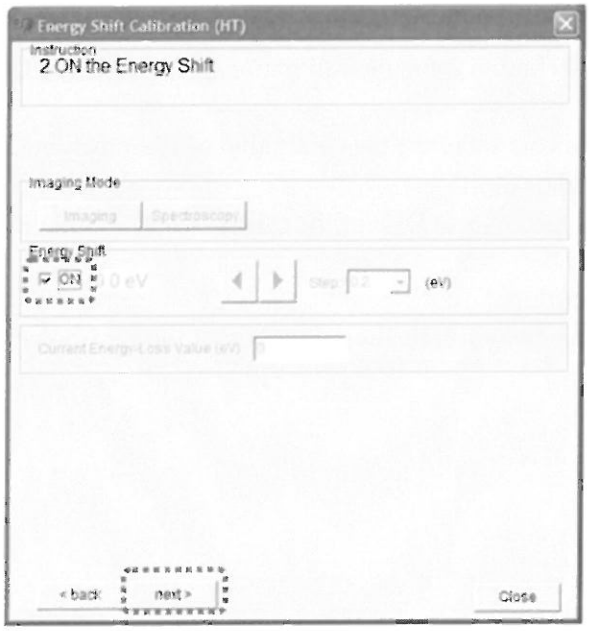


Fig. 5.38 Energy Shift Calibration (HT) - 2. ON the Energy Shift

3. Follow "Instruction – 3. Decrease Energy Shift to 0(eV)", use the "◀" "▶" buttons to adjust the Energy Shift to 0eV (Fig. 5.39). Select the setting of the movement amount from the combo box in the Step. "When the Energy Shift becomes 0 eV", press the **next** button and proceed to the next window.

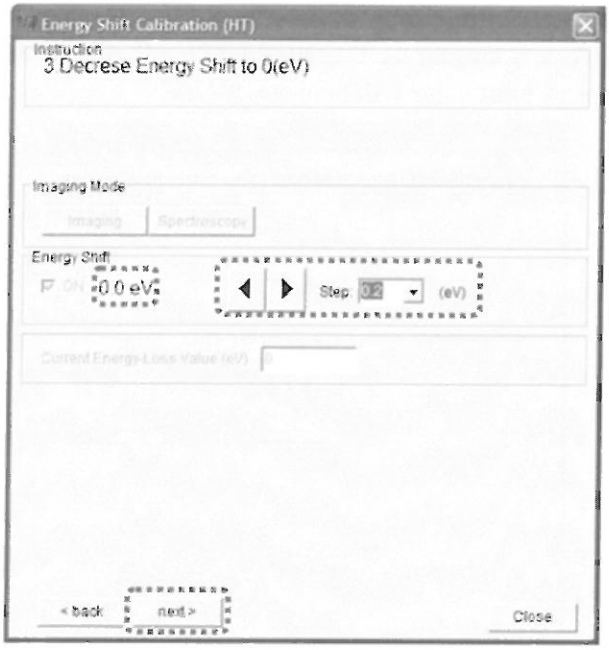


Fig. 5.39 Energy Shift Calibration (HT) - 3. Decrease Energy Shift to 0 (eV)

4. Follow "Instruction – 4. Adjust Zero–Loss spot to certain position using [FLFocus]", use the FOCUS knob (R1-⑧) to adjust the edge of the spectrum to the desired position (Fig. 5.40). After adjustment, press the **next** button and proceed to the next window.

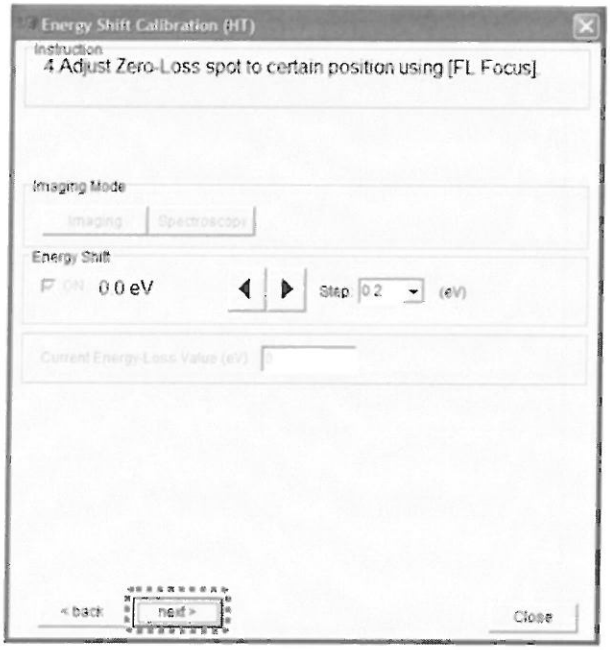


Fig. 5.40 Energy Shift Calibration (HT) - 4. Adjust Zero-Loss Spot to certain position using [FL Focus]

5. Follow "Instruction – 5. Adjust KNOWN absorption edge to the determined position using [Energy Shift]" use the "◀" "▶" buttons to adjust the known absorption edge to the desired position (Fig. 5.41). Select the setting of the movement amount from the combo box. After adjustment, press the **next** button and proceed to the next window.
For example, when using the C (carbon) with a K absorption edge of 284 eV, adjust so that the energy shift value will become 284 eV.

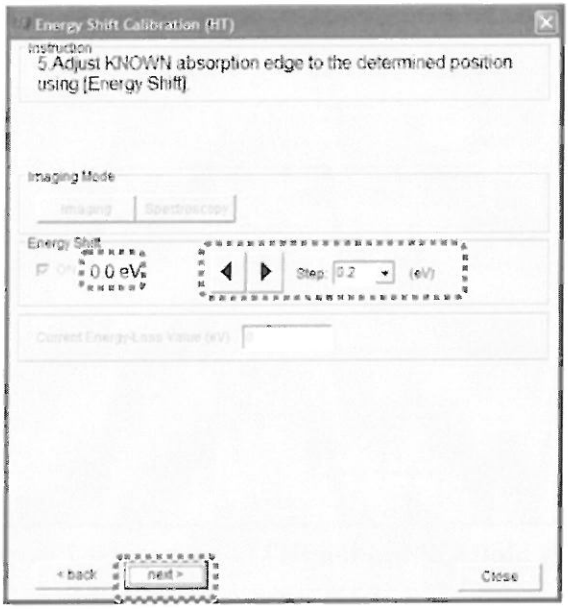


Fig. 5.41 Energy Shift Calibration (HT) - 5. Adjust KNOWN absorption edge to the determined position using [Energy Shift]

6. Follow "Instruction – 6. Input energy loss value", enter the absorption edge energy value set in 5 into the Current Energy - Loss Value (eV) and click the **next** button (Fig. 5.42).

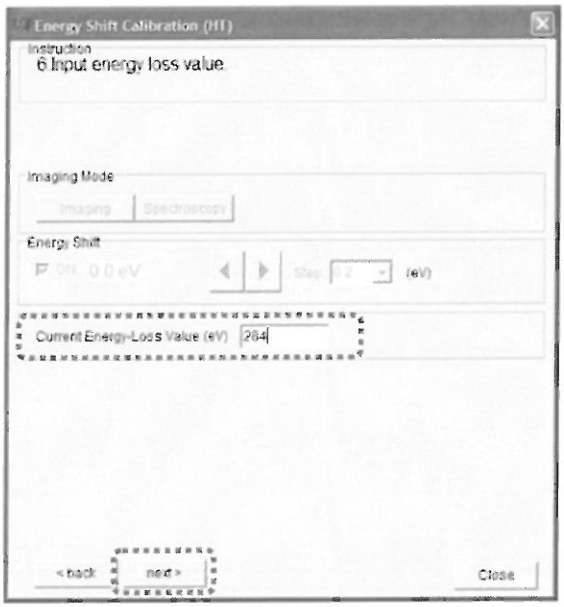


Fig. 5.42 Energy Shift Calibration (HT) - 6. Input energy loss value

7. Pressing the **next** button in procedure 6 will display the Confirm window. Press **Yes** and complete the calibration (Fig. 5.43).

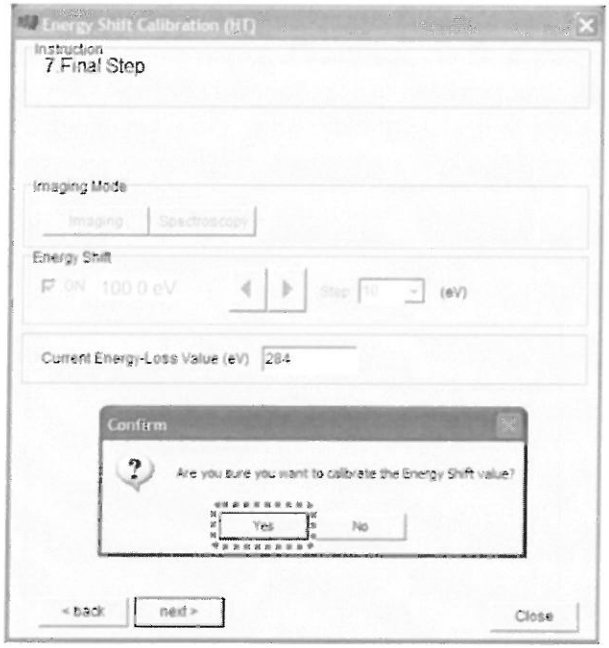


Fig. 5.43 Completing the Energy Shift Calibration (HT)

5.12.10c Calibration of the Energy Shift Value (FL)

Clicking this button starts the calibration of energy shift value by the Filter Lens (FL). Follow the instructions of the wizard and continue the process (Fig. 5.44 through Fig. 5.48).

1. Follow "Instruction – 1. Switch to SPCTR mode", press the **Spectroscopy** button and change to SPCTR mode (Fig. 5.44). After completing the change to SPCTR mode, press the **next** button and proceed to the next window.

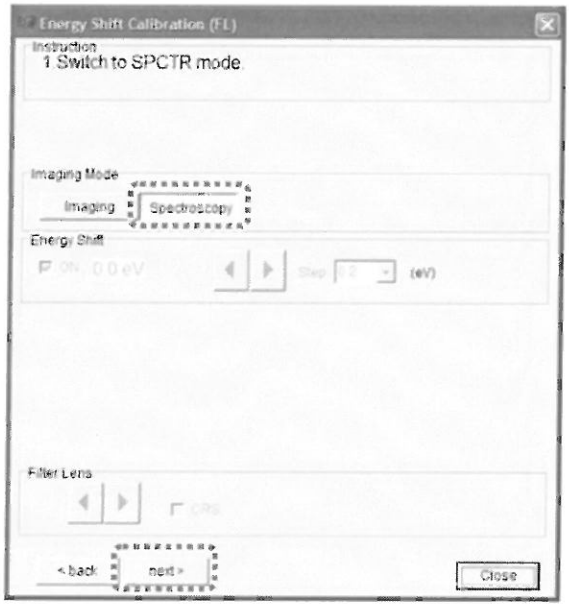


Fig. 5.44 Energy Shift Calibration (FL) - 1. Switch to SPCTR mode

2. Follow "Instruction – 2. ON the Energy Shift and Decrease Energy Shift to 0 (eV). Adjust Zero–Loss spot to certain position using FL and PL Alignment". Turn ON the Energy Shift and change the Energy Shift amount to 0eV with the "◀" "▶" buttons. Then use the FL alignment and PL alignment to adjust the Zero - Loss spot position to the desired position (Fig. 5.45). After adjustment, press the **next** button and proceed to the next window.

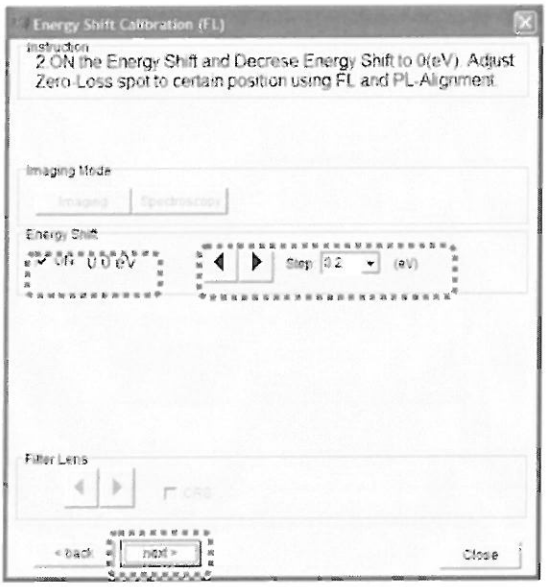


Fig. 5.45 Energy Shift Calibration (FL) - 2. ON the Enegy Shift and Decrease Energy Shift to 0 (eV). Adjust Zero - Loss spot to certain position using FL and PL - Alignment

3. Follow "Instruction – 3. Move the spectrum by Energy Shift (HT)" and move the spectrum by the Energy Shift (HT) (Fig. 5.46). When the movement is complete, press the **next** button and proceed to the next window.

☞ Make sure that the HT is selected from the combo box for selecting the Energy Shift method in Fig. 4.42-②.

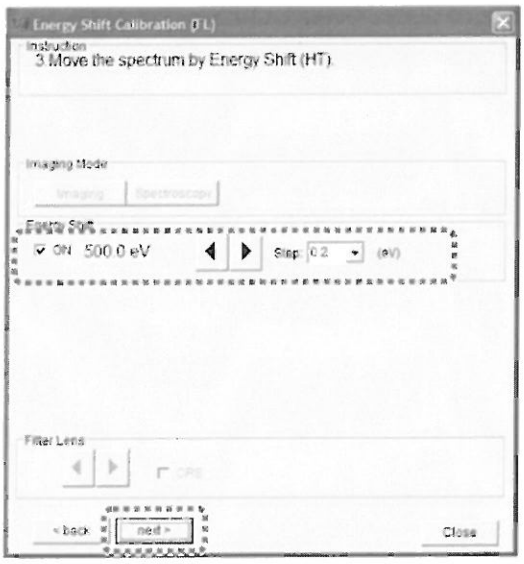


Fig. 5.46 Energy Shift Calibration (FL) - 3. Move the spectrum by Energy Shift (HT)

4. Follow "Instruction – 4. Compensate the spectrum position by FL" and correct the position of the spectrum with the Filter Lens (FL) (Fig. 5.47). Move the position using the "◀" "▶" buttons. If the CRS check box is selected, the variable amount will increase by 16 times. When the correction is complete, press **next** to proceed.

Fig. 5.47 Energy Shift Calibration (FL) - 4. Compensate the spectrum position by FL

5. Pressing the **next** button in procedure 4 will display the Confirm window. Press **Yes** and complete the calibration (Fig. 5.48).

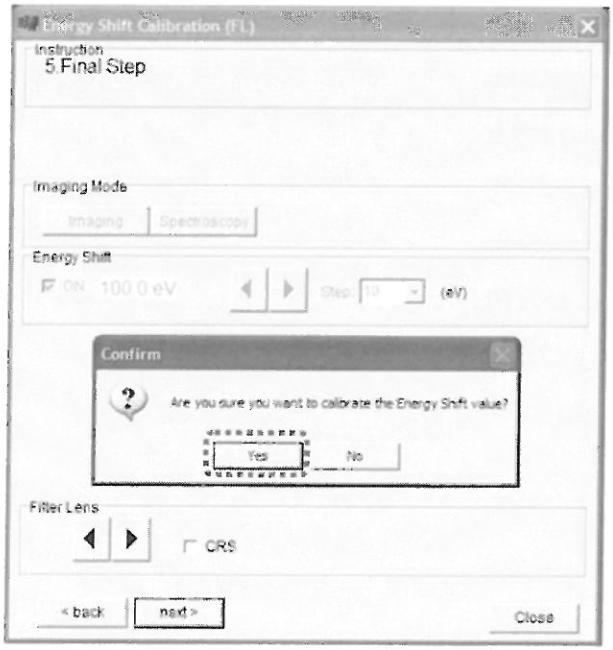


Fig. 5.48 Completing the Energy Shift Calibration (FL)

5.12.10d Calibration of Illumination System Compensation

Calibration of Illumination System Compensation Follow the instructions of the wizard and continue the process (Fig. 5.49 through Fig. 5.55).

1. Follow "Instruction – 1. Set Image Mode", select the Imagining mode by pressing the **Imaging** button (Fig. 5.49). After the selection, press **next** to proceed.

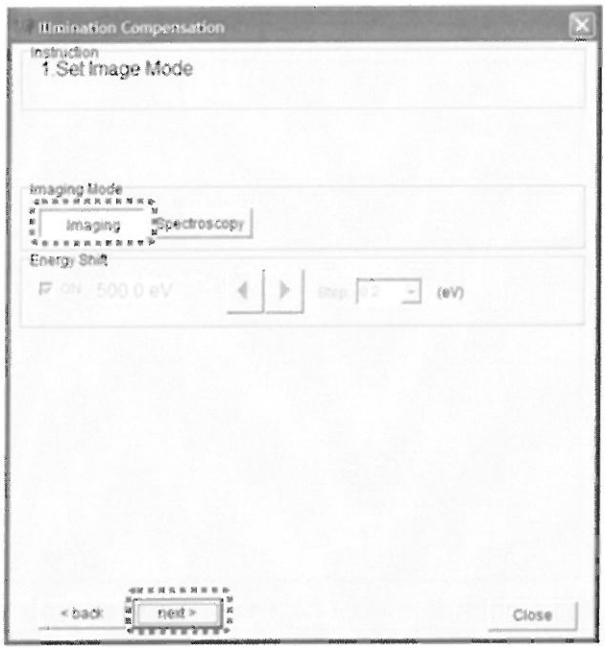


Fig. 5.49 Illumination Compensation 1 . Set Image Mode

2. Follow "Instruction – 2. On the Energy Shift", and turn ON the Energy Shift (Fig. 5.50). After the selection, press **next** and move on.

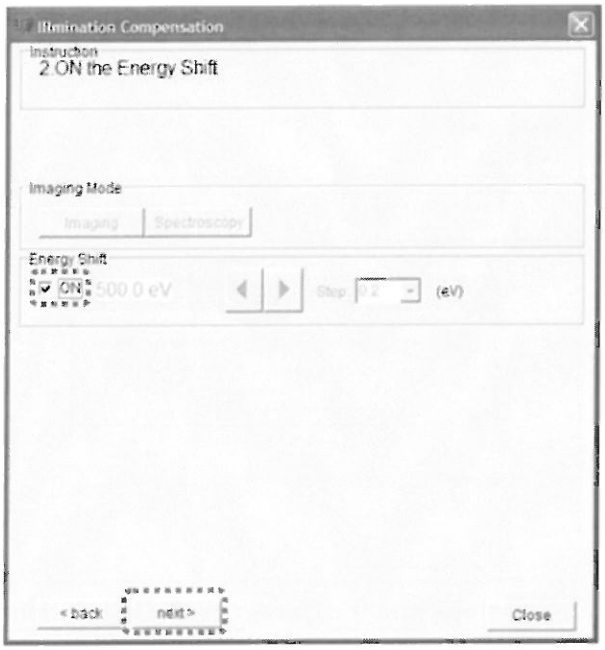


Fig. 5.50 Illumination Compensation - 2. On the Energy Shift

3. Follow "Instruction – 3. Set Energy Shift to certain value [e.g. 0]", use the "◀" "▶" buttons to adjust the Energy Shift to 0eV (Fig. 5.51). Select the setting of the movement amount from the combo box. When the adjustment is completed, press the **next** button to proceed.

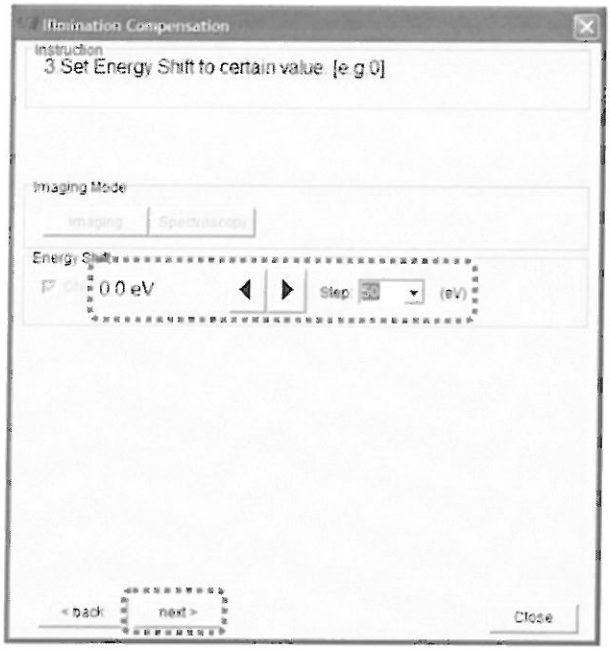


Fig. 5.51 Illumination Compensation - 3. Set Energy Shift to certain value. [e.g. 0]

4. Follow "Instruction – 4. Get Crossover using [BRIGHTNESS] and center it using [BRIGHT SHIFT]", and operate the BRIGHTNESS knob (L1-⑦) for crossover. Then use the BRIGHT SHIFT (L1-⑧, R1-④) to shift to the center (Fig. 5.52). After the shift is complete, press the **next** button to proceed.

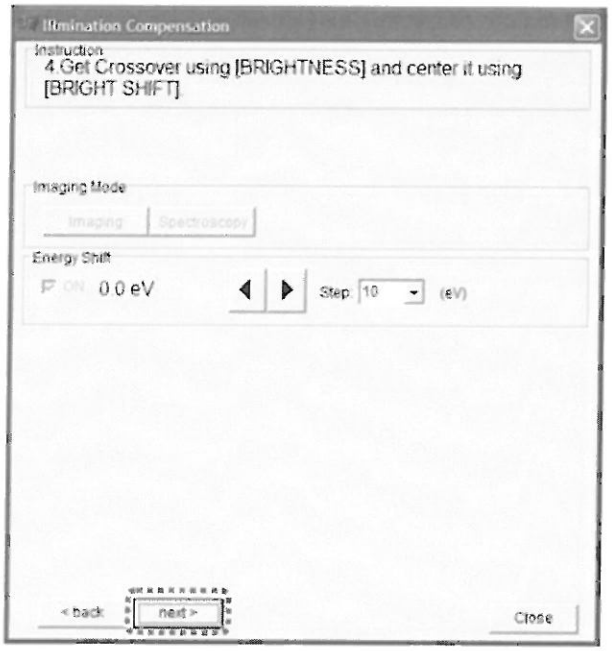


Fig. 5.52 Illumination Compensation - 4. Get Crossover using [BRIGHTNESS] and center it using [BRIGHT SHIFT]

5. Follow "Instruction – 5. Change Energy Shift to certain value [e.g. 200eV]" and use the "◀" "▶" buttons to change the Energy Shift value to an appropriate value (such as 200 eV) (Fig. 5.53). After changing the Energy Shift amount is complete, press the **next** button to proceed.

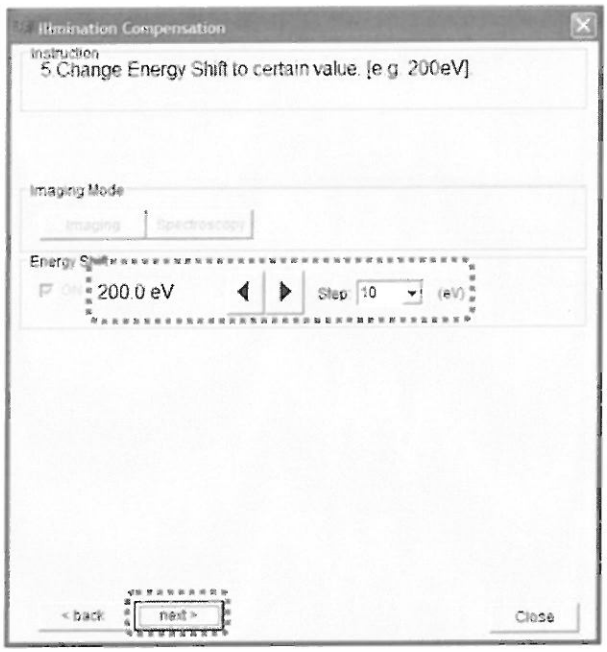


Fig. 5.53 Illumination Compensation - 5. Change Energy Shift to certain value [e.g. 200kV]

6. Follow "Instruction – 6. Get Crossover using [BRIGHTNESS] and center it using [BRIGHT SHIFT]", and adjust the changed size and position of the electron beam with BRIGHTNESS (L1-⑦) and BRIGHT SHIFT (L1-⑧, R1-④) again (Fig. 5.54). When the adjustment is complete, press the **next** button to proceed.

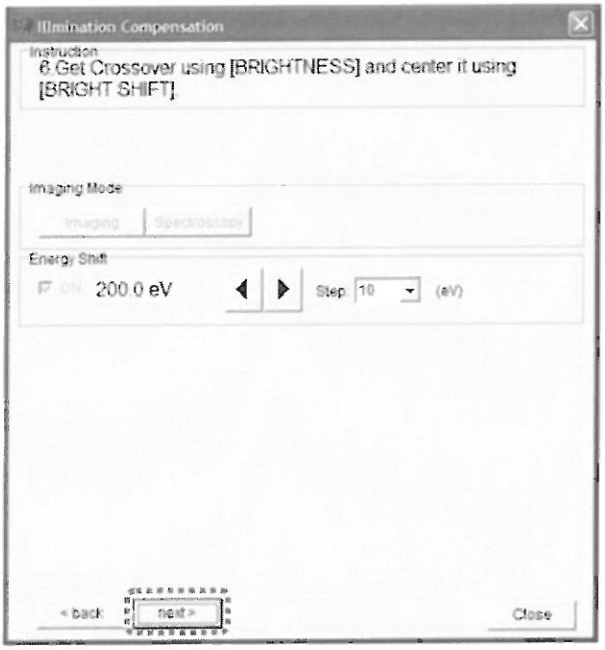


Fig. 5.54 Illumination Compensation - 6. Get Crossover using [BRIGHTNESS] and center it using [BRIGHT SHIFT]

7. Clicking the **next** button in procedure 6 will display the Confirm window. Click **Yes** and complete the calibration (Fig. 5.55).

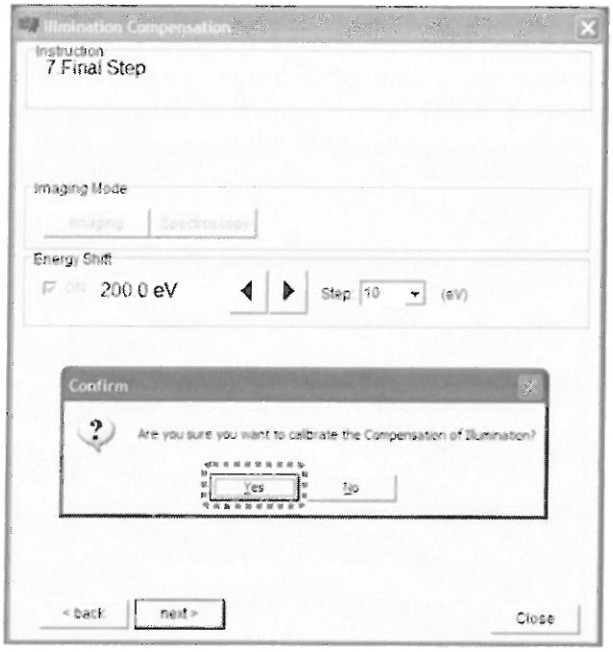


Fig. 5.55 Illumination Compensation Completion

5.12.10e Slit width zero adjustment

Slit width zero adjustment. Follow the instructions of the wizard and continue the process (Fig. 5.56 through Fig. 5.64).

1. Follow "Instruction – 1. Set DIFF mode", switch to DIFF mode by pressing the **DIFF** button (Fig. 5.56). After the switch, press the **next** button to proceed.

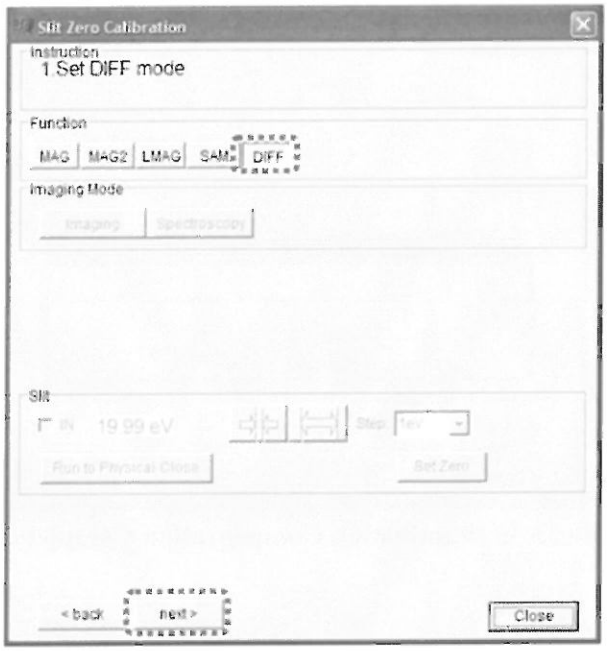


Fig. 5.56 Slit Zero Calibration - 1. Set DIFF mode

2. Follow "Instruction – 2. Set Spectroscopy mode", switch to SPCTRE mode by clicking the **Spectroscopy** button (Fig. 5.57). After the switch, click the **next** button to proceed.

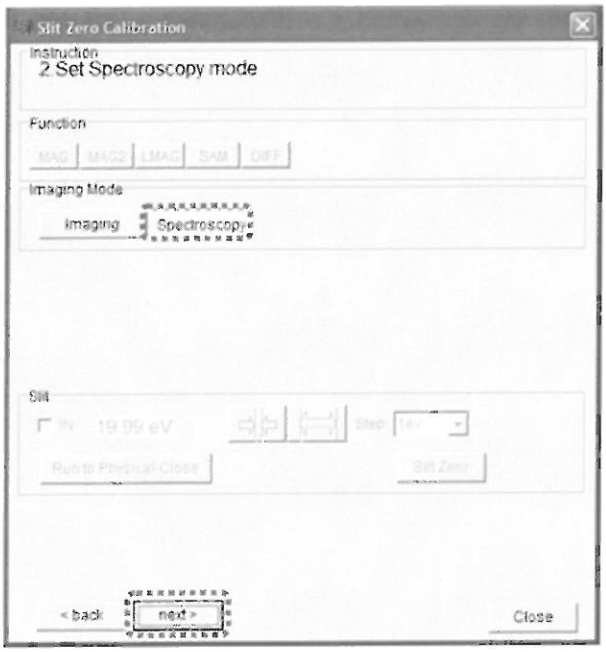


Fig. 5.57 Slit Zero Calibration - 2. Set Spectroscopy mode

3. Follow "Instruction – 3. Get slit image with FL focus", move the spectrum position with the FOCUS knob (R1-⑧) and adjust so that the gap in the slit is visible (Fig. 5.58). After the adjustment is complete, click the **next** button to proceed.

   It will be easier to observe if the slit width is widened temporarily.

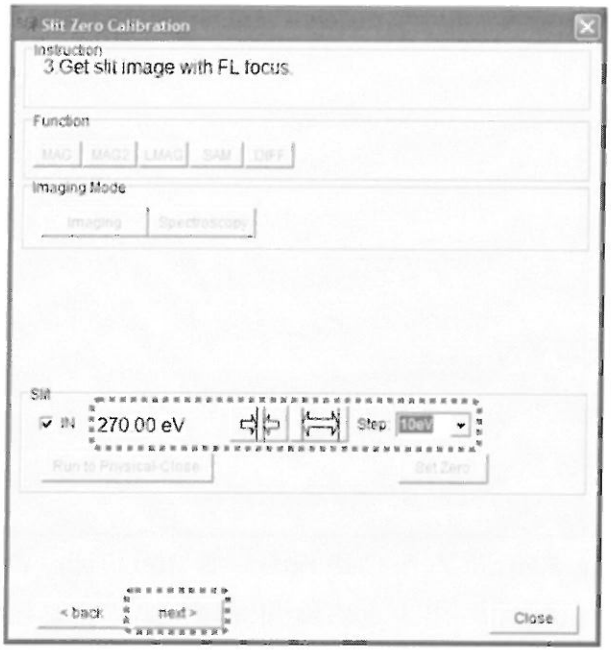


Fig. 5.58 Slit Zero Calibration - 3. Get slit image with FL focus

4. Follow "Instruction – 4. Decrease slit width", and decrease the slit width gradually until it becomes zero (Fig. 5.59). After the slit width becomes zero, click the **next** button to proceed.

   If the position of the edge of the spectrum and the gap of the slit has shifted and cannot be observed, move the spectrum position with the FOCUS knob (R1-⑧).

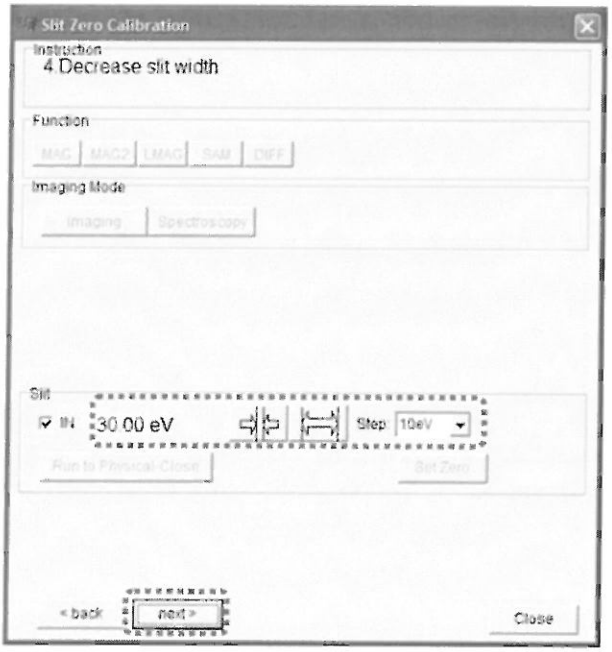


Fig. 5.59 Slit Zero Calibration - 4. Decrease slit width

5. Follow "Instruction – 5. Run to slit–Zero", click the **Run to Physical - Close** button (Fig. 5.60). After pressing the button, press the **next** button to proceed.

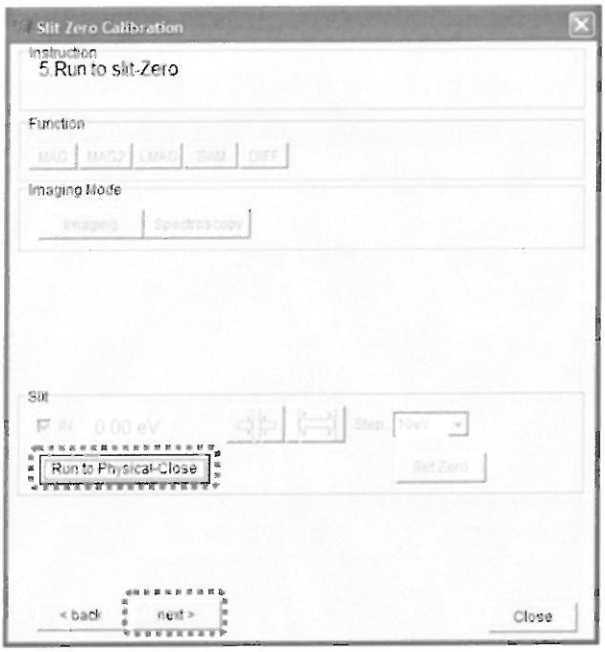


Fig. 5.60 Slit Zero Calibration - 5. Run to slit - Zero

6. Follow "Instruction – 6. Increase slit width until electron path through the slit", and increase the slit width gradually until the gap of the slit is visible (Fig. 5.61). When the gap of the slit is visible, click the **next** button to proceed.

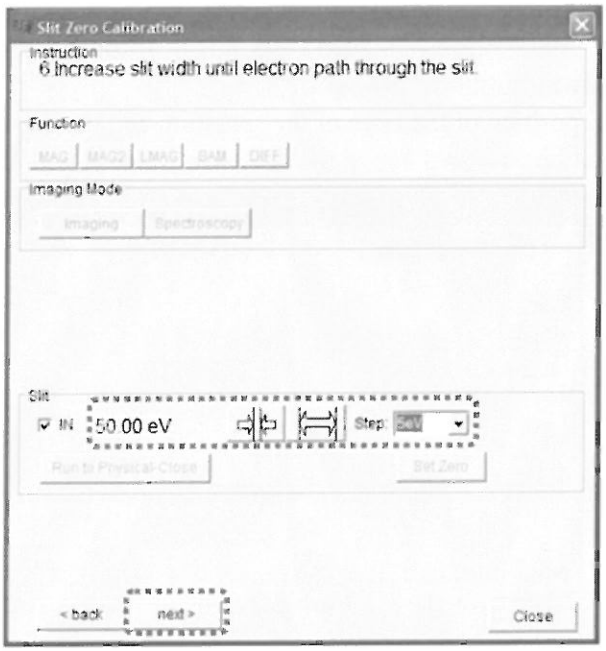


Fig. 5.61 Slit Zero Calibration - 6. Increase slit width until electron path through the slit

7. Follow "Instruction – 7. Decrease slit width FINE 1 step", and when the gap is visible, close the slit by 1 step (Fig. 5.62). After closing the slit by 1 step, click the **next** button to proceed.

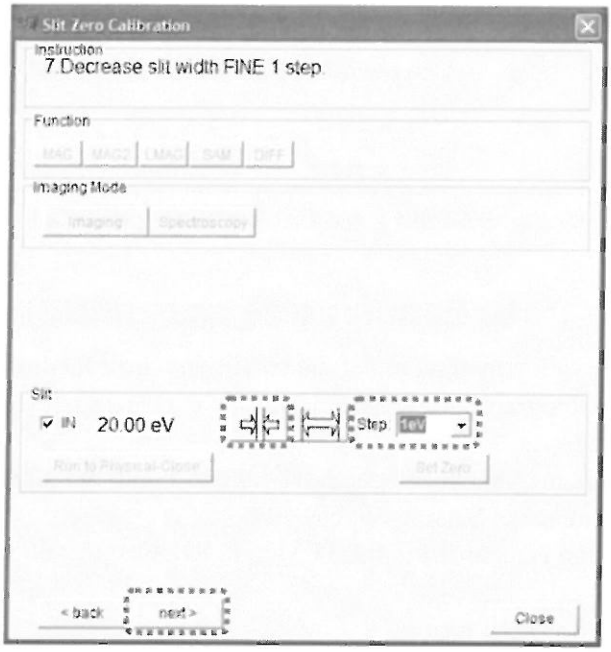


Fig. 5.62 Slit Zero Calibration - 7. Decrease slit width FINE 1 step

8. Follow ""Instruction – 8. Click Set Zero", and click the **Set Zero** button (Fig. 5.63). After clicking the **Set Zero** button, click the **next** button to proceed.

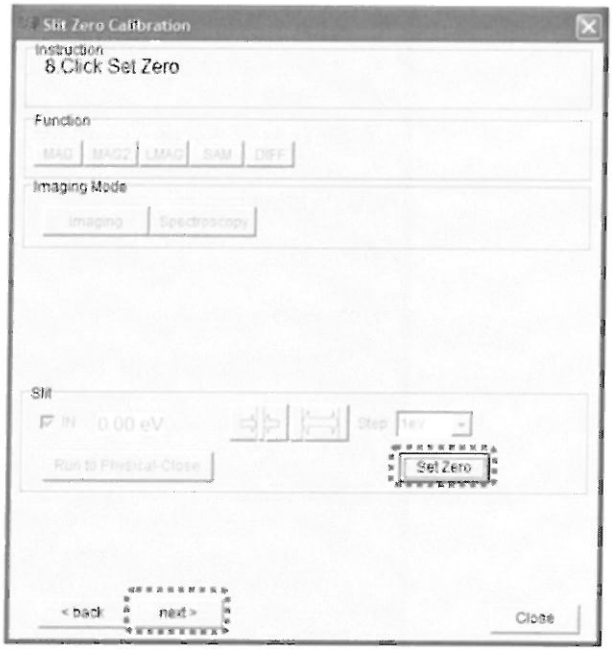


Fig. 5.63 Slit Zero Calibration - 8. Click Set Zero

9. The Confirm window will be displayed when the **next** button in step 8 is clicked. Click **Yes** and complete the calibration (Fig. 5.64).

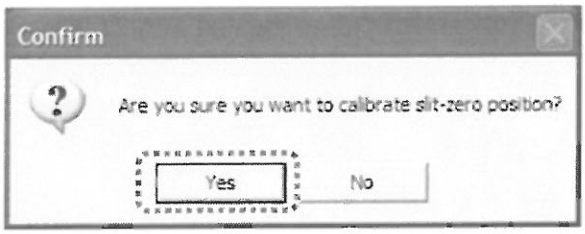


Fig. 5.64 Slit Zero Calibration Complete

5.12.11 Minimum Dose Exposure System (MDS)

This is an observation method under the condition where the irradiation dose is greatly reduced. The photography viewing field is only exposed to the electron beam during exposure.

- When switching between Search, Focus and Photo Set modes, be sure to switch them in the sequence of Search→Focus→Photo Set→Search.
- Each setting is recorded in the TEM unit. Readjust these settings each time you use the MDS.

1. Initialize the MDS mode.

a. Display the MDS window (Fig. 5.65, ☞ Sect. 4.4.7j).

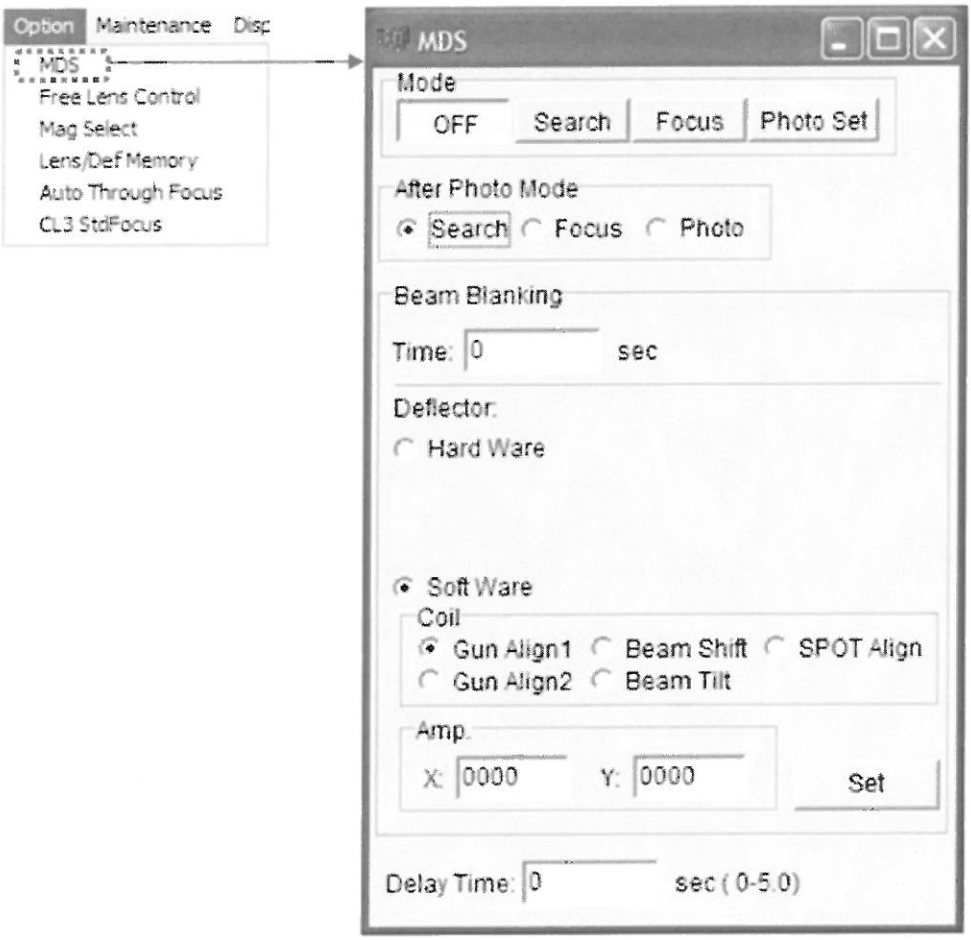


Fig. 5.65 MDS window

b. Set the (After Photo) mode after acquiring the image (Fig. 4.58-②), beam blanking time and beam blanking method (Fig. 4.58-③), and Delay Time (Fig. 4.58-④).

Beam Blanking Time is the time during which to blank the electron beam just before the camera shutter opens. Delay Time is the time from when the camera shutter opens after the beam blanking time has elapsed to when the exposure starts.

2. Set the PHOTO SET mode.

a. Select the **Photo Set** (Fig. 4.58-①) from the MDS window and switch to Photo Set mode.

b. Set the photography conditions such as magnification, brightness and irradiation area.

Normally, focus the beam and set the irradiation area to the minimum.

Set the exposure time using the manual exposure mode.

3. Set to SEARCH mode.

a. Select **Search** (Fig. 4.58-①) in the MDS window and switch to Search mode.

b. Set the photography conditions such as magnification, brightness and irradiation area.

Normally, low magnification is chosen, and the electron beam is widened to reduce the current density on the specimen. A low-magnification image can also be obtained by selecting the DIFF mode, opening the beam to maximum, and shifting the DIFF FOCUS greatly. It is also possible to use this image.

4. Set the FOCUS mode setting.

a. Select **Focus** (Fig. 4.58-①) from the MDS window and switch to Focus mode.

b. Set the photography conditions such as magnification, brightness and irradiation area.

Use magnifications higher than that used in PHOTO SET mode. Restrict the electron beam as much as possible while still being able to focus the image without difficulties.

5. Repeat readjustment in sequence of SEARCH → FOCUS → PHOTO SET
The beam deviation can be lowered to minimum.

6. Switch to FOCUS mode.

7. Press the DEF/STIG switch IMAGE SHIFT (L1-⑥). Or select the Alignment — **Image** (Fig. 4.33-⑦) from the Operation (Standard) window, or the DEF Select — **IS1** (Fig. 4.61-①) from the Alignment Panel for Maintenance.

8. Move the electron beam to the focusing field of view with the SHIFT knob (L1-⑧, R1-④) and move the focusing field of view to the center of the fluorescent screen with the DEF/STIG knobs.

Make sure it does not overlap with the irradiation area in PHOTO SET mode.

9. Confirm the conditions for each mode.

10. Search for the field of view to photograph in SEARCH mode.

11. Focus the image in the FOCUS mode.

12. Photograph the image.

a. Press the PHOTO switch.

b. The instrument enters the PHOTO SET mode and automatically performs photography.

c. After completing the photography, shift to After Photo mode.

13. Click on **OFF** in the MDS window (Fig. 4.58-①) to switch from MDS to normal mode.

5.12.12 Auto Through Focus

Serial photography can be executed automatically while changing the OL focus.

1. Select **TEM Controller — Option — Auto Through Focus** (Fig. 5.66).

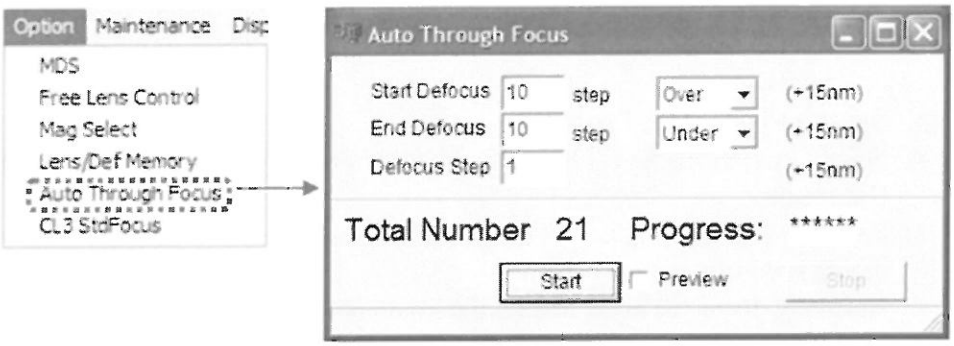


Fig. 5.66 Auto Through Focus window

2. Adjust the field of view, focus, astigmatism correction and exposure time in the same way as regular image observation.
   - In Auto Through Focus, the setting for Film Advance is not used.
3. Set the current focus position as a standard and enter the start defocus step, the end defocus step and the defocus step change.
   - The Start defocus step is the number of steps made from the current position before starting photography. Additionally, select either under focus or over focus as viewed from the current position.
   - The End defocus step is the number of steps made from the current position to the end of photography. Additionally, select either under focus or over focus as viewed from the current position.
   - The variable Defocus step is the number of notchs that the OBJ Focus Fine knob is shifted during the photography.
   - Fig. 5.66 shows the settings for photography to be made starting a setting of 10 steps of a 1 notch shift of the OL Fine knob toward the over focus side and continuing to a setting of 10 steps of a 1 notch shift of the OL Fine knob toward the under focus side.
4. To check if the setting is as desired, select Preview and click the **Start** button.
   - Only OL excitation change will be executed.
   - Before starting the photography, make sure that the Total Number (total images photographed) is fewer than the number of unused films (shown in Unused in the Film Camera Property window).
5. When performing serial photography, clear the Preview check box and click the **Start** button to raise the fluorescent screen and start the automatic serial photography. The status of the progress will be displayed in Progress. To stop the photography, click **Stop**.

5.13 USING THE ANTI-CONTAMINATION DEVICE

The anti-contamination device (ACD) greatly reduces the specimen contamination due to electron-beam irradiation. Therefore, it is 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 are used for micro-area diffraction studies. Also, even for normal microscopy, using the ACD makes it possible to spend more time to select the desired fields of view and perform image focusing.

5.13.1 Filling with Liquid Nitrogen

⚠ CAUTION

- **Liquid nitrogen is used for this instrument. Therefore, when using the instrument, make sure to ventilate the room sufficiently so that the oxygen will not run out.**
  There is a risk of oxygen deficiency.

- **When filling or draining the coolant (liquid nitrogen) into/from the anti-contamination device, wear appropriate protective eyeglasses, and gloves (made of leather that liquid nitrogen will not permeate).**
  There is a risk of eye injury resulting in vision loss or frostbite.

- **Use a stable workbench without rotating casters when supplying and evaporating the coolant.**
  There is a danger of falling.

1. Confirm that the column pressure is below 0.1 Pa (10^{-3} Torr) and the ground indication lamp (Fig. 5.67) does not light when its switch is pressed.
   If liquid nitrogen is poured into the reservoir of the anti-contamination device while the column pressure is above 0.1 Pa (10^{-3} Torr), since the pressure is not low enough, residual water vapor will condense into a liquid on the surface of the cold trap, thereby charging or oxidizing the trap. If charging occurs, the astigmatism of the objective lens increases and the image or the beam itself may become unstable.
2. Cover the viewing window with an appropriate lid.

—CAUTION—

Pour the coolant after covering the viewing window with an appropriate protective lid.
If the coolant is supplied without covering the viewing window, the coolant comes in contact with the window glass and there is a danger of the glass cracking, causing serious damage to the interior of the microscope column.

3. Remove the cap for the coolant fill opening of the coolant reservoir and insert the appropriate funnel into the fill opening.
4. Pour coolant (liquid nitrogen) into the funnel to fill the reservoir with it.
5. Approximately 15 minutes later, pour the coolant into the reservoir again.
6. Remove the funnel from the coolant water reservoir, and insert the cap into the fill opening.
   If you vent the column, first return the trap to room temperature (☞ Sect. 5.13.2).

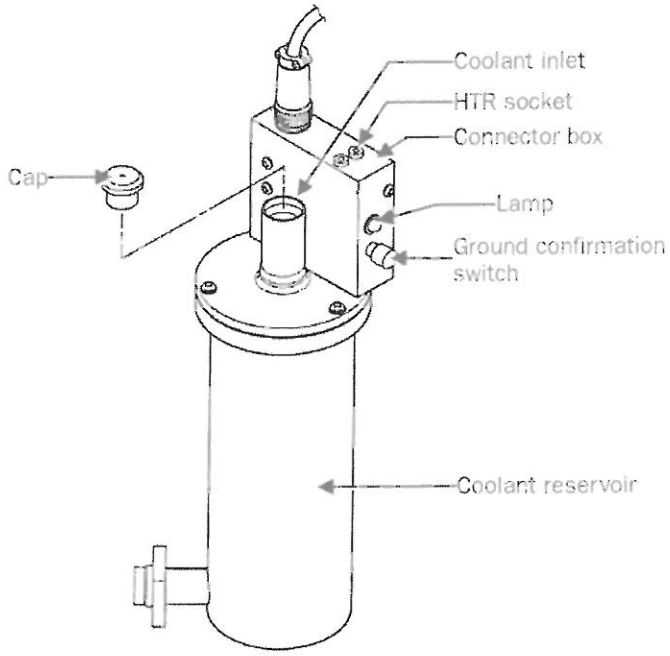


Fig. 5.67 Coolant reservoir

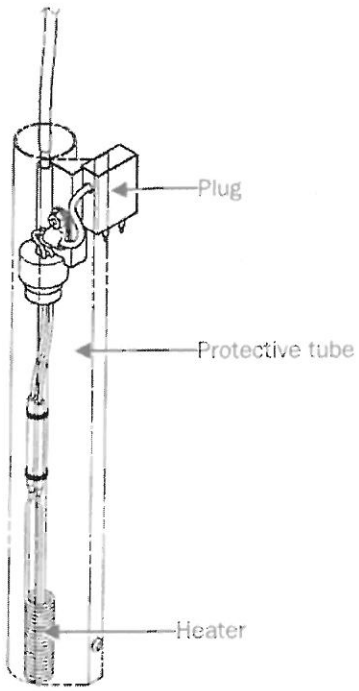


Fig. 5.68 Coolant evaporator

5.13.2 Returning the Anti-Contamination Device to Room Temperature

If the microscope is evacuated for a long time while the temperature of the anti-contamination device is lower than the room temperature, a large amount of gas from the trap can sometimes escape into the microscope column. This can harm the SIP (sputter ion-pump) evacuation system.
Also, if air is admitted to the column while the trap is being cooled, water vapor condenses and forms drops of water on the trap. This causes an electric charge to build up.
Therefore, for a TEM that has an anti-contamination device installed, it the TEM will remain in a vacuum state overnight, or if the column will be filled with air, the coolant needs to be drained from the ACD and the trap has to be heated until it reaches room temperature.

1. Cover the viewing window with an appropriate lid.
   If it is not covered with a lid, liquid nitrogen may come into contact with the window and the window glass may break.
2. Remove the cap for the coolant fill opening of the coolant reservoir.
3. Wear appropriate protective eyeglasses and gloves (made of leather that liquid nitrogen will not permeate) and insert the coolant evaporator into the reservoir.
   a. Lower the protective tube until it stops (Fig. 5.68).
   b. Put the lower end of the protective tube on the coolant inlet.
   c. Insert the coolant evaporator into the reservoir and insert the evaporator plug into the HTR socket in the connector box (Fig. 5.67).
4. Open the Bake Out/ACD Heat window (Fig. 4.62) from the Maintenance menu and click on the ACD Heat **On** button (Fig. 4.62-②).
5. Wait until ACD Heat turns OFF and after another 15 minutes or so, dismount the coolant evaporator.

⚠ CAUTION
 **Do not remove the evaporator while the lamp installed in the ACD HEAT is lit or immediately after it has been turned off.** The evaporator heater is at a high temperature when the lamp is lit or immediately after it is turned off. Therefore, you might burn yourself.

5.14 SPECIAL OPERATIONS

5.14.1 Saving Alignment Data

You can save all the alignment data in the computer and load them to restore the alignment conditions when necessary. This function can be used to save the alignment data set under special conditions or to find the lost beam using the saved data with which the most preferable alignment conditions have been obtained.

- Select **TEM Controller — Maintenance — Alignment** to display the "Alignment Panel for Maintenance" window.
  - The areas circled with a dotted line in the figure will be used for subsequent operations (Fig. 5.69).

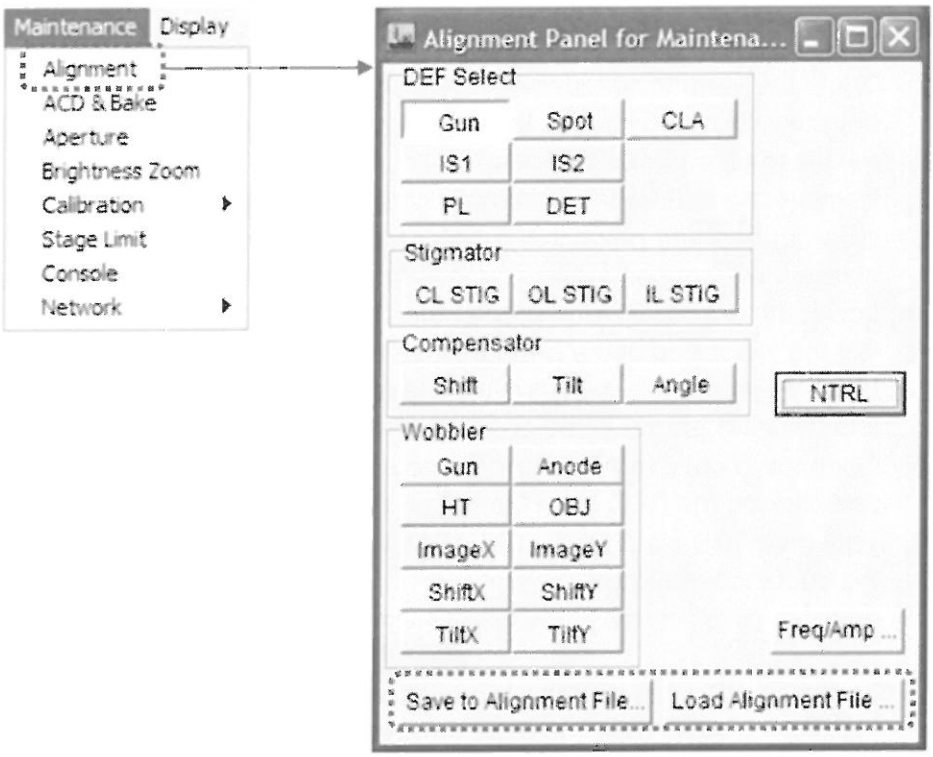


Fig. 5.69 Alignment Panel for Maintenance window

5.14.1a Saving

1. Click on **Alignment Panel for Maintenance — Save to Alignment File....**
   The Save As window appears (Fig. 5.70).
2. Enter the filename from the keyboard and click the **Save** button.

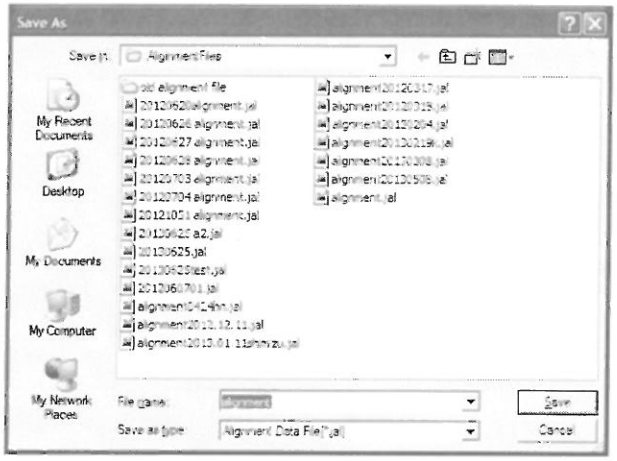


Fig. 5.70 Save window

When saving, all the deflection data is saved regardless of the microscope mode (TEM or STEM).

If you want to delete a saved file, right-click the file you want to delete in the Save or Open window, and select **Property — Delete**.

5.14.1b Loading the data

1. Click **Alignment Panel for Maintenance — Load Alignment File....**
   The Open window appears (Fig. 5.71).
2. Select the file you want to load and click the **Open** button.

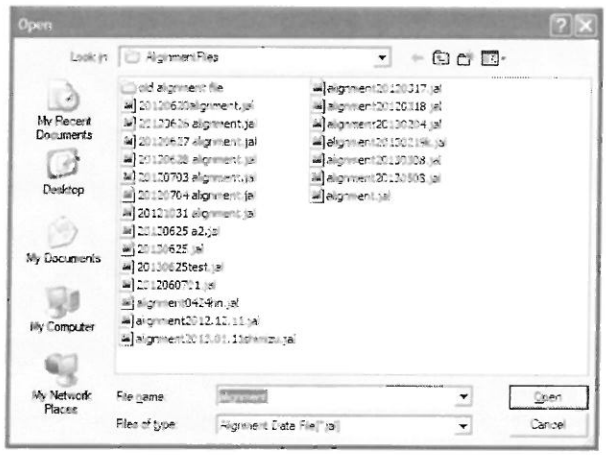


Fig. 5.71 Open window

When you load a file during the TEM (TEM image observation), all the deflection data necessary for TEM imaging is loaded. When you load a file during the STEM (STEM image observation), all the data necessary for STEM imaging is loaded.

If you want to delete a saved file, right-click the file you want to delete in the Save or Open window, and select **Property — Delete**.

5.14.2 Free Lens Control (FLC)

You can change each lens and create special lens conditions. Additionally, the created lens conditions can be saved.

1. Open the FLC Panel window (☞ Sect. 4.4.7k).

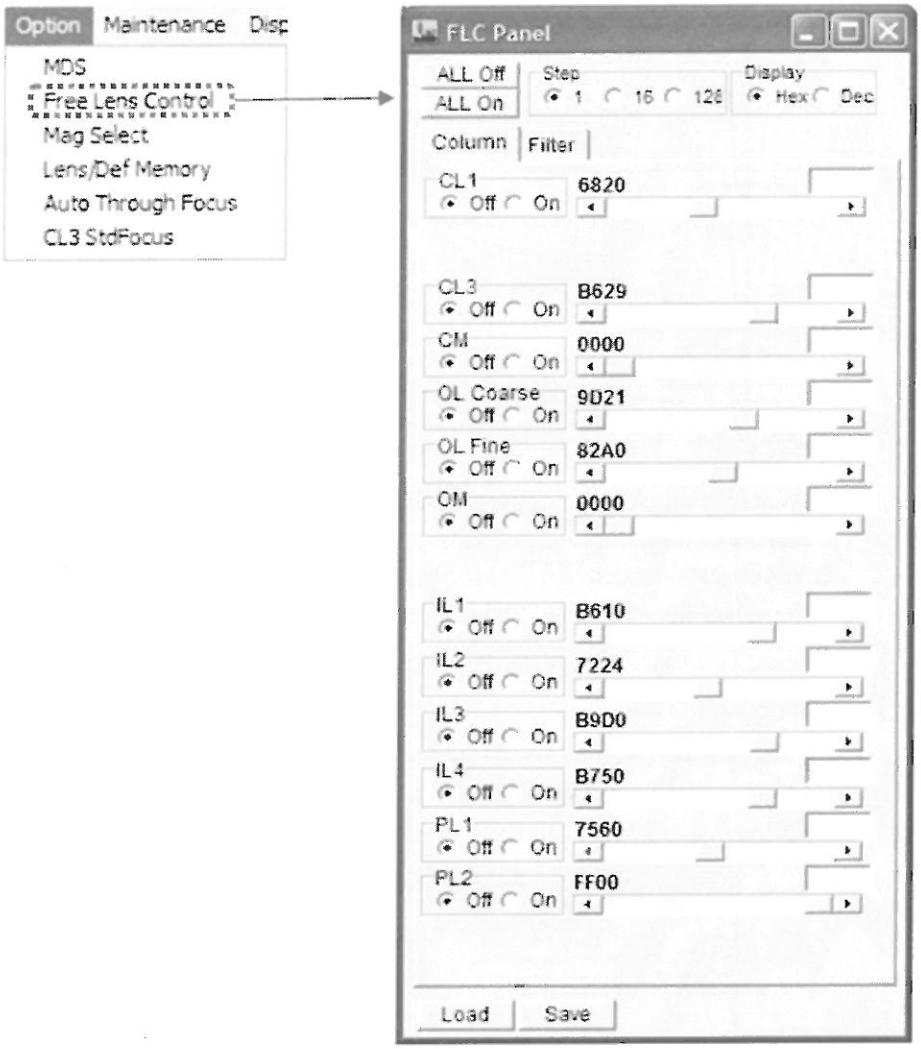


Fig. 5.72 FLC Panel window

2. Turn on the lens (Fig. 4.59-①) you want to change, or turn on ALL (Fig. 4.59-③).
3. Change the lens excitation value with the scrollbar (Fig. 4.59-⑥).
   You can also change the value using Step (Fig. 4.59-④).
4. To save, click **Save** (Fig. 4.59-⑨) and display the Save As dialog (Fig. 5.73). Then enter the file name and click the **Save** button. When loading the data, click "Load" (Fig. 4.59-⑧) and select the file to load from the file selection dialog (Fig. 5.74).

Fig. 5.73 FLC Data Saving

Fig. 5.74 FLC Data Loading

To delete a saved file, right click on the file to delete in the Save window or Open window. Then select **Property — Delete**.

5. Turn OFF the lens (Fig. 4.59-①) you have selected or turn OFF ALL (Fig. 4.59-③) to finish FLC.

   Before you close the window, all the items must be turned OFF (Fig. 4.59-③). If it is not turned OFF, free lens control will not be OFF even if the FLC Panel is shut down.

5.14.3 Lens / Deflection System Data Save Function

It is possible to save and load the currently used lens and deflector system data.

◆ Select **TEM Controller — Option — Lens/DEF Memory** (Fig. 5.75).

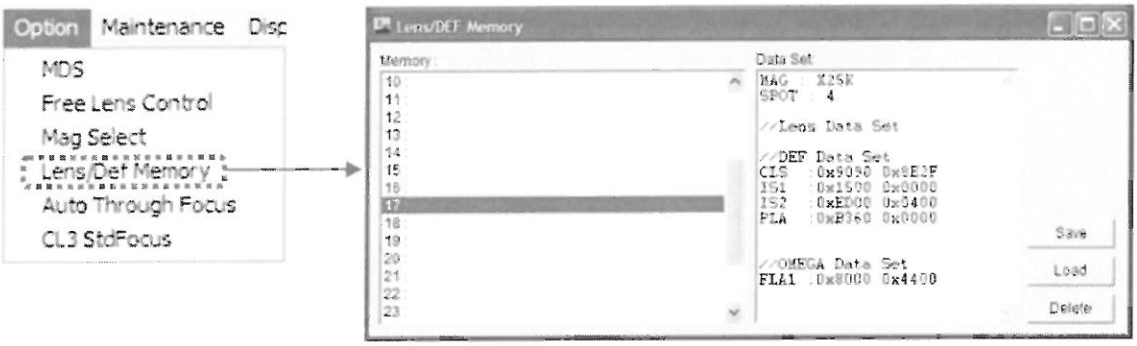


Fig. 5.75 Lens/DEF Memory window

5.14.3a Saving

1. To save the current values of the presently used lens and deflection system, click the **Save** button in "Lens/DEF Memory", and display the "Lens/DEF Memory Option" window (Fig. 5.76).
2. Select the check boxes of the lenses and the deflection systems to save. Then, type a comment in the Comment box from the keyboard, and click the **OK** button.

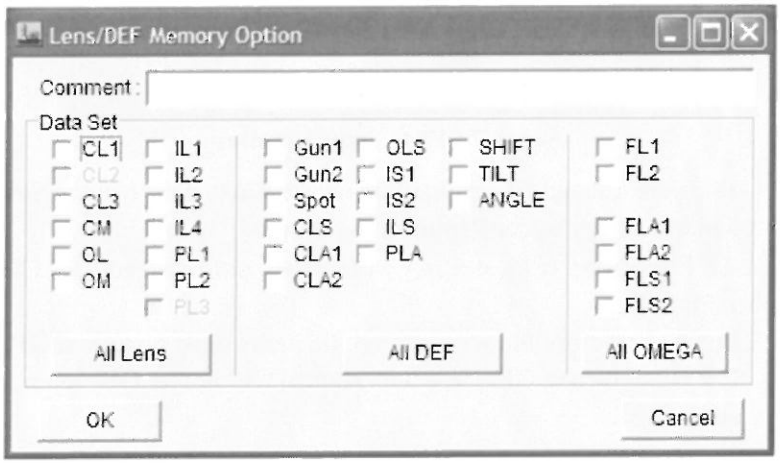


Fig. 5.76 Lens/DEF Memory Option window

- Clicking the **All Lens** button, selects all the lenses. Clicking the **All DEF** button, selects all the deflector systems.
- The information on the saved lenses and deflection systems will appear under "Data Set" field.

5.14.3b Load

1. To load a saved file, click on the file name in the Memory field on the "Lens/DEF Memory" window.
2. Click the **Load** button.
   - To load the saved lens current, use the FLC (Free Lens Control) function. After loading the lens current, display the FLC (☞ Sect. 5.14.2) and set to "All Off" in order to cancel this state.
   - When loading for the deflection system is executed, there is no function to return to the previous values. To return it to previous values, readjust the deflection system settings, or save the values beforehand and reload them.

5.14.3c Delete

1. Click on the file name to delete in the Memory field in the "Lens / DEF Memory" window.
2. Click the **Delete** button.
   The selected file is deleted.

5.14.4 Lens Relaxation

This is a function to increase and decrease the lens current periodically in order to relax the lens hysteresis. Normally, the menu does not display the function to open this window.

- To use it, contact your local JEOL service office.

◆ Select **TEM Controller — Option — Lens Relaxation**. The Lens Relaxation window is displayed (Fig. 5.77).

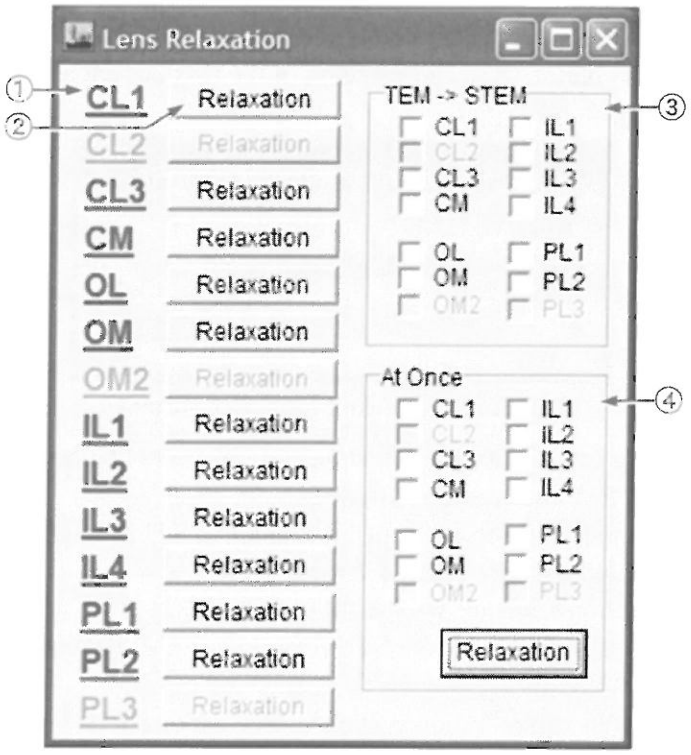


Fig. 5.77 Lens Relaxation window

① Setting

When a lens name is clicked, the setting window for that LENS will be displayed (Fig. 5.78). Select the Interval Time (unit milliseconds), Max/Min Value (initial oscillation value in Hex units), Difference Value (decrease value for each cycle in Hex units) in the Setting window. In addition, the approximate time of the Relaxation appears in Total Time. After the selection, click [×] at the top right of the Setting and close the window.

There is a separate setting window is for each LENS name.

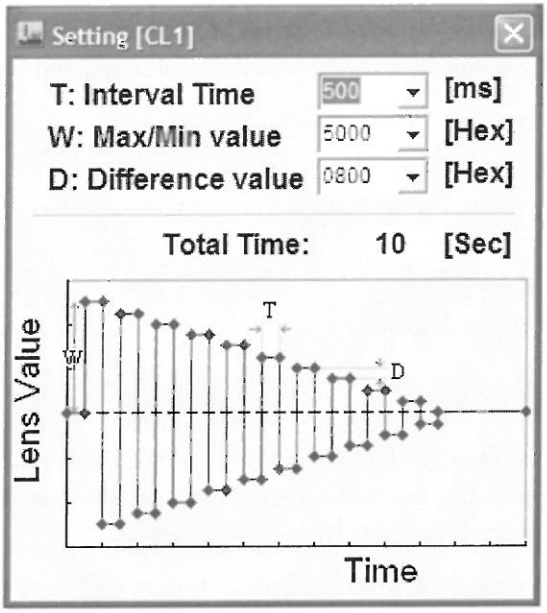


Fig. 5.78 Setting window

② Relaxation

Clicking this button starts the variation of the lens current according to the setting for the lens (Fig. 5.79).

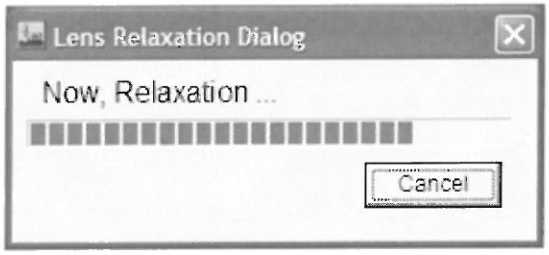


Fig. 5.79 Executing Lens Relaxation

During Lens Relaxation, other operations cannot be executed.

③ TEM→STEM automatic Relaxation

When the mode is switched from TEM mode to STEM mode, the Relaxation for the selected LENS will be executed automatically.

Relaxation sequence will be from CL1→PL.

When it is switched from STEM mode to TEM, Relaxation will not be executed.

④ At Once Relaxation

When the **Relaxation** button is clicked, Relaxation for the all the selected lenses will be executed in sequence.

Relaxation sequence will be from CL1→PL.

5.14.5 QES (Quick Emission Selector)

This function will save and load a value for the electron gun power supply that is different from the standard setting. Normally, it is set so that the QES cannot be used. To use this, contact your JEOL service office.

Varying the electron gun power value may damage the stable electron beam generating state.
To use this function, contact your JEOL service office.

—CAUTION—

Do not use the electron microscope for more than one day while the condition (value) of the electron gun power supply is other than the Standard status.

Varying the electron gun power value may damage the stable electron beam generating state.

◆ Open the "High Voltage Control" window (Fig. 5.80).
If the QES can be used, the QES 1, QES2 and QES3 buttons can be clicked. The power supply values of the gun saved in QES1 to QES3 are displayed in the "FEG and QES setting" window.

The initial setting values of QES are the standard values of the electron gun power supply except that the A2 voltage is 7.0 kV.

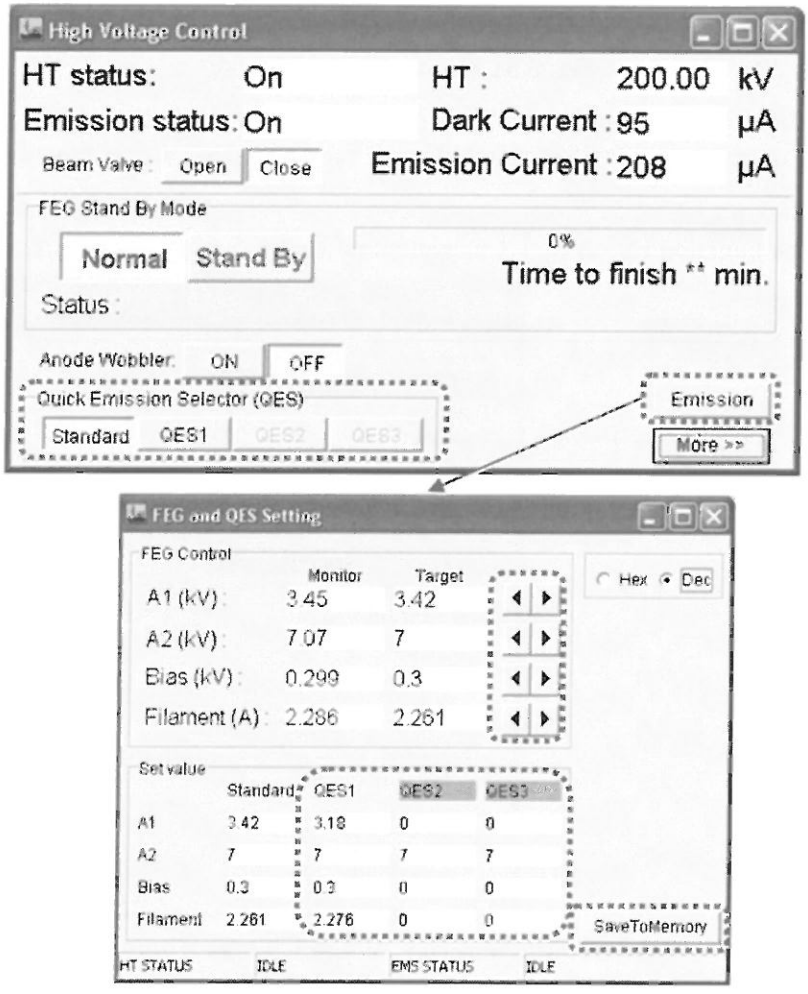


Fig. 5.80 QES window

● QES Method of use

If any one of QES1 to QES3 is clicked when electron beam is generated (Standard electron gun power supply value) the FEG power supply will shift to the electron gun power supply value saved in that QES number. If the electron gun power supply value is varied ([◀], [▶]) in that state (for that QES number), that value will be saved in that QES number. When the **Standard** button is clicked, the settings will return to the Standard electron gun power supply values.

The data changed with [◀], [▶] buttons will be cleared when the microscope is restarted. If you need to save the varied QES values after restarting the microscope, click **Save to Memory**.

5.14.6 Setting, Saving and Loading the Function Keys

It is possible to change the functions assigned to the Function switches (Fig. 4.3-⑫) in the control panel R1. Settings can also be saved and loaded.

5.14.6a Function Key Setting

The function set for each control panel R1 function switch is displayed at the upper part of the TEM Controller (Fig. 5.81).

Fig. 5.81 Function Key Display

The assigning of the function can be changed by clicking on the F numbers. Here, the Screen up/down, set to F1 as a default, will be changed to another function as an example.

1. Click **F1**.
   The Function Key Assign Change window (Fig. 5.82) will be displayed.

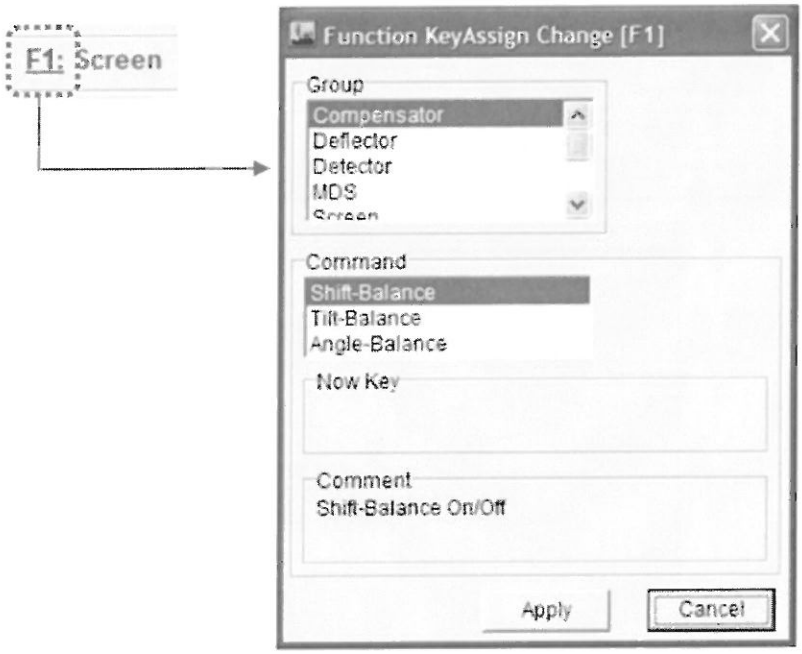


Fig. 5.82 Function Key Assign Change window

2. From the Group field, select the class name that has the target function.
   A list of correspnding functions will be displayed in the Command field.

3. Click on the **Command name** to set.
4. After clicking the **Apply** button, click the **Cancel** button or the × at the top right and close the window.
   The Function switch function will be changed after the window has closed.
   - If change of a function assignment will not be performed, click the **Cancel** button or × at the top right without clicking the **Apply** button.
   - Other Function switches can be changed in the same way.
   - When starting the TEM Controller, the last function that was set will be assigned to the Function switch.

5.14.6b Saving the Function Key Settings

The saved functions or those saved all at once that are set to the Function switches can be loaded all at once.

1. Click on **TEM Controller — Property — Function Key Assign.**
   The Function Key Status window is displayed. The functions currently set to the Function switches will be displayed in the Function Key Status field (Fig. 5.83).

Fig. 5.83 Function Key Status window

2. To save (save all at once) these functions, click on the **Save** button in the Setting File field.
3. The Save As window (Fig. 5.84) will be displayed, enter a file name from the keyboard and click the **Save** button.
   The settings for F1 to F6 will be saved all at once.

- When deleting a saved file, right click on the file you want to delete in the Save or Open window, and click **Property — Delete**.

Fig. 5.84 Save As window

5.14.6c Loading the Function Key Settings

1. To load a saved file, click the **Load** button in the Function Key Status window (Fig. 5.85).
2. Click on the file name you want to load and click the **Open** button.

Fig. 5.85 Open window

3. Close the Function Key Status window.
   The function switch function settings will be changed after the window has closed.

To delete a saved file, right click on the file you want to delete in the Save or Open window, and click **Property — Delete**.

5.14.6d Functions of Function Switches

This is a list of functions that can be assigned to the function switches.

There are some functions that cannot be used depending on the instrument.

Table 5.1 List of Function Switch Assignments (Compensator, Deflector)

Group	Command	Functions
Compensator	Shift-Balance	Assigns the Shift-Balance adjustment function to the DEF/STIG knobs.
	Tilt-Balance	Assigns the Tilt-Balance adjustment function to the DEF/STIG knobs.
	Angle-Balance	Assigns the Angle-Balance adjustment function to the DEF/STIG knobs.
Deflector	GUNA	Assigns the electron gun first and second deflector coil adjustment functions to the SHIFT and DEF/STIG knobs, respectively.
	SPOT	Assigns the spot alignment coil adjustment function to the DEF/STIG knobs.
	CLA	Assigns the CL first and second deflector coil adjustment functions to the SHIFT and DEF/STIG knobs, respectively.
	IS1	Assigns the first image shift coil adjustment function to the DEF/STIG knobs.
	IS2	Assigns the second image shift coil adjustment function to the DEF/STIG knobs.
	PLA	Assigns the PL deflector coil adjustment function to the DEF/STIG knobs.
	CL-STIG	Assigns the CL stigmator coil adjustment function to the DEF/STIG knobs.
	OL-STIG	Assigns the OL stigmator coil adjustment function to the DEF/STIG knobs.
	IL-STIG	Assigns the IL stigmator coil adjustment function to the DEF/STIG knobs.
	FLA	Assigns the filter lens first and second deflector coil adjustment functions to the SHIFT and DEF/STIG knobs, respectively (can only be used with JEM-2200FS/3200FS).
	FLS1	Assigns the filter lens first stigmator coil adjustment function to the DEF/STIG knobs (can only be used with JEM-2200FS/3200FS).
	FLS2	Assigns the filter lens second stigmator coil adjustment function to the DEF/STIG knobs (can only be used with JEM-2200FS/3200FS).

Table 5.2 A List of Function Switch Assignment (Detector, MDS)

Group	Command	Functions
Detector	Camera + Detector	Moves the Screen Up/Down. It also sets ON/OFF of the deflector coil assigned by the detector.
	GIF	Moves the Screen Up/Down. It sets the optical system GIF mode of the electron microscope ON/OFF. (It can only be used when the GIF is installed.)
	Holography	Sets the optical system holography mode of the electron microscope ON/OFF. (It can only be used when the electron beam biprism is installed.)
	STEM	Sets the optical system scanning image observation mode of the electron microscope ON/OFF. (It can only be used when the scanning image observation device is installed.)

Group	Command	Functions
	STEM-BF	Sets the pneumatic drive scanning transmission electron bright field detector IN/OUT. (It can only be used when the bright-field scanning transmission detector is installed.)
	STEM-DF	Sets the pneumatic drive scanning transmission electron dark field detector IN/OUT. (It can only be used when the bright-field scanning transmission detector is installed.)
	STEM-UDF	Sets the pneumatic drive upper omega dark field image observation detector IN/OUT. (It can only be used when the upper omega dark field image observation detector is installed.)
MDS	MDS-OFF	Turns off the MDS mode.
	MDS-Search	Moves to the Search mode of the MDS.
	MDS-Focus	Moves to the Focus mode of the MDS.
	MDS-Photo	Moves to the Photo mode of the MDS.
	MDS-Blanking	Performs BEAM Blanking at MDS.

Table 5.3 A List of Function Switch Assignment (Screen, Stage, Wobbler, etc.)

Group	Command	Functions
Screen	Screen	Moves the Screen up/down (it only moves 90° up).
Stage	Neutralize Stage	Sets the specimen stage (including the Superfine) to the neutral point.
	Neutralize Superfine	Sets the Superfine drive system to the neutral point. (It can only be used when piezo drive supply is installed.)
	Superfine	Switches the specimen stage from motor drive system to Superfine drive system. (It can only be used when piezo drive supply is installed.)
Wobbler	HT	Oscillates the high voltage periodically.
	GUN	Oscillates the first deflector coil X current of the electron gun periodically.
	OBJ	Oscillates the OL excitation periodically.
	Image X	Oscillates the CL deflector coil X current periodically (Image Wobbler X).
	Image Y	Oscillates the CL deflector coil Y current periodically. (Image Wobbler Y)
	Anode	Oscillates the second anode voltage of the electron gun periodically. (It can only be used on instrument with field emission electron gun installed.)
	Shift X	Oscillates the CL first deflector coil X current periodically. Use this function for the link adjustment of the Shift X.
	Shift Y	Oscillates the CL first deflector coil Y current periodically. Use this function for the link adjustment of the Shift Y.
	Tilt X	Oscillates the CL second deflector coil X current periodically. Use this function for the link adjustment of the Tilt Y.
	Tilt Y	Oscillates the CL second deflector coil Y current periodically. Use this function for the link adjustment of the Tilt Y.
Etc	Brightness Zoom	Turns ON the Brightness Zoom function.
	MAG2	Records the magnification to display when switching to the MAG2 mode.

5.15 PHOTOGRAPHY

5.15.1 Film Number and Film Text Setting

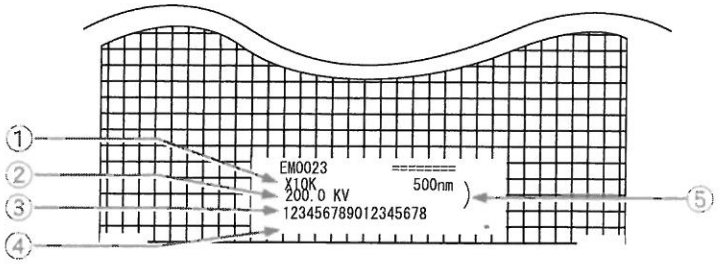


Fig. 5.86 Printing data on the film

① Film number
Set the initial value in the Film Camera Property window (☞ Sect. 4.4.7f).

② Photography Magnification
It is inserted automatically. Magnification will be inserted in MAG mode, Camera length in DIFF mode and variance will be inserted in SPCTR mode.

③ Accelerating voltage
It is inserted automatically.

④ Film Text
It is set in the Film Camera Property window (Fig. 4.44-⑤).

⑤ Micron scale
It is inserted automatically. It is not inserted in DIFF mode. It will be an energy value in SPCTR mode.

5.15.2 Photography by Manual Exposure

1. Clear the PHOTO AUTO switch (R1-⑩), or the Auto Exposure check box in Filter Camera Property window (Fig. 4.44-①) and change to manual exposure mode.
2. Set the exposure time with PHOTO EXP TIME knob (R1-⑩), or with Exp Time in the Film Camera Property window (Fig. 4.44-①).
3. Press the PHOTO switch (R1-⑩) and send the film to the photography position. When loading it automatically, set it using Advance in the Film Camera Property window (Fig. 4.44-②).
4. Press the PHOTO switch again (R1-⑩).
Photography is performed. The PHOTO EXP lamp is (R1-⑩) lit while the shutter is open. After the photographing, exposed films are stored in the receiving magazine.

5.15.3 Automatic Exposure

1. Change to automatic exposure mode with the PHOTO AUTO switch (R1-⑩), or the Auto Exposure check box in the Film Camera Property window (Fig. 4.44-①).
2. Perform the normal photographing procedure.
   Before the film exposure, the wide field of view CCD camera is retracted, the intensity is measured with the fluorescent screen in the image detection chamber and the exposure time is calculated automatically. Then the photographing is performed. To find out the exposure time beforehand, retract the wide field of view CCD camera before photographing. Then the exposure time will be displayed in the Exp Time section on the Film Camera Property window (Fig. 4.44-①). It is possible to start photographing when the CCD camera is in the retracted status.
   - The fluorescent screen that measures the exposure time is 25 mm in diameter and provides an average of only the center part of the field of view.
   - To stop the exposure midway, press the **PHOTO** button during exposure.

5.15.4 Multiple Exposures

There is a method to set a multiple exposure mode from the PC window and a method to perform multiple exposures from the panel.

● Setting to multiple exposure from the PC window

1. Select the Multi Exposure check box in the Film Camera Property window to switch to the multiple-exposure mode.
2. Perform the normal photographing procedure.
   The exposed film remains at the photographing position after the photography and it will not be stored in the magazine.
3. Photographing can be continued by pressing the PHOTO switch.
4. Send the exposed film to the receiving magazine using Film Eject in the Film Camera Property window.

● Performing Multiple Exposure from the Panel

1. Prepare for photographing as usual.
2. Press the **PHOTO** button and start photographing.
3. Press the **PHOTO** button again before starting the exposure (before the LED lights up). Or press the **PHOTO** button again after the exposure is finished (after the LED has turned off).
   The exposed film will not be stored in the magazine. It is retained at the photographing position.
   Exposure can be overlapped many times using this method.
   - An exposed film can be stored in the magazine if the **PHOTO** button is pressed once during the last exposure. Additionally, it is possible to send the exposed film immediately to the magazine using Film Eject in the Film Camera Property window.

- The film text and magnification printed on the multiple exposure photo will be the same as the first exposure.

5.16 FILM PROCESSING

1. Unload the receiving magazine from the camera chamber (☞ Sect. 5.3.2).
2. In the darkroom remove the lid from the receiving magazine, and take out the cassettes from the magazine under the red safelight.
3. Carefully remove the film from the cassette (Fig. 5.87).

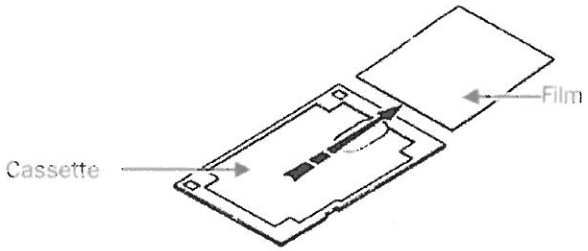


Fig. 5.87 Removing the film from the cassette

Immerse the film in a specified developer (20 ± 0.5 ℃) for 3 to 4 minutes (Fig. 5.88).

4. Develop the latent image of the exposed film until it is dark enough to be fully visible. During the developing process, stir the developer or move the film in order to avoid development streaks.

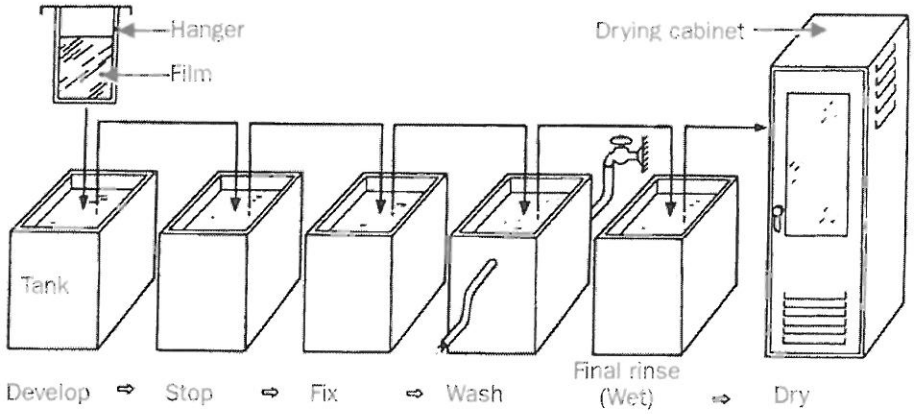


Fig. 5.88 Film processing

If only a few films are to be processed, developing trays may be used. If many films are to be processed at one time, it is recommended to use suitable tanks and hangers. However, these are not provided. Therefore, purchase commercially or manufacture appropriately (stainless steel or polyvinyl chloride tanks are the best).

5. Immerse the film in a stop bath (2 to 3% glacial acetic acid solution, 18 to 21 ℃) and leave it in for approximately 30 seconds.
   Doing so arrests development to prevent the film from becoming spotty and to prolong the effectiveness of the fixer.
6. Immerse the film in a rapid acid hardening fixer (at 18 to 21 ℃) and leave it in for approximately ten minutes.
   The fixing time should be at least two or three times the time it takes for the white portions of the film to become clear.
   This dissolves (changes to soluble complex salt) the photosensitive silver halides (the white part of the film) and thereby makes the unexposed part of the film transparent.

- Subsequent processing can be carried out under an 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 fixer solution from the film. The washing time can be reduced considerable by immersing the film in a rinse accelerator prior to washing it in running water.
8. Immerse the film in a commercially available 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 unevenness from developing on the film.
9. Dry the film in a drying cabinet (small cabinet is enough). (Or dry it naturally by hanging it in a well-ventilated, dust-free place away from direct sunlight.)
   Store the dried film in a film bag (made of polyethylene, cellophane, or similar material) and keep the envelope in a dry place away from direct sunlight.

Problems with the film processing can be determined from the table below (assuming the proper exposure time).

Table 5.4 Identifying film processing problems

Phenomenon	Cause
● No picture	○ The film was set on the wrong side when it was photographed.
● Blackening	○ Magazine lid inadvertently opened while being carried
● Fogging	○ Faulty safelight
	○ Film expired
● High density	○ Developer temperature too high
● Low density	○ Developer temperature too low
● Too grainy (Blackened silver particles)	○ Developing time is too long
● Uneven density	○ Developing time is too short
	○ Developer is too old
● Spotty stains (mottling)	○ Developer agitation insufficient
	○ Film electrically charged before developing
● Scratches, streaks	○ Film emulsion surface rubbed
● Discoloration of film during storage	○ Insufficient fixing and rinsing
● It becomes moldy during storage	○ Method and place of storage unsuitable
	○ Insufficient drying
● Particulates are attached	○ Impurities in water
● Unevenness on film	○ Water droplets left on film before drying
● Crease on the surface	○ Tap water temperature too high

5.17 OPERATION WHEN A PROBLEM OCCURS

5.17.1 If the Electron Beam is not Emitted

Even when you carry out normal operation, the electron beam may not be emitted. Avoid changing something such as alignment without reason, and verify the following items one by one. If you still cannot find the electron beam, please contact a JEOL service engineer.

● Is the electron gun isolation valve V1 open?

If the conditions for opening the electron gun isolation valve are not fulfilled, the Beam Valve display on the "TEM Controller" left main window (Fig. 4.20-④) will remain gray. Therefore, V1 will not open even if Beam Valve Open is performed.
Verify that the following permission conditions are fulfilled.

1. Make sure that the pressure in the camera chamber is low enough and that the Camera/PIG3 in Valve Status window is set to "Evac Ready" (☞ Sect. 4.4.7h).
2. Make sure the specimen holder is inserted into the column.
3. Make sure that the high voltage is applied to the electron gun (☞ Sect. 4.4.7b).

● Is the electron gun isolation valve V1 open?

1. Make sure the electron beam generating setup is completed (☞ Sect. 4.4.7b).
2. Make sure that the electron gun power supply value is normal (☞ Sect. 4.4.7b).

● Is the lens power supply turned on?

1. Make sure that the LENS switch (L2-③) is turned ON.
2. Verify that current is actually flowing to the lens using the Lens Voltage window (☞ 4.4.7g) in the Status Monitor. If the lens voltage is 0 V or -10 V, turn the LENS switch off once, and turn it ON.

   ✍ If cooling of the Lens coil is insufficient, the safety circuit turns off the Lens power supply. Therefore, check the Lens cooling water. When the Lens coil cools off, you can turn on the Lens power supply.

● Is there any obstacle on the electron beam axis?

A variable aperture or a specimen itself may be an obstacle to the electron beam. Follow the procedure below to search for the electron beam.

1. Set the irradiation system to TEM mode, spot size to No. 1, and α selector to No. 3, and turn the BRIGHTNESS knob (L1-⑦).
2. Open all the variable apertures or turn the BRIGHTNESS knob.
3. Decrease the magnification and turn the BRIGHTNESS knob.
4. Try to move the specimen.
5. Insert the specimen holder with the specimen removed into the column.

● Restoring the Lens/Deflection System Data

Click "Load Alignment File" in the "Alignment Panel for Maintenance" window (☞ Sect. 5.14.3b) to load the saved data.

✍ To handle such cases, it is recommended to save the data for the lens in normal state / deflection system. By default, the Lens/deflection system data is saved in **C drive – Program Files – JEOL – TEM Controller – Temcon - Alignment Files** folder with the extension "jal". In case the PC breaks down, it is recommended to save the data on other media.

5.17.2 When the Operation System Freezes

If the operation GUI or panel cannot be operated (freezes), follow the procedure below. If the function still does not operate, contact your JEOL service office.

1. Press the RESET switch located under the operation table to restart the system (☞ Sect. 4.2.7).
   ✍ It takes several minutes to restart the system. Since the evacuation system and the electron gun power supply will not reset, the system returns in the safe state.
2. Terminate the TEM Controller software, restart the PC and start the application software (☞ Sect. 4.4.1).

6 MAINTENANCE

6.1 ROUTINE INSPECTION

6.1.1 Items for Routine Inspection

When using the microscope, we recommend that you inspect the following items periodically.

Table 6.1 Routine check items

Inspection item	Period	Reference	Measure
Emission current value	Every day	Setting value of service engineer ☞ Sect. 6.1.2	If it deviates 20 μA or more, contact your JEOL service office.
Dark Current	Every day	☞ Sect. 6.1.3.	If it increases or decreases by ±2 μA or more, contact your JEOL service office.
Electron Gun Pressure (Vacuum)	Every day	60 L/s power supply 0.4 x10^{-6}Pa or less 20 L/s power supply 0.5 x10^{-6}Pa or less ☞ 6.1.4 Sect.	Contact your JEOL service office.
Gun insulation gas pressure	Every week	0.30 to 0.32 MPa at gauge pressure ☞ Sect. 6.1.5b	Add gas if the pressure is low. ☞ Sect. 6.2
High voltage tank insulation gas pressure	Every week	Gage pressure is inside of a normal range. ☞ Sect. 6.1.6	Add gas if the pressure is low. ☞ Sect. 6.2
Compressed air pressure	Every week	0.5 MPa at gauge pressure ☞ Sect. 6.1.5a	Adjust the pressure if it deviates from the reference value.
Cooling water temperature and flow rate	Every week	Setting value of service engineer	If it deviates from the setting value, contact your JEOL service office.
Volume of water in the chiller water tank	3 months	Reference surface level or specified value by service engineer	Refill.
Drainage of the compressor	Every month	–	Drain the water. ☞ Sect. 6.1.7.
Oil Level of the Rotary Pump	Every month	Position of the white circle ☞ Sect. 6.1.8	Replace the oil after stopping the instrument or contact your JEOL service office.
Replacing oil for the rotary pump	Every six months	Change in color (colorless at first)	Replace the oil after stopping the instrument or contact your JEOL service office.
Dry pump	Every year	–	Overhaul the pump. Contact your JEOL service office.
Replacing oil for the diffusion pump	1 to 3 years	–	Contact your JEOL service office.
Battery of the turbo-molecular pump (optional)	Every year	–	Contact your JEOL service office.
Turbo molecular pump	1 to 3 years	–	Overhaul the pump. Contact your JEOL service office.
Replacing the Gun insulation gas	3 to 5 years	–	Contact your JEOL service office.
Replacing the high voltage insulation gas	3 to 5 years	–	Contact your JEOL service office.

6.1.2 Emission Current (Replacing the Emitter)

The emission current is displayed on the TEM Controller (Fig. 6.1).

Fig. 6.1 Emission current display

- If the emission deviates 20 µA or more from the value set by the JEOL service engineer in charge of installation, contact your JEOL service office.
- Also, if the emission current is not displayed even after completing the automatic electron beam generation, the emitter has probably reached the end of its service life. In such a case, you must replace the emitter. Contact your JEOL service office.
- When you generate the electron beam after stopping it for a long time, the emission current might sometimes be lower than the value set by the installation and service personnel. In such a case, do not operate the Gun power supply (such as increasing the A1 voltage), but monitor the current for a while. It will return in a few days.

6.1.3 Dark Current

Dark current depends on the accelerating voltage that is applied to the acceleration tube, and it is different from the beam current.

- **TEM Controller – Operation – High Voltage Control** Open window. Check the numerical value for Dark Current in the Current Monitor field (Fig. 6.2).

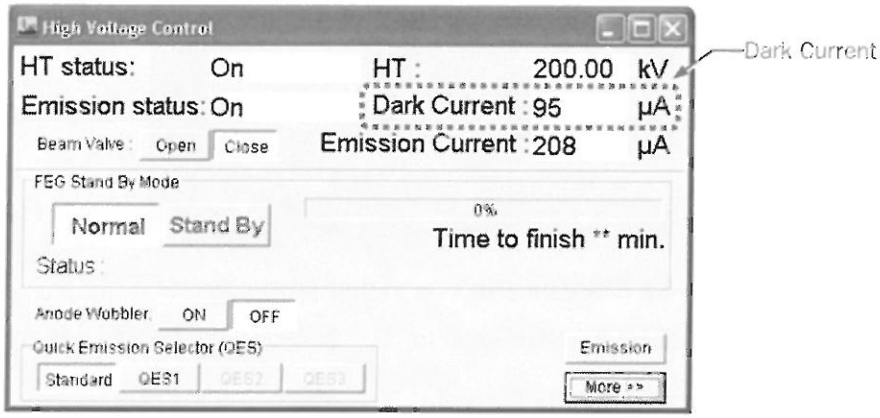


Fig. 6.2 High Voltage Control Window

The Table 6.2 shows the values of the dark currents while the microscope is generating an electron beam. If it deviates ±2 µA from the value shown below, contact your JEOL service office.

Table 6.2 Dark current (while the microscope is generating the electron beam)

Accelerating Voltage (HT)	Dark Current
200 kV	95 µA
180 kV	86 µA
160 kV	76 µA
140 kV	67 µA
120 kV	57 µA
100 kV	48 µA

The dark currents while the microscope is not generating the electron beam will be1 µA lower than the values listed in Table 6.2.

6.1.4 Electron Gun Pressure (Vacuum Pressure)

The electron gun chamber evacuation pump power supply (60 L/s) and intermediate chamber evacuation pump power supply (20 L/s) are installed at the top of inside the power supply console.

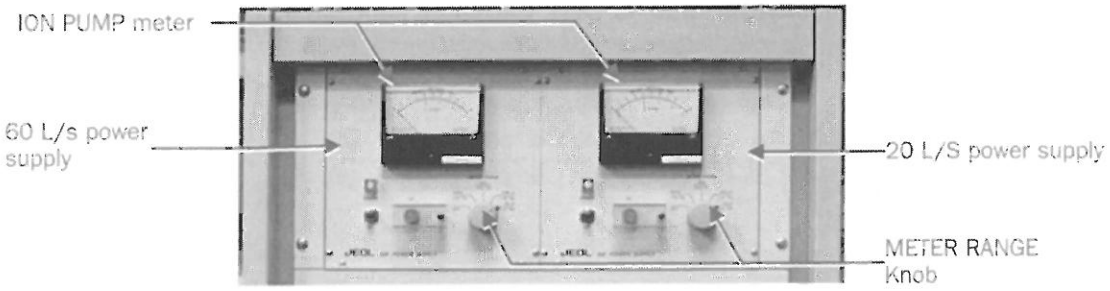


Fig. 6.3 Electron gun evacuation power supply

After setting the METER RANGE knob to "10^{-6} Pa", read the ION PUMP meter pump's "Pa".

For 60 L/s power supply 0.4×10^{-6} Pa or lower

For 20 L/s power supply 0.5×10^{-6} Pa or lower

If it meets the condition, it is normal. If the value is larger than above, contact your JEOL service office.

- If there different value has been set by JEOL personnel, that value has precedence.
- The power supply for the 20 L/s ion pump is used as the electron gun evacuation device (60 L/s ion pump) power supply. If it is a normal 60 L/s ion pump pressure, it will be 1/3 of the displayed value. However, it is not a genuine pressure gauge. Therefore, it cannot be used for absolute value evaluation of the electron gun pressure.

6.1.5 Compressed Air Gauge Pressure and Electron Gun Insulation Gas Gauge Pressure

6.1.5a Compressed air gauge pressure

On the left side panel of the microscope base frame, there is a gauge door where you can see the gun insulation gas pressure gauge and the compressed air pressure gauge (Fig. 6.4). The upper window gauge is the compressed air pressure gauge and the black pointer shows the current pressure. The normal value is 0.5 MPa. The red needle indicates the lower limit of the compressed air. If the pressure gets lower than this value, the microscope stops.

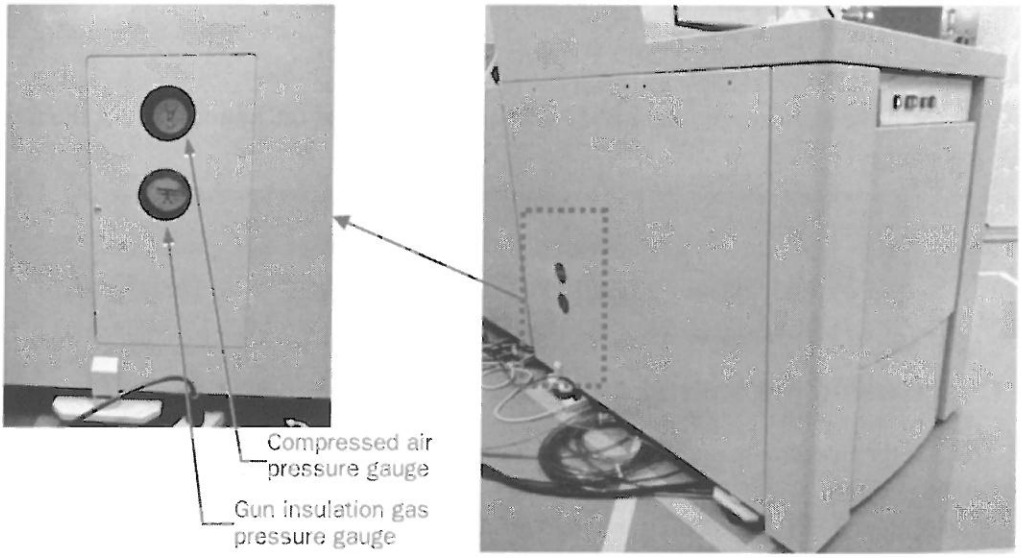


Fig. 6.4 Gauge door

- **Compressed air adjustment method**

1. Open the gauge door.
2. Pull up the adjustment knob (Fig. 6.5).
3. To increase the supply pressure, turn the adjustment knob clockwise. (Direction of the arrow in the diagram) To decrease the pressure, turn it counterclockwise.
4. When the pressure gauge reaches 0.5 MPa, push down the adjustment knob.

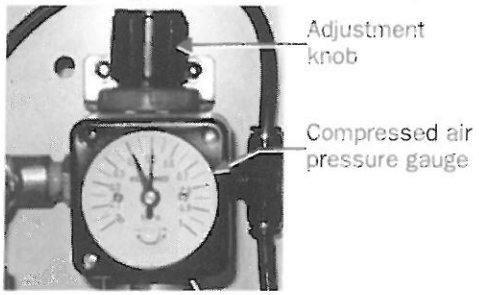


Fig. 6.5 Compressed air pressure regulator

6.1.5b Gun insulation gas gauge pressure

The lower gauge window on the gauge door (Fig. 6.4) is the gun insulation gas pressure gauge. The normal value of the gauge pressure is 0.30 to 0.32 MPa. If the insulation gas gauge pressure becomes 0.3 MPa or less, you cannot apply a high voltage.

☞ Refer to Section 6.2 for how to supply insulation gas.

6.1.6 High Voltage Tank Insulation Gas Pressure Gauge

The insulation gas gauge is located at the bottom of the high voltage tank. If the gauge pressure is lower than the lowest value of the normal range, high voltage cannot be applied (Emergency Tank Gas).
The normal range of the insulation gas pressure differs depending on when it was manufactured. Check the normal range and the standard pressure using the standard gas pressure indication or the instrument code on high voltage tank.
If the pressure is outside the normal range, please contact your JEOL service office.

☞ Refer to Section6.2 for how to supply insulation gas.

● Check using the Standard Pressure Indication

Check if the standard pressure (0.14 MPa) is displayed at the bottom part of the insulation gas gauge.

With or Without the Display	Normal Range	Standard Pressure
If it is not displayed	0.10 to 0.12 MPa	0.10 MPa
If it is displayed	0.12 to 0.16 MPa	0.14MPa

● Check using the Instrument Code

Check the instrument code engraved on the label attached at the bottom part of the high voltage tank.
Instrument code starts with the letter "S", followed by 3 digit number.

Instrument Code	Standard Value Range	Standard Pressure
532 and less	0.10 to 0.12 MPa	0.10 MPa
533 and more	0.12 to 0.16 MPa	0.14 MPa

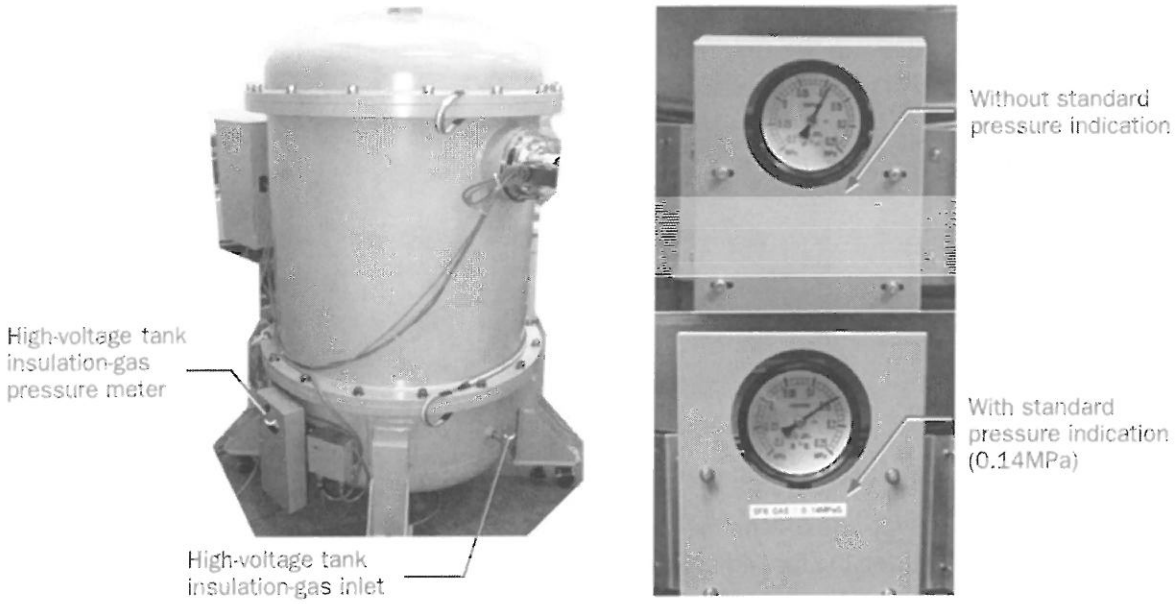


Fig. 6.6 Gas pressure gauge/gas inlet of the high voltage tank

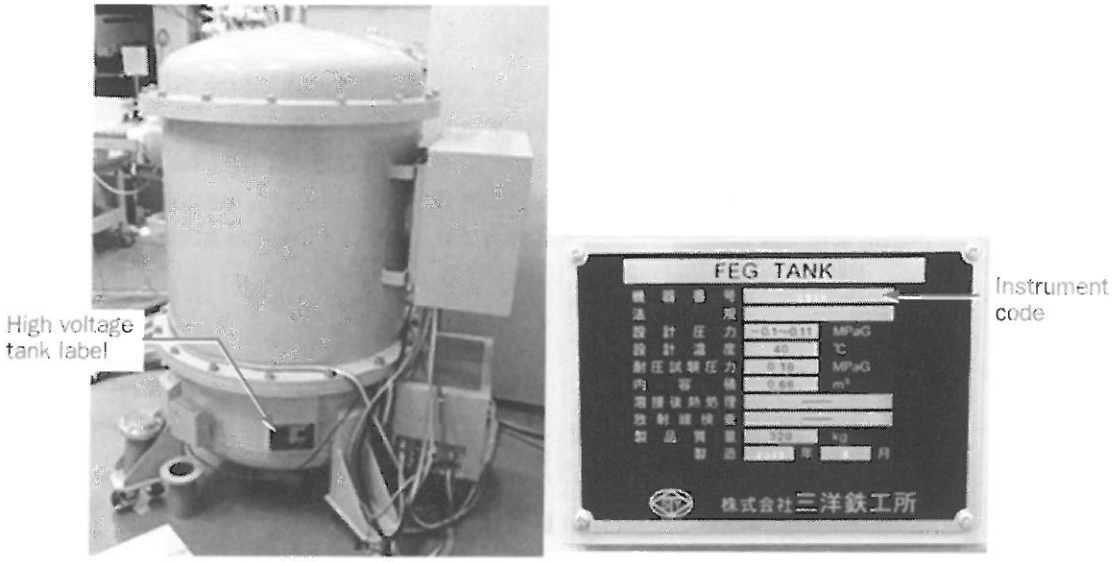


Fig. 6.7 High voltage tank instrument code

6.1.7 Draining the Compressor

This section describes the procedure for removing water when you use the EM-08011CP21 Air Compressor (Fig. 6.9). If you use another air compressor, refer to the instruction manual of the air compressor.

You can drain water from the EM-08011CP21 while the microscope is in operation. However, do not perform microscopy while you are removing the water.

1. Close valve A. Record the pressure gauge value.
2. Turn off the POWER switch.
3. Place an appropriate vessel under valve B, and slowly turn it counterclockwise to open it.
   Air and water will start to be emitted.
4. When the air stops being emitted, close valve B.
5. Turn on the POWER switch.
6. When the pressure gauge increases to the value recorded at Step 1, open valve A.

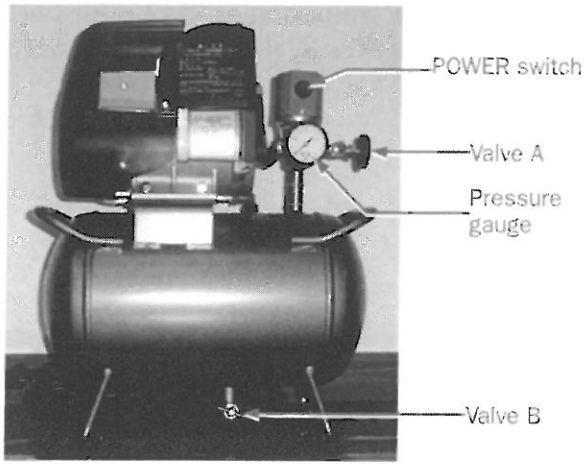


Fig. 6.8 EM-08011CP21 air compressor

6.1.8 Oil Level of the Rotary Pump

On the side panel of the rotary pump, there is a window through which you can see the oil surface level. A white mark is printed on the window (Fig. 6.9). Make sure that the oil is filled up to the mark. If the rotary pump is not filled with oil, it is necessary to refill the pump with oil. In addition, if the deterioration of the oil continues, the color of the oil seen through the oil window changes to dark brown. So, replace the oil as needed.

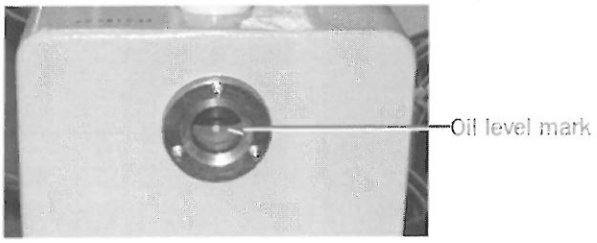


Fig. 6.9 Oil level mark of the rotary pump

● Refilling the rotary pump with oil or replacing oil

1. Stop the accelerating voltage and the beam generation (☞ Sect. 5.5.5).
   a. Click **More** in High Voltage Control window.
   b. Click the **Turn off** button under "Auto HT and Emission".
   The generation of the accelerating voltage and the electron beam stops automatically.
2. Close the "TEM Center" (☞ Sect. 5.2.4).
3. Shut down the main PC.
4. Stop the instrument.
5. Remove the white cap at the top of the rotary pump, and add or replace the oil.
6. Start up the instrument (☞ Sect. 5.2.1).

—CAUTION—

- **Stop the instrument before refilling the rotary pump with oil or replacing the oil.**
  If refill or replacement of the oil is performed while the oil rotary pump is operating, high temperature oil may splatter causing ignition or burns.
- **Use "NEOVAC-MR-200A" when refilling the rotary pump with the oil.**
  If you use other oils, it might cause malfunction of the pump.
- **Be sure to fasten the white cap at the upper part of the rotary pump.**
  If the cap is loose, it might cause the leakage of oil and damage the pump.

6.2 REFILLING THE ELECTRON GUN CHAMBER WITH SF_6 GAS

6.2.1 Cautions for Handling SF_6 Gas

⚠ WARNING

■ Handling high-pressure gas

- **Even if you use only a small amount of gas, provide sufficient ventilation.**
  You run the risk of suffocation due to a low oxygen concentration.

- **Because the inner pressure of the gas supply source such as a gas cylinder is very high, mount a pressure regulator on the gas outlet to decrease the secondary side pressure for the gas being used.**

- **When you operate the gas valve do not stand directly in front of the gauge. Operate it from an off-center position.**
  If the pressure gauge is damaged, shards of glass may be scattered and cause injury.

- **When you open the primary gas valve, open the valve slowly by one quarter or half rotation and check the increase in primary pressure on the pressure gauge. After that, fully open the valve.**
  Do not open the primary gas valve rapidly. The pressure gauge may be damaged due to the applied pressure.

● Sulfur hexafluoride (SF_6)

- **SF_6 is highly stable chemically and thermally and it has good insulation characteristics, but do not inhale the high density SF_6.**
  You run the risk of suffocation due to a low oxygen concentration.

- **If you need to repair the high-voltage tank, consult the JEOL service office. Do not open the tank. Provide a low humidity work environment for handling the gas container for the electron gun and for the gas refilling work.**

● Handling gas cylinders

- **When you install a gas cylinder, comply with the following.**
  - To prevent the gas cylinder from falling, it must be locked to the wall using a chain, or stabilize using a designated stand.
  - Ensure that the temperature of the installation room does not exceed 40 °C.
  - Do not place a heater near the gas cylinder.
  - Do not apply any shock to the gas cylinder.

  Always keep the handle close to the gas cylinder to open/close the primary valve.

- **Always confirm the service life of the gas cylinder. In addition, do not use a gas cylinder past the recommended service life.**

6.2.2 Characteristics of SF_6 Gas

The SF_6 gas specification is as shown below (Table 6.3).

Table 6.3 Characteristics of SF_6 Gas

Color	Smell	Toxicity	Combustibility	Molecular weight	Evaporation pressure	Purity
None	None	None	None	146.5	2.21 MPa (at 20 °C)	99.99 or more

6.2.3 Supplying SF_6 Gas to the Electron Gun Chamber

If the reading of the gas pressure gauge for the Gun (Fig. 6.10) decreases to 0.3 MPa or less, refill the electron gun chamber with SF_6 gas following the procedure below.

1. Stop the accelerating voltage and the beam generation (☞ Sect. 5.5.5).
   a. Click **More** in High Voltage Control window.
   b. Click the **Turn off** button under "Auto HT and Emission".
   The generation of the accelerating voltage and the electron beam stops automatically.
2. Connect the gas supply port (Fig. 6.10) to the SF_6 gas cylinder using a hose (with a quick coupling).
3. Open the gas supply valve of the gas cylinder, and when the reading of the gas pressure gauge reaches 0.3 MPa, close the gas supply valve and remove the hose from the gas supply port.
4. Make sure that the gas pressure gauge reads 0.3 MPa.
   If the reading of the gas pressure gauge is lower than 0.3 MPa, supply the gas again.

—CAUTION—

Do not operate the knob of gas control section.
If you do, the gun insulation gas will be forcibly discharged.

A JEOL service engineer in charge of installation will replace the insulation gas. Please do not replace it yourself.

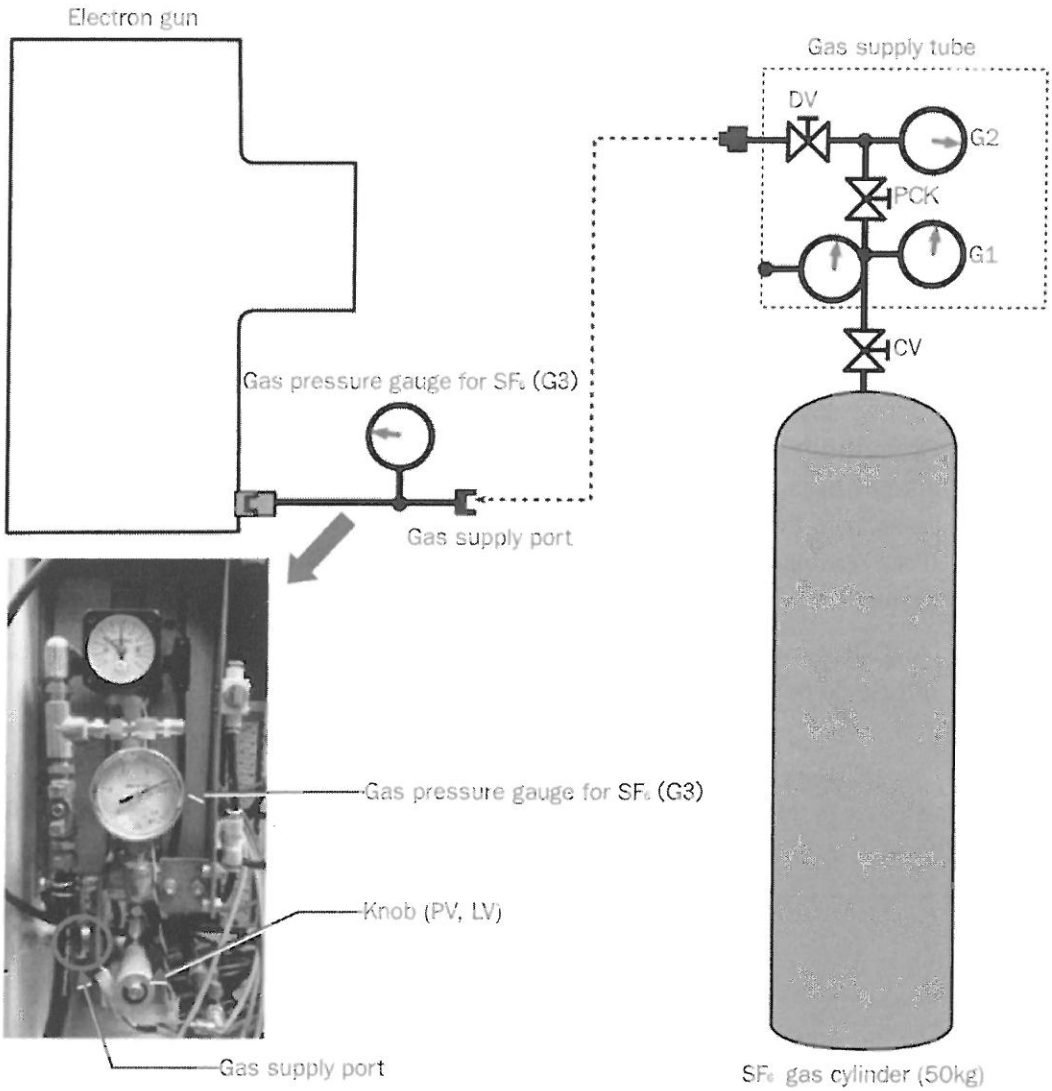


Fig. 6.10 Diagram of the SF_6 gas supply system to electron gun gas chamber

6.2.4 Supplying SF_6 Gas to the HT Tank

If the reading of the gas pressure gauge (Fig. 6.6) at the bottom of the HT tank decreases to 0.1 MPa or less, refill the HT tank with SF_6 gas following the procedure below (Fig. 6.11).

1. Stop the accelerating voltage and the beam generation (☞ Sect. 5.5.5).
   a. Click **More** in High Voltage Control window.
   b. Click **Turn off** under "Auto HT and Emission".
   The generation of the accelerating voltage and the electron beam stops automatically.
2. Connect the insulation gas introduction port (Fig. 6.11) to the SF_6 gas cylinder supply valve using a hose (with a quick coupling).
3. Open the gas supply valve of the gas cylinder. When the reading of the gas pressure gauge at the bottom of the HT tank reaches 0.1 MPa, remove the hose from the gas supply port.
   If the reading of the gas pressure gauge decreases to 0.1 MPa or lower, supply the gas again.

✍ A JEOL service engineer in charge of installation will replace the insulation gas. Please do not replace it yourself.

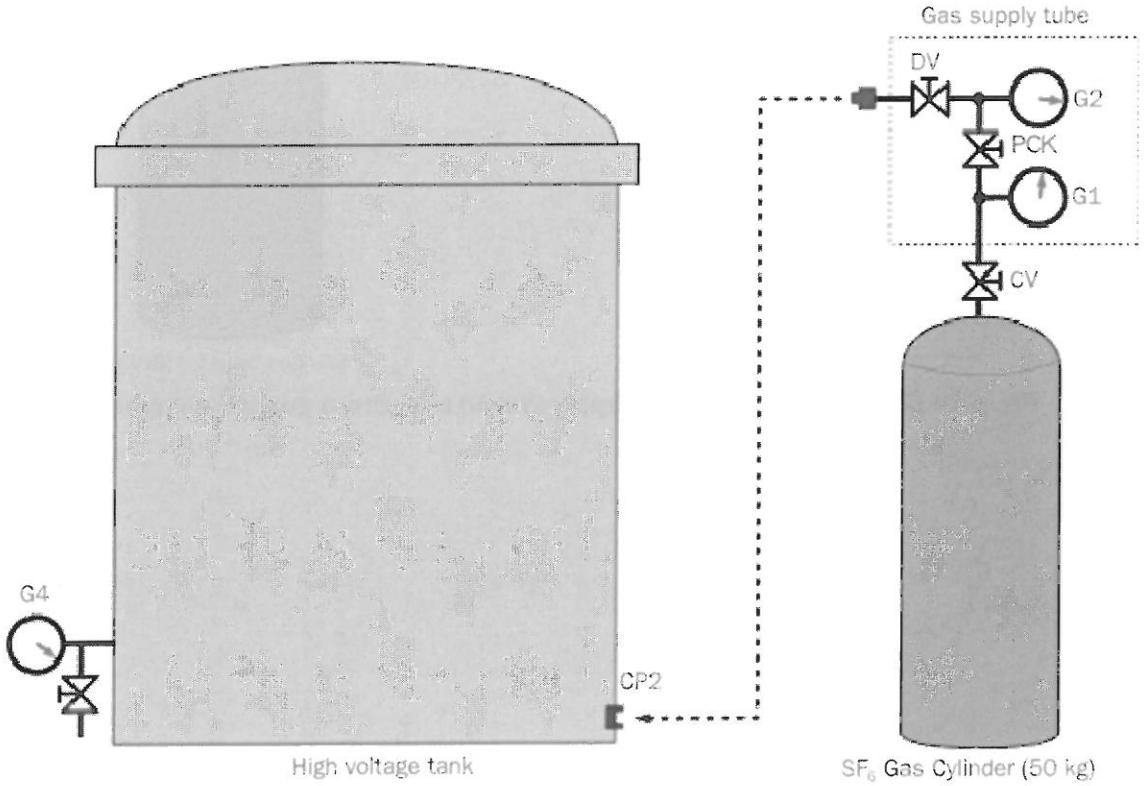


Fig. 6.11 Diagram of the SF_6 gas supply system to high voltage tank.

6.3 CLEANING THE COLUMN PARTS

While you use the instrument for a long time, various parts in the electron beam path become contaminated by beam irradiation, causing the performance of the instrument to be degraded. Therefore, in order to obtain clear images at all times, you must clean (or replace) these parts periodically. For cleaning (or replacing) these parts, consult your JEOL service office.

6.4 BAKING OUT THE COLUMN

Raising the temperature of the column and releasing the adsorbed gas from column inner wall greatly reduces the specimen contamination. Bake out is recommended when air has been left inside the column for a long time.

⚠ CAUTION

■ Bake out

- **During bake out operation, the part and its surroundings become hot. Do not touch or put anything flammable close to these parts.**
  Failure to observe this warning may cause fire or burn injury.

- **To prevent other people from touching or using the instrument accidentally, put up a sign or notice to the effect that the instrument is under baking.**
  Failure to observe this warning may result in fire or burn injury.

Display Bake Out/ACD Heat window (**TEM Controller — Maintenance — ACD& Bake**) and double click on the **Bake Out** tab.

1. Stop the accelerating voltage and the beam generation (☞ Sect. 5.5.5).
   a. Click **More** in High Voltage Control window (Fig. 4.29).
   b. Click the **Turn off** button under "Auto HT and Emission"(Fig. 4.31).
   The generation of the accelerating voltage and the electron beam stops automatically.
2. Select the check box for **Column** and **Stage** in the Bake Out/ACD Heat window if they are not selected (Fig. 6.12).
   ✍ Both Column and Stage are both selected as a default.

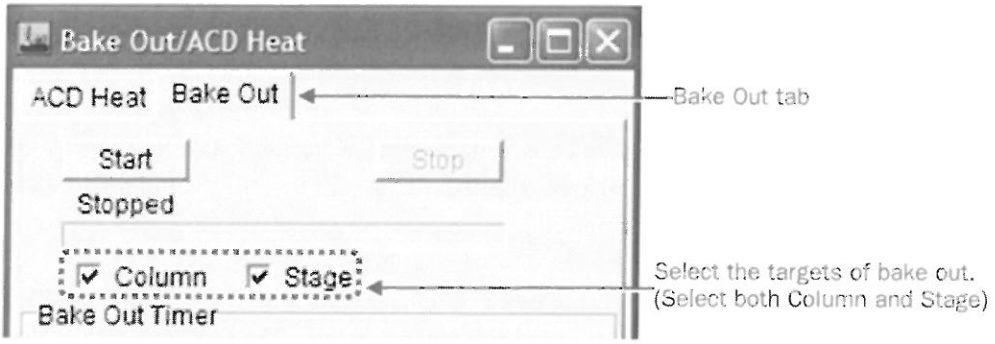


Fig. 6.12 Selecting the targets of bake out (Bake Out/ACD window)

3. Set the desired baking time and cooling time in Bake Out Timer field in Bake Out/ACD window (Fig. 6.13).
   a. Set the bake out stop date in Finish Date: Select the stop date on the calendar (Fig. 6.13).

b. Set the baking time using the ▲ and ▼buttons in the Bake Out Time box (Fig. 6.13).
   - It is possible to set hour, minute, second, PM and AM.
   - Finish Time is the time when the cooling time ends after the bake out.

c. Set the cooling time using the [▲] [▼] in Cooling Time (Fig. 6.13).
   As a default, cooling time is set to 4 hours.
   - Enter 4 hours or more for cooling time.
   - The total time for the bake out time and cooling time is indicated in the Total Time (include Cooling Time) box.

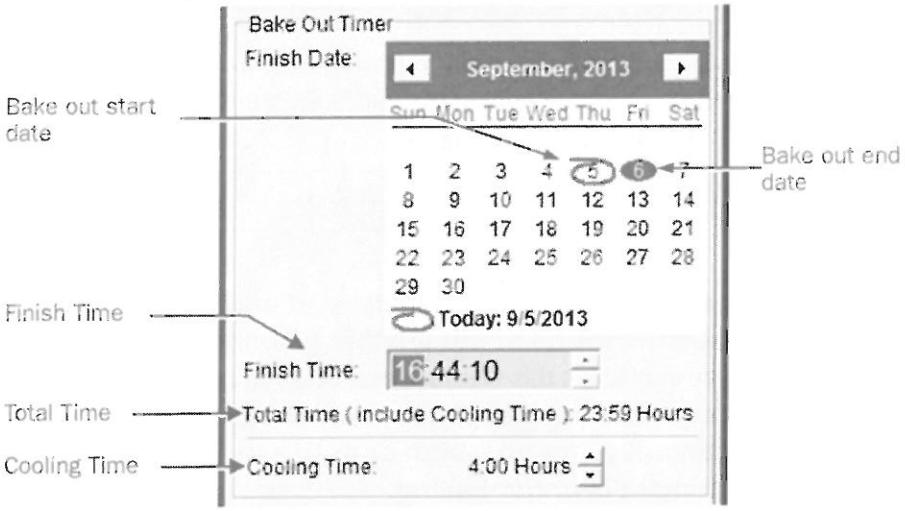


Fig. 6.13 Setting the bake out time and cooling time (Bake Out/ACD window)

4. Make sure that the LENS switch (L2-③) is ON. Clicking **Start** in the Bake Out/ACD Heat window will start the bake out. (Fig. 6.14)

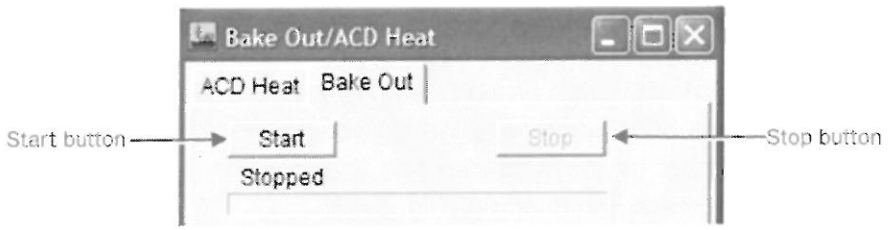


Fig. 6.14 Starting bake out (Bake Out/ACD window)

   - Do not close the "Bake Out/ACD Heat" window until the bake out stops.

5. When the cooling state is finished, a message will appear on the window. Click **OK**.
   - When the cooling state ends, lens cooling water will start flowing. Additionally, lens excitation will also be applied. (This will be 200 kV, but an accelerating voltage will not be applied.)

6. Generate the electron beam (☞ Sect. 5.5).
   - If you want to cancel the bake out halfway, turn the LENS switch OFF. Then click **Stop** in the Bake Out/ACD Heat window. The system switches to the Cooling mode. If **Stop** is clicked again, the Cooling mode will also be canceled.
   - When the cooling mode is forcibly canceled and the column temperature is high (50 ℃ or more), the safety circuit of the LENS power will activate and LENS power will be OFF. Turn the LENS switch OFF/ON after the column temperature has cooled down.

6.5 CAUSES OF MALFUNCTIONS AND COUNTERMEASURES

6.5.1 EM Basic Instrument Unit Does Not Start Up

Table 6.4 EM Basic Instrument Unit Does Not Start Up.

Cause	Measure
The circuit breaker is off. ⇒ The circuit breaker is located on the front panel of the power supply chassis.	Turn on the circuit breaker with the instrument power turned off, and then turn on the power to start up the instrument. If the instrument does not start up even after performing this, contact your JEOL service office.
Fuse blew	Contact your JEOL service office.

6.5.2 EM Basic Unit Starts Up, But Stops after a Certain Period of Time

Table 6.5 EM Basic Unit Starts Up, But Stops after a Certain Period of Time.

Cause	Measure
Rotary pump belt is broken.	Contact your JEOL service office.
Compressed air pressure is less than 0.5 MPa	Increase the compressed air pressure to 0.5 MPa.
Cooling water is not flowing.	Perform inspection for cooling water system.
DP heater is disconnected.	Contact your JEOL service office.
If the TMP vacuum system is used, TMP rotation does not reach the specified value.	Contact your JEOL service office.

6.5.3 "Not Ready" is left Displayed in HT Status

Table 6.6 "Not Ready" remains displayed in HT Status.

Cause	Measure
Cannot communicate with HT SUB.	Reset or HT SUB reset is required. If the communication is not possible after the reset, (L2-④), contact the JEOL service office.
High voltage cable is disconnected.	Contact your JEOL service office.
Insulation gas pressure in the electron gun chamber is insufficient.	Refill the insulation gas. ☞ Sect. 6.2
Insulation gas pressure in the HT tank is insufficient.	Refill the insulation gas. ☞ Sect. 6.2
The conditioning knob at the upper part of the Gun is not set to the position of Operate or Cond.	Set the conditioning knob to the position of Operate or Cond. ☞ Sect. 5.5.2

6.5.4 The Emission Status Remains "Not Ready"

Table 6.7 The Emission Status remains "Not Ready"

Cause	Measure
The acceleration voltage (HT) is not turned on.	Generate the electron beam. ☞ Sect. 5.5.5
The conditioning knob at the upper part of the Gun is not set to Operate.	Set the conditioning knob to Operate (☞ Sect. 5.5.2)

6.5.5 An electron Beam is not Emitted

Table 6.8 An electron beam is not emitted

Cause	Measure
The conditioning knob at the upper part of the Gun is not set to Operate.	Set the conditioning knob to Operate. ☞ Sect. 5.5.2
The acceleration voltage (HT) is not turned on.	Generate the electron beam. ☞ Sect. 5.5.5
The electron source has reached the end of its service life	☞ Sect. 6.1.2.

6.5.6 Cannot Open the Electron Gun Isolating Valve V1

Table 6.9 Cannot open the electron gun isolating valve V1

Cause	Measure
The electron beam is not generated.	Generate the electron beam. ☞ Sect. 5.5.5
Column vacuum does not become Ready.	Check the Column/PIG1 Status of the Valve Status window (☞ Sect. 4.4.7h). If SIP vacuum system is used, SIP must be activated, the vacuum pressure has to be 1×10^{-4}Pa or lower, or the Penning gauge vacuum pressure has to be 1×10^{-4}Pa or lower.
The vacuum pressure of the camera chamber is not Ready.	Check the Camera/PIG3 Status in the Valve Status window (☞ Sect. 4.4.7h). If it is Not Ready, wait until it is Ready. It depends on the state of the loaded film. However, if it does not become Ready, check that there is no dust on the O ring of the camera chamber door.
The specimen holder is not inserted into the column.	Insert the specimen holder into the goniometer.

6.5.7 Electron Beam Cannot be Confirmed

Table 6.10 Electron Beam cannot be Confirmed

Cause	Measure
Gun isolation valve V1 is not open.	Turn the operation panel L1 Beam switch ON.
The beam is interrupted by the specimen or grid mesh.	Set a low magnification, and move the specimen.
The position of the variable aperture is shifted.	Set the variable aperture to OPEN.
The lens power supply is off.	Press the LENS switch (R2-③) to turn it on. If the voltage of the Lens Voltage window (☞ Sect. 4.4.7g) in Status Monitor reads 0 V or -10 V, turn off the LENS switch once, and then turn it on. Also, if the lens cooling is insufficient, the safety circuit operates to turn off the LENS switch.
The deflection system data is abnormal.	Load the deflection system data. ☞ Sect. 5.14.1b

☞ Refer to the Section 5.17.1.

6.5.8 Image Does Not Appear on the CCD Camera below the Camera Chamber

Table 6.11 Image does not appear on the CCD Camera below the Camera Chamber

Cause	Measure
Film is set to the image acquisition position.	Perform film feed (Click **Film Eject** in the Film Camera Property window).

6.5.9 If the Exposure Time is Displayed as *** in Auto Exposure Mode

Table 6.12 If the Exposure Time is displayed as *** in Auto Exposure

Cause	Measure
Electron beam is not irradiated to the fluorescent screen.	Irradiate the electron beam to the fluorescent screen.
The Sens: is 0 in the Film field in Film Camera Property window. (optional configuration)	Select the Film field from Film Camera Property window and set the Sens: to 10 to 12 using the [▼][▲] buttons.

6.5.10 Notes on System

When an abnormality occurs on the operation system, such as the freezing of the operation GUI or the control panel, carry out the following procedure, in order. If the function still does not return, contact a JEOL service engineer.

1. Restart the system by pressing the RESET switch below the operation table. (☞ Sect. 4.2.7)
   ✍ It takes several minutes to restart the system. Since the evacuation system and the electron gun power supply are not reset, the system returns in the safe state.
2. Terminate the TEM Center software, restart the PC, log in to the PC, and start the application software (☞ Sect. 4.4.1).

6.6 HANDLING NITROGEN GAS

6.6.1 Cautions for Handling Nitrogen Gas

Dry nitrogen gas is stored in a high-pressure container, so you must pay extreme care when handling it. Also, check the following items before installing the gas cylinder.

⚠ WARNING

■ Handling high-pressure gas

- **Even if you use only a small amount of gas, provide sufficient ventilation.**
  You run the risk of suffocation due to a low oxygen concentration.

- **Because the inner pressure of the gas supply source such as a gas cylinder is very high, mount a pressure regulator on the gas outlet to decrease the secondary side pressure for the gas being used.**

- **When you operate the gas valve do not stand directly in front of the gauge. Operate it from an off-center position.**
  If the pressure gauge is damaged, shards of glass may be scattered and cause injury.

- **When you open the primary gas valve, open the valve slowly by one quarter or half rotation and check the increase in primary pressure on the pressure gauge. After that, fully open the valve.**
  Do not open the primary gas valve rapidly. The pressure gauge may be damaged due to the applied pressure.

● Nitrogen Gas

- **Nitrogen gas is inert and harmless. However, it is hazardous if a large amount of gas leaks into a sealed room.**
  You run the risk of suffocation due to a low oxygen concentration.

● Handling high pressure gas cylinders

- **When you install a gas cylinder, comply with the following.**
  - To prevent the gas cylinder from falling, it must be locked to the wall using a chain, or stabilize using a designated stand.
  - Ensure that the temperature of the installation room does not exceed 40 °C.
  - Do not place a heater near the gas cylinder.
  - Do not apply any shock to the gas cylinder.

  Always keep the handle close to the gas cylinder to open/close the primary valve.

- **Always confirm the service life of the gas cylinder. In addition, do not use a gas cylinder past the recommended service life.**

6.6.2 Stopping and Restarting the Nitrogen Gas Supply

Normally, keep the pressure regulator set to 0.02 MPa even after stopping the instrument, and leave the valve open fully if a delivery valve is attached. Therefore, when starting or stopping the instrument will just open or close the cylinder valve (main cock). The procedure for complete shutdown of the nitrogen gas supply or supplying the nitrogen gas again after exchanging the nitrogen gas cylinder (if it is used) is shown below.

6.6.2a Complete Shutdown of Nitrogen Gas Supply

1. Turn the pressure regulator knob counterclockwise until it stops to close it (Fig. 6.15).
2. If a delivery valve is provided, turn the delivery-valve knob clockwise until it stops to close it (Fig. 6.15).
3. Turn the cylinder valve (main cock) handle clockwise until it stops to close it (Fig. 6.15).

   In order to be able to respond to an emergency, always leave a handle for opening and closing the main cock attached to the gas cylinder.

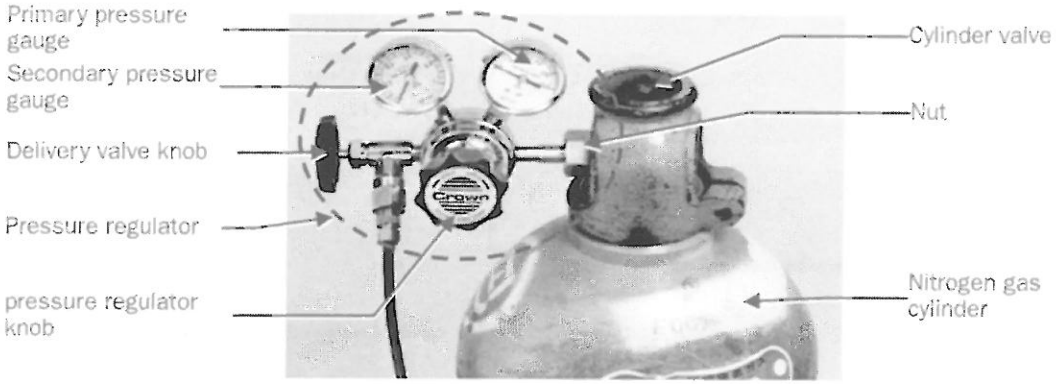


Fig. 6.15 Nitrogen gas cylinder and pressure regulator

6.6.2b Restarting the nitrogen gas supply

1. After confirming that the pressure regulator knob is turned counterclockwise until it stopped (it is closed), turn the cylinder valve handle counterclockwise until it stops to open the cylinder valve (main cock) (Fig. 6.15).
2. Slowly turn the pressure regulator clockwise to open it, and adjust it so that the secondary side pressure gauge reads the specified pressure, 0.02 MPa (Fig. 6.15).

   To prevent a dangerous situation, do not stand in front of the pressure regulator, but operate the valve from the side.
3. After setting the pressure regulator to the specified pressure, leave it running for one to two minutes, and confirm that the pressure reading does not change.

   If the pressure reading gradually increases, the pressure regulator is defective. You must replace it. To replace the pressure regulator (complete assembly including the pressure gauge), follow the procedure below.

a. Stop the nitrogen gas supply completely following the procedure in Section 6.6.2a.

b. Disconnect the delivery valve (or hose).

c. Loosen the nut and remove the pressure regulator from the connection part of the gas cylinder.
d. Connect the normal pressure regulator (with a full scale of about 1 MPa for the secondary side pressure gauge) to the gas cylinder, and fasten it securely using the nut.
   In order to avoid having the glass surface of the pressure gauge directed at the worker's face when it is installed, tilt it upward by 45° for a large cylinder and downward by 45° for a small cylinder when installing it.
e. Connect the delivery valve (or hose).

4. If a delivery valve is provided, turn the delivery valve knob fully counterclockwise to open it.
   The reading of the secondary side pressure gauge might temporarily decrease. If the reading does not return to the specified value, a gas leak is considered to occur in the receiving side of the gas supply. So, check the gas line of the receiving side (Fig. 6.16) .

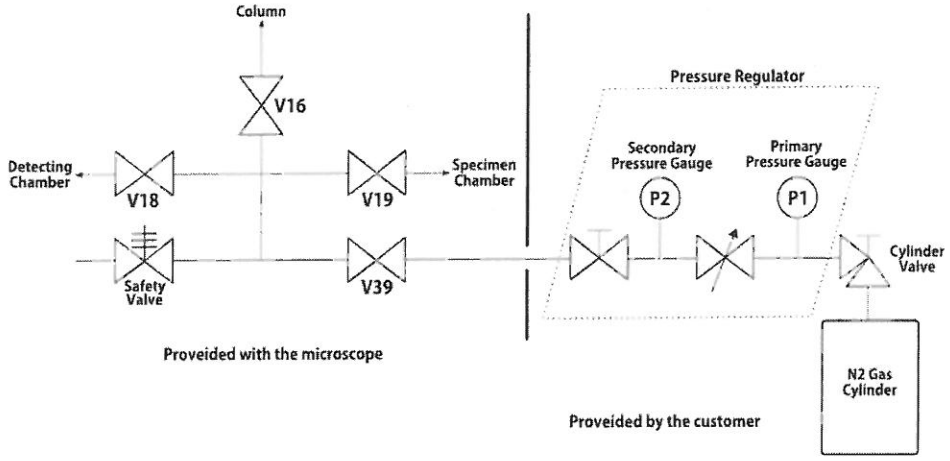


Fig. 6.16 Connection example of the nitrogen gas cylinder with the peripheral apparatuses

6.6.3 Replacing Nitrogen Gas Cylinder (If it is used)

A gas cylinder with 46.7 L capacity and 15 MPa inner pressure, as an example, typically provides about three months of normal usage.

1. Stop the nitrogen gas supply following the procedure in Section 6.6.2a.
2. Loosen the nut and remove the pressure regulator from the connection part of the gas cylinder.
3. Install a gas cylinder filled with dry nitrogen gas instead of the empty cylinder in the stand (or fasten the filled gas cylinder to the wall using a chain).
4. Connect the pressure regulator to the gas cylinder, and fasten it securely using the nut.
   Fasten the nut at the connection part sufficiently to prevent the gas leaking out wastefully. Also, you can detect a gas leak by applying liquid soap or similar substances to the connection part.
5. Supply the nitrogen gas again following the procedure in Section 6.6.2b.
   When the dry nitrogen gas is introduced in the column and the inner pressure exceeds 1 atm., the safety valve opens. The safety valve functions to discharge excess gas so that the inner pressure does not exceed 1 atm.

6.6.4 Connection to Nitrogen Gas Supply Piping

When performing the plumbing work for the dry nitrogen gas supply, connect a two-stage pressure regulator to the outlet, and connect the special-purpose nitrogen gas introduction hose (10 m) included in the JEM-2200FS accessories to the secondary side of the two-stage pressure regulator.

6.7 SF_6 GAS USED AS A HIGH VOLTAGE INSULATOR

SF_6 gas is used as a high voltage insulator in the accelerating voltage generator tank and in the gas chamber of electron gun. Over time, there can be minute leaks when using SF_6 gas, so it is necessary to replenish the gas every 24 months.

⚠ CAUTION

Gas leaks are more likely to occur in older instruments. Be sure to perform periodic inspection to prevent leaks of the high-pressure tank.

The SF_6 gas specification is as shown below.

6.7.1 Product Identification

Product name:	Sulfur Hexafluoride (English: Sulfur hexafluoride)
Chemical Name:	Sulfur Hexafluoride (English: Sulfur hexafluoride)
Chemical Formula:	SF_6
Molecular weight:	146.05

6.7.2 Hazards

Reactivity:	The gas reacts with almost no chemical compounds at normal temperature and pressure.
Danger to human health:	Little to none. There is a danger of suffocation due to oxygen deficiency if the gas concentration in a room exceeds a certain limit. To avoid this, make sure that there is adequate ventilation.

6.7.3 Emergency and First Aid Procedures

Inhalation:	If SF_6 gas is inhaled, remove the affected individual to a place with fresh air. Give artificial respiration if the individual is not breathing. It is recommended to administer oxygen if there are any signs of difficulty in breathing.

6.7.4 Measures in the Event of Fire

Extinguisher:	SF_6 gas is non-flammable. If fire occurs, use an extinguisher appropriate to the surrounding fire.
Warning:	Thermal decomposition due to fire may produce toxic fumes of fluoride and sulfur oxides.

Procedure:	Evacuate personnel from the area. Thoroughly wet the containers with water spray from the maximum distance possible until they are cooled down. Move the containers away from the fire when it is possible to do so. Wear fireproof clothes and self-contained breathing apparatus or similar gear whenever fighting a chemical fire.

6.7.5 Physical Data

Appearance:	Colorless, odorless gas at normal temperature and pressure.
Sublimation point:	-63.8 °C
Boiling point:	-50.8 °C (224 kPa)
Specific gravity:	5.11 (20 °C, 0.1 MPa)
Evaporation pressure:	2.307 MPa (At 21.1 °C)
Critical temperature:	45.55 °C
Critical pressure:	3.76 MPa
Solubility:	5.4 cm^3/kg water

6.7.6 Reactivity

Flash point:	Not applicable
Flammability:	Not applicable
Auto ignition:	Not applicable
Oxidization:	Does not occur
Explosion hazards:	Explodes violently on contact with disilane
Warning:	Never bring disilane materials near the SF_6 gas.

6.7.7 Health Hazards

Skin absorption:	None
Skin contact:	No harmful effects (gas)
Eye contact:	No harmful effects (gas)

6.7.8 Waste Disposal Methods

Although flammability and toxicity are extremely low, handle the gas in well-ventilated areas to avoid suffocation. Discard any product, residue, disposable containers, or liners in an environmentally acceptable manner.

6.7.9 MSDS (Material Safety Data Sheet)

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CRYODYNE TECHNOLOGIES -- SULFUR HEXAFLUORIDE - SULFUR HEXAFLUORIDE MATERIAL SAFETY
DATA SHEET
NSN:  6830009857283
Manufacturer's CAGE:  0EHW9
Part No. Indicator:  A
Part Number/Trade Name:  SULFUR HEXAFLUORIDE
==========================================================================
General Information
==========================================================================
Item Name:  SULFUR HEXAFLUORIDE
Company's Name:  CRYODYNE TECHNOLOGIES INC
Company's Street:  67 WINTHROP RD
```

Company's P. O. Box: 233
Company's City: CHESTER
Company's State: CT
Company's Country: US
Company's Zip Code: 06412
Company's Emerg Ph #: 860-526-5000
Company's Info Ph #: 860-526-5000
Record No. For Safety Entry: 002
Tot Safety Entries This Stk#: 010
Status: SE
Date MSDS Prepared: 01MAR90
Safety Data Review Date: 07MAY97
Supply Item Manager: CX
MSDS Preparer's Name: UNKNOWN
MSDS Serial Number: CDQMH
Specification Number: BB-S-1419
Spec Type, Grade, Class: NONE
Hazard Characteristic Code: G3
Unit Of Issue: CY
Unit Of Issue Container Qty: 100 LBS
Type Of Container: CYLINDER
Net Unit Weight: 100 LBS

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Ingredients/Identity Information

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Proprietary: NO
Ingredient: SULFUR HEXAFLUORIDE
Ingredient Sequence Number: 01
Percent: MAJOR
NIOSH (RTECS) Number: WS4900000
CAS Number: 2551-62-4
OSHA PEL: 1000 PPM
ACGIH TLV: 1000 PPM; 9596
Other Recommended Limit: NONE RECOMMENDED

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Physical/Chemical Characteristics

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Appearance And Odor: COLORLESS, ODORLESS GAS.
Boiling Point: -83F, -64C
Melting Point: -59F, -51C
Vapor Pressure (MM Hg/70 F): 319.1PSIA
Vapor Density (Air=1): SUPPL
Specific Gravity: SUPPL
Decomposition Temperature: UNKNOWN
Solubility In Water: NEGLIGIBLE
Percent Volatiles By Volume: 100
Corrosion Rate (IPY): UNKNOWN

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Fire and Explosion Hazard Data

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Flash Point: NONE
Extinguishing Media: NON FLAMMABLE, INERT GAS.
Special Fire Fighting Proc: HMIS SUGGESTS USING A SELF-CONTAINED BREATHING APPARATUS WHENEVER FIGHTING A CHEMICAL FIRE.
Unusual Fire And Expl Hazrds: SEE STABILITY SECTION REGARDING SELECTION OF METALS CONTAINERS.

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Reactivity Data

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Stability: NO
Cond To Avoid (Stability): TEMPERATURES ABOVE 400F(IN CONTACT WITH METALS OTHER THAN THOSE LISTED BELOW).

Materials To Avoid: STORE ONLY IN ALUMINUM, STAINLESS STEEL, COPPER, BRASS OR SILVER.
Hazardous Decomp Products: DECOMP PRODS W/METALS: SF*2,S*2F*2,SF*4, S*2F*10; IF OXYGEN IS PRESENT, SOFL*2,SO*2F*2,THIONYL FLUORIDE AND FLUORIDE CMPDS.
Hazardous Poly Occur: NO

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Health Hazard Data

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LD50—LC50 Mixture: TLV=1000 MOLAR PPM
Route Of Entry — Inhalation: YES
Route Of Entry — Skin: NO
Route Of Entry — Ingestion: NO
Health Hazard Acute And Chronic: INHAL: SIMPLE ASPHYXIANT.
Carcinogenicity — NTP: NO
Carcinogenicity — IARC: NO
Carcinogenicity — OSHA: NO
Explanation Carcinogenicity: THERE ARE NO INGREDIENTS ABOVE 0.1% WHICH ARE IDENTIFIED AS CARCINOGENS BY NTP, IARC OR OSHA.
Signs/Symptoms Of Overexp: NONE SPECIFIED BY MANUFACTURER.
Med Cond Aggravated By Exp: NONE SPECIFIED BY MANUFACTURER.
Emergency/First Aid Proc: PROMPT MEDICAL ATTENTION IS REQUIRED IN ALL CASES OF OVEREXPOSURE. RESCUE PERSONNEL SHOULD WEAR A SCBA.

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Precautions for Safe Handling and Use

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Steps If Matl Released/Spill: USE PROPER RESPIRATORY AND PROTECTIVE EQUIPMENT. VENTILATE AREA. CONTACT THE NEAREST CRYODYNE LOCATION.
Neutralizing Agent: NOT APPLICABLE.
Waste Disposal Method: RETURN TO CRYODYNE. SECURE VALVES AND CAPS AND PROPERLY LABEL BEFORE OFFERING FOR TRANSPORTATION.
Precautions—Handling/Storing: STORE IN A COOL, DRY, WELL—VENTILATED PLACE. KEEP CONTAINER CLOSED WHEN NOT IN USE. KEEP AWAY FROM HEAT, SPARKS, FLAMES AND INCOMPATIBLE MATERIALS.
Other Precautions: PURGE PIPING WITH AN INERT GAS BEFORE ATTEMPTING REPAIRS.

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Control Measures

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Respiratory Protection: WHERE ENVIRONMENTAL CONTROLS ARE LACKING OR IN ENCLOSED SPACES USE A SELF—CONTAINED BREATHING APPARATUS USED IN THE POSITIVE PRESSURE MODE OR AN AIR—LINE RESPIRATOR.
Ventilation: USE A FUME HOOD.
Protective Gloves: COTTON FOR HANDLING CYLINDERS.
Eye Protection: SAFETY GLASSES OR GOGGLES.
Other Protective Equipment: NONE SPECIFIED BY MANUFACTURER.
Work Hygienic Practices: EXECISE GOOD LABORATORY PRACTICES. WASH HANDS AFTER USE AND BEFORE EATING.
Suppl. Safety & Health Data: SPECIFIC GRAVITY:(OF GAS AT STP) IS 5.13 X AIR @70F OR 0.005 G/ML;(OF LIQUID @59F) IS 89.83LB/FT*3. GAS DENSITY @68F IS .3847LB/FT*3.

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Transportation Data

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Trans Data Review Date: 97191
DOT PSN Code: NTF
DOT Proper Shipping Name: SULFUR HEXAFLUORIDE
DOT Class: 2.2
DOT ID Number: UN1080
DOT Label: NONFLAMMABLE GAS
IMO PSN Code: OFB
IMO Proper Shipping Name: SULPHUR HEXAFLUORIDE
IMO Regulations Page Number: 2179
IMO UN Number: 1080
IMO UN Class: 2 (2.2)
IATA PSN Code: XIS

IATA UN ID Number: 1080
IATA Proper Shipping Name: SULPHUR HEXAFLUORIDE
IATA UN Class: 2.2
IATA Label: NON-FLAMMABLE GAS
AFI PSN Code: XIS
AFI Prop. Shipping Name: SULPHUR HEXAFLUORIDE
AFI Class: 2.2
AFI ID Number: UN1080
AFI Basic Pac Ref: A6.3, A6.5
MMAC Code: NR
==========
Disposal Data
==========
==========
Label Data
==========
Label Required: YES
Technical Review Date: 07MAY97
MFR Label Number: UNKNOWN
Label Status: F
Common Name: SULFUR HEXAFLUORIDE
Signal Word: WARNING!
Acute Health Hazard-Moderate: X
Contact Hazard-None: X
Fire Hazard-Slight: X
Reactivity Hazard-None: X
Special Hazard Precautions: INHAL: SIMPLE ASPHYXIANT. STORE IN A COOL, DRY, WELL-VENTILATED PLACE. KEEP CONTAINER CLOSED WHEN NOT IN USE. KEEP AWAY FROM HEAT, SPARKS, FLAMES AND INCOMPATIBLE MATERIALS. FIRST AID: PROMPT MEDICAL ATTENTION IS REQUIRED IN ALL CASES OF OVEREXPOSURE. RESCUE PERSONNEL SHOULD WEAR A SCBA.
Protect Respiratory: Y
Label Name: CRYODYNE TECHNOLOGIES INC
Label Street: 67 WINTHROP RD
Label P.O. Box: 233
Label City: CHESTER
Label State: CT
Label Zip Code: 06412
Label Country: US
Label Emergency Number: 860-526-5000
Year Procured: 1997

6.8 WASTE DISPOSAL INFORMATION

When it becomes necessary to discard the system or some of its component parts, take every possible measure to recycle the resources. Then consult all applicable hazardous waste regulations for proper disposal.

6.8.1 Major Materials

Iron:	Column, chambers, mounting frame and racks
Copper:	Electron optical lenses
Stainless steel:	Evacuation tube
Nylon:	Cooling water tubes, compressed air and nitrogen gas tubes

6.8.2 Recycle Parts and Units

PC (with keyboard and mouse)
LCD monitor
Vacuum pumps (with power supply)
DC power supply unit
CPU board
Solenoid valve
Motors (with driver units)
Vibration isolator
Water chiller (if installed)

6.8.3 Residual Hazardous Materials

SF_6 gas: Insulating gas for the electron gun and the high-voltage tank

Rotary Pump Oil: Vacuum evacuation pump oil

Rotary pump oil will be classified into flammable liquid. Be sure to ventilate the room well. Refer to Section 6.8.3a "Material Safety Data Sheet / MR-200A" for details on handling flammable liquid.

The following replacement parts for maintenance are in this category (Table 6.13).

Table 6.13 Replacement parts that are included in hazardous materials

Item	Material or Product name	Quantity	Interval between replacement	Method of disposal
Rotary Pump Oil	NEOVAC MR-200A	1300 mL	Approx. year	To be poured into a container. If you have a problem disposing the waste oil, contact your JEOL service office.
Emitter of Electron Gun	ZrO/W (100)	1 pc.	–	Replacement of the emitter cannot be performed at the customer site. Therefore there will be no disposal.
Battery used in the PC	Lithium Battery	1 pc.	Approx. 5 years	Follow the local regulations.
Penning Gauge Head	Radioisotope 241 Am, 0.08 μCi, sealed Note: •1 Ci = 3.7×10^{10} Bq •0.08 μCi = 2960 Bq •A human body typically contains approx. 5000 Bq.	1 pc.	–	In Japan, the quantity or amount of a radioisotope waste specified below can be disposed as a general industrial waste. •Sealed Radioisotope: 3.7 MBq •Non- Sealed Radioisotope: 3.7 KBq Therefore, if you are disposing a multiple gauge head together, follow the related local regulations for the disposal of the radioisotope waste. Reference The Japan Isotope Association handles those wastes for a fee in japan. If you have a problem of disposing JEOL Penning Gauge Head, contact your JEOL service office.

6.8.3a Material Safety Data Sheet / MR-200A

The MSDS (Material Safety Data Sheet) for rotary pump oil NEOVAC MR-200A, which is used for oil rotary pump configured in JEM-2200FS and EM-23100 TMP vacuum evacuation unit is shown below.

1. Product name and company information

Product name:	NEOVAC MR-200A
Product code:	00025
Company name:	MORESCO CO., LTD.
Address:	5-5-3, Minatojima Minamimachi, Chuo-ku, Kobe-city
Customer center (contact information)	
	TEL: 06-6262-3385
	FAX: 06-6262-3327
	E-mail: customercenter@moresco.co.jp
Emergency contact	
Specialty Products Sales Dept, Sales Division	
	TEL: 06-6262-3310
	FAX: 06-6262-3327
Specialty Products Sales Dept, Tokyo Sales Division	
	TEL: 03-3273-7526
	FAX: 03-3281-7756
Lubricant manufacturing Dept, Quality Management Division	
	TEL: 0791-42-2100
	FAX: 0791-43-3179
Recommended use and restrictions:	Oil rotary vacuum pump oil

2. Hazard and toxicity

GHS classification

Physiochemical hazard	Not applicable to GHS classification standards
Toxicity to health	Not applicable to GHS classification standards
Toxicity to environment	Not applicable to GHS classification standards

Label elements

Picture indication or a symbol:	None
Warning statement:	None
Hazard and toxicity information:	None
Notes:	Safety measures None Emergency first aid None Storage None Disposal None

3. Composition, component information

Specimen

Distinction of single product and a mixture: Mixture

Chemical name or general name: Petroleum hydrocarbon, lubricating oil additive

Chemical Formula: Cannot be determined

Component and content: Lubricant base oil approx. 99%
Lubricating oil additive approx. 1%

4. Emergency measures

If it is inhaled: Move the affected individual to a place with fresh air. Gargle with water. Wrap the individual with blanket, keep warm and at rest. Contact a doctor immediately.

If it comes in contact with the skin: Wash the area with water and soap.

If it entered the eye: Immediately rinse the eye for at least 15 minutes with clean water, Remove contact lenses if used. Continue to wash. If the pain continues, get treated by a doctor.

If it is swallowed: Contact the doctor immediately. Do not make the individual vomit. If inside the mouth is contaminated, wash it thoroughly with water.

Expected acute symptoms and late-onset:
If swallowed, there is a possibility of diarrhea and vomiting.

Symptoms and most important signs and symptoms
If it enters the eye, it may cause inflammation.
If it comes in contact with the skin, it may cause irritation.
If the mist is inhaled, it may cause nausea.

5. Measures during fire

Extinguisher: Water and alkali salt fine mist, foam, powder or carbon dioxide fire extinguishers are effective.

Extinguishers that should not be used: Do not use direct water spray to extinguish the fire.

Specific hazard and toxicity: Depending on the fire, it may produce irritating, corrosive or poisonous gas.

Specific extinguishing method: Cut off the combustion source.
In an early stage of fire, use a powder and carbon dioxide extinguisher.
In a large-scale fire, it is effective to use the foam extinguisher and block the air. Pouring water on the flames may spread the fire and it may be dangerous.
Sprinkle the surrounding equipment with water to cool them down.

Do not let anyone other than fire-fighters enter the area near the place the fire started.

Protections for those fighting the fire: When fighting fire, wear safety glasses, protective clothing, and respiratory protective devices, depending on the situation and stay upwind of the fire.

6. Measures when there is a spill:

Precautions and protective equipment for human body:

If there is a possibility of coming in contact with skin or getting in the eye, use the protective equipment and execute emergency measures. If mist is generated, use respiratory protective devices and such and do not inhale the mist.

Precautions for the environment: Recover as much as possible because it can cause soil and water contamination.
Make sure it does not get discharged into rivers and sewage.
It cannot be discharged into the environment.

Collection, neutralization and containment:

Remove all surrounding ignition sources.

Purification methods and equipment

If it is a small amount: Use sand or waste cloths to absorb and collect the fluid in an empty container. Additionally, wipe it up completely with rags and such.

If it is a large amount: Surround it with embankment to prevent further spread, then gather it, collect it in an empty container and dispose it in a safe place. After the disposal, wash the area with a large amount of water. At this time, make sure that the high-concentration waste water does not flow into public waterways such as a river.

If it is at sea: Prevent dispersion by building an oil fence and absorb it with absorption mats and such. If chemicals are used, they must be compatible with the technical standards set by the agency with jurisdiction in the area.

Preventing secondary disaster: Remove all ignition sources (Smoking nearby, sparks and blaze are prohibited)
Report to all relating places and call for help.

7. Handling and storage warning

Handling

Technical measures: When repairing the machinery with oil and grease still remaining, make sure to place it in a safe place and repair the machine after removing all the oil and grease.
Execute countermeasures against static electricity. Work clothes and shoes must be

	conductive. Vapors that are generated from petroleum products are heavier than air, so are more likely to pool and collect. Therefore, it extra care is required regarding ventilation and ignition sources. It is handled in room temperature. During handling, make sure that no water or dirt enters. Wear protective equipment if it may come in contact with the skin or enter the eye. If mist is generated, use protective respiratory devices and do not inhale the mist. Use pumps and such when removing from the container. Use a narrow tube and do not use your mouth to suck it up. Do not weld, heat up, punch a hole or cut the container. Residual material may ignite causing an explosion.
Local ventilation equipment / General ventilation:	
	8. Refer to exposure prevention and protection measures.
Contact avoidance:	10. Refer to stability and reactivity.
Safe handling precautions:	Make sure to obtain the instruction manual before use. Do not use it until all safety precautions are read and understood. Keep away from fire. In order to keep the concentration in the air lower than the exposure concentration, ventilate the exhaust. Wash your hands thoroughly after use. Only use it outside or in areas with good ventilation. Do not drink, eat or smoke when using this instrument. Do not apply pressure on the empty container. If pressure is applied, it may burst. Do not drink. Keep away from children.
Storage	
Technical measures:	Avoid heat, spark, flame and electrostatic accumulation. Seal the container tightly. Store it away from the sun.
Mixture restricted substance:	10. Refer to stability and reactivity.

Storage condition:	Store in a well ventilated place. Store away from direct sunlight. Keep the storage locked.
Container wrapping material:	When removing to other container, use either a metallic or glass container. Resin containers may melt, depending on the type. Keep it in something that does not break and that can be sealed.

8. Exposure prevention and protection measures.

Concentration management:	No regulation. (Working environment standards: 2009 notification of the Ministry of Health, Labor, and Welfare No. 194/195)
Acceptable concentration (Exposure Limit, a biological exposure index) Japan Society for Occupational Health (2010):	3 mg/m^3 (mineral oil mist) [1)]
ACGIH (2010):	TWA 5 mg/ m^3 (mineral oil mist) [2)]
Facility measures:	If the mist or the vapor is produced, seal the generation source or set up an exhaust system. Facilities for rinsing eyes and washing the body are required near the workplace.
Protective equipment	
Respiratory protection:	Wear appropriate respiratory protection.
Hand protection:	If necessary, wear oil-resistant protective gloves.
Eye protection:	If diffusion is possible, wear eye protection.
Skin and body protection:	If necessary, wear protective clothing and face protection.
Hygienic precautions:	Wash hands thoroughly after handling. Inspect the protective equipments periodically following the inspection table. Do not eat, drink or smoke when using this product.

9. Physical and Chemical Properties

Physical State	
Appearance:	Liquid
Color:	Light yellow
Odor:	Slight Oily odor
pH:	Not applicable
Melting/Freezing Point:	Not applicable
Boiling Point:	195 ℃/0.1 mmHg
Flash Point:	≧ 200℃ (COC)
Explosive Range (Explosive Limits)	
Upper limit:	7%
Lower limit:	1% (estimated value)
Evaporation pressure:	No data
Vapor Density (air=1):	No data

Specific Gravity (Density):	0.88 g/cm^3 (15 ℃)
Solubility:	Insoluble in water
Partition Coefficient: n-octanol/water:	No data
Auto-ignition Temperature:	No data
Pore point:	-15% or less
Volatility:	None (at room temperatures)

10. Stability and Reactivity

Stability:	Stable
Possibility of Hazardous Reactions:	Reacts with strong oxidizer.
Conditions to Avoid:	No data available (Hazardous reactions will not occur under normal use)
Incompatible Materials:	Strong oxidizer
Hazardous Decomposition Products:	None

11. Toxicological Information

Oral:	Acute toxicity (oral) estimate ATE mix 5000 mg/kg or higher (GHS classification).
Dermal:	Acute toxicity (dermal) estimate ATE mix 5000 mg/kg or higher (GHS classification).
Inhalation:	Acute toxicity (inhalation) estimate ATE mix 5 mg/L or higher (GHS classification)
Skin Corrosion/Irritation:	No information for the Skin Corrosion/Irritation classification. If in contact for a long period of time or multiple times, there is a possibility of dermatitis by defatting of skin.
Serious Eye Damage/Eye Irritation:	No information for the Serious Eye Damage/Eye Irritation classification.
Respiratory or Skin Sensitization:	No information for the Respiratory or Skin Sensitization classification.
Germ Cell Mutagenicity:	No information for the Germ Cell Mutagenicity classification.
Carcinogenicity:	No information for the Carcinogenicity classification.
Reproductive Toxicity:	No information for the Reproductive Toxicity classification.
STOT/Systemic Toxicity (Single Exposure):	No information for the Specific Target Organ Toxicity/Systemic Toxicity (Single Exposure) classification.
STOT/Systemic Toxicity (Repeated Exposure):	No information for the Specific Target Organ Toxicity/Systemic Toxicity (Repeated Exposure) classification.
Aspiration Hazard Aspiration Hazard:	No information for the Aspiration Hazard classification.

12. Ecological Information

Ecotoxicity:	No information for the Aquatic Toxicity.
Persistence and Degradability:	No information available

Bioaccumulative Potential: No information available
Mobility in Soil: No information available
Other Adverse Effects: No information available
Environmental Criteria: No information available

13. Disposal Considerations

Waste Residues: The company should dispose the industrial waste themselves or dispose through a disposal company that has been authorized by the local regulatory authority. When disposing, follow the standards of related laws and regulations and the local government.
Dumping of waste is prohibited.
When performing land disposal, incinerate using an incineration system. Make sure the cinder is lower than the "order relating to waste disposal and cleaning" standard.
Perform burning in a safe area and use a method that will not hurt or damage others by fire or explosion. Make sure there is a guard.

Contaminated Containers and Packaging: The container should be cleaned and recycled or is should be disposed following the related laws and regulations and the local government standards. When disposing the container, make sure the content has been completely removed.

14. PRECAUTIONS FOR USE

International Regulation

UN Classification: Not applicable

Domestic regulation

On land: Fire defense law non-hazardous material (designated combustibles / flammable liquids)

On sea: Ship safety law non-hazardous material private delivery and bulk delivery

By flight: Aviation law non-hazardous material

Special Precautions: "Caution: inflammable"
When shipping, avoid direct sunlight. Load and prevent load shift securely to prevent damage, corrosion or leak of the container.
Do not load heavy goods on top.

15. Applicable laws

Industrial safety and health law. Notice target
(Order separate table 9 No.168 mineral oil)

Chemical substance emission control accelerating method (PRTR method) : Not applicable

Poisonous and Deleterious Substances Control Act: Not applicable

Fire defense law: Non hazardous materials (designated combustibles / flammable liquids)

The water pollution prevention act: Oil discharge regulation (5 mg/L acceptable concentration) It will be detected as n-hexane extraction.

Marine pollution prevention law: Oil discharge regulation (Generally prohibited)

Sewage law: Mineral oil discharge regulation

Law relating to processing disposals and cleaning: Industrial waste regulation (diffusion, discharge prohibited)

16. Other Information

Cited document: 1) Recommendation of Occupational Exposure Limits by Japan Society for Occupational Health

2) Thresholds limit values for chemical substances and physical agents and biological exposure indices. ACGIH

3) MSDS of raw materials

(1)As evaluations on hazards are not necessarily complete, special attention should be paid for use.

(2)This MSDS, summarizing matters to be attended to, is required for proper use of the product and is intended for normal use.

(3)Referring to this MSDS, properly use and handle this product on the user's own responsibility.

(4)The contents of this MSDS are based on information available as of the date of writing and current knowledge. The information, data, and evaluations herein are not guaranteed, and in addition, may be revised due to revision of laws or knowledge newly obtained.

6.9 LIFT AND LIFT POLE

The JEM-2200FS includes a lift and a lift pole for maintenance. These are for the installation and service personnel. The customer should never move, assemble or use them alone. JEOL cannot accept any responsibility for any accident that occurs during unauthorized use of the lift and lift pole.

6.10 PERIODIC INSPECTION

6.10.1 General

The inspections for this instrument are classified into 3 levels. The daily routine and monthly inspections are conducted by the customer. Other periodic maintenance is performed by JEOL. The values related to the instrument operating status that are obtained during the daily and monthly inspections are used to evaluate whether the instrument is operating correctly.

6.10.2 Routine Inspection

For details, refer to Section 6.1.

SF_6 gas pressure of the electron gun:	0.3 MPa
SF_6 gas pressure of the HT (high-tension) tank:	Inside of a normal range (☞ sect. 6.1.6)
Pressure of compressed air line:	0.5 MPa

6.10.3 Monthly Inspection

Oil level of oil rotary pumps
Water level of the chilled water circulator (if installed)
Removing condensed water from the reservoir tank of air compressor (if installed)

6.10.4 Periodic Inspection

Since periodic inspections are performed in accordance with the JEOL periodic inspection plan, consult your local JEOL service center.

6.11 LIST OF CONSUMABLES AND PERIODICALLY REPLACED PARTS

All the parts that need to be replaced periodically and the consumables for the JEM-ARM200F are listed in this chapter. Contact your JEOL service office when any parts require replacement.

6.11.1 JEM-2200FS Basic Unit

The following list identifies the parts to be replaced periodically and the consumables, necessary for the electron microscope basic unit (Table 6.14).

Table 6.14 LIST OF CONSUMABLES AND PERIODICALLY REPLACED PARTS

Part name	Specification	Part No.	Quantity	Replacing period (year)	UNIT name
Condenser Lens (CL) aperture	ϕ10 μm (PT)	810299780	1	※5	APERTURE
Condenser Lens (CL) aperture	ϕ 40 μm (PT)	810299801	1	※5	APERTURE
Condenser Lens (CL) aperture	ϕ 100 μm (PT)	812153405	1	※5	APERTURE
Condenser Lens (CL) aperture	ϕ 200 μm (PT)	812153413	1	※5	APERTURE
Selected-area aperture	ϕ 10 μm (VMP)	418000085	1	※5	IL APERTURE
Selected-area aperture	ϕ 20 μm (VMP)	418000107	1	※5	IL APERTURE
Selected-area aperture	ϕ 50 μm (VMP)	418000123	1	※5	IL APERTURE
Selected-area aperture	ϕ 100 μm (VMP)	418000590	1	※5	IL APERTURE
Cooling water tube (Nylon)	AS-4-35-08(4*6)	405004087	1	5	COOLING SYSTEM
Polyurethane tube for cooling water	UF-25-08 (5*8)	405007761	15	5	COOLING SYSTEM
Cooling water tube (Nylon)	6.5*10circleUF-25-10blue	405005504	12	5	COOLING SYSTEM
Cooling water hose (with vinyl cord)	TR-12 (12*18)	405000553	47	5	COOLING SYSTEM
Pneumatic tube (Nylon)	AS4-50-04 (2.5*4)	405004079	50	5	COMP AIR SYS
Pneumatic rubber hose (multipurpose)	Excel Rubber (63 × 13.4 black)	405012918	5	5	COMP AIR SYS
Pneumatic tube (Nylon)	AS4-50-06 (4*6)	405004087	1	5	COMP AIR SYS
Vacuum hose	18*42*1000 KUNIRON	405008368	2	5	HT EVAC LINE
Solenoid valve for cooling water	AD11-10A-03A-24V	349005605	3	5	WATER DISTRIB
pressure regulator	INA-13-956-A-00	349016534	3	5	WATER DISTRIB
Pressure gauge for cooling water	S-130	364006561	3	5	WATER DISTRIB
Oil mist filter	DT-250-25A	490020666	1	5	ACCESS(R,P)
Vacuum hose	18*42*1000 KUNIRON	405008368	2	5	ACCESS(R,P)
RP oil	MR-200A	423011707	2	0.5	ACCESS(R,P)
V-belt		420028188	1	2	ACCESS(R,P)

Check or replace parts within each replacement period as a guide. *Star marked parts: No replacement is necessary if no problem exists during your check.

6.11.2 Objective Lens Aperture

Consumable goods list of OL aperture (Table 6.15,Table 6.16,Table 6.17).

■ EM-20610(UHR Configuration)

Table 6.15 EM-20610(UHR Configuration) OL aperture

Part name	Specification	Part No.	Qua ntity	Replacing period (year)	UNIT name
High contrast (HC) aperture	ϕ 5-20-60-120 μm (Cu)	810357089	1	※5	ACCESSORIES
In-gap OL aperture	ϕ 10-25 μm (Mo)	811402088	1	※5	ACCESS (SFOA)

■ EM-20620 (HR Configuration), EM-20630 (HT Configuration), EM-20640 (CR Configuration)

Table 6.16 EM-20620(HR Configuration), EM-20630(HT Configuration), EM-20640(CR Configuration) OL aperture

Part name	Specification	Parts No.	Qua ntity	Replacing period (year)	UNIT name
High contrast (HC) aperture	ϕ 5-20-60-120 μm (Cu)	810357089	1	※5	ACCESSORIES
In-gap OL aperture	ϕ 5-30-40-60 μm (Cu)	802472516	1	※5	APERTURE

■ EM-20650 (HC Configuration)

Table 6.17 EM-20650 (HC Configuration) OL aperture

Part name	Specification	Parts No.	Qua ntity	Replacing period (year)	UNIT name
In-gap OL aperture	ϕ 5-15-30-50 μm (Cu)	811198669	1	※5	APERTURE
High contrast (HC) aperture	ϕ 5-20-60-120 μm (Cu)	810357089	1	※5	ACCESSORIES

Check or replace parts within each replacement period as a guide. * No replacement is required if no problem is found after inspection.

6.11.3 Vacuum pumps

List of consumable goods and periodic replacement parts of vacuum pump (Table 6.18).

■ EM-23100 TMP main vacuum exhaust unit

Table 6.18 List of consumable goods and periodic replacement parts of EM-23100 TMP main vacuum exvacuation unit

Part name	Specification	Parts No.	Quantity	Replacing period (year)	UNIT name
TMP damper	PM006492-X	460001922	2	3	EVAC LINE (UPR)
Vacuum gauge (PEG head)	PR25,DN25KF	364005033	1	1	ACCESSORIES
Oil mist filter	DT-250-25A	490020666	1	5	ACCESS(R,P)
Rubber hose (for vacuum)	18*42*1000 KUNIRON	405008368	2	5	ACCESS(R,P)
RP oil	MR-200A	423011707	2	0.5	ACCESS(R,P)
V-belt		420028188	1	2	ACCESS(R,P)

—CAUTION—

Use NEOVAC-MR-200A when refilling the rotary pump with the oil.
If you use other oils, you might cause malfunction of the pump.

6.12 SERVICE OFFICE

For maintenance, contact your local JEOL service office.

Country	Subsidiary company	Telephone Number
Australia:	JEOL (AUSTRALIA) PTY. LTD	+61 2 9451 3855
Belgium:	JEOL (EUROPE) B. V	+32 2 720 0560
Canada:	JEOL CANADA, INC.	+1 514 482 6427
Brazil:	JEOL BRASIL Instrumentos Cientificos Ltda.	+55 11 3983 8144
China:	JEOL (BEIJING) CO., LTD.	+86 10 6804 6321
	Shanghai office	+86 21 6248 4868
France:	JEOL (EUROPE) SAS	+33 13015 3737
Germany:	JEOL (GERMANY) GmbH	+49 8165 77346
Great Britain:	JEOL (U. K.) LTD	+44 1707 377117
Hungary:	JEOL (EUROPE) SAS	+36 1 356 3008
Italy:	JEOL (ITALIA) S.p.A.	+39 02 9041431
Japan:	JEOL LTD	0120-134-788
Korea:	JEOL KOREA LTD.	+82 2 511 5501
Malaysia:	JEOL (MALAYSIA) SDN.BHD.	+60 3 7492 7722
Mexico:	JEOL DE MEXICO S.A. DE C.V.	+52 5 55 211 4511
The Netherlands:	JEOL (EUROPE) B. V.	+31 252 623 500
Norway:	JEOL (SKANDINAVISKA) A. B.	+47 2 2 64 7930
Poland:	JEOL (EUROPE) S. A.	+48 22 826 12 52
Russia:	JEOL LTD. MOSCOW OFFICE	+7 495 748 7791
Singapore:	JEOL ASIA PTE.LTD.	+65 6565 9989
Sweden:	JEOL (SKANDINAVISKA) A. B.	+46 8 28 28 00
Taiwan:	JEOL TAIWAN SEMICONDUCTORS LTD.	886 3 523 8490
United States:	JEOL USA, INC.	
	New England district:	+1 978 535 5900
	Far west district:	+1 925 737 1740