

JEM-2100F

**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.

JEM-2100F

FIELD EMISSION
ELECTRON
MICROSCOPE

NOTICE

- This instrument generates, uses, and can radiate radio-frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to the environment, especially radio communications.
- This instrument must not be modified, and products other than those manufactured by JEOL Ltd. must not be attached to this instrument, without prior written permission. If any such modification or attachment is made, all the stipulated warranties and services contracted by JEOL Ltd. or its affiliated company will be void.
- Replacement parts for maintenance of the instrument performance are available for seven 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.
- After installation of the instrument, when the instrument will be moved or transported, be sure to contact your JEOL service office. If the instrument is moved or transported by people other than engineers employed or specified by JEOL, JEOL Ltd. cannot accept responsibility for any of the accidents and problems with the instrument after transport.
- The information in this manual, which is based on specifications believed correct at the time of publication, is subject to change without notice due to improvements made in the instrument.
- In order to assist us in preparing future documentation, please advise your JEOL service office if you find any errors in this manual. Kindly note that while the instrument can be used in combination with various attachments to serve a number of purposes, this special feature of the instrument is only briefly described in this manual, which chiefly provides information on basic operations.
- In no event will JEOL Ltd. be liable for direct, indirect, incidental or consequential damages resulting from the use of software described in this manual.
- This manual is copyrighted. All rights are reserved. This document may not, in whole or part, be copied, photocopied, reproduced, translated or reduced to any electronic medium or machine readable form without prior consent, in writing, from JEOL Ltd.
- When this manual or the software described in this manual is furnished under a license agreement, it may only be used or copied in accordance with the terms of such license agreement.

Copyright © 2003 JEOL Ltd.

MANUFACTURER

JEOL Ltd.

1-2 Musashino 3-chome Akishima Tokyo 196-8558 Japan

Telephone: 81-42-528-3353

Facsimile: 81-42-528-3385

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

NOTATIONAL CONVENTIONS AND GLOSSARY

■ General notations

-  **DANGER:** An imminent hazardous situation which, if not avoided, will result in death or serious injury.
-  **WARNING:** A potentially hazardous situation which, if not avoided, could result in death or serious injury.
-  **CAUTION:** A potentially hazardous situation which, if not avoided, could result in minor or moderate injury. Also could mean a potentially hazardous situation which could result in serious damage to facilities and acquired data.
- CAUTION - :** Points requiring great care and attention when operating the device to avoid damage to the device itself.
-  : Additional points to remember regarding the operation.
-  : A reference to another section, chapter or manual.
- 1, 2, 3 :** Numbers indicate a series of operations that achieve a task.
-  : A diamond indicates a single operation that achieves a task.

CONTENTS

SAFETY PRECAUTIONS

1. GENERAL

2. SPECIFICATIONS

2.1 PERFORMANCE	2-1
2.2 ELECTRON OPTICAL SYSTEM.....	2-2
2.2.1 Illuminating System	2-2
2.2.2 Image Forming System	2-2
2.3 SPECIMEN STAGE.....	2-2
2.4 CAMERA CHAMBER	2-3
2.5 EVACUATION SYSTEM	2-3
2.5.1 For Microscope Column.....	2-3
2.5.2 For Electron Gun Chamber	2-3
2.5.3 Vacuum Valves	2-3
2.6 CONTROL SYSTEM	2-3
2.7 INSTALLATION REQUIREMENTS.....	2-4
2.7.1 Power, Water and Nitrogen Gas	2-4
2.7.2 Installation Room	2-4
2.8 NITROGEN AND GAS SUPPLIES	2-4
2.9 DIMENSIONS AND WEIGHT (MM AND KG)	2-5
2.10 WARRANTY	2-5

3. COMPOSITION AND CONSTRUCTION

3.1 COMPOSITION.....	3-1
3.2 ACCESSORIES	3-1
3.3 CONSTRUCTION OF COLUMN.....	3-2
3.3.1 Column Exterior.....	3-2
3.3.2 Column Interior.....	3-3
3.3.3 Location of Coils and Lenses.....	3-4
3.4 LOCATION OF CONTROL PANELS	3-5
3.5 RAY DIAGRAMS.....	3-6
3.5.1 Illumination System	3-6
3.5.2 Image Forming System	3-7

4. DESCRIPTION OF CONTROLS

4.1 COLUMN	4-1
4.1.1 Condenser Aperture Assembly.....	4-1
4.1.2 Condenser Mini Lens Shift Screws.....	4-1
4.1.3 Specimen Holder.....	4-1
4.1.4 Goniometer.....	4-1
4.2 CONTROL PANELS.....	4-3
4.2.1 Control Panel L1	4-3
4.2.2 Control Panel R1	4-6
4.2.3 Control Panel L2	4-8

4.2.4	Control Panel R2.....	4-9
4.2.5	Control Panel SC	4-10
4.2.6	Power Supply Console.....	4-11
4.3	MONITOR DISPLAY	4-14
4.3.1	Page 1	4-14
4.3.2	Page 2	4-15
4.3.3	Page 3	4-16
4.3.4	Page 4	4-16
4.3.5	Page 5	4-17
4.4	PC SCREENS.....	4-18
4.4.1	Application Start-up	4-18
4.4.2	TEM Controller Screen	4-19
4.4.3	Switches.....	4-19
4.4.4	Main Screen.....	4-20
4.4.5	Menu Bar.....	4-22
4.4.6	Screens from the Menu Bar.....	4-24
4.4.7	Emergency Screen.....	4-45
5.	OPERATION	
5.1	EMERGENCIES	5-1
5.1.1	Power Suspension.....	5-1
5.1.2	Cooling Water Suspension.....	5-1
5.1.3	Faulty Operation	5-1
5.2	METHOD A	5-2
5.2.1	Startup Procedure	5-2
5.2.2	Shut Down Procedure.....	5-2
5.2.3	Film Loading	5-2
5.2.4	Electron Beam Generation.....	5-8
5.2.5	Aperture Insertion.....	5-15
5.2.6	Photographing.....	5-17
5.2.7	Image Observation.....	5-20
5.2.8	Film Processing	5-22
5.3	METHOD B.....	5-25
5.3.1	Conditions for High Resolution Microscopy.....	5-25
5.3.2	Illumination System Alignment.....	5-28
5.3.3	Condenser Lens Astigmatism Correction.....	5-29
5.3.4	Beam Deflector Adjustment	5-29
5.3.5	Voltage/current Center Adjustment	5-30
5.3.6	Objective Lens Astigmatism Correction	5-32
5.3.7	Image Focusing.....	5-34
5.3.8	Focusing with Fine Structure.....	5-37
5.4	SPECIAL OBSERVATION	5-38
5.4.1	Bright Field Image.....	5-38
5.4.2	Dark Field Image.....	5-38
5.4.3	Low Magnification Image	5-39
5.4.4	Minimum Dose Exposure (MDS).....	5-41
5.5	ELECTRON DIFFRACTION	5-43
5.5.1	Selected Area Diffraction	5-43
5.5.2	Microbeam Electron Diffraction	5-44

5.5.3	High Dispersion Electron Diffraction	5-45
5.6	USE OF THE ANTICONTAMINATION DEVICE	5-47
5.6.1	Filling the Refrigerant Tank.....	5-47
5.6.2	Raising the Trap Temperature to Room Temperature	5-48
5.7	SPECIAL OPERATION.....	5-51
5.7.1	Alignment Data Saving.....	5-51
5.7.2	Free Lens Control (FLC).....	5-52
5.8	APPENDIX	5-53
5.8.1	Microscope Console and Column	5-53
5.8.2	Objective Aperture	5-54
5.8.3	Vacuum Pumps.....	5-54

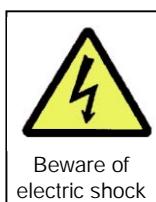
SAFETY PRECAUTIONS

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

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

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

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



Beware of
electric shock



Beware of high
temperature



Beware of
getting caught



Don't
disassemble

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

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

⚠ **WARNINGS**

- Since the inner pressure of the SF₆ gas cylinder is very high (about 3 times that of Freon 12 gas at room temperature), attach a reducing valve to the mouthpiece of the cylinder to reduce the secondary pressure when it is used.
- To avoid any accident of oxygen shortage, exercise care to keep ventilation of the workplace good.

- When discharge occurs in the electron gun gas chamber or high voltage tank, in which contains moisture, etc., poisonous gas may be generated. In order to prevent discharge, attention should be paid to humidity, needless to say cleaning of the chamber or tank
- To avoid any accident of oxygen shortage, exercise care to keep ventilation of the workplace good.



CAUTIONS

- Do not remove the grounding wire. Improper grounding may cause electrical shock
- Do not remove the grounding wire. Improper grounding may cause electrical shock.
- Do not mount on the operating table and/or console.
- Do not dismount and/or reassemble the microscope column. The column dismounting and reassembling are allowed to only JEOL engineer. Contact your nearest JEOL subsidiary when dismounting and/or reassembling the column is/are required.
- If any abnormality occurs, immediately shut down the instrument and contact your nearest JEOL subsidiary.
- Be careful not to pinch your fingers between the specimen holder and goniometer when inserting the holder into the goniometer.
- Do not touch the Wehnelt unless the Wehnelt is grounded by the grounding rod when exchanging the electron gun filament in order to avoid electrical shock.
- Do not put your hand between the upper and lower electron gun chambers while the electron gun lift is functioning.
- Never deactivate the safety devices.
Do not make any modification such as removing protective parts, exchanging component parts, or unlocking or defeating safety devices.
- The instrument and related attachments should be installed by JEOL engineers. Please contact your nearest JEOL subsidiary if installation is required.
- Please consult with a JEOL subsidiary before discarding and/or scrapping the followings since they should be discarded/scrapped in the way that JEOL approved.
 - Main unit and attachments
 - Insulating gas (SF_6) in the high voltage tank
 - Oil in the vacuum pump

1

GENERAL

The JEM-2100F is a high resolution analytical electron microscope in the van of the new era accomplished by further improving the JEM-2101F field emission electron microscope that had a ultra high image quality and resolution in 200 kV class electron microscopes. The various optional attachments such as a scanning image acquirement unit are provided for the JEM-2100F to give full play to the microscope performance over the application especially in the material, biological and medical fields.

The following are the main features of the JEM-2100F.

- **New control system**

The built-in computer assures the programmed control of the microscope operation and centralized various attachments. The optimum lens data and beam deflector data are collectively managed to ease the reproduce the lens condition on the GUI instantly enabling everyone to use such data in anytime. The conventional microscopy while observing the image on the fluorescent screen is possible.

- **Newly developed goniometer**

The use of a new servomotor improves the specimen stage driving circumstances. The image shifting in high magnification will be further eased when a piezo-drive mechanism (on optional attachment) is employed.

- **New column basement**

The microscope column supporting point is located near the column barycenter and passive air-mounts are used to improve the mechanical stability affected mainly by external vibration. Inconsequence of the above improvements, microscope installation room restriction is relaxed. Only this passive air-mounts can be used instead of the large-scale vibration-prove system required for the original microscope column frame.

2

SPECIFICATIONS

2.1	PERFORMANCE.....	2-1
2.2	ELECTRON OPTICAL SYSTEM.....	2-2
2.2.1	Illuminating System	2-2
2.2.2	Image Forming System.....	2-2
2.3	SPECIMEN STAGE.....	2-2
2.4	CAMERA CHAMBER	2-3
2.5	EVACUATION SYSTEM	2-3
2.5.1	For Microscope Column.....	2-3
2.5.2	For Electron Gun Chamber.....	2-3
2.5.3	Vacuum Valves	2-3
2.6	CONTROL SYSTEM.....	2-3
2.7	INSTALLATION REQUIREMENTS	2-4
2.7.1	Power, Water and Nitrogen Gas	2-4
2.7.2	Installation Room	2-4
2.8	NITROGEN AND GAS SUPPLIES	2-4
2.9	DIMENSIONS AND WEIGHT (MM AND KG)	2-5
2.10	WARRANTY.....	2-5

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

2.1 PERFORMANCE

Accelerating voltage: 160 and 200 kV.
80, 100 and 120 kV are optionally available.

High dispersion diffraction camera length: 4 to 80 m (14 steps).

High resolution diffraction camera length: 333 mm (high resolution diffraction stage: optional).

Magnification and selected area electron diffraction camera length:

- When the EM-20014 ultrahigh resolution polepiece is used.

Accelerating voltage (kV)	Standard magnification	Diffraction camera length
200	2,00 to 1,500,000 times	8 to 200 cm

- When the EM-20023 specimen high resolution polepiece is used.

Accelerating voltage (kV)	Standard magnification	Diffraction camera length
200	2,00 to 1,500,000 times	8 to 200 cm

- When the EM-20043 specimen high tilt polepiece is used.

Accelerating voltage (kV)	Standard magnification	Diffraction camera length
200	2,00 to 12500,000 times	8 to 200 cm

- When the EM-20193 high contrast polepiece is used.

Accelerating voltage (kV)	Standard magnification	Diffraction camera length
200	1,000 to 800,000 times	15 to 300 cm

- When the EM-20458 polepiece is used.

Accelerating voltage (kV)	Standard magnification	Diffraction camera length
200	1,200 to 1,000,000 times	10 to 250 cm

2.2 ELECTRON OPTICAL SYSTEM

2.2.1 Illuminating System

- Electron gun

Emitter:	ZrO/W (100)
Electron gun lens:	Electrostatic lens.
Axis alignment:	Electromagnetic 2-stage interlocking system.
Airlock:	Automatic.
- Condenser lens

Type:	Three-stage (1st, 2nd and mini).
Aperture:	10, 40, 100, 250 μm in diameter (click stop type).
Stigmator:	Electromagnetic type complete with centering device.
Alignment:	Electromagnetic 2-stage interlocking system, 4 circuits for exclusive use in 4 modes (TEM, EDS, NBD and CBD).
- Beam tilting angle: Max. 5° in all directions.

2.2.2 Image Forming System

- Image forming lenses: Rotation-free, electromagnetic 6-stage system (objective lens, OM lens, 1st, 2nd and 3rd intermediate lenses, projector lens).
- Objective apertures (click stop mechanism)

When the EM-20193 or 20458 polepiece is used:	5, 30, 40 and 60 μm in diameter
When the EM-20014, 20023 or 20043 polepiece is used:	5, 20, 60 and 120 μm in diameter
- Field limiting apertures (click stop mechanism): 10, 20, 50 and 120 μm in diameter
- Stigmator: Electromagnetic type; complete with centering device; and five control circuits.

2.3 SPECIMEN STAGE

- Specimen exchange: Automatic (airlock mechanism).
2-stage evacuation.
- Loading capacity: One specimen.
- Specimen movement range

X and Y directions:	± 1 mm, position of field of view under observation displayed on the monitor.
---------------------	---
- Z direction:

When the EM-20014 polepiece is used:	± 0.1 mm
When the EM-20023, EM-20043, or EM-20193 polepiece is used:	± 0.2 mm
- Specimen tilt angle (when a double tilt specimen holder is used):

When the EM-20014 polepiece is used:	$\pm 25^\circ/\pm 25^\circ$
When the EM-20023 polepiece is used:	$\pm 35^\circ/\pm 30^\circ$
When the EM-20043 polepiece is used:	$\pm 42^\circ/\pm 30^\circ$
When the EM-20193 polepiece is used:	$\pm 38^\circ/\pm 30^\circ$

- When the EM-20458 polepiece is used: $\pm 60^\circ$ (single tilt)
- Specimen shift: Motor driven (X, Y and Z directions), A trackball and buttons are used.

2.4 CAMERA CHAMBER

- Film

Standard size:	A, E, J or S size
Loading capacity:	Up to 50.
Feeding:	Automatic.
Exchange mechanism:	Airlock type.
- Exposure: Automatic and manual.
- Data recording: Film number, magnification/camera length, accelerating voltage, micron bar and calibrated length, and characters (keyboard entry).

2.5 EVACUATION SYSTEM

2.5.1 For Microscope Column

- Vacuum pumps

For rough evacuation:	Oil rotary pump/oil diffusion pump or dry pump/turbo molecular pump
For fine evacuation:	Sputter-ion pump or turbo molecular pump
- Ultimate pressure: 10^{-5} Pa order (specimen chamber).
- Vacuum gauges: Penning and Pirani gauges.

2.5.2 For Electron Gun Chamber

- Vacuum pumps: Ion pump
- Vacuum gauge: By means of ion pump current
- Ultimate pressure: 10^{-8} Pa order

2.5.3 Vacuum Valves

- Automatically controlled pneumatic and solenoid valves

2.6 CONTROL SYSTEM

- Control panels (located beside the viewing chamber)

Used for setting the observation condition
--
- Monitor: Used for displaying the observation condition.
- Personal computer: Used for displaying and setting the observation condition.

2.7 INSTALLATION REQUIREMENTS

2.7.1 Power, Water and Nitrogen Gas

- Power source: Single-phase, 200/220/240 V, 10.0 kVA (7 kVA in normal condition)
- Grounding terminal: One, 100 ohms or less.
- Cooling water:
 - Flow rate: 7.5 L/min.
 - Pressure: 0.2 to 0.3 MPa (Gauge pressure).
 - Temperature: 15 to 20°C.
 - Faucet: One, ISO 7/1 RC1/2 (internal thread).
- Dry nitrogen₂ gas: Pressure: 0.01 to 0.02 MPa (should be provided by the user).

2.7.2 Installation Room

- Floor space: 5,000 (W) × 5,400 (D) mm or more.
- Ceiling height: 3,000 mm or more.
- Entrance: 1,000 (W) × 1,900 (H) mm or more.
- Temperature: 15 to 25°C.
- Humidity: 60% or less.
- Stray magnetic field: 0.1 µT or less.
- Compressed air: 0.35 to 0.45 MPa (gauge pressure).

2.8 NITROGEN AND GAS SUPPLIES

- Dry nitrogen gas (provided by the customer):
 - Gas pressure: 0.02 MPa (0.2 kg/cm²), gauge pressure. A gas cylinder or central nitrogen gas supply system equipped with a two-stage pressure regulator is required.
- Two-stage pressure regulator:
 - An exclusive use for nitrogen gas, Vacuum-proof structure, provided by the customer.
- Nozzle: Interior screw (ISo 7/1 Rc1/4).
- Primary pressure gauge: 0 to 25 MPa (the maximum pressure at gauge inlet: 15 MPa).
- Secondary pressure gauge: 0 to 0.1 MPa.

2.9 DIMENSIONS AND WEIGHT (MM AND KG)

	Height	Depth	Width	Mass
Main console	2,530	1,740	2,250	1,200
Power supply	1,750	800	570	400
HT tank	1,640	1,210	970	450
Rotary Pump*	410	270	205	33
Dry pump*	340	440	310	32

-  The number of pumps depends on the evacuation system.
- In the case of the EM-23075 with EM-23080 evacuation system
Two oil rotary pumps
 - In the case of the EM-23078 with EM-23080 evacuation system
Three oil rotary pumps
 - In the case of the EM-23075 with EM-23085 evacuation system
One oil rotary pump and one dry pump (scroll pump)
 - In the case of the EM-23078 with EM-23085 evacuation system
Two oil rotary pumps and one dry pump (scroll pump)

2.10 WARRANTY

With the exception of damage resulting from natural disasters and careless handling, this instrument is guaranteed for a period of one year from the time of installation, and any and all faults or failures occurring during this period will be repaired free of charge at the installation site.

3

COMPOSITION AND CONSTRUCTION

3.1	COMPOSITION.....	3-1
3.2	ACCESSORIES.....	3-1
3.3	CONSTRUCTION OF COLUMN	3-2
3.3.1	Column Exterior.....	3-2
3.3.2	Column Interior	3-3
3.3.3	Location of Coils and Lenses	3-4
3.4	LOCATION OF CONTROL PANELS.....	3-5
3.5	RAY DIAGRAMS	3-6
3.5.1	Illumination System	3-6
3.5.2	Image Forming System.....	3-7

3.1 COMPOSITION

The figure shown below is the layout diagram when the EM-23075 and EM-23080 are used in the JEM-2100F as the evacuation system.

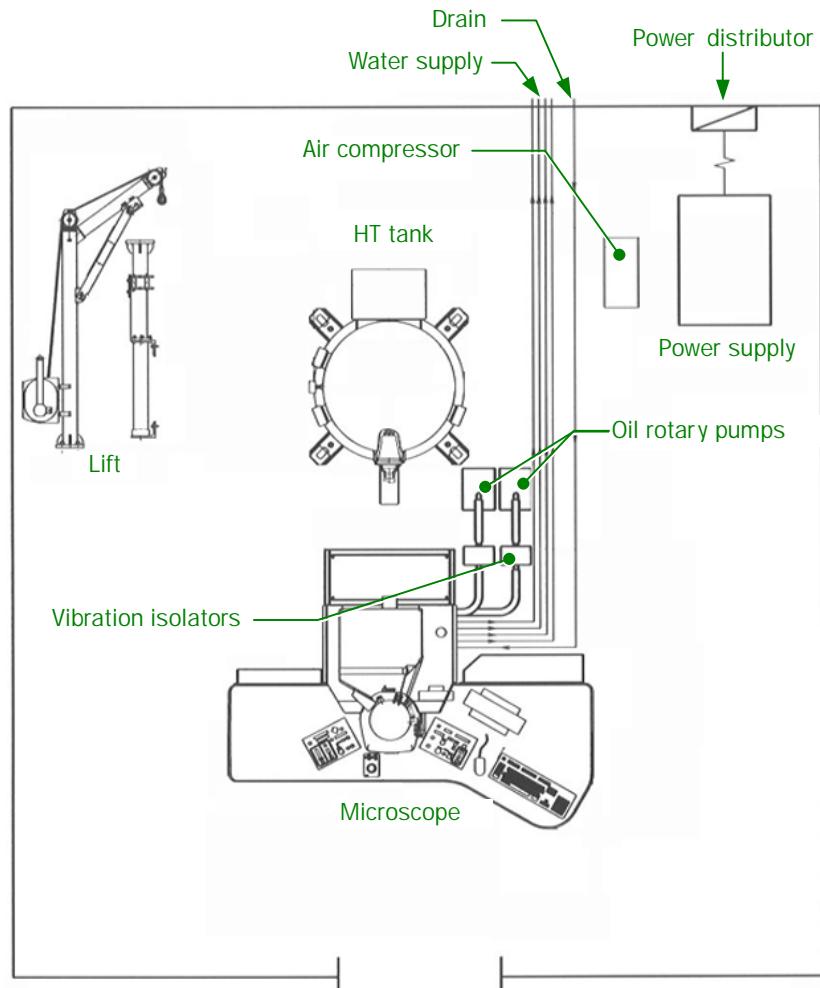


Fig 3.1 Composition and layout diagram

3.2 ACCESSORIES

Although some of the items are not used by the users, they should nevertheless be carefully stored as they will be required for servicing purposes.

- | | |
|----------------------|---|
| Lens lifting tool: | For disassembling and reassembling the anode chamber and lenses |
| Gun lifting tool: | For lifting the electron gun |
| Wire rope with hook: | For hoisting the HT tank inner part |

3.3 CONSTRUCTION OF COLUMN

3.3.1 Column Exterior

Optional attachments are included in this photograph and the shape may not be identical with yours in detail.

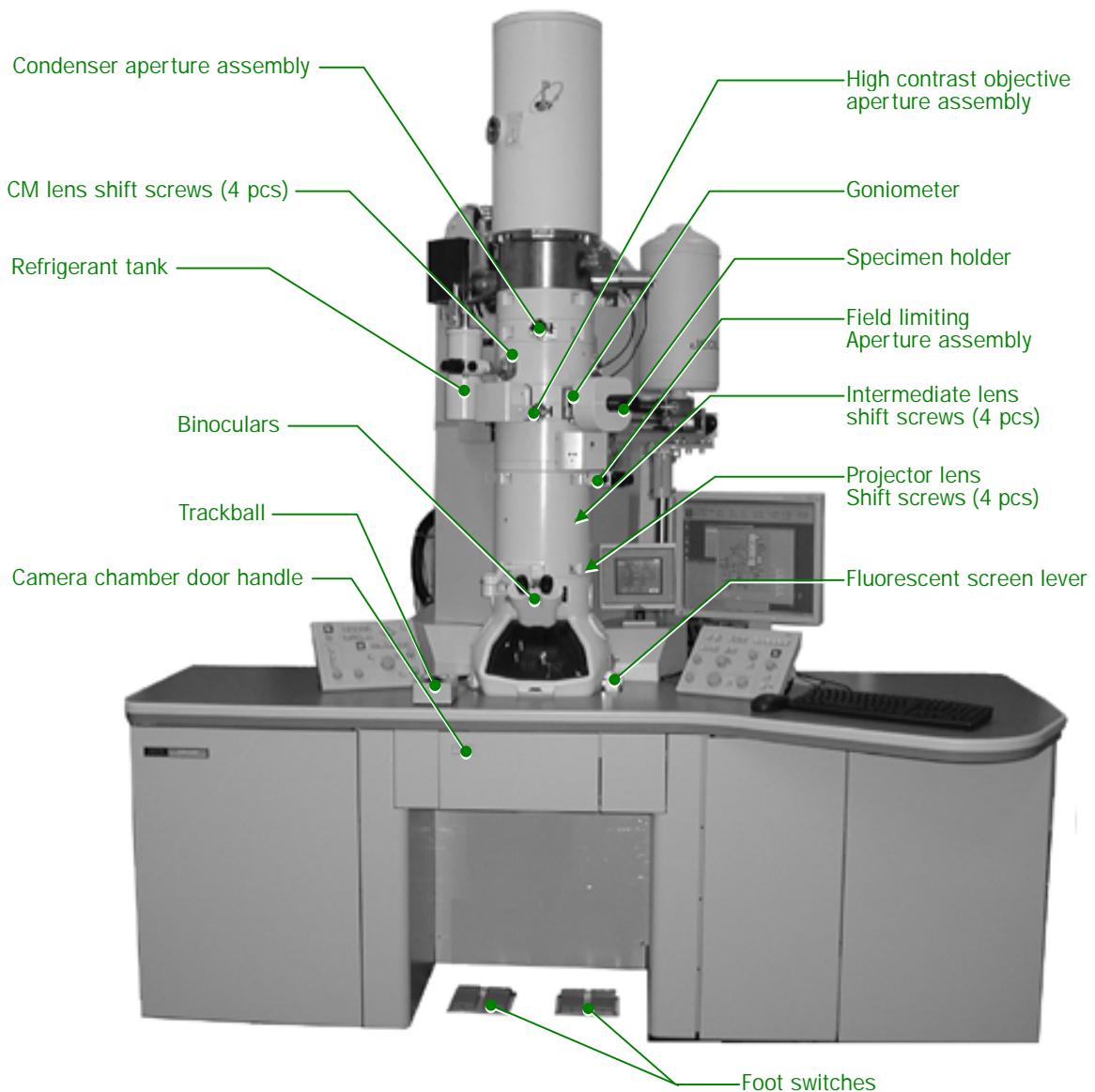


Fig 3.2 Column exterior

3.3.2 Column Interior

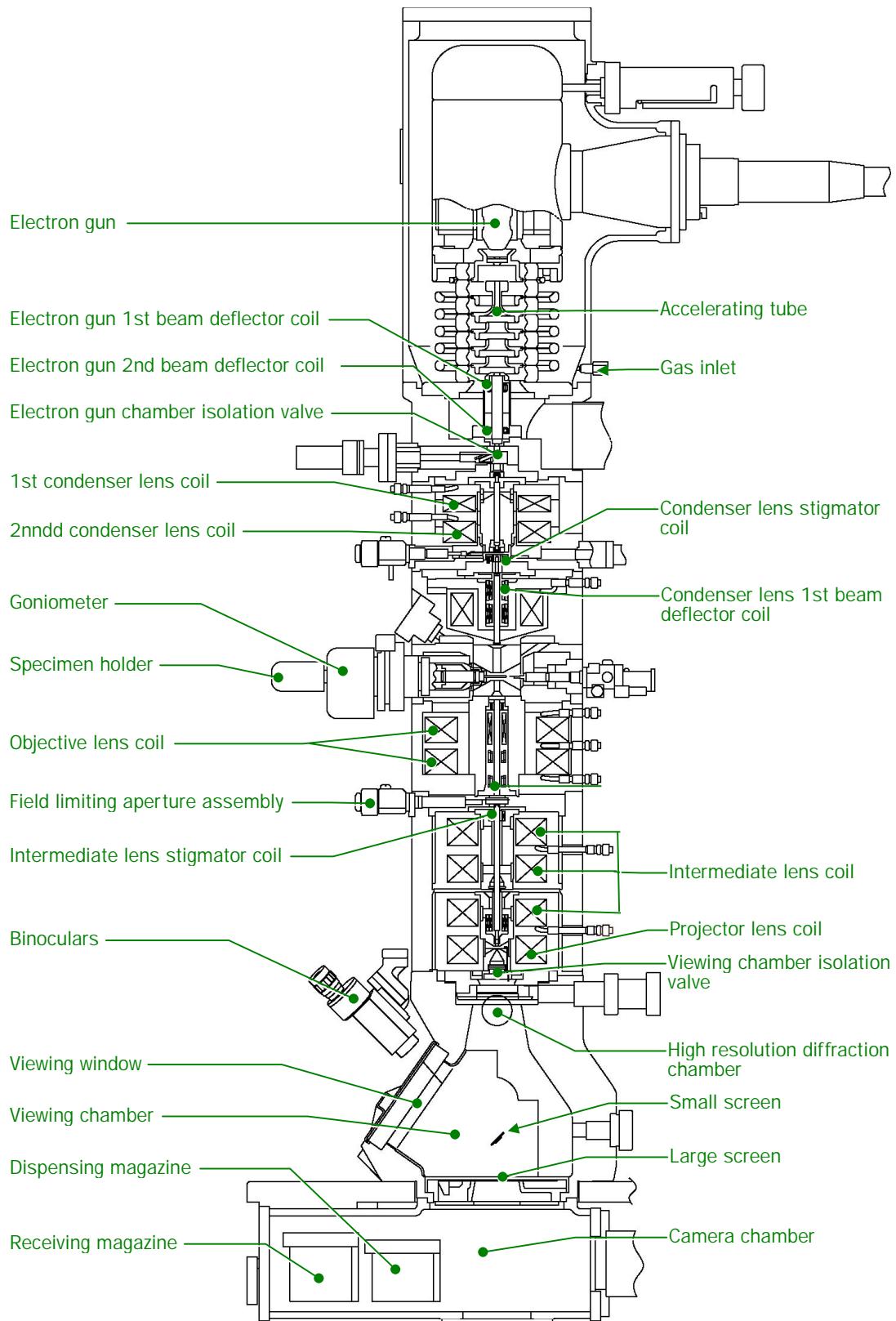


Fig 3.3 Cross section of column

3.3.3 Location of Coils and Lenses

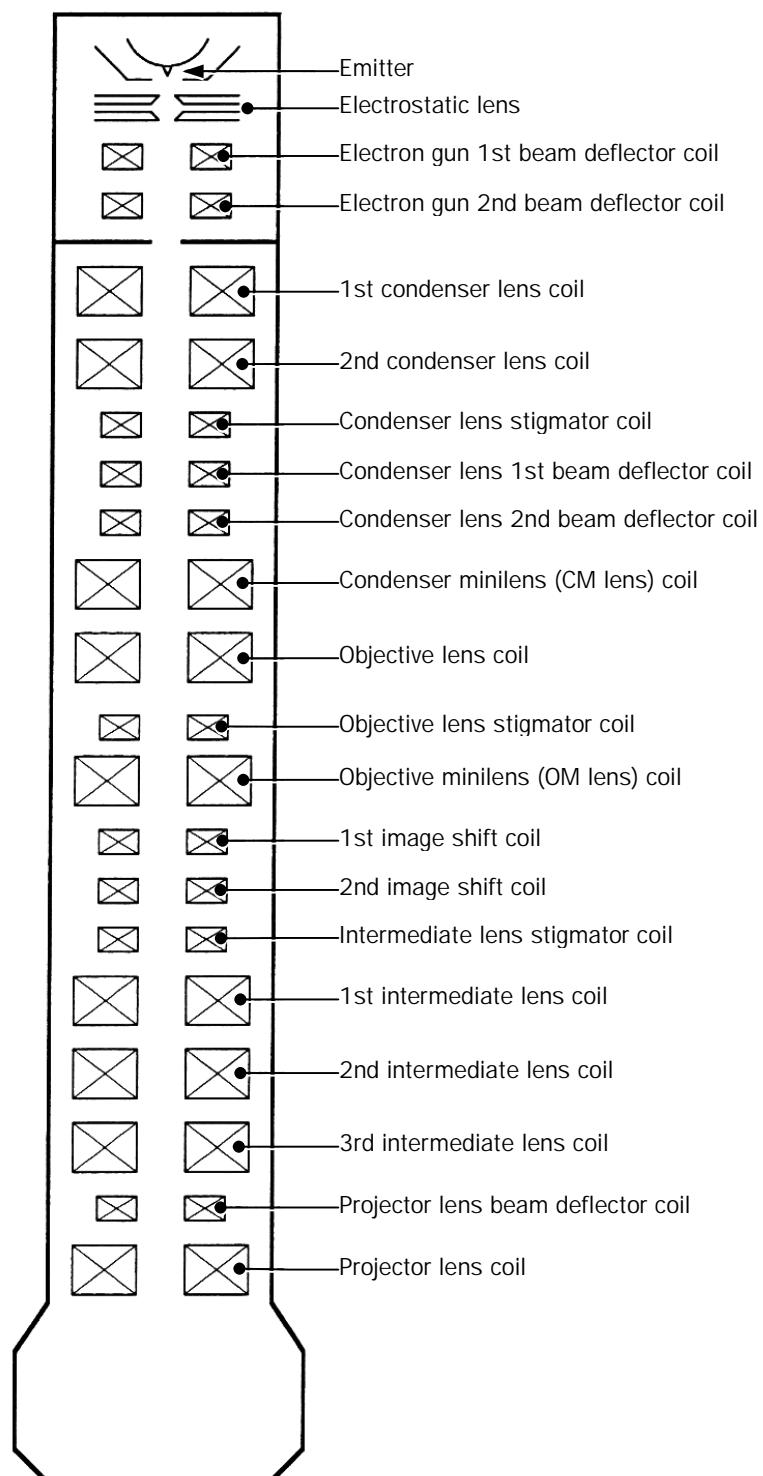


Fig 3.4 Location of coils and lenses

3.4 LOCATION OF CONTROL PANELS

Control panel R2 is accessible by pulling out panel R2 housing and control panel L2 is accessible when cover L2 is opened. The PC is accessible when cover PC is opened.

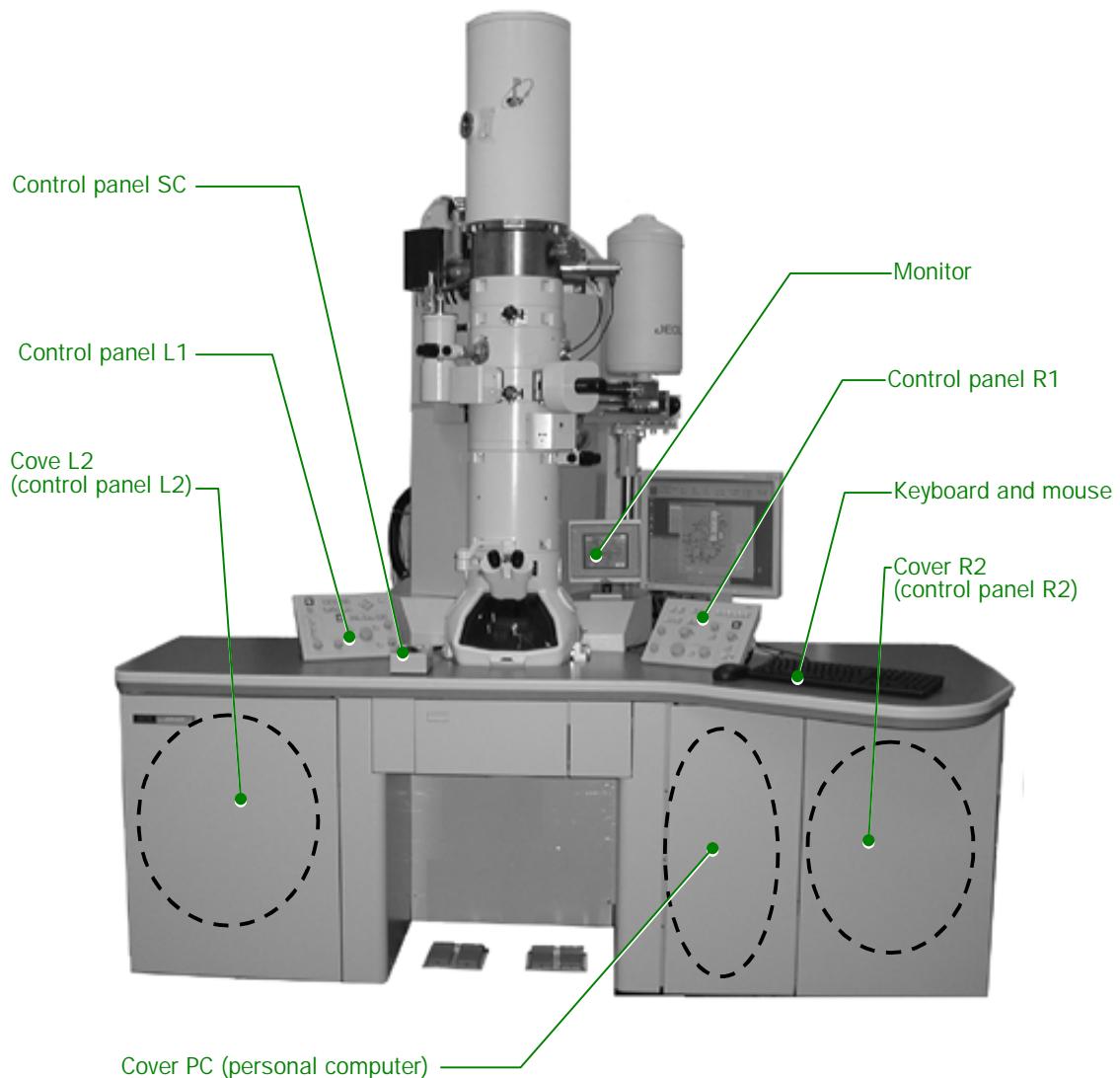
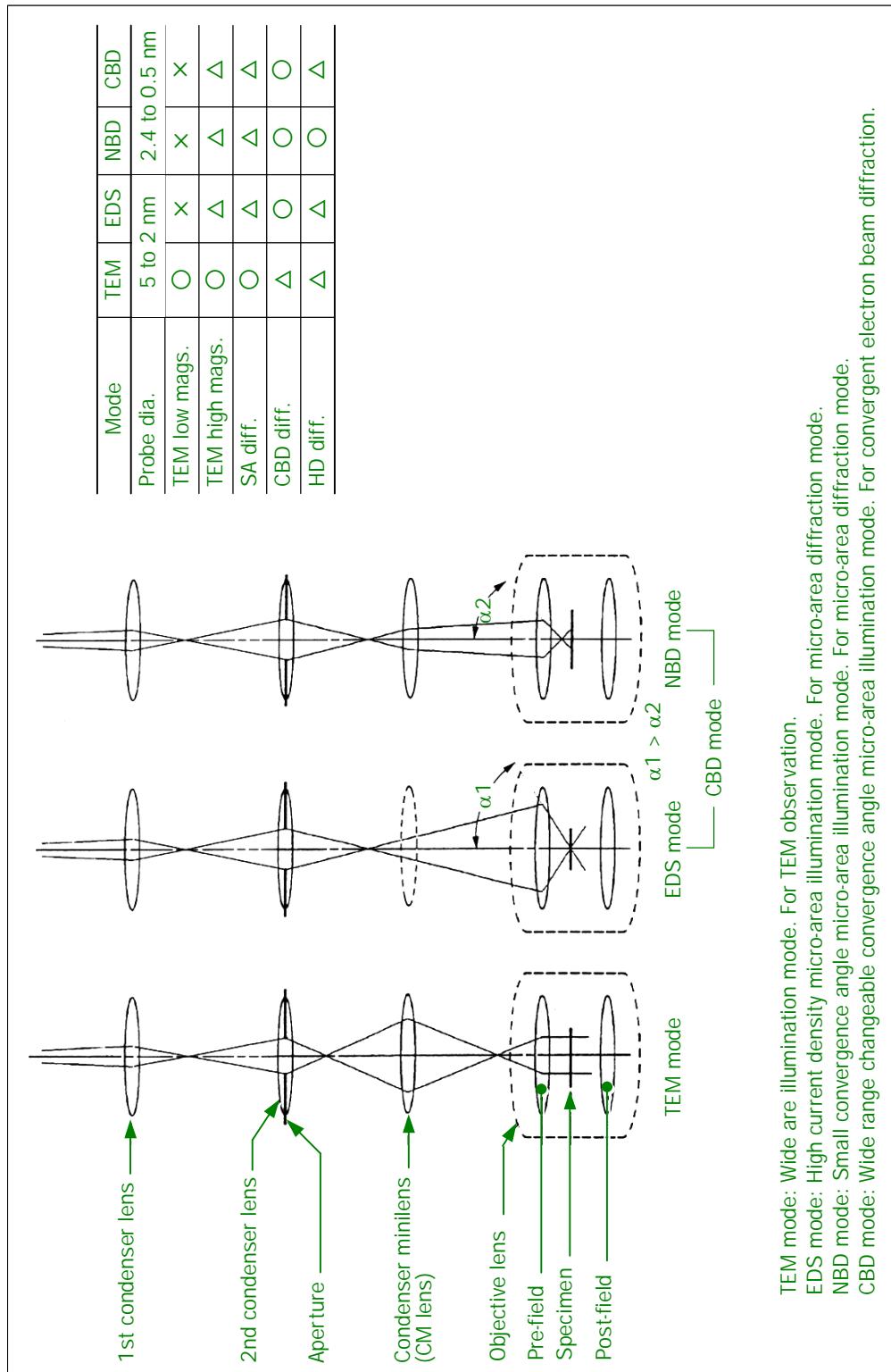


Fig 3.5 Location of control panels

3.5 RAY DIAGRAMS

3.5.1 Illumination System



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

Fig 3.6 Ray diagram (Illumination system)

3.5.2 Image Forming System

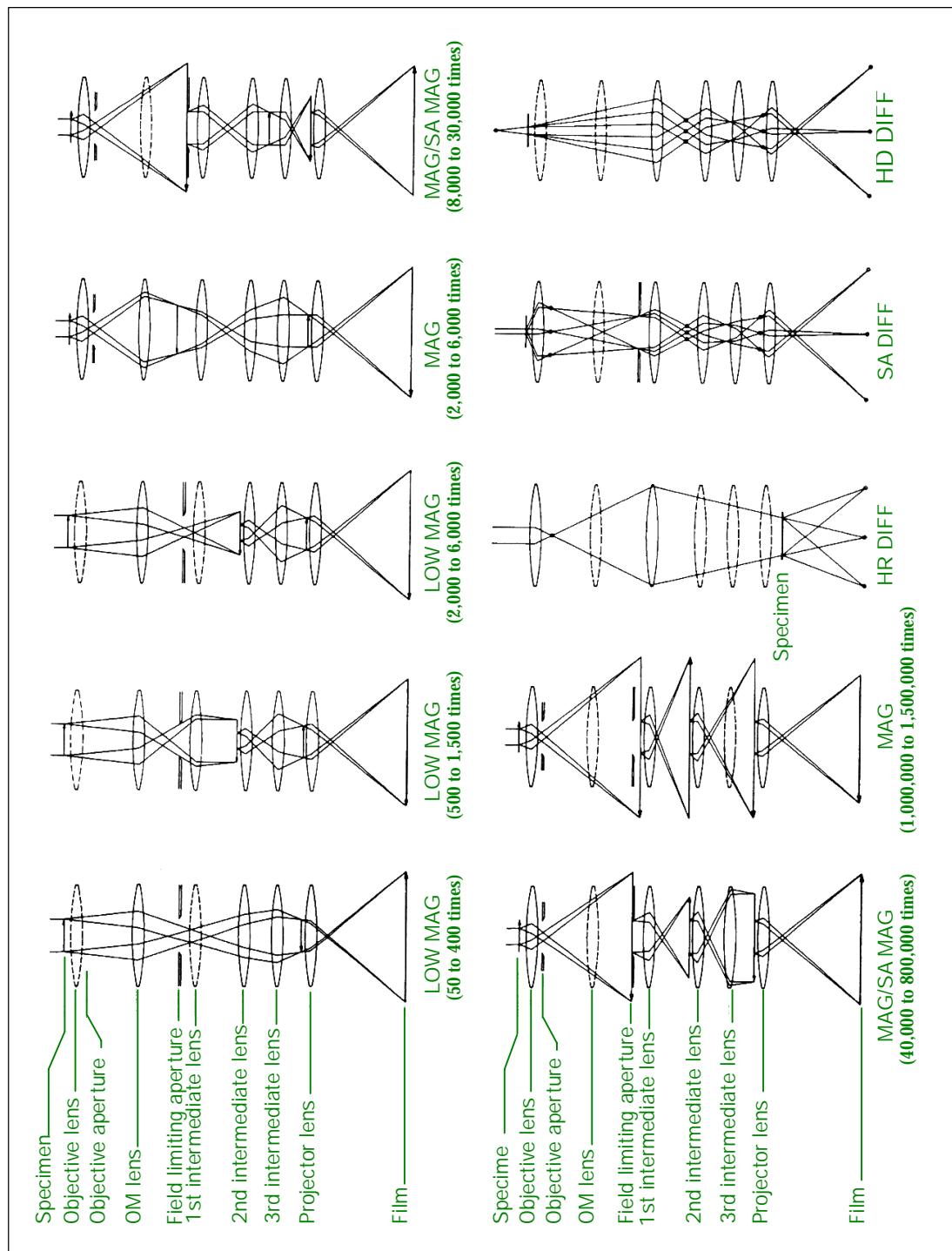


Fig 3.7 Ray diagram (image forming system)

4

DESCRIPTION OF CONTROLS

4.1	COLUMN (See Fig. 3.2)	4-1
4.1.1	Condenser Aperture Assembly.....	4-1
4.1.2	Condenser Mini Lens Shift Screws	4-1
4.1.3	Specimen Holder	4-1
4.1.4	Goniometer.....	4-1
4.2	CONTROL PANELS.....	4-3
4.2.1	Control Panel L1.....	4-3
4.2.2	Control Panel R1	4-6
4.2.3	Control Panel L2.....	4-8
4.2.4	Control Panel R2	4-9
4.2.5	Control Panel SC	4-10
4.2.6	Power Supply Console	4-11
4.2.6a	Control panel P1.....	4-12
4.2.6b	Control panel P2.....	4-12
4.2.6c	Control panel P3.....	4-13
4.2.6d	Control panel P4.....	4-13
4.2.6e	Control panel P5.....	4-13
4.3	MONITOR DISPLAY	4-14
4.3.1	Page 1	4-14
4.3.2	Page 2	4-15
4.3.3	Page 3	4-16
4.3.4	Page 4	4-16
4.3.5	Page 5	4-17
4.4	PC SCREENS.....	4-18
4.4.1	Application Start-up	4-18
4.4.1a	TEM Server.....	4-18
4.4.1b	TEM Controller.....	4-18
4.4.2	TEM Controller Screen	4-19
4.4.3	Switches	4-19
4.4.4	Main Screen.....	4-20
4.4.4a	Left main screen.....	4-20
4.4.4b	Center main screen.....	4-21

4.4.4c	Right main screen.....	4-21
4.4.5	Menu Bar.....	4-22
4.4.5a	File.....	4-22
4.4.5b	Dialogue	4-22
4.4.5c	Monitor.....	4-22
4.4.5d	Property	4-22
4.4.5e	Option.....	4-23
4.4.5f	Maintenance	4-23
4.4.5g	Display.....	4-23
4.4.5h	JEOLS	4-23
4.4.5i	Help	4-23
4.4.6	Screens from the Menu Bar	4-24
4.4.6a	Photo History screen.....	4-24
4.4.6b	High Voltage Control screen	4-25
4.4.6c	Operation screen.....	4-26
4.4.6d	Specimen Position screen	4-30
4.4.6e	Film Camera Property screen	4-31
4.4.6f	Status Monitor screen.....	4-32
4.4.6g	Valve Status screen.....	4-34
4.4.6h	EOS Property screens	4-35
4.4.6i	Specimen Property screen	4-36
4.4.6j	MDS screen	4-37
4.4.6k	Free Lens Control screen.....	4-38
4.4.6l	Mag select screen	4-39
4.4.6m	Lens/Def Memory screen.....	4-39
4.4.6n	Alignment Panel for Maintenance screen.....	4-40
4.4.6o	Bake Out/ACD screens.....	4-41
4.4.6p	Aperture screen.....	4-43
4.4.6q	Stage Limit screen.....	4-44
4.4.7	Emergency Screen	4-45

4.1 COLUMN (See Fig. 3.2)

4.1.1 Condenser Aperture Assembly

- Condenser aperture assembly (☞ Fig. 4.1)

Knob 1:

The apertures are selected corresponding to the knob 1 position.

Knob 1 position					
Aperture size	Open	○	○	◦	◦

Knobs 2 and 3:

Knobs 2 and 3 are used to move the apertures in X and Y directions.

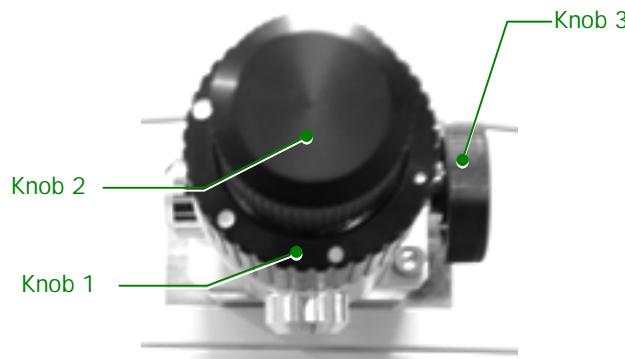


Fig. 4.1 Condenser lens aperture assembly

4.1.2 Condenser Mini Lens Shift Screws

Used for illumination system alignment.

4.1.3 Specimen Holder

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

4.1.4 Goniometer

A specimen loaded in a specimen holder is inserted in the goniometer and tilted with a motor built in the goniometer.

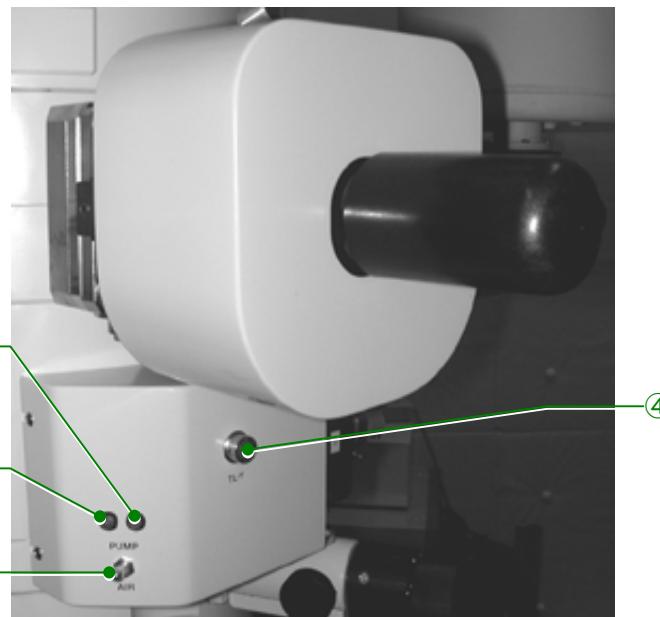


Fig. 4.2 Goniometer

- ① Green lamp
Indicates, when lit, that specimen holder insertion and removing is ready.
- ② Yellow lamp
Indicates, when lit, that the goniometer is being roughly evacuated.
- ③ PUMP/AIR switch
Setting this switch to PUMP evacuates the goniometer (the yellow lamp lights up during evacuation) and the goniometer vacuum is broken when this switch is set to AIR.
Switch setting can not be performed unless the switch is pulled.
- ④ Connector
For optional specimen holders such as a double-tilt specimen holder.

4.2 CONTROL PANELS

4.2.1 Control Panel L1

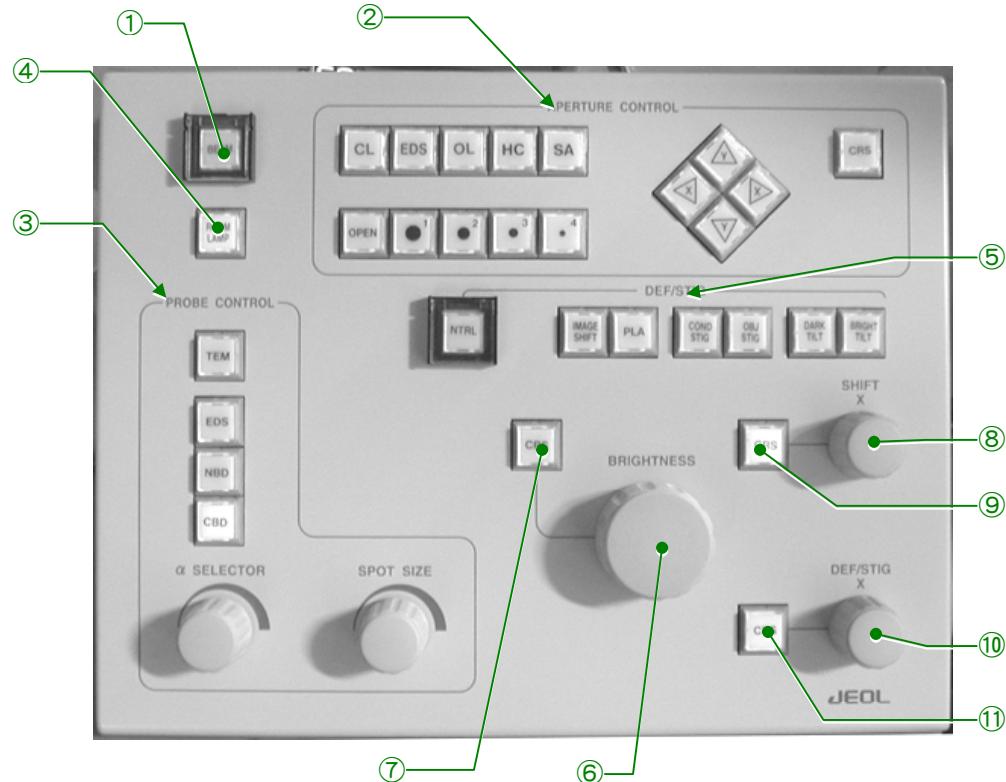


Fig. 4.3 Control panel L1

① BEAM VALVE switch

Pressing this switch opens valve V1 (isolation valve between the microscope column and electron gun chamber).

② APERTURE CONTROL

When one of aperture switches (CL, EDS, OL, HC or SA) is depressed, the built-in lamp lights up and the selected aperture can controlled using the aperture number select switches (OPEN, 1, 2, 3 or 4) and X, Y shift switches. Aperture control is impossible when the aperture is not attached to the microscope.

• Aperture select switches

CL: Used to select the condenser aperture assembly.

EDS: Used to select the hard X-ray aperture assembly.

OL: Used to select the objective aperture assembly.

HC: Used to select the high contrast objective aperture assembly.

SA: Used to select the field limiting aperture assembly.

- Aperture number select switches

When one of these switches is depressed, the corresponding aperture size of the selected aperture assembly is selected.

- OPEN: The aperture is opened.
- 1: Aperture number 1 is selected.
- 2: Aperture number 2 is selected.
- 3: Aperture number 3 is selected.
- 4: Aperture number 4 is selected.

- X, Y shift switches

Used to shift the aperture in the X and Y directions.

- CRS switch

Depressing this switch multiplies the amount of the aperture shift when one of the X, Y switches is depressed by 16 times.

③ PROBE CONTROL

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

TEM switch: When this is turned on, the built-in lamp brightens and the illumination mode is set to the TEM mode (wide area illumination mode).

EDS switch: When this is turned on, the built-in lamp brightens and the illumination mode is set to the EDS mode (high current density micro-area illumination mode).

NBD switch: When this is turned on, the built-in lamp brightens and the illumination mode is set to the NBD mode (small convergence angle micro-area illumination mode).

CBD switch: When this is turned on, the built-in lamp brightens and the illumination mode is set to the CBD mode (wide range chargeable convergence angle micro-area illumination mode).

- α SELECTOR knob

Selects the convergent angle with the illuminating area kept unchanged in size. The CM lens current decreases and illuminating angle becomes larger as this is turned clockwise. The CM lens current decreases to zero when this is turned fully clockwise.

- SPOT SIZE knob

Turning this switch one step increases or decreases the spot size (the size of the electron beam when converged minimally using the BRIGHTNESS knob). The SPOT SIZE number increases when the spot size is decreased and the SPOT SIZE number decreases when the spot size is increased.

④ ROOM LAMP switch

Used to turn on and off the room lamp when provided.

⑤ DEF/STIG switches

Depressing one of these switches lights up the built-in lamp and the selected coil current can be controlled with the SHIFT knobs (L1-⑦, R1-⑤) or DEF/STIG knobs (L1-⑨, R1-⑤). Depressing the switch again turns off the built-in lamp and the selected coil current is fixed to the value when this switch is depressed (the built-in lamp goes out).

IMAGE SHIFT switch: Used for image shift at high magnifications.

- PLA switch:** Used to vary the projector lens deflector coil current when shifting the diffraction spot or specimen image.
- COND STIG switch:** Used to adjust the condenser lens stigmator coil current when performing the condenser lens astigmatism correction.
- OBJ STIG switch:** Depressing this switch supplies the current stored in the selected memory to the objective lens stigmator coil and the current can be adjusted using the SHIFT and DEF/STIG knobs becomes. Used to correct the objective lens astigmatism correction.
- DARK TILT switch:** Depressing this switch supplies the current stored in the selected memory to the condenser lens beam deflector coil and the current can be adjusted using the SHIFT DEF/STIG knobs. Used to tilt the electron beam when observing dark field images.
- BRIGHT TILT switch:** Depressing this switch supplies the current stored in the selected memory to the condenser lens beam deflector coil and the current can be adjusted using the SHIFT DEF/STIG knobs. Used to tilt the electron beam when observing dark field image.
- NTRL switch:** Depressing this switch brightens the built-in lamp and clears the current data stored in the memory corresponding to the selected switch.
- ⑥ BRIGHTNESS knob
Converges and spreads the electron beam.
 - ⑦ BRIGHTNESS CRS switch
When this switch is depressed, the current rate per notch of the BRIGHTNESS knob (L1-⑥) is enlarged by 16 times.
 - ⑧ SHIFT X knob
Used to shift the electron beam in the X direction by varying the condenser lens beam deflector coil current. The condenser lens 1st beam deflector coil current is varied when the Align-Gun is selected on the Alignment Panel for Maintenance screen.
 - ⑨ SHIFT CRS switch
When this switch is depressed, the current rate per notch of the SHIFT knobs (L1-⑧, R1-④) is enlarged by 16 times.
 - ⑩ DEF/STIG X knob
Used to vary the X current in the coil selected on the Alignment Panel for Maintenance screen (☞ Fig. 4.44-①).
 - ⑪ DEF-STIG CRS switch
When this switch is depressed, the current rate per notch of the DEF/STIG knobs (L1-⑩, R1-⑤) is enlarged by 16 times.

4.2.2 Control Panel R1

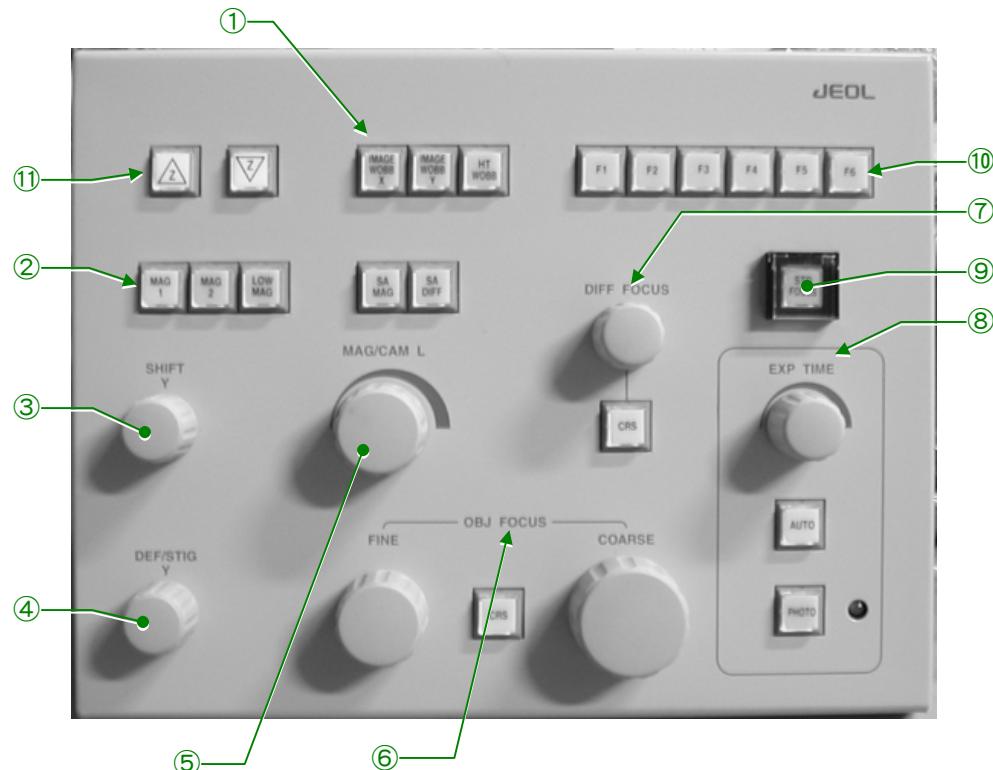


Fig. 4.4 Control panel R1

① WOBBLER switches

IMAGE WOB X:

Used for focusing. The 1st and 2nd beam deflector coil currents vary periodically when this switch is turned on. If the image is out of focus, it wobbles in the X direction.

IMAGE WOB Y:

Used for focusing. The 1st and 2nd beam deflector coil currents vary periodically when this switch is turned on. If the image is out of focus, it wobbles in the Y direction.

HT WOB:

By turning on this switch, the high voltage is periodically varied, facilitating the voltage center alignment.

② FUNCTION switches

Used for selecting an image forming mode. The magnification or camera length in the selected mode can be varied with the MAG-CAM L knob (R1-⑥) and is displayed on the monitor. The magnification or camera length set by the MAG-CAM L knob is stored so that even if another mode is once selected, the magnification or camera length can be set to the stored value by selecting the original mode again.

MAG 1 switch:

Used for selecting the normal magnification mode.

MAG 2 switch:

By depressing this switch, a specific magnification is obtained. The magnification set in this mode is not stored.

LOW MAG switch:

Used for selecting the low magnification mode.

SA MAG switch:

Used for selecting the selected area magnification mode.

- SA DIFF switch:** Used for selecting the selected area diffraction mode.
- ③ SHIFT Y knob
Used for shifting the electron beam in the Y direction by varying the condenser lens beam deflector coil current. The electron gun 1st beam deflector coil current is varied when the Align-Gun is selected on the Alignment Panel for Maintenance screen.
- ④ DEF-STIG Y knob
Used for varying the Y current in the coil selected by DEF-STIG Y switch or selected on the Alignment Panel for Maintenance screen.
- ⑤ MAG/CAM L knob
Used for varying the normal magnification when the FUNCTION-MAG 1 or -MAG 2 switch (R1-②) is depressed, the low magnification when the FUNCTION-LOW MAG switch is depressed. The selected area magnification is varied when the SA MAG is selected and the camera length is varied when the SA DIFF is selected. Turning this knob clockwise increases the magnification or camera length and turning it counterclockwise decreases the magnification or camera length.
- ⑥ OBJ FOCUS knob
Used for focusing the image by varying the objective lens current (OM lens in case of LOW MAG mode).
- FINE knob:
The amount of current variation when the large knob is turned minimum.
- COARSE knob:
The amount of current variation when this knob is turned one notch is the same as when the FINE knob is turned 16 notches.
- CRS Switch:
Turning this switch on enlarges the amount of current variation per notch by 16 times.
- ⑦ DIFF FOCUS Knob:
Used for focusing the selected area image when the FUNCTION (R1-②) is set to the SA MAG and the FUNCTION (R1-②) is set to the SA DIFF.
Turning this switch on enlarges the amount of current variation per notch of the FOCUS knob by 16 times.
- ⑧ EXP TIME/PHOTO EXP TIME knob:
Used for vary the exposure time. Turning this knob clockwise increases the exposure time and turning it counterclockwise decreases the exposure time.
- AUTO switch:
Depressing this switch lights up the built-in lamp and selects the automatic exposure mode. Depressing this switch again selects the manual exposure mode (the built-in lamp goes out).
- PHOTO switch:
By depressing this switch when the lamp is unlit, a film is advanced to the exposure position, the lamp lights up when the film reaches the said position, the film is exposed and advanced, and the lamp goes out. By depressing this button when the lamp is lit, that is, when a film is in the exposure position, the film is exposed.

The timing of the film advancement and the photographing can set on the Film Camera Property screen.

Lamp:
Indicates, when lit, that the shutter

- ⑨ STD FOCUS switch
Depressing this switch sets the objective lens current to the original reference value.
- ⑩ F switch
This is used to allocate the function selected by the operator to the F1 to F6 switches.
- ⑪ Z switch
Used to shift the specimen in the vertical direction.

4.2.3 Control Panel L2

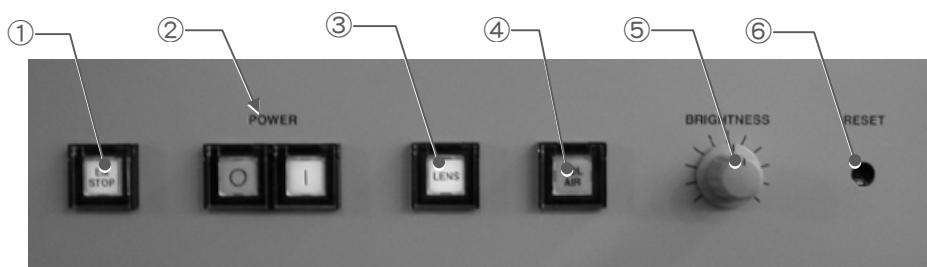


Fig. 4.5 Control panel L2

- ① EM STOP switch
Used for emergency shut down.
- ② POWER switch
Depressing the “|” switch turns off the instrument and “○” switch turns on the instrument.
- ③ LENS switch
Tuning this switch on turns on all the lenses, beam deflectors and stigmators power supplies.
- ④ COL AIR switch
Turning this switch on exposes the microscope column to the atmosphere and turning this switch off this switch evacuates the column.
- ⑤ BRIGHTNESS knob
Used to adjust the brightness of the film numbering characters.
- ⑥ RESET switch
Depressing this switch starts again the instrument main system.

4.2.4 Control Panel R2



Fig. 4.6 Control panel R2

Variable resistors (round holes):

Used for maintenance.

Dip switches (square holes):

Used for turning on and off lens current and deflector coil current power supplies.

4.2.5 Control Panel SC

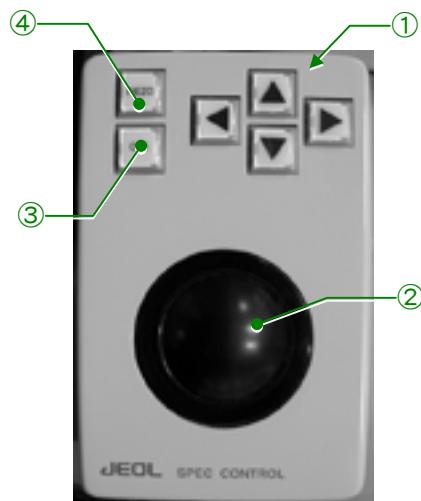


Fig. 4.7 Control panel SC

① ▲ switches

Used for to the specimen in the X and Y directions.

② Trackball

Used to shift the specimen. The shift specimen image shift direction is roughly same as the direction in which the ball is turned.

③ CRS switch

Used to select the specimen shift speed. Turning this switch on (built-in lamp is lit) selects the fast speed and turning this switch off selects the low speed (built-in lamp goes out). This is applied to the specimen X, Y and Z shifts and X and Y tilts.

④ PIEZO switch

Turning this switch on selects the specimen shift using the piezo shift drive mechanism (the piezo shift mechanism is an optional attachment).

4.2.6 Power Supply Console

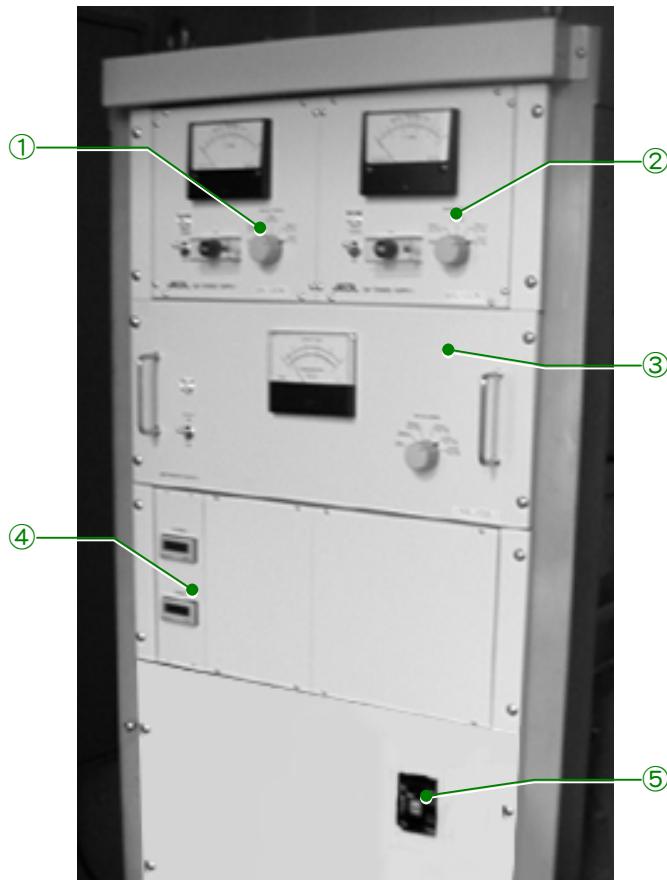


Fig. 4.8 Power Supply console

- ① Control panel P1
SIP POWER SUPPLY (20 L)
- ② Control panel P2
SIP POWER SUPPLY (60 L)
- ③ Control panel P3 (optional attachment)
SIP POWER SUPPLY (150 L)
- ④ Control panel P4
Digital hour meter
- ⑤ Control panel P5
Circuit breaker

4.2.6a Control panel P1

This is a power supply for the 20 L ion pump (used for the electron gun chamber evacuation).

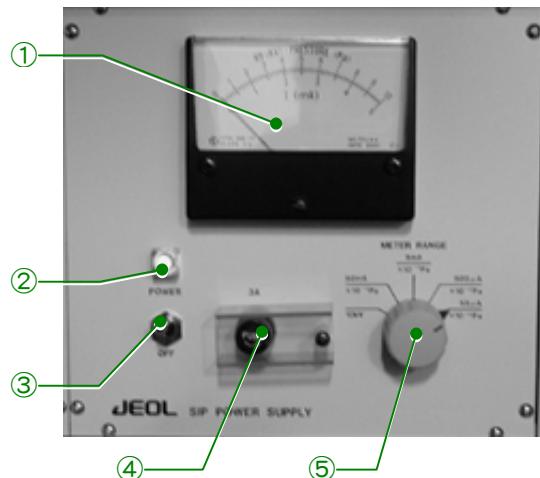


Fig. 4.9 Control panel P1, P2

- ① Meter
Displays the value selected with the METER RANGE knob (P1-⑤).
- ② POWER lamp
Indicates when lit, that the POWER switch (P1-③) is at the on position.
- ③ POWER switch
Setting this to the upper position turns on this power supply.
- ④ 3 A
This is a fuse holder for a 3 A delay fuse.
- ⑤ METER RANGE knob
Used to select the value to be displayed on the meter (P1-①).

4.2.6b Control panel P2

This is a power supply for the 60 L ion pump (used for the electron gun chamber evacuation).

- ① Meter
Displays the value selected with the METER RANGE knob (P2-⑤).
- ② POWER lamp
Indicates when lit, that the POWER switch (P2-③) is at the on position.
- ③ POWER switch
Setting this to the upper position turns on this power supply.
- ④ 3 A
This is a fuse holder for a 3 A delay fuse.
- ⑤ METER RANGE knob
Used to select the value to be displayed on the meter (P2-①).

4.2.6c Control panel P3

This is a power supply for the 150 L ion pump (an optional attachment used for the microscope column evacuation).

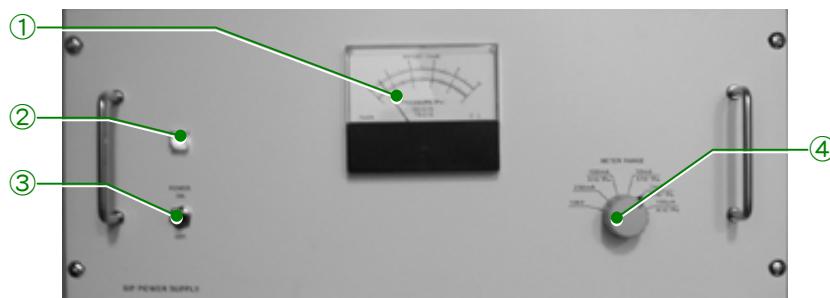


Fig. 4.10 Control panel P3

- ① Meter
Displays the value selected with the METER RANGE knob (P3-④).
- ② POWER lamp
Indicates when lit, that the POWER switch (P3-③) is at the on position.
- ③ POWER switch
Setting this to the upper position turns on this power supply.
- ④ METER RANGE knob
Used to select the value to be displayed on the meter (P3-①).

4.2.6d Control panel P4

A FILAMENT and a POWER hour meters are mounted on this panel. The FILAMENT displays the total period of time in which the filament is being heated. The POWER displays the total period if time in which the power of the instrument is being turned on.

4.2.6e Control panel P5

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

4.3 MONITOR DISPLAY

4.3.1 Page 1

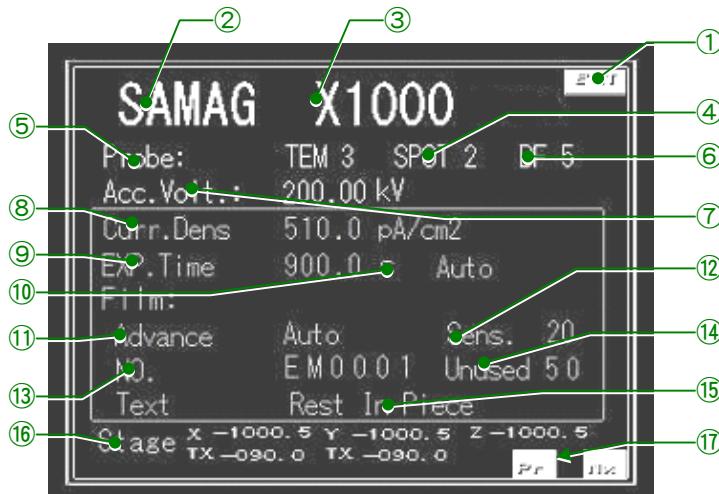


Fig. 4.11 Page 1

- ① Used to adjust the monitor brightness.
- ② Displays the image forming mode selected with the FUNCTION (R1-③).
- ③ Displays the magnification, camera length or size of the spectrum selected with the MAG/CAM L knob (R1-⑥).
- ④ Displays the illumination mode and α -selector number selected with the PROBE CONTROL (L1-③).
- ⑤ Displays the spot size value selected with the SPOT SIZE knob (L1-③).
- ⑥ Displays the memory number of the bright/dark field image.
- ⑦ Displays the accelerating voltage Value.
- ⑧ Displays the current density on the fluorescent screen.
- ⑨ Displays the exposure time. The displayed time can be varied using the PHOTO EXP TIME knob (R1-⑩) when the manual exposure mode is selected. When the automatic exposure mode is selected, the exposure time is determined automatically by means of the exposure meter.
- ⑩ Displays the exposure mode selected with the PHOTO AUTO knob (R1-⑩).
- ⑪ Displays the film dispensing mode.
- ⑫ Displays the exposure meter sensitivity. The smaller the value, the longer the exposure time
- ⑬ Displays the film code (two letters) and film number (four digits). The film number increases by one every time the photographing is performed. The film code however remains unchanged.
- ⑭ Displays the number of the unused films.
- ⑮ Displays the film text that is printed on the film.
- ⑯ Used to display the specimen position and tilt angle.
- ⑰ Pr is used to go back to the previous page and Nx is to display the next page.

4.3.2 Page 2

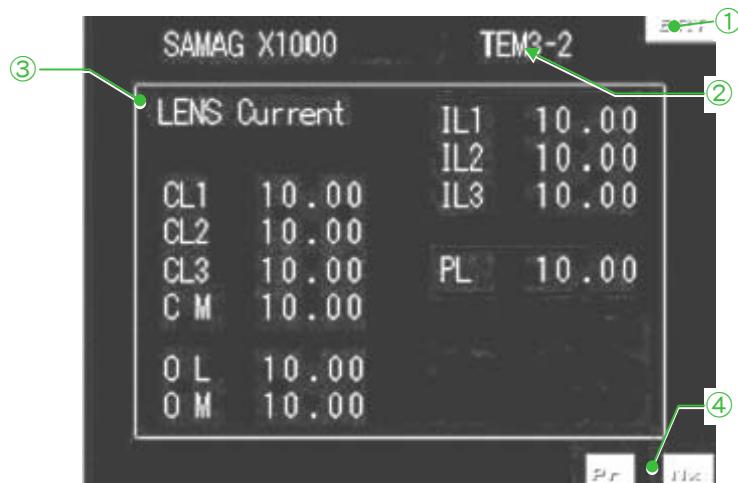


Fig. 4.12 Page 2

- ① Same as ① on Page 1.
- ② Same as ②, ③, ④, ⑤ and ⑥ on Page 1.
- ③ Displays the power values of the lenses.
- ④ Same as ⑯ on Page 1.

4.3.3 Page 3

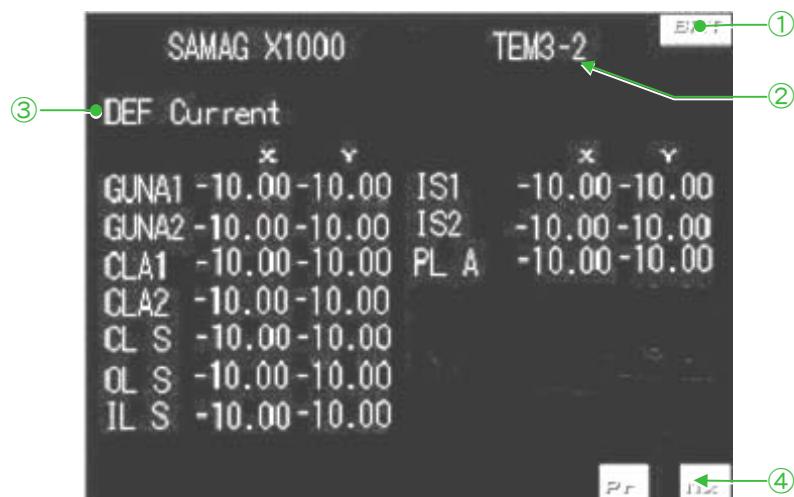


Fig. 4.13 Page 3

- ① Same as ① on Page 1.
- ② Same as ②, ③, ④ and ⑤ on Page 1.
- ③ Displays the power values of the coils.
- ④ Same as ⑯ on Page 1.

4.3.4 Page 4

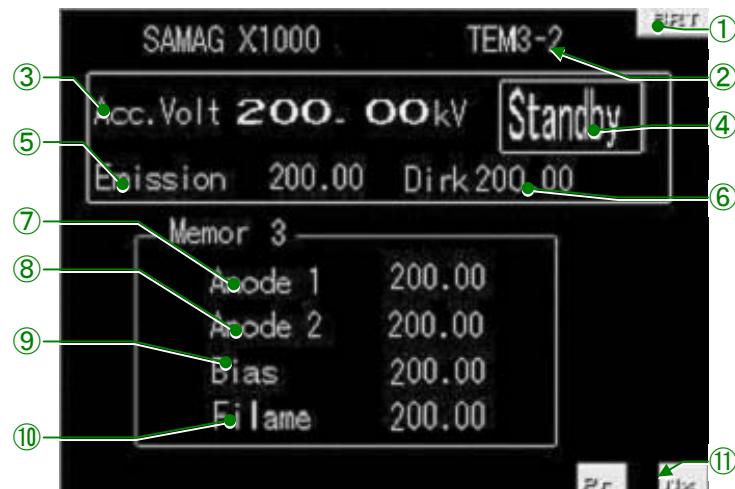


Fig. 4.14 Page 4

4.3.5 Page 5

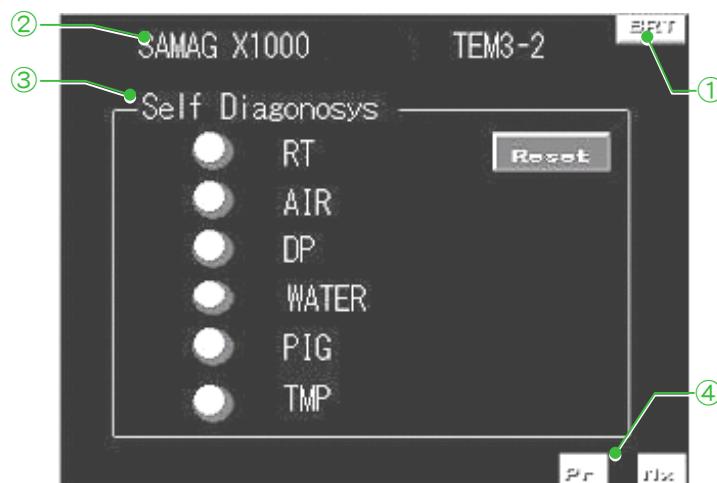


Fig. 4.15 Page 5

- ① Same as ① on Page 1.
- ② Same as ②, ③, ④ and ⑤ on Page 1.
- ③ Self Diagnosis

Displays the system abnormality.

RT: Indicates, when lit, that the pressure in the vacuum reservoir is higher than the specified value.

AIR: Indicates, when lit, that the compressed air pressure is lower than the specified value.

DP: Indicates, when lit, that the heater in the DP (oil diffusion pump) is broken.

WATER: Indicates, when lit, that the water flow late in the DP is lower than the specified value.

PIG: Indicates, when lit, that the Pirani gauge head is broken.

TMP: Indicates, that the TMP (turbo-molecular pump, optional attachment) function is abnormal.

RESET: Used to reset the warning circuit.

4.4 PC SCREENS

4.4.1 Application Start-up

4.4.1a TEM Server

Double-clicking the TEM Server icon on the PC monitor start up the TEM Server. The icon is also displayed on the task tray.



Fig. 4.16 TEM Server icon

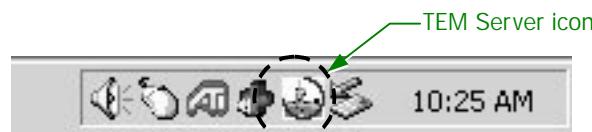


Fig. 4.17 Task tray

4.4.1b TEM Controller

Double-clicking the TEM Controller icon on the PC monitor displays the TEM Controller screen.



Fig. 4.18 TEM Controller icon

4.4.2 TEM Controller Screen

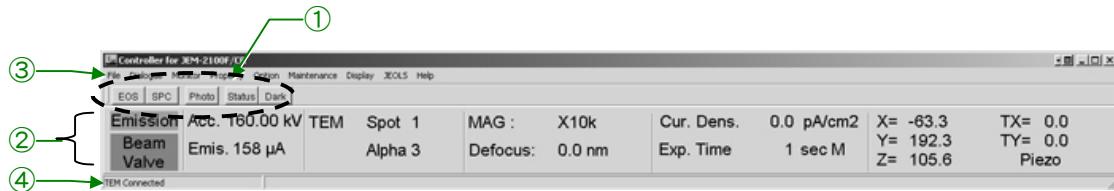


Fig. 4.19 TEM Controller Screen

① Switches

Pressing one of these switches selects a function used routinely.

☞ Sect. 4.4.3 for the detail.

② Main screen

This screen is divided in five sections.

☞ Sect. 4.4.4 for the detail.

③ Menu bar

Used to select a window and set a function.

☞ Sect. 4.4.5 for the detail.

④ Indicator

Indicates that whether the system is connected to the TEM server.

4.4.3 Switches

Used to select a function used frequently.

EOS : Opens the EOS Property screen. (☞ Sect. 4.4.6h)

SPC : Opens specimen Position screen. (☞ Sect. 4.4.6d)

Photo : Opens the Film Camera Property screen. (☞ Sect. 4.4.6e)

Status : Opens the Status Monitor screen. (☞ Sect. 4.4.6f)

Dark : Clicking this switch with the mouse darkens the monitor screen.

Clicking this switch with the mouse again restores the screen brightness.

4.4.4 Main Screen

Left main screen				Center main screen				Right main screen		
Emission Beam Valve	Acc. 160.00 kV Emis. 158 μ A	TEM	Spot 1 Alpha 3	MAG : X10k Defocus: 0.0 nm	Cur. Dens. Exp. Time	0.0 pA/cm ² 1 sec M	X= -63.3 Y= 192.3 Z= 105.6	TX= 0.0 TY= 0.0 Piezo		
TEM Connected										

Fig. 4.20 Main screen

4.4.4a Left main screen

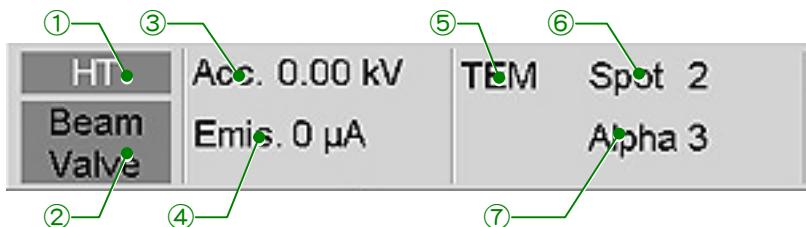


Fig. 4.21 Left main screen

- ① HT or Emission
 - HT
 - Appears when electron beam is not being generated.
 - Gray background color: Indicates that the accelerating voltage is turned off.
 - Green background color: Indicates that the accelerating voltage is being generated.
 - Emission
 - The background color is green while the electron beam is being generated.
- ② Beam Valve
 - Indicates that valve V1 can be opened.
 - Green background color: Indicates that valve V1 can be opened.
 - Gray background color: Indicates that valve V1 cannot be opened.
- ③ Acc
 - Indicates the accelerating voltage (kV).
- ④ Emis.
 - Indicates the electron beam current (μ A).
- ⑤ Observation mode
 - TEM, EDS, NBD or CBD is displayed.
- ⑥ Spot
 - Displays the spot size value (1 to 5 in the TEM mode).
- ⑦ Alpha
 - Displays the electron beam convergent angle (1 to 9).

4.4.4b Center main screen

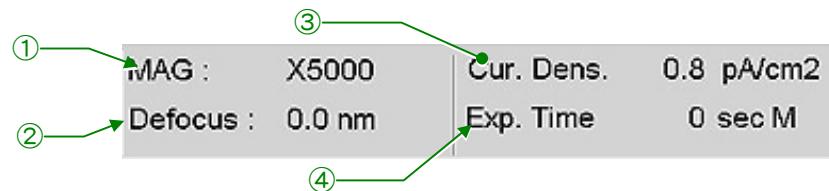


Fig. 4.22 Center main screen

- ① MAG
Shows the present magnification.
- ② Defocus
Displays the difference between the reference focus value and the present focus value in mm.
- ③ Cir. Dens.
Shows the current density on the fluorescent screen in pA/cm².
- ④ Exp. Time
Shows the exposure time and exposure mode (M or A). When the manual exposure mode is selected "M" appears at the end of this line, and the exposure time can be varied with the EXP TIME (R1-⑧) (0.1 to 900.0 and B). When the automatic exposure mode is selected, "A" appears.

4.4.4c Right main screen

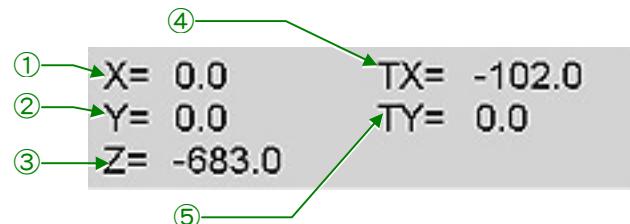


Fig. 4.23 Right main screen

- ① X
Shows the present specimen position in the X direction.
- ② Y
Shows the present specimen position in the Y direction.
- ③ Z
Shows the present specimen position in the Z direction.
- ④ TX
Shows the present specimen tilt angle in the X direction.
- ⑤ TY
Shows the present specimen position in the Y direction when a double tilt specimen holder is used.

4.4.5 Menu Bar

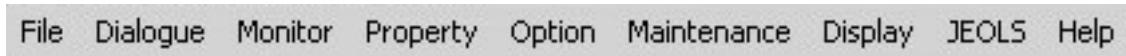


Fig. 4.24 Menu bar

4.4.5a File

- Photo history
Opens the Photo History screen (☞ Sect. 4.4.6a). The screen shows the photographing history.
- Exit
Terminates the TEM Controller.

4.4.5b Dialogue

- High Voltage Control
Opens the High Voltage Control screen (☞ Sect. 4.4.6b). This screen is used to set the high voltage condition.
- Operation
Opens the operation screen (☞ Sect. 4.4.6c). This screen is used to set the operation condition.
- Specimen position
Opens the specimen Position screen (☞ Sect. 4.4.6c). This is used to display the specimen position and to set the specimen position.
- ASID
Opens the ASID (optional attachment) screen if incorporated.
- Photo Set
Opens the Film Camera Property screen (☞ Sect. 4.4.6d). This is used to display the electron beam and film status.

4.4.5c Monitor

- Status
Opens the Status Monitor screen (☞ Sect. 4.4.6f). This is used to display the sub monitor contents and alarm status.
- Vac Status
Opens the Valve status screen (☞ Sect. 4.4.6g). This screen is used to display the evacuation system diagram.
- Dark window
Darkens the monitor.

4.4.5d Property

- EOS
Opens the EOS Property screen (☞ Sect. 4.4.6h). This screen is used to set the wobbler.
- Stage
Opens the Stage Property screen (☞ Sect. 4.4.6i). This screen is used to set the goniometer function.
- Others
Not used on this instrument.

4.4.5e Option

- MDS
Opens the MDS screen (☞ Sect. 4.4.6j). this screen is for the MDS operation.
- Free Lens Control
Opens the Free Lens Control screen (☞ Sect. 4.4.6k). This screen is used to set the lens currents individually.
- Mag Select
Opens the Mag Select screen (☞ Sect. 4.4.6l).
- Lens/Def Memory
Opens the Lens/Def Memory screen (☞ Sect. 4.4.6m).
- Imaging Filter
Used for an optional attachment.
- Holography
Used for an optional attachment.
- Inter Face for 20xxFEF enabled
This is for the external control of the instrument.

4.4.5f Maintenance

- Alignment
Opens the Alignment Panel for Maintenance screen (☞ Sect. 4.4.6k). This screen is for the microscope column alignment.
- Bake Out/ACD Heat
Opens the Bake Out/ACD Heat screen (☞ Sect. 4.4.6o). This screen is used to bake out the microscope column and anti-contamination device (ACD).
- Aperture
Opens the Aperture Adjust screen (☞ Sect. 4.4.6p). This screen is used for aperture setting.
- Stage Limit
Opens the Stage Limit screen (☞ Sect. 4.4.6q).
- Net Work
Connect: Used to connect the microscope system to the TEM Server.
Disconnect: Used to disconnect the microscope system to the TEM Server.

4.4.5g Display

- PutInOrder
This is used to arrange the displayed screen in order.
- StayOntop
Used to display the TEM Control screen at the display front.
- ShrtCut
Displays the short cut screen (☞ Sect. 4.4.3) on the monitor.

4.4.5h JEOLS

Used for the instrument maintenance carried out by the JEOL service engineer.

4.4.5i Help

- Instruction
Displays the instrument Instruction Manual.
- Version
Displays the instrument software version information.

4.4.6 Screens from the Menu Bar

This describes the display contents, function of the buttons briefly.

 Chapter 5 for the details.

4.4.6a Photo History screen

Photograph information shown on the TEM Controller screen is saved on this screen when photographing.

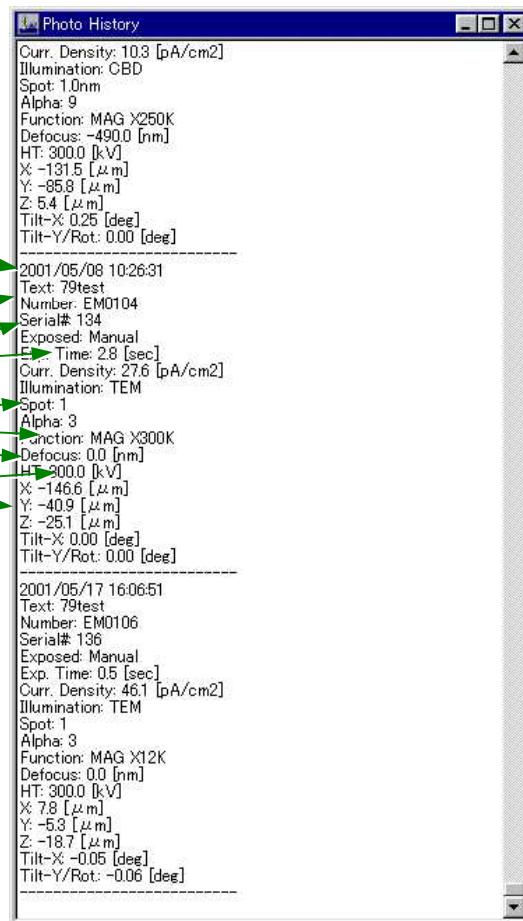


Fig. 4.25 Photo History screen

- ① Date of the photographing
- ② Film information ( Fig. 4.23)
 - Text: The text printed on the film (Photo screen ⑥)
 - Number: The film number printed on the film (Photo screen ⑤)
- ③ The total number of the photographs
- ④ Photographing condition ( Fig. 4.23)
 - Exposed: Exposure mode when photographing is performed (Photo screen ②)
 - Exp. Time: Exposure time when photographing is performed (Photo screen ④)
 - Curr. Density: The current density on the fluorescent screen when the photographing is performed (Photo screen ③)

- ⑤ Illumination condition when the photographing is performed (☞ Fig. 4.21).
Illumination: The illumination mode when the photographing is performed (Left main screen ①)
Spot: The spot size value when the photographing is performed (Left main screen ③)
Alpha: The α -value when the photographing is performed (Left main screen ④)
- ⑥ The magnification, camera length or energy dispersion when photographing (Left main screen ②)
⑦ Amount of focus change when photographing (Left main screen ⑤)
⑧ Accelerating voltage (☞ HT screen ②, Fig. 4.22)
⑨ Specimen position

4.4.6b High Voltage Control screen

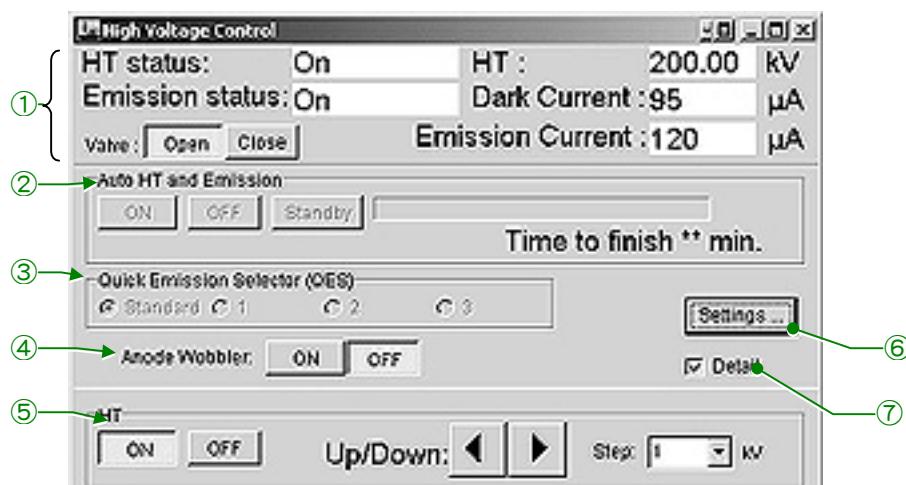


Fig. 4.26 High Voltage Control screen

- ① HT and Filament mission

HT Status: “Ready” is displayed when accelerating voltage generation is allowed and “Not Ready” is displayed when accelerating voltage generation is not allowed. “On” is displayed when an accelerating voltage is being generated.

Mission Status: “Ready” is displayed when electron beam generation is allowed and “Not Ready” is displayed when electron beam generation is not allowed. “On” is displayed when an electron beam is being generated.

HT:

The present accelerating voltage value

Dark Current:

The dark current in the high voltage circuit

Mission current:

The electron beam current

Valve buttons

Open:

Depressing this button opens valve V1. The electron beam reaches the fluorescent screen when the valve opens.

Close:

Depressing this button closes valve V1. The electron beam stops at the valve when this valve closes.

- ② Auto HT and Emission
Used for automatic high voltage generation and electron beam generation.
- ③ Quick Emission Selector (QES)
Not used in this instrument.
- ④ Auto Wobbler
Used for electron gun alignment.
- ⑤ HT
Used for accelerating voltage setting. **<** and **>** buttons vary the voltage and the amount of the voltage change per step can be set in the Step box.
- ⑥ Setting
Displays the FEG and QES Setting screen. The screen is used to set the FEG condition.
- ⑦ Detail
Giving a check mark in this box displays the maintenance items under the screen.

4.4.6c Operation screen

- Standard screen

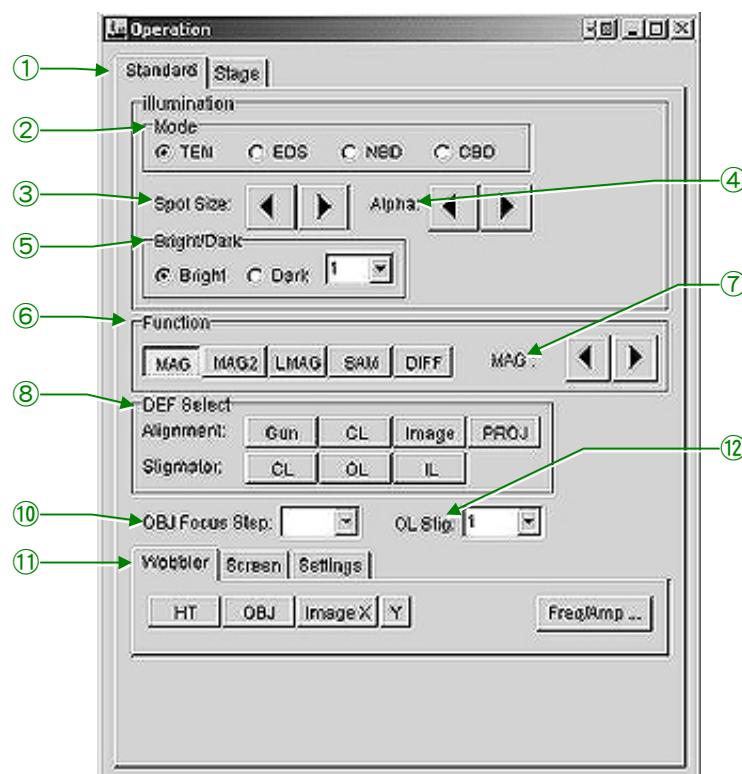


Fig. 4.27 Operation screen (standard)

- ① Standard
Displays the Standard screen.
- ② Mode
Used to select an illumination mode (TEM, EDS, NBD or CBD).
- ③ Spot Size
Varies the spot size value.

- ④ Alpha
Used to vary the electron beam convergent angle.
- ⑤ Bright/Dark
Used to select the bright field image (Bright) or dark field image (dark).
- ⑥ Function
Used to select the image forming system. The magnification, camera length or spectrum in the selected mode can be varied with the MAG/CAM L knob (R1-⑤). The magnification, camera length and spectrum designated by the MAG/CAM L knob are stored.
The stored magnification, camera length and spectrum are reproduced when the mode is changed to the original mode from another mode (this is available when a mode other than MAG2 is used).
 - MAG1: This is the conventional magnification mode.
 - MAG2: This is a specified magnification mode. The magnification in this mode is not stored.
 - LMAG: This is a low magnification mode.
 - SMAG: This is a selected area magnification mode (MAG-B-mode in this instrument).
 - DIFF: This is a selected area diffraction mode.
- ⑦ MAG
◀ AND ▶ vary the magnification.
- ⑧ DEF Select
 - Alignment
 - Gun: The Gun shift function is designated to the SHIFT knobs (L1-⑧, R1-③).
 - CL: The Beam shift function is designated to the SHIFT knobs (L1-⑧, R1-③) and Beam tilt function is designated to DEF/STIG knob (L1-⑩, R1-④).
 - Image: The image shift function is designated to the DEF/STIG knob (L1-⑩, R1-④).
 - Proj: The Projector lens alignment function is designated to the DEF/STIG knob (L1-⑩, R1-④).
 - Stigmator
 - CL: The condenser lens stigmator coil is designated to DEF/STIG knob (L1-⑩, R1-④).
 - OL: The objective lens stigmator coil is designated to DEF/STIG knob (L1-⑩, R1-④).
 - IL: The intermediate lens stigmator coil is designated to DEF/STIG knob (L1-⑩, R1-④).
- ⑨ OBJ Focus Steep
Varies the amount of the objective lens focus change.
- ⑩ OL Stig
Used to select the number of the memory in which the astigmatism correction data is to be saved or has been saved. Five memories are provided in this instrument for saving astigmatism correction data.

(11) Tabs**• Wobbler**

Used to select a wobbler.

HT: Oscillates the high voltage. This is used for voltage center adjustment.

OBJ: Oscillates the objective lens current. This is used for current center adjustment.

Image X: Activates the image wobbler. The wobbler current oscillates in the X direction when this is selected.

Image Y: Activates the image wobbler. The wobbler current oscillates in the Y direction when this is selected.

Freq/Amp: Opens the EOS Property screen (☞ Sect. 4.4.6h).

• Screen

This moves up and down the fluorescent screen.

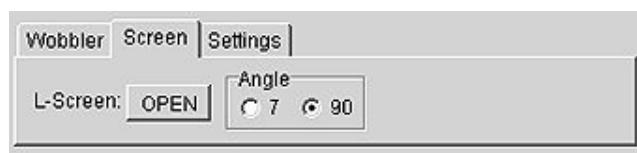


Fig. 4.28 Screen

OPEN: Moves up the screen to incline it at the angle selected in the Angle box.

Angle: Select the screen tilt angle (7° or 90°).

• Settings

Opens the Setting screen.



Fig. 4.29 Settings

OUF: OFF, 1, 2 and 3 are provided. Used to set the OUF (Optical Under Focus) value (1, 2, 3). The focus value is set to the original value when OFF is selected. The value is set to the small value when “1” is selected and to the large value when “3” is selected.

STD Focus: Changes the focus value to that is designated by the JEOL service engineer.

● Stage screen

This is used when a specimen holder is inserted in the microscope column.

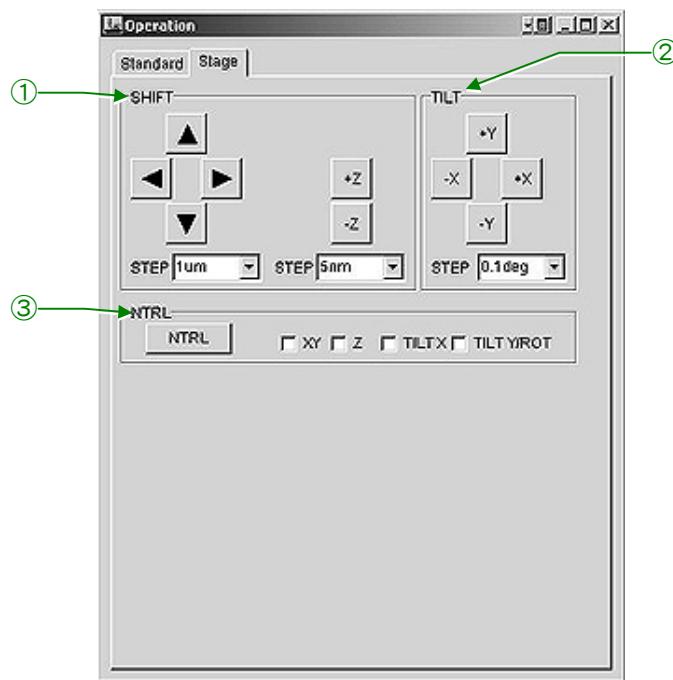


Fig. 4.30 Stage screen

① SHIFT

The ► and ◀ buttons shift the specimen in the X directions and the ▲ and ▼ buttons shift the specimen in the Y directions. The Z buttons shift the specimen in the Z direction. The amount of the specimen shift per step can be varied in the STEP boxes under the triangle buttons and the amount of the specimen tilt per step under the Z buttons.

② TILT

The X buttons tilt the specimen in the X directions and Y buttons in the Y directions. The Y tilts is impossible when a single tilt specimen holder is used. The amount of the tilt angle per step can be varied in the STEP box. The specimen can be rotated using these buttons when a specimen rotation holder is used.

③ NTRL

Used to neutralize the values in the selected box (XY, Z, TILT X and TILT Y/ROT).

4.4.6d Specimen Position screen

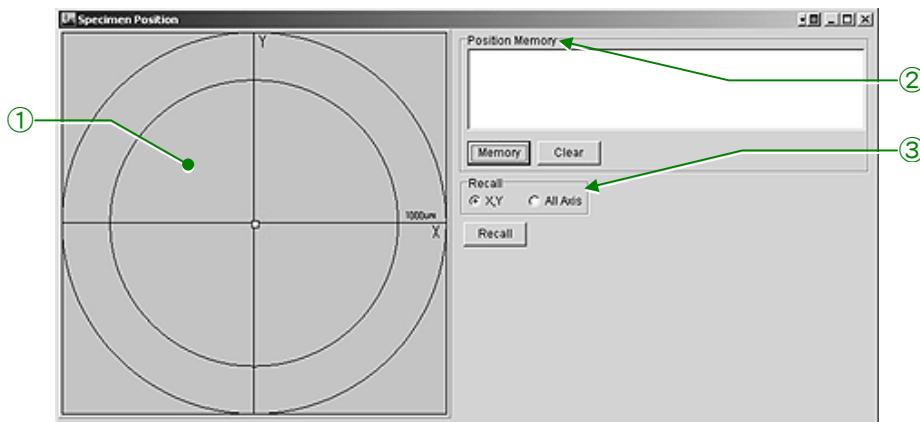


Fig. 4.31 Specimen position screen

① Coordinates

Shows the present specimen position and the positions stored in the memories.

② Position Memory

Window: Shows the specimen position when the Memory button is depressed.

Memory: Pressing this button stores the present specimen position and shows the stored position in the window and on the coordinates.

Clear: The specimen positions stored in the memory are deleted when this button is depressed.

③ Recall

XY: The specimen will move to the selected position (X and Y positions) when Recall button is depressed after giving a check mark in the XY box.

All axis: The specimen will move to the selected position (X, Y and Z positions) when Recall button is depressed after giving a check mark in this box.

4.4.6e Film Camera Property screen

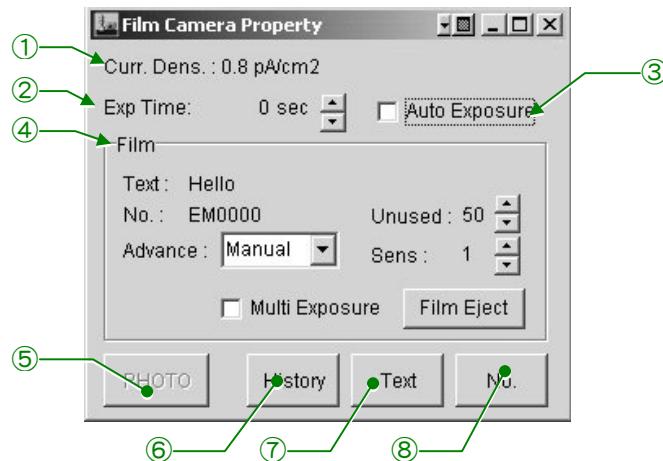


Fig. 4.32 Film Camera Property screen

- ① Curr. Dens
Shows the electron beam density (pA/cm^2) on the fluorescent screen.
- ② Exp Time
Shows the exposure time for the manual exposure mode. The exposure time can be varied using the \blacktriangle and \blacktriangledown buttons.
- ③ Auto Exposure
Giving a check mark to this box selects the automatic exposure mode.
- ④ Film
 - Text: A text recorded on the film.
 - No: A film number recorded on the film.
 - Advance: Used to select the film dispensing mode (Manual, Auto 1 or Auto 2).
 - Manual: Selects the manual exposure mode.
 - Auto 1: Selects the automatic exposure mode 1. The fresh film moves to the exposing position every time the photographing is performed.
 - Auto 2: Selects the automatic exposure mode 2. The fresh film moves to the exposing position and the next photographing is performed successively every time the photographing is performed.
 - Unused: Shows the number of the fresh films. The number can be varied using the \blacktriangle and \blacktriangledown buttons.
 - Sens: Shows the exposure meter sensitivity. The sensitivity can be changed using the \blacktriangle and \blacktriangledown buttons.
 - Multi Exposure: The double exposure mode is selected by giving a check mark to this box.
 - Film Eject: Depressing this button moves the film to the receiving magazine.
- ⑤ PHOTO
Depressing this button performs the photography in the film dispensing mode shown in the Advance box in the Film area.
- ⑥ History
- ⑦ Text
- ⑧ Nu.

- ⑥ HISTORY
Opens the Photo History screen (☞ Sect. 4.4.6a).
- ⑦ Text
Opens the screen on which the text can be written.
- ⑧ No.
Opens the screen on which the film number can be changed

4.4.6f Status Monitor screen

- Standard screen

The information shown in this screen is the same as that shown in the main screen on the TEM controller screen (☞ Sect. 4.4.4).

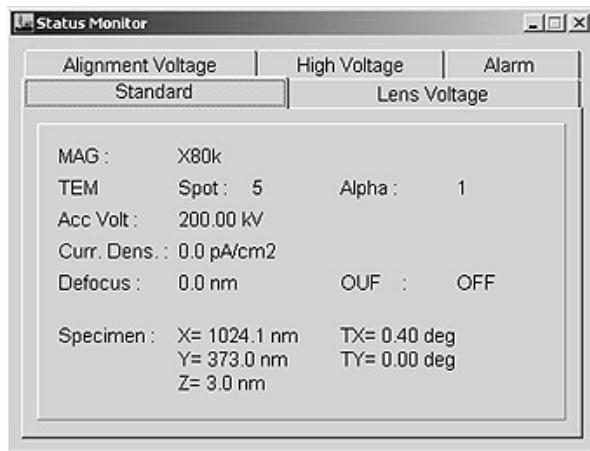


Fig. 4.33 Standard screen

- Lens Voltage screen

The data of all the lenses is shown on this screen.

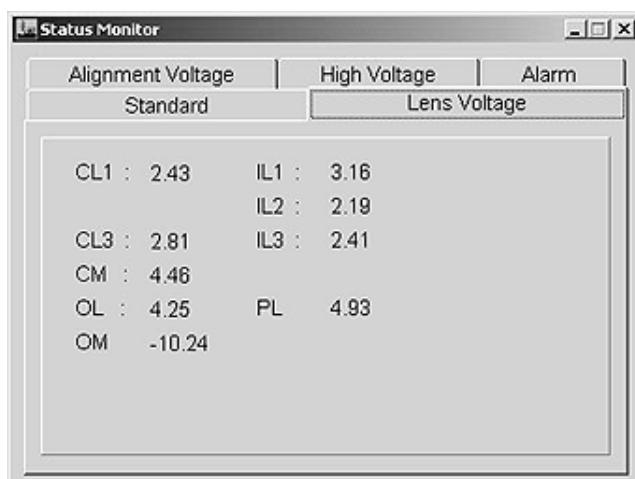


Fig. 4.34 Lens Voltage screen

● **Alignment voltage screen**

The data of all the beam deflectors is shown on this screen.

Standard		Lens Voltage	
Alignment Voltage		High Voltage	Alarm
X	Y	X	Y
Gun1 :	-1.68 -0.85	OL Stig :	0.55 -0.29
Gun2 :	-2.16 -0.84	Image 1 :	-10.24 -10.24
Spot :	-1.24 -0.82	Image 2 :	-10.24 -10.24
CL Stig :	-10.24 -10.24	IL Stig :	-0.08 -0.12
Cond 1 :	-0.40 -10.24	Proj :	-10.24 -10.24
Cond 2 :	-10.24 -0.39		

Fig. 4.35 Alignment Voltage screen

● **High Voltage screen**

This screen shows the accelerating voltage, electron beam current and anode voltage.

Depressing the FEG Control Panel opens the High Voltage Control screen (☞ Sect. 4.4.6b).

Standard		Lens Voltage	
Alignment Voltage		High Voltage	Alarm
Acc. Voltage :	200.00 kV		
Dark Current :	95.0 μA		
Emis. Current :	119.7 μA		
A1 :	2.990 kV		
A2 :	7.140 kV		
Bias :	0.303 kV		
Filament :	2.299 A		

Fig. 4.36 High Voltage screen

● Alarm screen

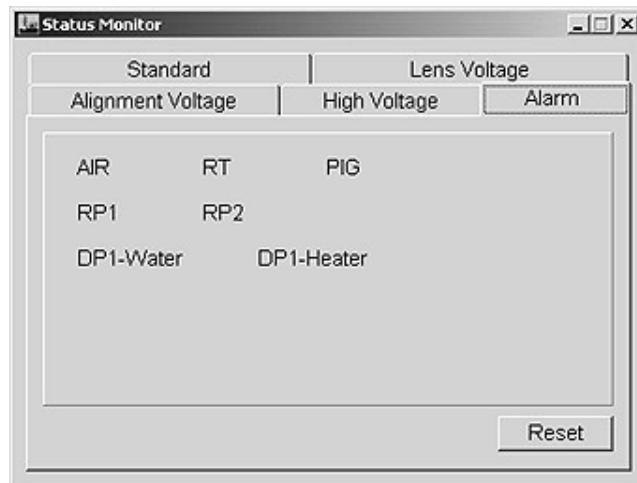


Fig. 4.37 Alarm screen

When any abnormality is detected, the background of the related item on this screen turns to red.

- | | |
|--------------|--|
| AIR: | The compressed air pressure is insufficient. |
| RT: | The pressure in the compressed air reservoir is too low. |
| PIG: | The Pirani gauge is damaged. |
| RP1: | Rotary pump 1 is not normal. |
| RP2: | Rotary pump 2 is not normal. |
| DP-1 Water: | The cooling water temperature of oil diffusion pump 1 is too high. |
| DP-2 Heater: | The heater of oil diffusion pump 1 is damaged. |

4.4.6g Valve Status screen

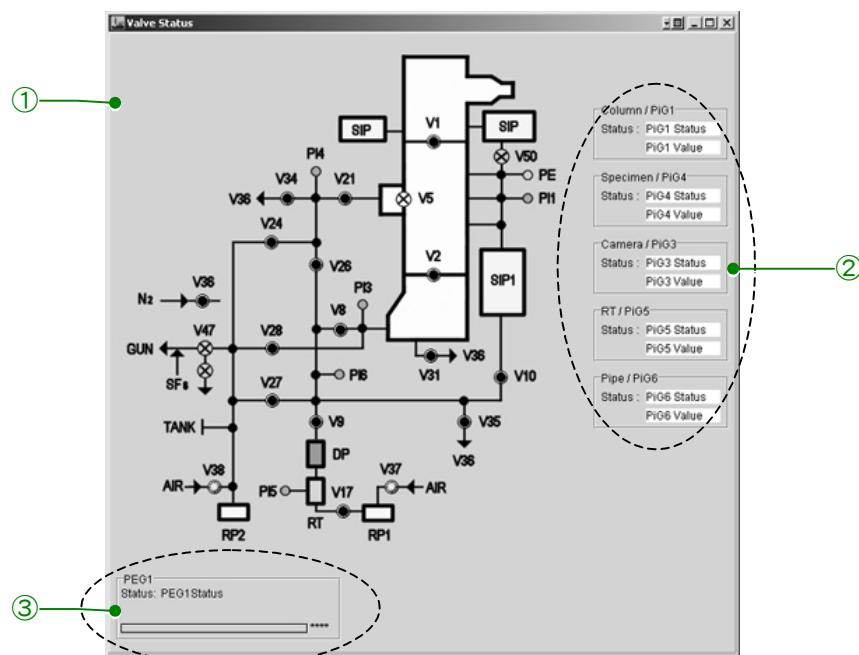


Fig. 4.38 Valve Status screen

- ① System diagram
This shows the state of the valves and Pirani gauges. The valve lamp lights up when the valve opens and the lamp goes out when the valve closes.
- ② Gauge status

Column:	The state of the microscope column vacuum and reading of the Pirani gauge 1 are shown.
Specimen:	The state of the specimen chamber vacuum and reading of the Pirani gauge 4 are shown.
Camera:	The state of the camera chamber vacuum and reading of the Pirani gauge 3 are shown.
RT:	The state of the vacuum reservoir vacuum and reading of the Pirani gauge 5 are shown.
Pipe:	The state of the evacuation pipe vacuum for the oil diffusion pump and reading of the Pirani gauge 1 are shown.
- ③ PEG 1
The state of the Penning gauge is shown. “Status” changes as shown follows.
OFF→Evac. / Low→Evac. / High→Vac. / Ready

4.4.6h EOS Property screens

- Wobbler Freq/Amp screen

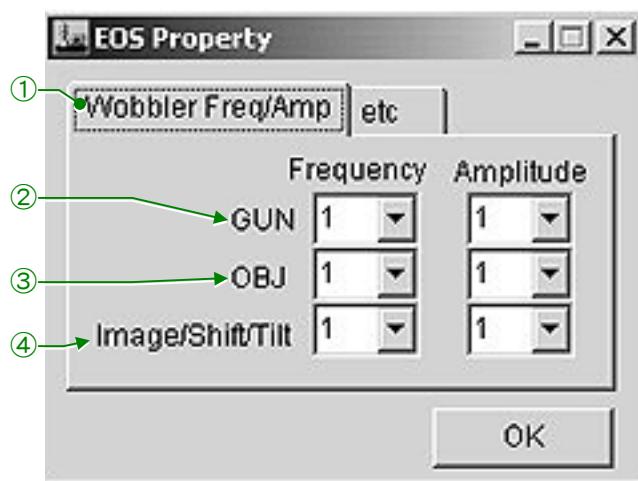
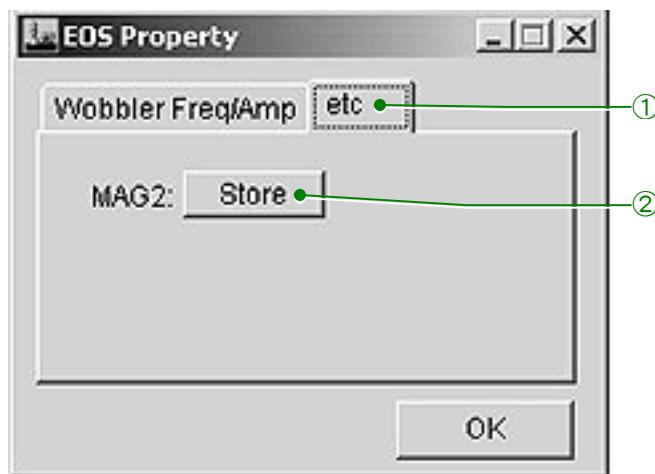


Fig. 4.39 EOS Property screen

- ① Wobbler freq/Amp
Selects the Wobbler Freq/Amp screen.
- ② GUN
Used to set the electron gun 1_{st} beam deflector wobbler. “Frequency” is used to vary the wobbler frequency and “Amplitude” is used to vary the wobbler frequency.
- ③ OBJ
Used to set the objective lens stigmator wobbler. “Frequency” is used to vary the wobbler frequency and “Amplitude” is used to vary the wobbler frequency.

④ Image/Shift/Tilt

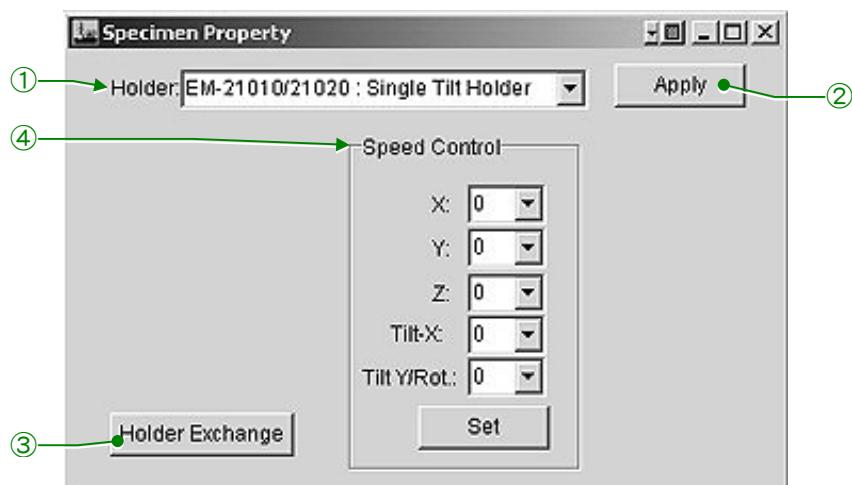
Used to set the wobbler for the image shift coil, electron beam shift coil and tilt coils. “Frequency” is used to vary the wobbler frequency and “Amplitude” is used to vary the wobbler frequency.

● Etc screen**Fig. 4.40 Etc screen****① Etc**

Opens the etc screen.

② Store

The present magnification is stored when this button is clicked after depressing the MAG 2 switch (R1-②).

4.4.6i Specimen Property screen**Fig. 4.41 Specimen Property screen**

- ① Holder
Used to select the specimen holder to be used.
- ② Apply
The system confirms the selected specimen holder when this button is clicked.
- ③ Holder Exchange
Clicking this button moves the specimen to the neutral position. This is used when removing the specimen holder from the goniometer.
- ④ Speed Control

X, Y, Z:	Vary the specimen shift speed using the triangle buttons.
Tilt X:	Varies the specimen tilt-X speed using the triangle button.
TiltY/Rot:	Varies the specimen tilt-Y speed (or rotation speed when a rotation holder is used) using the triangle button.
Set:	Sets the selected speed.

4.4.6j MDS screen

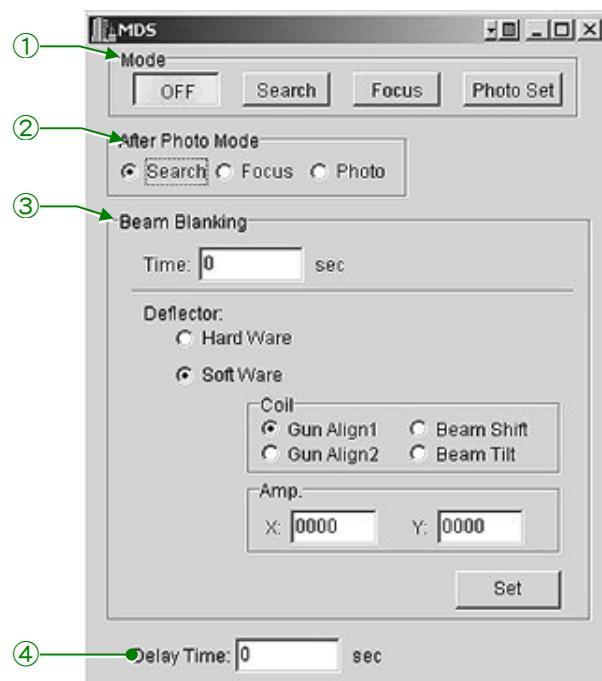


Fig. 4.42 MDS screen

- ① Mode

Off:	Selects the MDS (minimum dose system).
Search:	Selects the MDS-Search mode.
Focus:	Selects the MDS-Focus mode.
Photo Set:	Selects the MDS-Photo set mode.
- ② After Photo Mode
Used to select an MDS mode (Search, Focus or Photo) for after photographing.
- ③ Beam Blanking
This is for setting the beam blanking time.

Time:	Used to set a beam blanking time.
Deflector:	Used to select the beam blanking method.

- ④ Delay Time
Used to set the delay time.

4.4.6k Free Lens Control screen

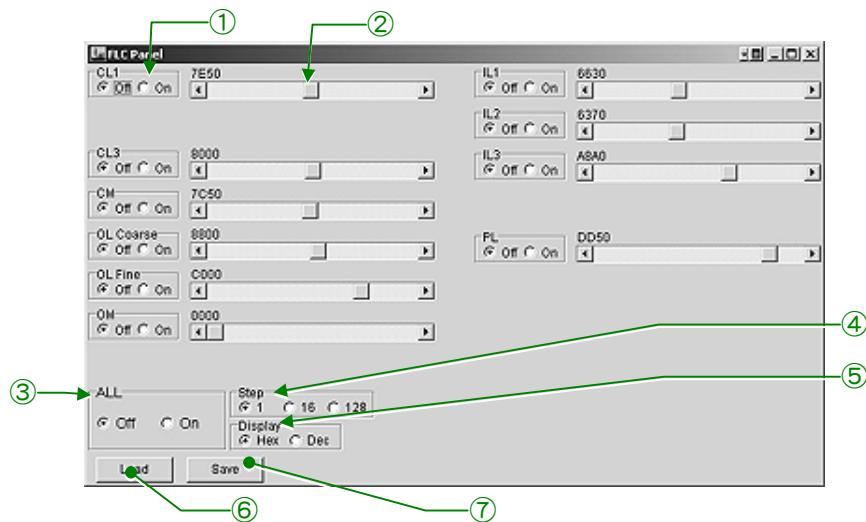


Fig. 4.43 Free Lens Control screen

- ① Off/On
Turns on and off the free lens control function of the individual lens.
- ② Sliders
Used to vary the lens current.
- ③ All
Turns on and off the free lens control function of all the lenses.
- ④ Hex-Dec
Selects hexadecimal or decimal system.
- ⑤ Load
Calls the stored lens current.
- ⑥ Save
Saves the present lens current.

4.4.6l Mag select screen

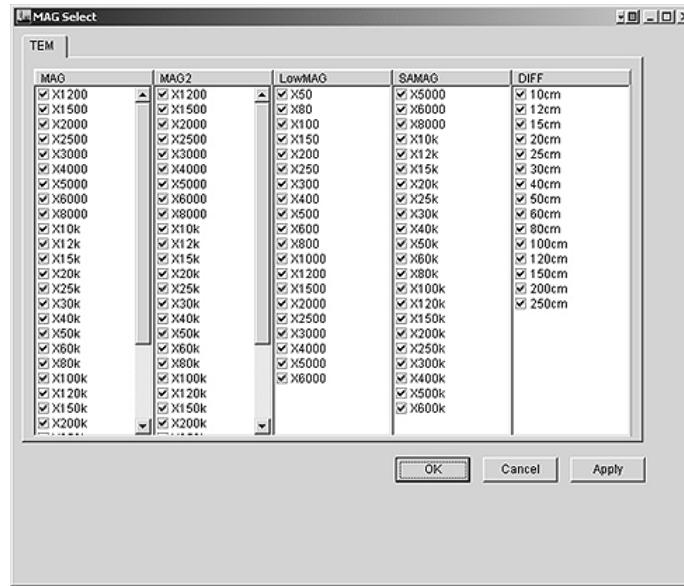


Fig. 4.44 Mag Select screen

Removing the check mark in the check boxes disables from using the corresponding magnification and camera length. All the magnifications and camera lengths having no check mark are ignored when the MAG/CAM knob is turned.

4.4.6m Lens/Def Memory screen

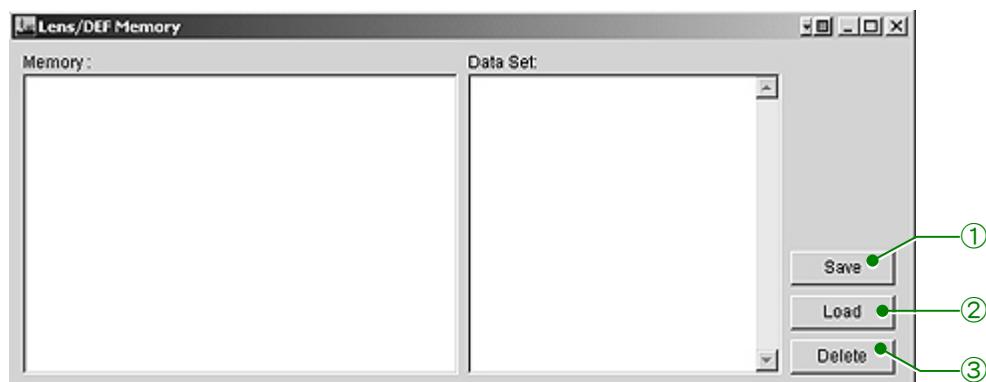


Fig. 4.45 Lens/def Memory screen

This is used to save the lens and beam deflector current data.

① Save

Depressing this button displays the lens list in the Memory box. Selecting the lens on the list saves the lens data. The saved lens name is displayed in the "Memory" box and the data of the saved lens is displayed in the "Data Set" box.

② Load

Depressing this button sets the selected lens data to the saved data.

③ Delete

Depressing this button deletes the saved lens data.

4.4.6n Alignment Panel for Maintenance screen

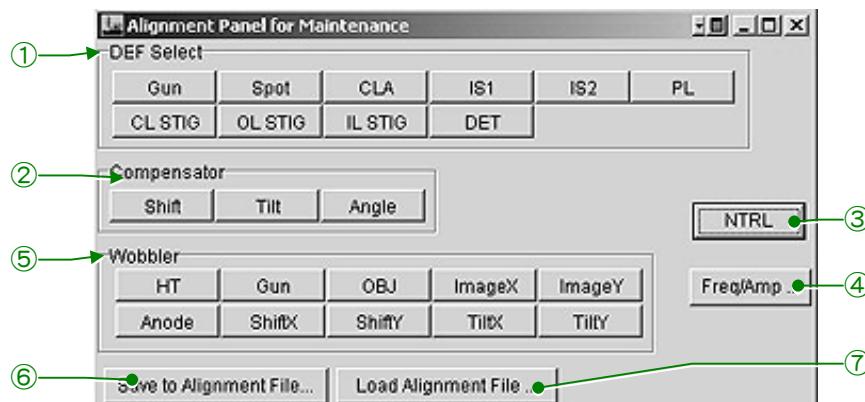


Fig. 4.46 Alignment Panel for Maintenance screen

① DEF Select

- Gun: Assigns the “Gun Shift” function to the SHIFT knobs (L1-③, R1-③) and “Gun Tilt” function to the DEF/STIG knobs (L1-⑩, R1-⑤).
- Spot: Assigns the spot alignment function to the DEF/STIG knobs (L1-⑩, R1-⑤).
- CLA: Assigns the “Beam Shift” function to the SHIFT knobs (L1-③, R1-③) and “Beam Tilt” function to the DEF/STIG knobs (L1-⑩, R1-⑤).
- IS1: Assigns the image shift 1function to the DEF/STIG knobs (L1-⑩, R1-⑤).
- IS2: Assigns the beam shift 2 function to the DEF/STIG knobs (L1-⑩, R1-⑤).
- PLA: Assigns the PL alignment function to the DEF/STIG knobs (L1-⑩, R1-⑤).
- CL STIG: Assigns the condenser lens stigmator function to the DEF/STIG knobs (L1-⑩, R1-⑤).
- OL STIG: Assigns the objective lens stigmator function to the DEF/STIG knobs (L1-⑩, R1-⑤).
- IL STIG: Assigns the intermediate lens stigmator function to the DEF/STIG knobs (L1-⑩, R1-⑤).
- DET: Used for the detector of an optional attachment.

② Compensator

- Shift: Assigns the “Shift Balance” function to the DEF/STIG knobs (L1-⑩, R1-⑤).
- Tilt: Assigns the “Tilt Balance function to the DEF/STIG knobs (L1-⑩, R1-⑤).
- Angle: Assigns the “Angle Balance” function to the DEF/STIG knobs (L1-⑩, R1-⑤).

③ NTRL

Used to set the selected “Deflector” data to the neutral values.

- ④ Freq/Amp...
Opens the EOS Property screen (☞ Sect. 4.4.6h) for setting the frequency and amplitude of the wobblers.
- ⑤ Wobbler
 - HT: Clicking this button pulsates the high voltage. Used for the voltage center adjustment.
 - Gun: Clicking this button pulsates the coil current in the electron gun 1_{st} beam deflector. Used for electron gun alignment.
 - OBJ: Clicking this button pulsates the objective lens current. Used for the current center adjustment.
 - ImageX/Y: Clicking this button pulsates the condenser lens beam deflector current. Used for the “Shift Balance” adjustment.
 - TiltX/Y: Clicking this button pulsates the condenser lens beam deflector current. Used for the “Tilt Balance” adjustment.
- ⑥ Save to Alignment File...
Saves the lens and deflector data.
- ⑦ Load Alignment File...
Read the saved lens data.

4.4.6o Bake Out/ACD screens

- ACD Heat screen

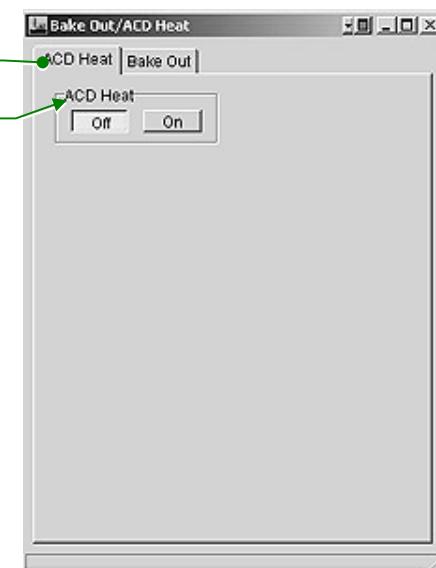


Fig. 4.47 ACD Heat screen

- ① ACD Heat tab
Opens the ACD Heat screen.
- ② ACD Heat
Turns on and off the heater in the liquid nitrogen tank for the anti-contamination device. Used for increasing the tank temperature to the room temperature.

- **Bake Out screen**

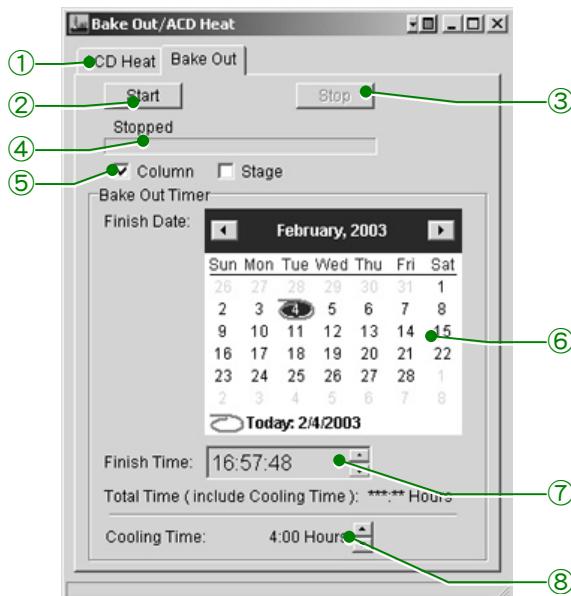


Fig. 4.48 BAKE Out screen

- ① Bake Out
Opens the Bake Out screen.
- ② Start
Starts the bake-out.
- ③ Stop
Stops the bake-out.
- ④ Bar
Shows the bake-out process.
- ⑤ Column/Stage
Used to select the microscope column or stage for bake-out.
- ⑥ Calendar
Used to check the date for the bake-out.
- ⑦ Finish Timer
Used to set the stopping time of the bake-out.
- ⑧ Cooling
Used to set the period of the cooling time.

4.4.6p Aperture screen

This is for aperture control when the motor drive aperture assembly is used.

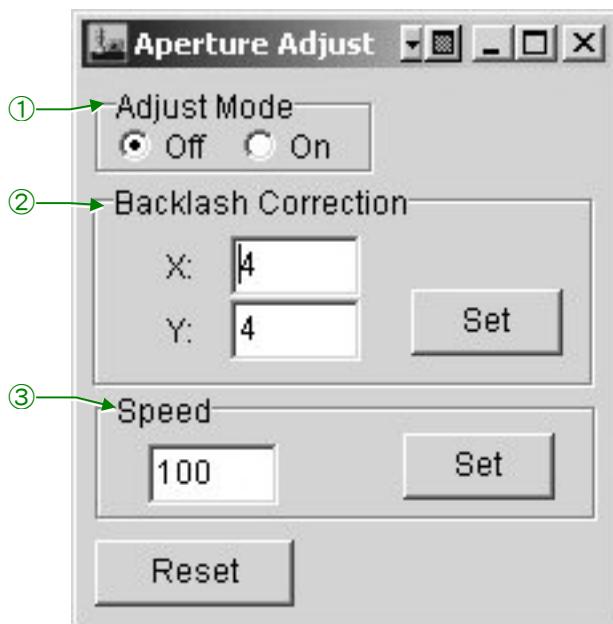


Fig. 4.49 Aperture screen

- ① Adjust Mode

Turns on and off the Adjust Mode.

- ② Backlash Correction

Sets the backlash in the X and Y directions of the aperture shift.

- ③ Speed

Sets the aperture shift speed.

4.4.6q Stage Limit screen

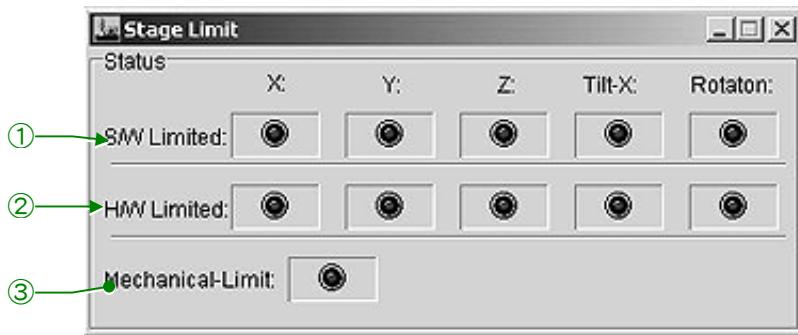


Fig. 4.50 Stage Limit screen

① S/W limited

Alarms that the specimen movement (X, Y, Z, Tilt-X and/or Rotator) reached the limit (the corresponding lamp lights up). The movement is detected using a potentiometer in this case.

② H/W limited

Alarms that the specimen movement (X, Y, Z, Tilt-X and/or Rotation) reached the limit (the corresponding lamp lights up). The movement is detected using an optical censor in this case.

③ Mechanical-Limit

Alarms that the specimen holder is grounded.

4.4.7 Emergency Screen

This screen appears when any abnormality is detected in the microscope. The item concerning the abnormality is underlined and the left side lamp lights up. This screen will disappear when the cause of the abnormality is removed. The abnormality sign left displayed unless the abnormality is removed.

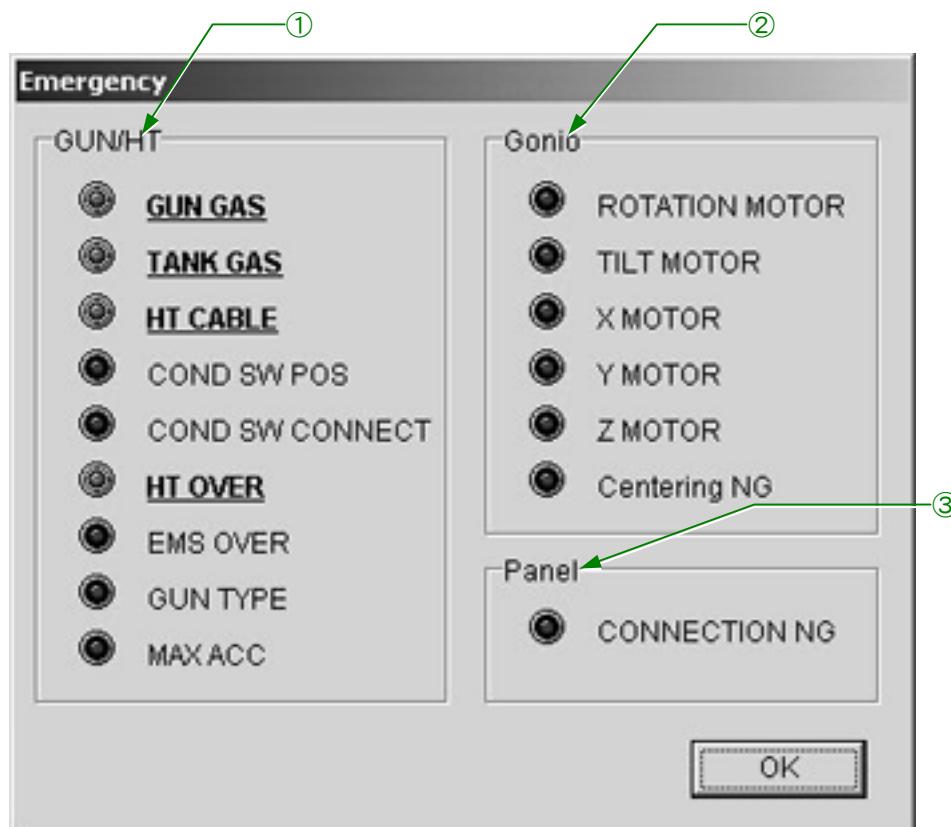


Fig. 4.51 Emergency screen

- ① GUN/HT
Items concerning the high voltage and electron beam generation
- ② Gonio
Items concerning the goniometer
- ③ Panel
This item is underlined and the red lamp lights up when the control panel cable(s) connection is (are) not normal.

5

OPERATION

5.1	EMERGENCIES	5-1
5.1.1	Power Suspension.....	5-1
5.1.2	Cooling Water Suspension.....	5-1
5.1.3	Faulty Operation.....	5-1
5.2	METHOD A	5-2
5.2.1	Startup Procedure	5-2
5.2.2	Shut Down Procedure.....	5-2
5.2.3	Film Loading	5-2
5.2.3a	Loading films into the dispensing magazine.....	5-2
5.2.3b	Inserting/removing the magazines into/ from the camera chamber	5-3
5.2.3c	Loading the Specimen Holder with a Specimen	5-5
5.2.3d	Inserting the Specimen Holder in the Microscope Column	5-6
5.2.3e	Removing the specimen holder from the goniometer	5-7
5.2.4	Electron Beam Generation	5-8
5.2.4a	Outline of beam generation.....	5-8
5.2.4b	HT conditioning	5-9
5.2.4c	Accelerating voltage generation.....	5-12
5.2.4d	Electron beam generation in the automatic mode	5-12
5.2.4e	Beam generation stopping in the automatic mode	5-13
5.2.4f	Beam generation in the automatic mode.....	5-13
5.2.4g	Beam generation stopping it manual mode	5-14
5.2.5	Aperture Insertion.....	5-15
5.2.5a	Condenser aperture.....	5-15
5.2.5b	Objective aperture	5-16
5.2.5c	Field limiting aperture.....	5-17
5.2.6	Photographing	5-17
5.2.6a	Data Printout on Micrograph.....	5-17
5.2.6b	Manual exposure	5-17
5.2.6c	Automatic exposure.....	5-19
5.2.6d	Multiple exposure.....	5-19
5.2.7	Image Observation	5-20
5.2.8	Film Processing.....	5-22

5.3	METHOD B.....	5-25
5.3.1	Conditions for High Resolution Microscopy.....	5-25
5.3.2	Illumination System Alignment.....	5-28
5.3.3	Condenser Lens Astigmatism Correction.....	5-29
5.3.4	Beam Deflector Adjustment	5-29
5.3.4a	Tilt adjustment.....	5-29
5.3.4b	Shift adjustment.....	5-30
5.3.5	Voltage/current Center Adjustment	5-30
5.3.5a	Current center adjustment.....	5-31
5.3.5b	Voltage center adjustment.....	5-31
5.3.6	Objective Lens Astigmatism Correction	5-32
5.3.6a	At Middle Magnifications	5-32
5.3.6b	At High Magnifications	5-33
5.3.7	Image Focusing.....	5-34
5.3.7a	Using Image Wobbler.....	5-34
5.3.7b	Using Fresnel Fringe.....	5-36
5.3.8	Focusing with Fine Structure	5-37
5.4	SPECIAL OBSERVATION	5-38
5.4.1	Bright Field Image.....	5-38
5.4.2	Dark Field Image	5-38
5.4.3	Low Magnification Image	5-39
5.4.3a	Low magnification image observation	5-39
5.4.3b	Current center adjustment.....	5-39
5.4.3c	Astigmatism Correction.....	5-40
5.4.4	Minimum Dose Exposure (MDS).....	5-41
5.5	ELECTRON DIFFRACTION	5-43
5.5.1	Selected Area Diffraction	5-43
5.5.2	Microbeam Electron Diffraction.....	5-44
5.5.3	High Dispersion Electron Diffraction.....	5-45
5.6	USE OF THE ANTICONTAMINATION DEVICE.....	5-47
5.6.1	Filling the Refrigerant Tank	5-47
5.6.2	Raising the Trap Temperature to Room Temperature.....	5-48
5.7	SPECIAL OPERATION	5-51
5.7.1	Alignment Data Saving.....	5-51
5.7.1a	Saving.....	5-51
5.7.1b	File Reading.....	5-51
5.7.2	Free Lens Control (FLC)	5-52
5.8	APPENDIX.....	5-53
5.8.1	Microscope Console and Column.....	5-53
5.8.2	Objective Aperture.....	5-54
5.8.2a	UHR, HR and HT configurations	5-54
5.8.2b	CR and HC configurations	5-54
5.8.3	Vacuum Pumps	5-54
5.8.3a	EM-23075 evacuation system	5-54
5.8.3b	EM-23078 evacuation system	5-54
5.8.3c	EM-23080 evacuation system	5-55
5.8.3d	EM-23085 evacuation system	5-55

This chapter describes the operation procedures up to and including image recording. Method A covers the startup, image recording, and shutdown procedure, and method B the procedure for routine observation. The symbols L1, R1 and SC appearing in parentheses after the names of panel controls designate the respective control panels.

Various objective polepieces are provided in this instrument. This chapter describes all the operation procedures in the case of using the EM-20014 (ultrahigh resolution polepiece).

EM-23078 or EM-23075 vacuum system is incorporated in this instrument. A TMP (turbo-molecular pump) is used in the EM-23078 system. An SIP (sputter ion pump) is used in the EM-23075. this chapter describes operation assuming that the EM-23075 system is used.

■ METHOD A (Sect. 5.2)

It is advisable to become familiar with method A before attempting methods B. Procedures detailed in this section are skeletonized in the section on method B.

■ METHOD B (Sect. 5.3)

This section covers the routine operation of the microscope. Practice method A (☞ Sect. 5.2) repeatedly before attempting method C. If a high resolution image is to be obtained, see also Sect. 5.4.

5.1 EMERGENCIES

The “Emergency” screen (Fig. 4.51) appears when an abnormality is detected in this instrument.

5.1.1 Power Suspension

The microscope automatically shuts down safely. When power is restored, it is necessary to manually restart the microscope (☞ Sect. 5.2.1).

5.1.2 Cooling Water Suspension

If water suspension continues for some time, the high voltage power and lens power supplies are turned off and the evacuation system goes into the protected state. When the supply of cooling water recommences, the microscope must be manually restarted (☞ Sect. 5.2.1).

5.1.3 Faulty Operation

The microscope is protected by safety devices.

5.2 METHOD A

It is advisable to become familiar with method A before attempting method B. Procedures detailed in this section are skeletonized in the section on method B.

5.2.1 Startup Procedure

1. Open the cooling water faucet.
2. Turn on the main power switch on the distribution board and open the nitrogen gas source valve.
3. Start up the microscope using the POWER switch (L2-②).
4. Start up the computer.
5. Start up the TEM server (☞ Sect. 4.6.1a).
6. Start up the TEM Controller (☞ Sect. 4.6.1b).

5.2.2 Shut Down Procedure

1. Stop the electron beam generation and turn off the high voltage.
2. Remove the specimen holder (☞ Sect. 5.4.3).
3. Remove all the aperture from the beam path (or set it to bubble).
4. Shut down the TEM Controller.
5. Shut down the TEM Server.
6. Shut down the computer.
7. Shut down the microscope using the POWER switch (L2-②).
8. Wait for 5 to 10 minutes and close the water supply and turn off the main power switch on the distribution board.
9. Close the nitrogen gas source valve.

5.2.3 Film Loading

5.2.3a Loading films into the dispensing magazine

1. Insert an unexposed film into each cassette with the emulsion side facing up under a safelight in a dark room.
 2. Remove the lid from the dispensing magazine and fully depress the bottom plate until it is clamped.
 3. Place the loaded cassettes in the dispensing magazine and replace the magazine lid. Up to 50 cassettes can be loaded in one magazine.
-  **Do not mistake the dispensing magazine for the receiving magazine.**

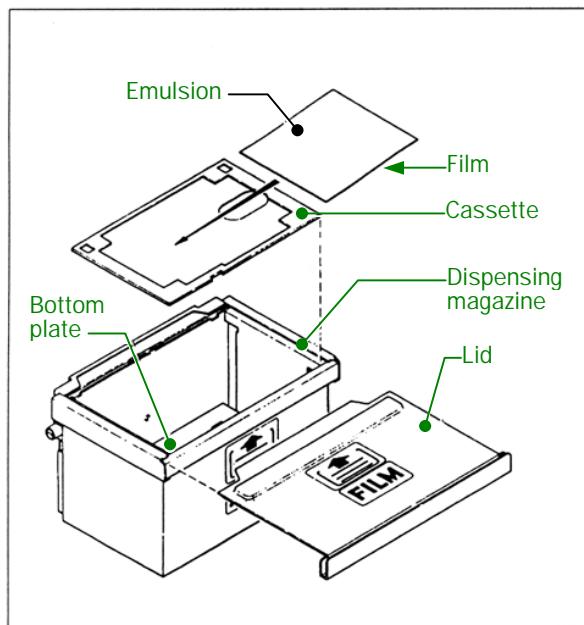


Fig. 5.1 Loading films into the dispensing magazine



Dispensing magazine



Receiving magazine

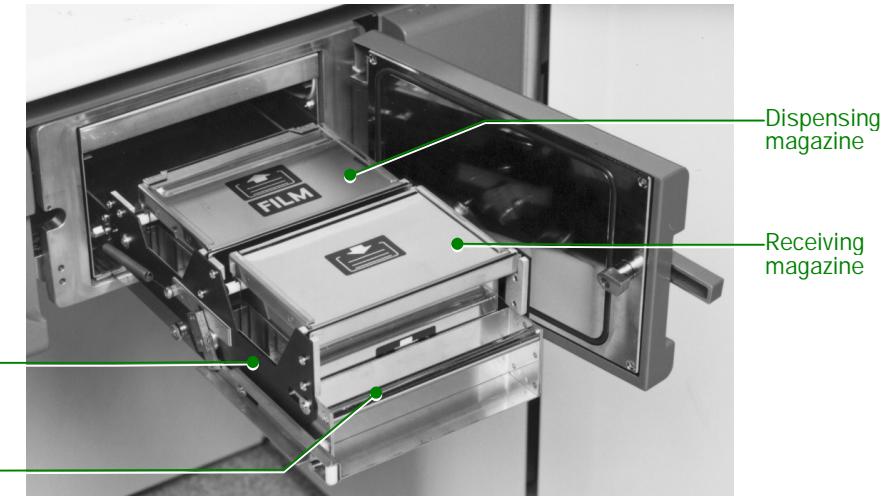
Fig. 5.2 Magazines

5.2.3b Inserting/removing the magazines into/ from the camera chamber

1. Make sure valve V1is closed.
2. Open the nitrogen gas source valve and turn the camera chamber door handle clockwise until it stops.
☞ The door will open in 5 minutes.
3. Open the camera chamber door and close the nitrogen source valve.
If the door does not open in five minutes after turning the door handle clockwise, turn the handle fully counterclockwise, then turn the handle clockwise again and wait for another five minutes. Repeat this turning and waiting until the door opens.
☞ If the gas source valve is not open and/or no nitrogen gas is stored, the camera chamber door does not open.
4. Draw out the magazine stand by pulling the handle.

⚠ CAUTION

Do not touch the camera drive mechanism in the camera chamber.

**Fig. 5.3 Magazine stand**

5. If there is an empty dispensing magazine in the magazine stand, remove it by lifting it out. Then place the dispensing magazine loaded with unexposed films squarely in the magazine stand.
 - ☞ If the magazine is not placed squarely in the magazine stand, it will be impossible to insert the magazine stand smoothly.**
 - ☞ Two dispensing magazines and two receiving magazines (☞ Fig. 5.2) are provided in order to enhance throughput. That is to say, while one dispensing magazine is being used, the other can be kept in the desiccator (optionally available) so that the loaded films are ready and demoisturized when needed. Also, as one receiving magazine is being filled during the course of photography, the second one can be kept handily, ready for the next sequence of filming.**
 - ☞ When handling the magazines, hold them so as to prevent the magazine lid from dropping out.**
6. If there is a receiving magazine loaded with exposed films in the magazine stand, remove it by lifting it out and replace it with an empty receiving magazine.
 - ☞ Never remove the lid from a loaded magazine outside a dark room.**
7. Push the magazine stand fully in.
8. Close the camera chamber door and, while holding it closed, turn the door handle counterclockwise as far as it will go.
 - ☞ Before closing the camera chamber door, check the O-ring and its contact surfaces for dust, lint, etc. A dirty O-ring may adversely affect the camera chamber vacuum.**
9. Write the number of unused films (the number of films loaded in the dispensing magazine) on the monitor (☞ Sect. 4.4.6e).

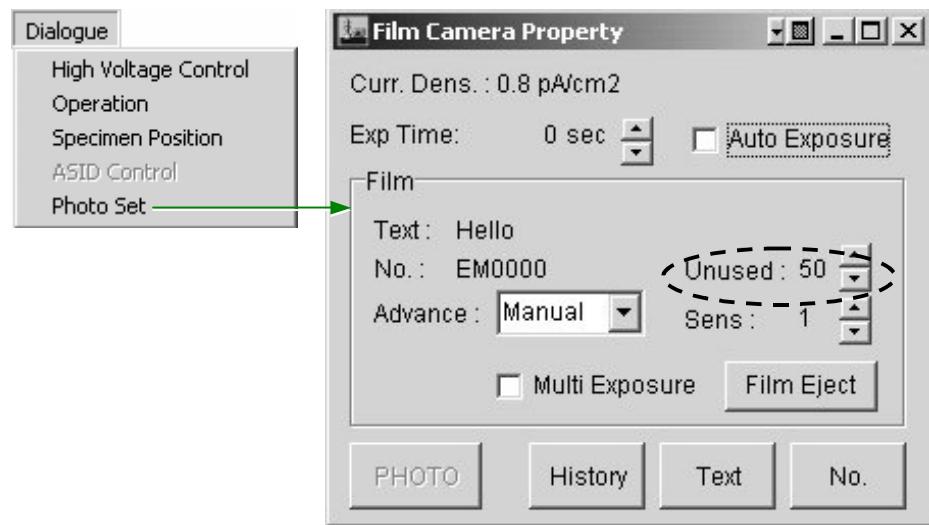


Fig. 5.4 Writing the UNUSED number

5.2.3c Loading the Specimen Holder with a Specimen

1. Insert the cartridge removing tool into the cartridge fixing nipper at the specimen holder end, open the nipper by raising the tool and remove the cartridge from the holder.
2. Loosen the specimen securing plates, rotate the specimen securing plate and remove the specimen.

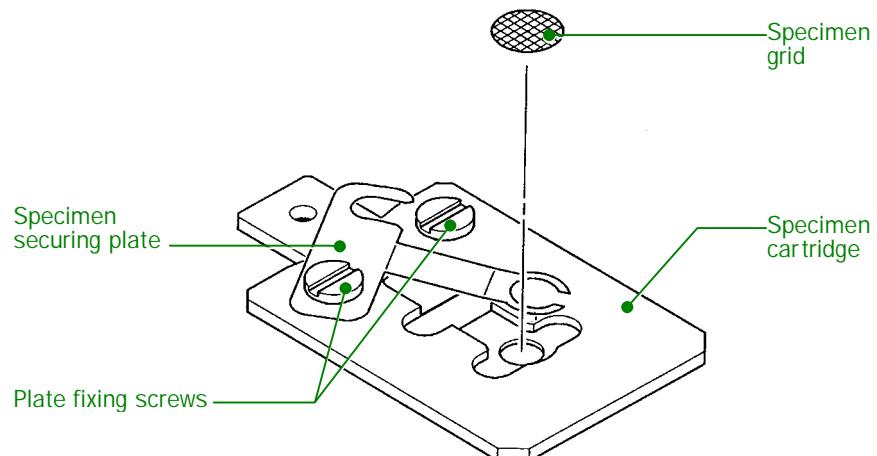


Fig. 5.5 Specimen loading

3. Place a specimen grid with the specimen facing upward in the specimen cartridge.
4. Return the specimen securing plate to the original position and secure it with the specimen securing screws.

5. Insert the cartridge removing tool into the cartridge fixing nipper at the specimen holder end, open the nipper by raising the tool and remove the cartridge from the holder.
 6. Insert the cartridge into the cartridge fixing nipper at the specimen holder end, align the guide hole on the cartridge with the guide pin on the nipper and nip the cartridge by lowering the tool.
-  **The cartridge should be firmly secured in the nipper (there should be no gap between the cartridge and nipper).**

5.2.3d Inserting the Specimen Holder in the Microscope Column

1. Turn off the BEAM VALVE switch (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 on the microscope column (or goniometer), push the holder in the goniometer until it stops and set the goniometer PUMP/AIR switch ( Fig. 4.2) to PUMP.

The yellow lamp lights up and the goniometer evacuation commences.

 **Do not turn the holder while carrying out this step.**

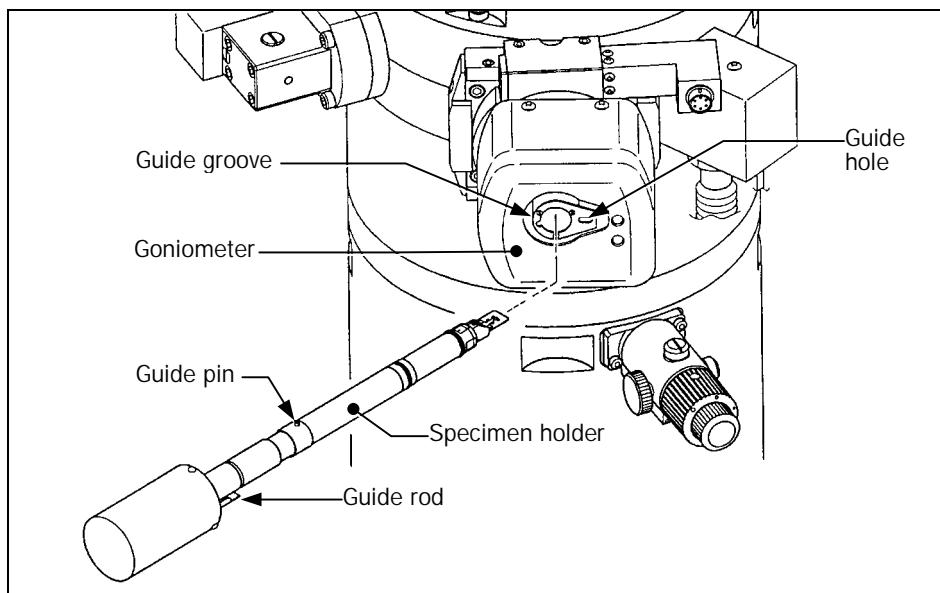


Fig. 5.6 Goniometer

4. Insert the specimen holder into the goniometer.
 - a. Turn the specimen holder clockwise after making sure that the green lamp on the goniometer is lit.
 - b. Push the holder into the goniometer as far as it will go.
 - c. Turn it fully clockwise.
 - d. Further push it in to the goniometer until it stops

The yellow lamp on the goniometer goes out.
5. Select "Property" on the "TEM Controller" main menu to open the "Specimen Property" screen.
6. Select the specimen holder name in the "Holder" box on the screen.

7. Click "Apply" on the screen.

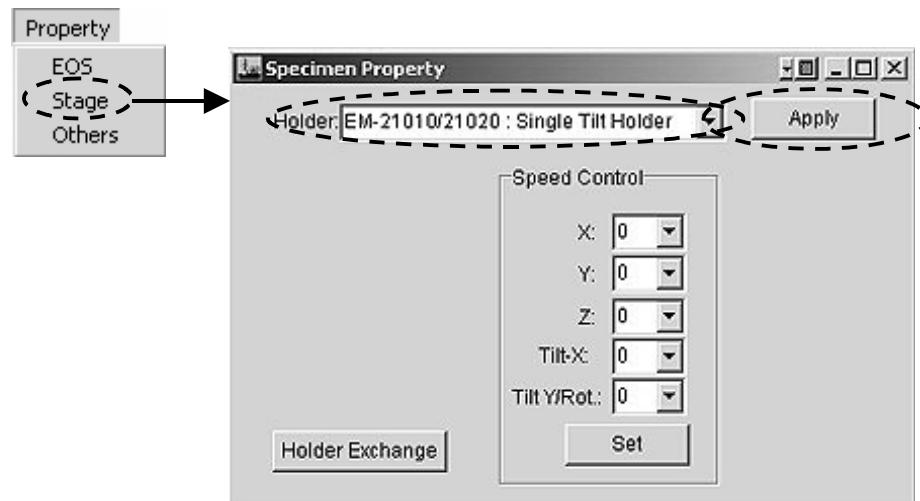


Fig. 5.7 Specimen Property screen

⚠ CAUTION

- Be careful not to pinch your fingers between the specimen holder and goniometer.
- Always hold the specimen holder while the holder is being inserted into the goniometer. If you do not do so, the specimen holder may hit the goniometer causing damage to the goniometer due to the force of vacuum.

5.2.3e Removing the specimen holder from the goniometer

1. Turn off BEAM VALVE (L1-①).
 2. Select "Property" on the "TEM Controller" main menu to open the "Specimen Property" screen.
 3. Click "Holder Exchange" on the screen.
- When a double-tilt specimen holder is used, "Holder Exchange" should be clicked again.

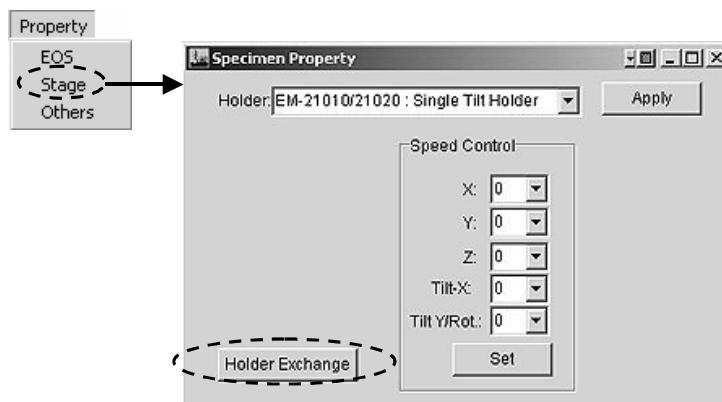


Fig. 5.8 "Holder Exchange" selection

4. Open the nitrogen gas source valve.
5. Remove the holder from the goniometer.
 - a. Pull the specimen holder until it stops.
 - b. Turn it fully counterclockwise.
 - c. Pull it until it stops
 - d. Turn it fully counterclockwise.
 - e. Set the PUMP/AIR switch on the goniometer and wait 30 seconds.
 - f. Remove the holder from the goniometer.

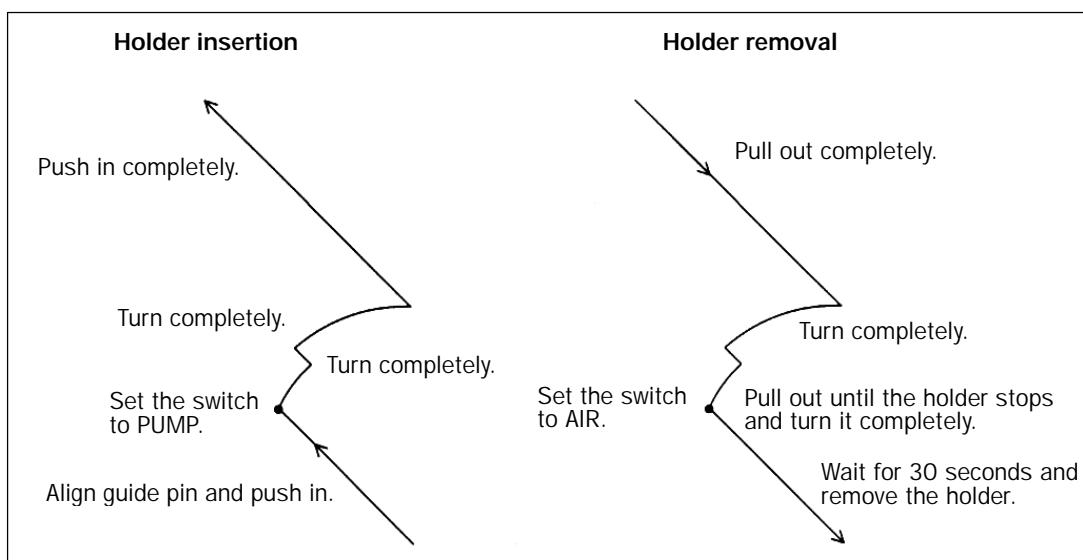


Fig. 5.9 Specimen holder handling

5.2.4 Electron Beam Generation

The “High Voltage Control” screen is used to generate electron beam generation. The generation condition in the automatic mode can be changed on the screen. The new condition is saved and used when generating an electron beam next time.

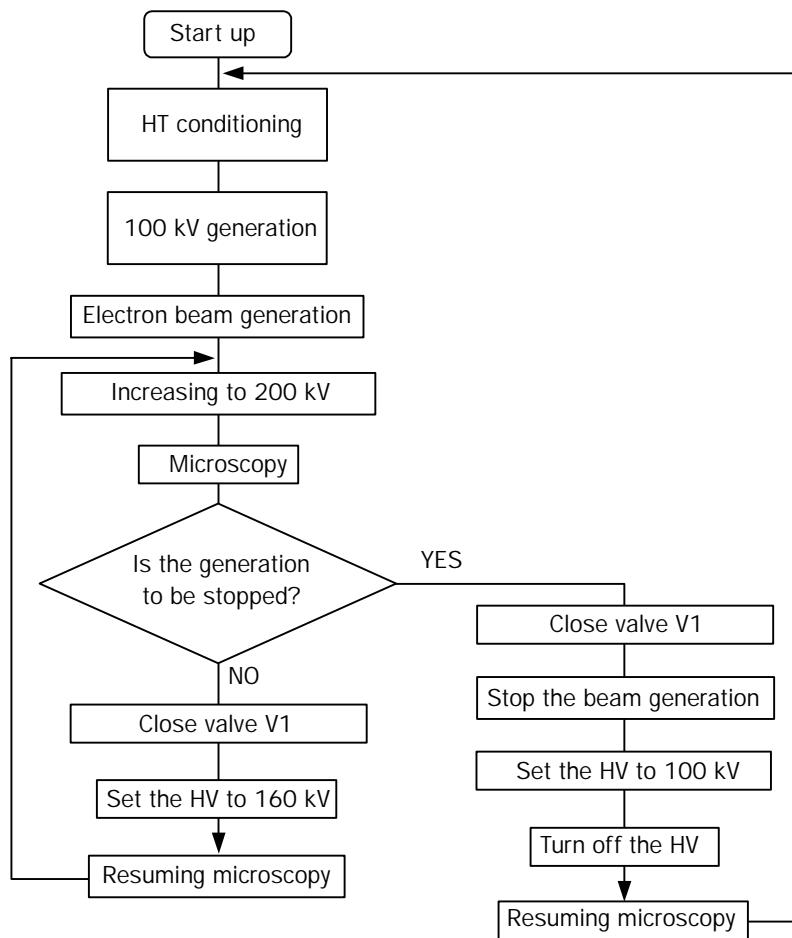
The following items should be kept in mind while the electron beam is being generated. The electron gun filament may be damaged if these items are ignored.

- The isolation valve (V1) should be closed before carrying out specimen holder insertion/removal.
- The valve (V1) should be closed after shutting down the instrument.
- The accelerating voltage should not be turned off.
- The conditioning knob should not be moved.

5.2.4a Outline of beam generation

The following is a flowchart of the routine operation assuming that the instrument is used at 200 kV. The HT conditioning is required before generating an electron beam. The period of the time required for generating/stopping the beam is as follows:

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



5.2.4b HT conditioning

The HT conditioning is required before generating a high voltage.

1. Display the "High Voltage Control" screen and give a check mark to "Detail".
☞ A complete "High Voltage Control" screen appears.
2. Set the "HT status" to "Ready" on the "High Voltage Control" screen (☞ Sect. 4.4.6b) after setting "HT" to OFF.
3. Ready a stable and solid step, mount on the step and set the conditioning knob (☞ Figs. 4.6 and 5.10) to COND.
☞ The "Cond Knob position" on the screen shows COND.
 - a. Turn the knob fully clockwise.
 - b. Push it toward the gun chamber until it stops.
 - c. Turn it fully counterclockwise.
 - d. Pull it until it stops.
 - e. Turn it fully clockwise.
4. Set the accelerating voltage to 100 kV with the UP/DOWN on the High Voltage Control screen)
5. Press the Manual conditioning-ON.
☞ The accelerating voltage now increases to 120 kV the HT value on the "High Voltage control" screen and "TEM Controller" screens leaves unchanged.

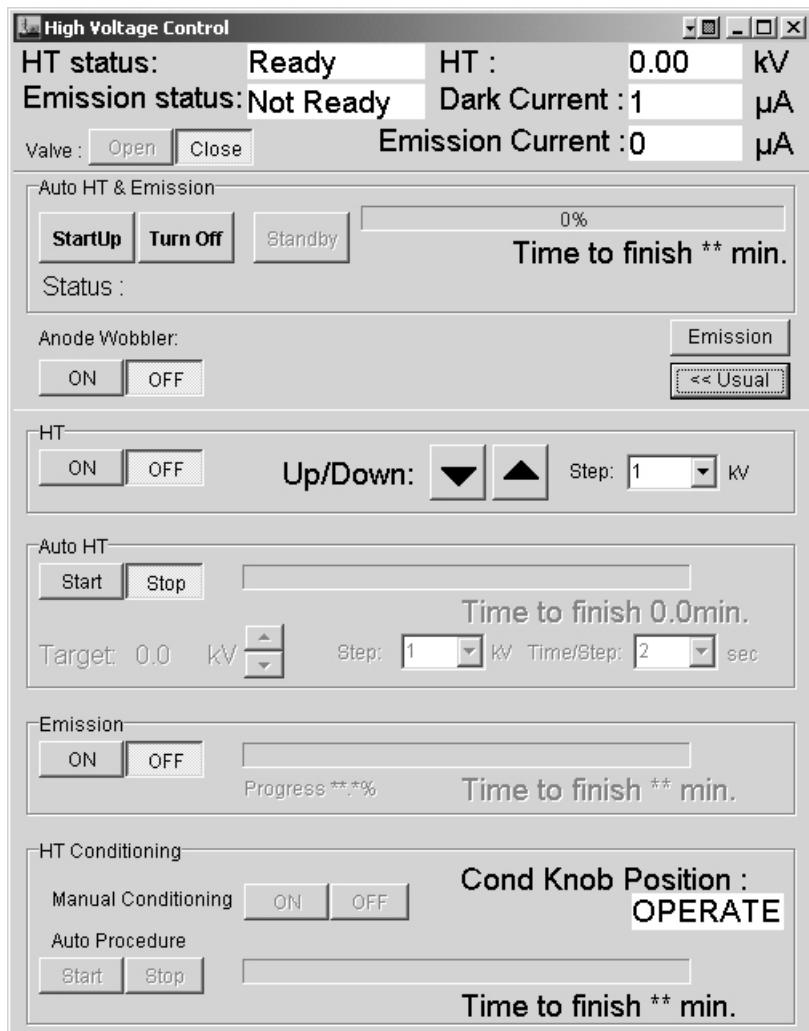


Fig. 5.10 High Voltage Control screen

6. Increase the voltage to 200 kV as follows.
 - a. Increase the voltage to 140 kV at the speed of 1 kV per minute.
 - b. Increase the voltage to 180 kV at the speed of 1 kV per 15 minutes.
 - c. Leave it for 10 minutes.
 - d. Increase the voltage to 200 kV at the speed of 1 kV per 30 seconds.
 - e. Leave it for 15 minutes.
7. Press Manual Conditioning-OFF on the High Voltage screen.
The HT conditioning is now complete. The voltage applied is now the same as that shown on the screen.
8. Decrease the voltage value shown on the screen to 100 kV using UP/DOWN triangles on the screen.
9. Depress the HT-OFF button on the screen.
10. Set the conditioning knob to OPERAT after making sure that the HT value on the screen is 0.00.
The "Cond Knob Position" shows now OPERATE.

Accelerating voltage

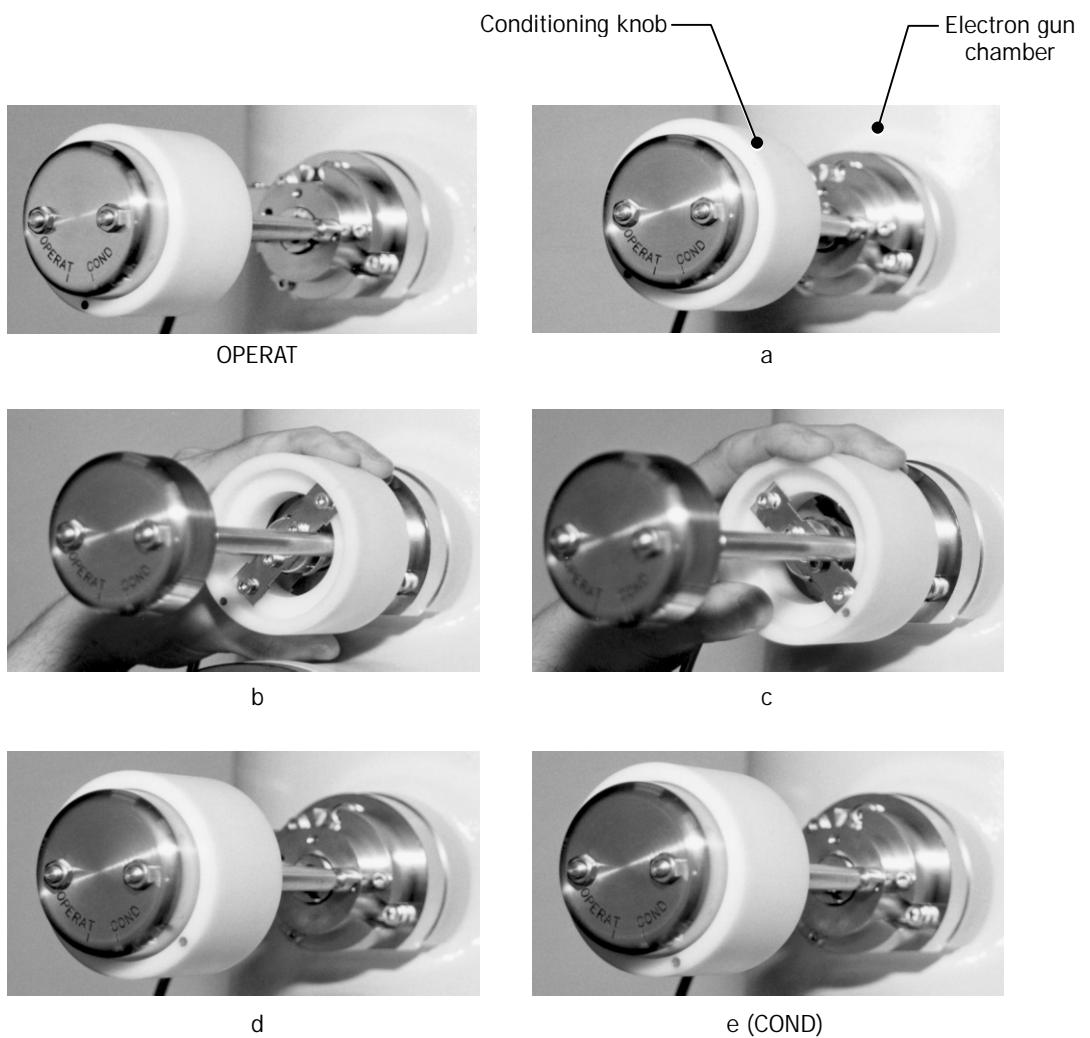
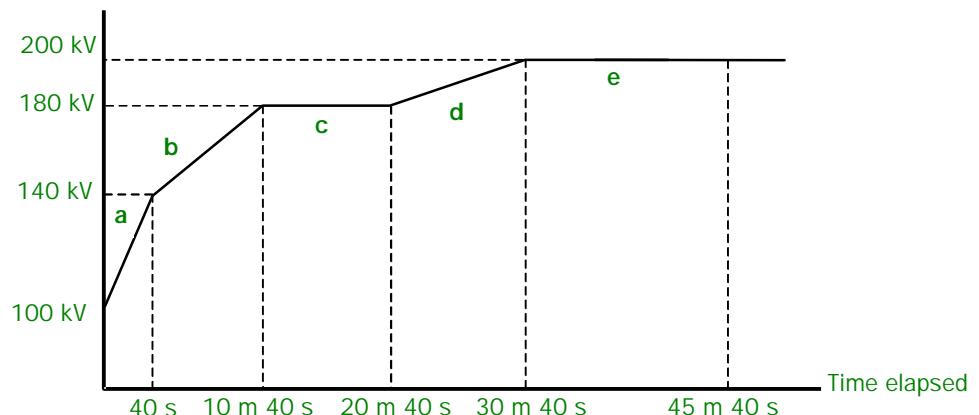


Fig. 5.11 Conditioning knob setting

5.2.4c Accelerating voltage generation

1. Confirm every three months that the reading of the pressure meter for the HT tank is 1.0 or more. If less, replenish the tank with gas (☞ the maintenance manual).
2. Confirm that the column pressure is lower than 4×10^{-5} Pa (displayed on the 150 L ion pump power supply).
3. Make sure that the dispensing and receiving magazines are in the camera chamber, and the specimen holder is in the goniometer.

☞ When the specimen holder is not in the goniometer, electron gun chamber isolation valve (V1) can not be opened.
4. Make sure that the "Cond Knob Position" is "OPERATE"
5. Make sure that "HT status" on the screen is "Ready".
6. Set the HT value to 100 kV using the UP/DOWN triangles on the screen.
7. Depress the HT-ON button on the screen.

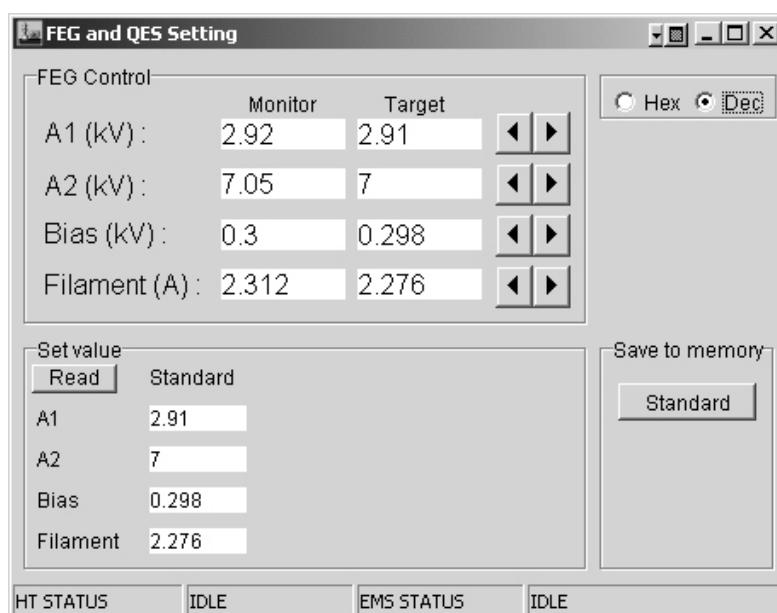
5.2.4d Electron beam generation in the automatic mode

The "High Voltage Control screen is used for the automatic mode.

1. Make sure that an accelerating voltage of 100 kV is being generated (The HT value on the screen is 100 kV).
2. Make sure that the "Emission Status" on the screen is "Ready".
3. Set "Auto HT and Emission" to ON.

☞ Electron beam is generated automatically. The generation completes in 60 minutes or 90 minutes.
4. Make sure that the "Emission Current" on the screen is the specified value or less.

☞ If the "Emission Current" is not the specified value, open the FEG and QES setting screen and consult the JEOL service center.



5.2.4e Beam generation stopping in the automatic mode

1. Open the "High Voltage Control" screen.
2. Set "Emission" on the screen to OFF.
3. Set Auto HT-step to 1 kV on the screen.
4. Set HT value to 100 kV with "Up/Down" on the screen.
5. Depress HT-OFF on the screen.

5.2.4f Beam generation in the automatic mode.

Electron beam generation in the manual mode will be impossible while the automatic beam generation and/or stopping are/is performed. Beam generation in the manual mode will be possible if the beam is stopped manually and the special mode for maintenance is used. This operation should be performed under the directions from a JEOL service office.

1. Make sure the followings.
 - An accelerating voltage of 100 kV is being generated.
 - "Emission Currents..." on the screen is "Ready".
 - "Cond Knob Position" on the screen is OPERATE.
2. Depress "Emission Current" on the screen.
☞ "Emission Currents" is switched to ON and commences flickering.
3. Set the emitter temperature to 1800 K as follows.
 - a. Set the value on "Monitor" of "Filament..." to 1.0 A using the triangles.
☞ The value of "Target" changes with the triangle buttons. The value on the "Monitor" increases toward the "Target" value.
 - b. Use the triangle buttons to set "Monitor of "Filament..." so that the "Monitor" value increases 0.1 A per one minute, increase the value to the specified value (given when the instrument is installed), and leave it until for 20 minutes.

A current of about 10 μ A should now be generated when no bias is applied.
☞ The emitter will be damaged if the emitter temperature exceeds 1800 K. The emitter may also be damaged if the emitter is left for over 2 hours without beam generation.
4. Use the triangle buttons to set the value on "Monitor" of "Bias..." to the specified value.
5. Use the triangle buttons to set the value on "Monitor" of "A2..." to the specified value. Use the triangle buttons of the to set the value on "Monitor" of "A2..." to the specified value.
6. Set the 1_{st} anode voltage A1 as follows.
 - a. Use the triangle buttons of "Monitor" to set the value on "Emission Currents..." to 1.0 and leave it for 5 minute.
 - b. Use the triangle buttons of "Monitor" to set the value on "Emission Currents..." to 5.0 and leave it for 5 minute.
 - c. Use the triangle buttons of "Monitor" to set the value on "Emission Currents..." to 10.0 and leave it for 5 minute.
 - d. Increase the "Emission Currents" value to the specified value in the same way at intervals of 5 minutes.

7. Make sure that the filament current is the specified value (the same value as that corresponds to the 1800K of the filament temperature).

If not, carry out Step 3 above to obtain the specified value.

The present data is stored in the memory by setting all the “Save to memory” buttons.

The present data is stored in the memory by pressing the “Standard” button.

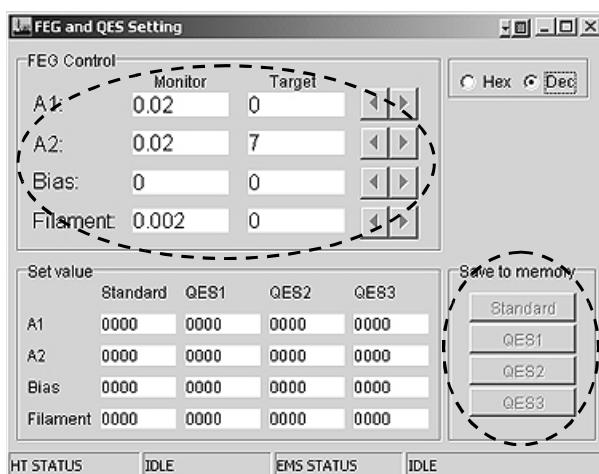


Fig. 5.12 Emitter temperature setting

5.2.4g Beam generation stopping it manual mode

This operation should be performed under the directions from a JEOL service office.

1. Close isolation valve V1.
2. Minimize the value on the “Monitor” of “A1...” using the triangle buttons.
☒ The 1_{st} anode voltage is set to 0.
3. Minimize the value on the “Monitor” of “A2...” using the triangle buttons.
☒ The 2_{nd} anode voltage is set to 0.
4. Minimize the value on the “Monitor” of “Bias...” using the triangle buttons.
☒ The bias voltage is set to 0.
5. Minimize the value on the “Monitor” of “Filament...” using the triangle buttons.
☒ The filament current is set to 0.
6. Set the “Emission” on the “High Voltage Control” screen to OFF.
7. Set the “Step” value on the screen to 1 kV.
8. Set the value to 100 kV using the UP/DOWN buttons on the screen.

5.2.5 Aperture Insertion

5.2.5a Condenser aperture

This aperture restricts the illumination area on the specimen and illumination angle. The larger the aperture size, the larger the illumination angle. The image brightness becomes brighter when a bigger aperture is used.

1. Obtain the MAG mode.
2. Converge the electron beam as much as possible with the BRIGHTNESS knob (L1-⑨).
3. Center the beam with the SHIFT knobs (L1-⑧, R1-③).
4. Select the largest aperture.
☞ Manipulate knob 2 and 3 to find the aperture on the fluorescent screen if aperture does not appear on the screen.
5. Select the aperture size to be used with knob 1.

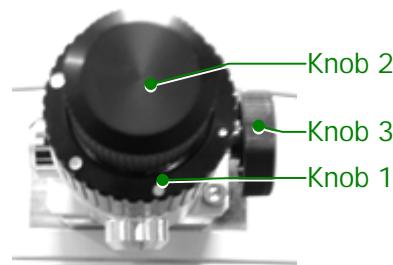
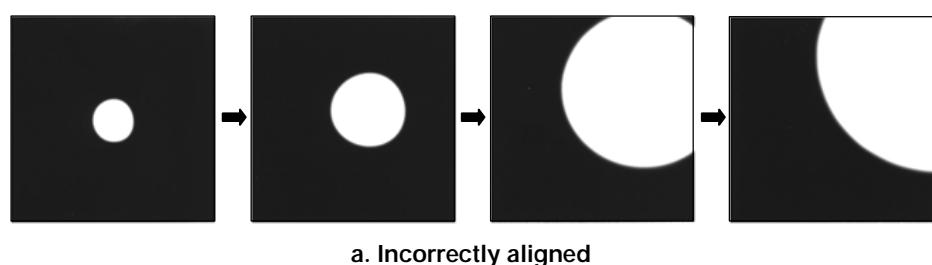
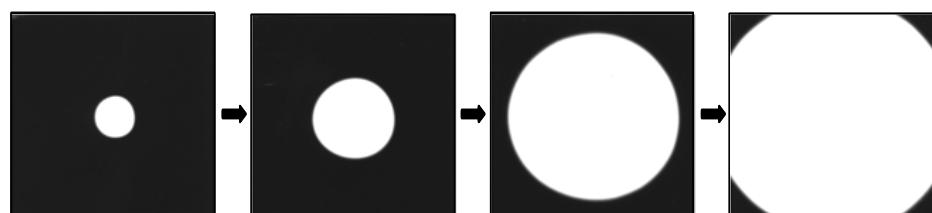


Fig. 5.13 Aperture knobs

6. Adjust the aperture position using the aperture shift knobs so that the electron beam converges and diverges concentrically when the BRIGHTNESS knob (L1-⑨) is turned slowly clockwise and counterclockwise.



a. Incorrectly aligned



b. Correctly aligned

Fig. 5.14 Aperture adjustment

5.2.5b Objective aperture

1. Insert a specimen into the beam path (refer a specimen holder's Instruction manual) and, depress the SA DIFF switch (R1-②).
2. Converge the electron beam with the BRIGHTNESS knob (L1-⑥) and keep the electron beam converged.
3. Obtain a caustic spot (zero magnification spot) with the DIFF FOCUS knob (R1-⑥) as shown below. If the caustic spot is off the screen center, turn on the PLA switch (L1-⑤) and center the spot with the DEF/STIG knobs (L1-⑩, R1-④). Turn off the PLA switch after centering.

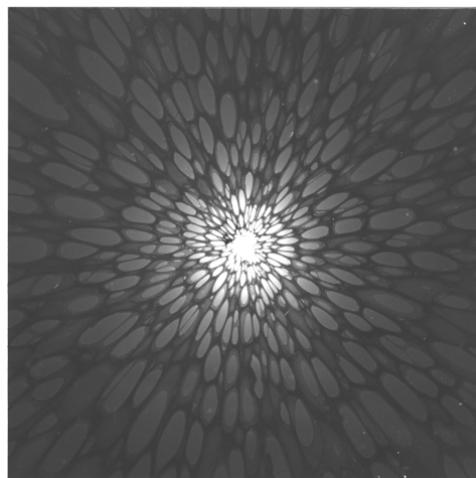
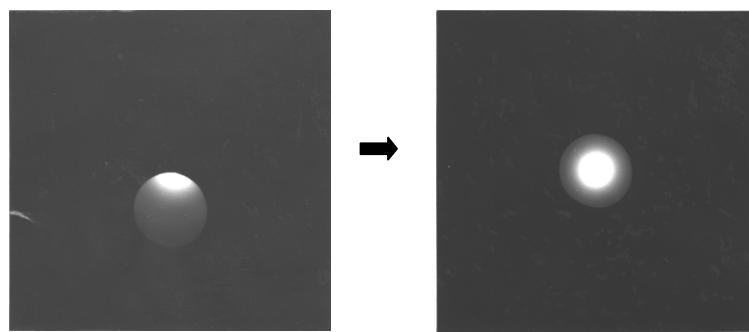


Fig. 5.15 Caustic spot

4. Obtain the smallest illumination spot with the BRIGHTNESS knob (L1-⑥) and make the illumination spot coincide with the screen center by manipulating the SHIFT-X and -Y knobs (L1-⑧, R1-③).
5. Insert the desired objective aperture into the beam path with objective aperture assembly knob 1.
6. Focus the aperture image (shadow) with the DIFF FOCUS knob (R1-⑦).
7. Manipulate an aperture assembly knob 2 and3 so that the caustic spot lies in the center of the aperture hole image.



When the aperture is not centered

When the aperture is centered

Fig. 5.16 Objective aperture centering

5.2.5c Field limiting aperture

The field limiting aperture is used to limit an area on the specimen for observing a diffraction diagram.

1. Set the FUNCTION (R1-②) to SA MAG, MAG1 or MAG2.
2. Select a magnification to be used using the MAG/CAM L knob (R1-⑤).
3. Manipulate aperture assembly knob 1 to insert an aperture to be used.
4. Clarify the aperture (shadow) on the fluorescent screen using the DIFF FOCUS knob (R1-⑦).
☒ This cannot be done in the MAG mode.
5. Select a FIELD view to be observed using control panel SC (☞ Sect. 4.2.5).

5.2.6 Photography

5.2.6a Data Printout on Micrograph

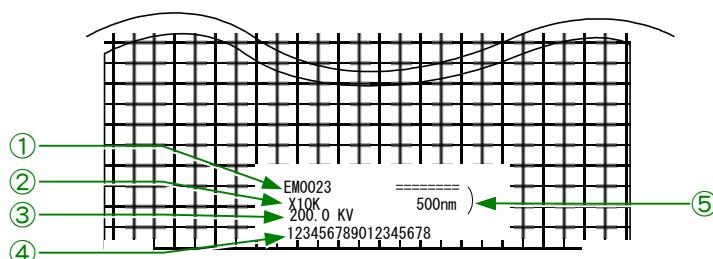


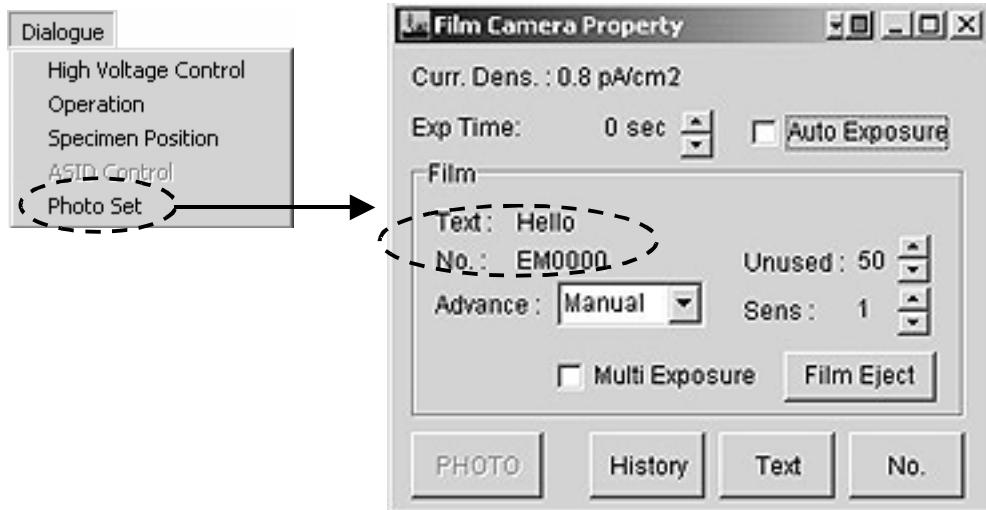
Fig. 5.17 Data printout

- ① TEXT (specimen name, etc.)
Entered on the “Film Camera Property” screen (☞ Sect. 4.4.6e).
- ② Magnification or camera length
- ③ Accelerating voltage
- ④ Film number
Six digits
☞ The last four digits indicate the film number and the first two are optionally entered for other identification, refer to Sect. 4.4.6e.
- ⑤ Micron bar
The calibrated length of the bar corresponds to the length on the specimen. This does not appear in the DIFF mode.

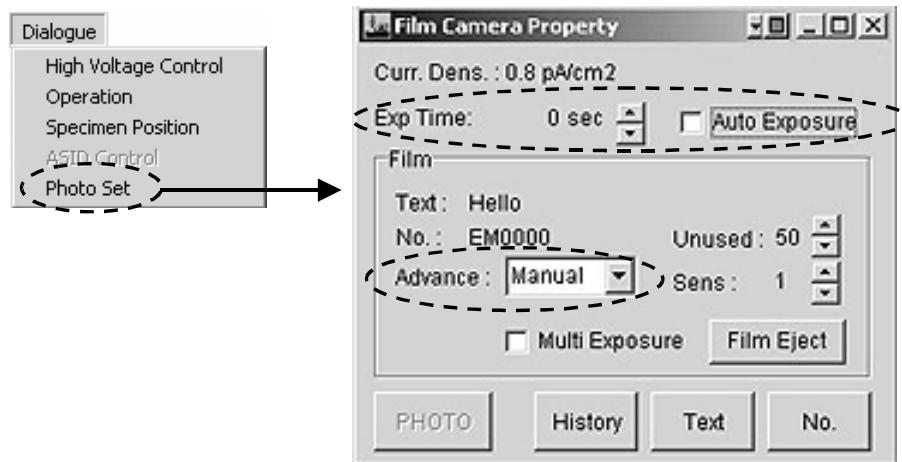
5.2.6b Manual exposure

Use this method if the exposure time is to be freely set without using the exposure meter (when a diffraction pattern is to be photographed etc.).

1. Turn off the AUTO switch (R1-⑧) or remove the check mark in the “Auto Exposure” box of the “Film Camera Property” screen (☞ Sect. 4.4.6e) to obtain the manual exposure mode.

**Fig. 5.18 Film Camera Property screen**

2. Set the exposure time by manipulating the EXP TIME knob (R1-⑧) or using the triangle buttons on the "Exp Time" line on the "Film Camera Property" screen (☞ Sect. 4.4.6e).
3. Depress the PHOTO switch (R1-⑧) to bring the film to the photographing position.
☒ "Advance:" can be used to select the film advancing mode (☞ Sect. 4.4.6e).
4. Depress the PHOTO switch (R1-⑧) again to carry out photographing.
☒ The lamp located at the left side of the switch flickers while the shutter is open. The film moves into the receiving magazine after completion of the photographing.

**Fig. 5.19**

5.2.6c Automatic exposure

1. Depress the AUTO switch (R1-⑧) (built-in lamp lights up) or give a check mark to the "Auto Exposure" box of the "Film Camera Property" screen (☞ Sect. 4.4.6e) to obtain the automatic exposure mode.
2. Manipulate the image brightness (L1-⑥) to obtain an optimum image brightness.
☞ The exposure time is determined by an amount of entire electrons either on the small or large fluorescent screen. Therefore, The correct exposure time cannot be obtained if the large screen is not covered with electron beam. remove the small screen out of beam path if this is the case.
3. Depress the PHOTO switch (R1-⑧) to bring the film to the photographing position.
☞ "Advance:" can be used to select the film advancing mode (☞ Sect. 4.4.6e).
4. Depress the PHOTO switch (R1-⑧) again to carry out photographing.
☞ The lamp located at the left side of the switch flickers while the shutter is open. The film moves into the receiving magazine after completion of the photographing.

5.2.6d Multiple exposure

1. Give a check mark to the "Multi Exposure" box of the "Film Camera Property" screen (☞ Sect. 4.4.6e) to obtain the multiple-exposure mode.
2. Carry out the photographing in the conventional way.
☞ The exposed film remains after completion of the first exposure in this case.
3. Depress the PHOTO switch (R1-⑧) again.
☞ The second exposure on the same film is performed.
4. Depress the "Film Eject" button on the "Film Camera Property" screen.
☞ The exposed film moves to the receiving magazine.

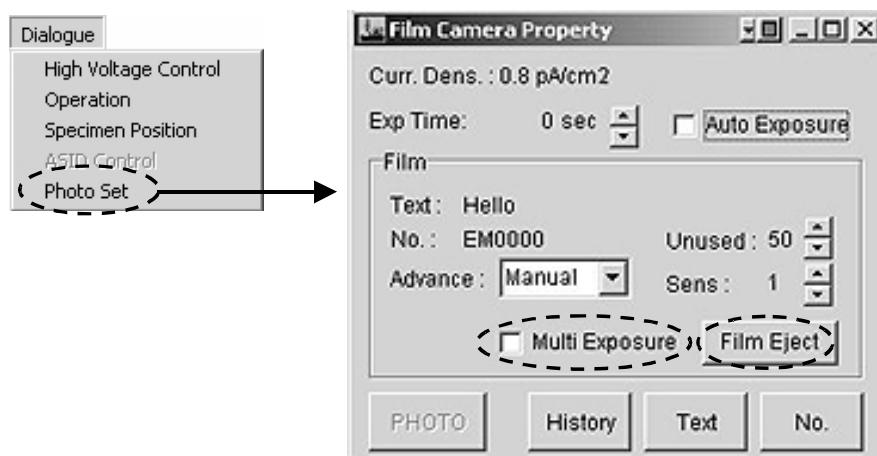


Fig. 5.20

5.2.7 Image Observation

This describes the operation for the conventional image observation assuming that the automatic exposure mode is used (☞ Sect. 5.2.6).

1. Prepare the specimen for observation (☞ Sects. 5.2.3d, 5.2.3e).
2. Generate an electron beam (☞ Sect. 5.2.4).
3. Obtain the beam on the fluorescent screen.
 - a. Use a larger condenser aperture.
 - b. Decrease the magnification.
 - c. Slowly turn the BRIGHTNESS knob counterclockwise from the fully clockwise position.
 - d. Select LOW MAG mode.
 - e. Remove the specimen holder from the beam path (the holder should be left in the goniometer).

☞ Electron beam generation is impossible if the specimen holder is not in the goniometer.
 - f. Find the beam on the fluorescent screen.
 - g. Place the specimen in the beam path.
4. Depress the STD FOCUS button to set the objective lens current to the reference value.
5. Obtain the optimum brightness using the BRIGHTNESS knob and center the beam position using the SHIFT knobs (L1-⑧, R1-③).
6. Bring the field of view for microscopy to the screen center using control panel SC. (☞ Sect. 4.2.5).
7. Store the specimen position if necessary on the "Specimen Position" screen (☞ Sect. 4.4.6d).

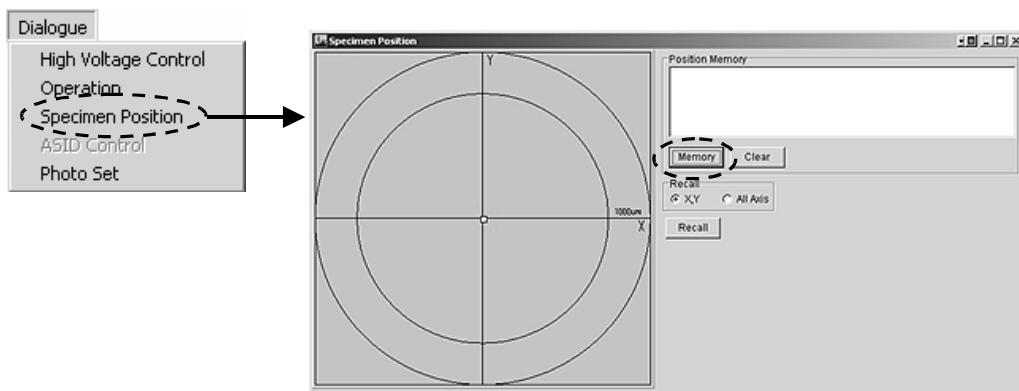
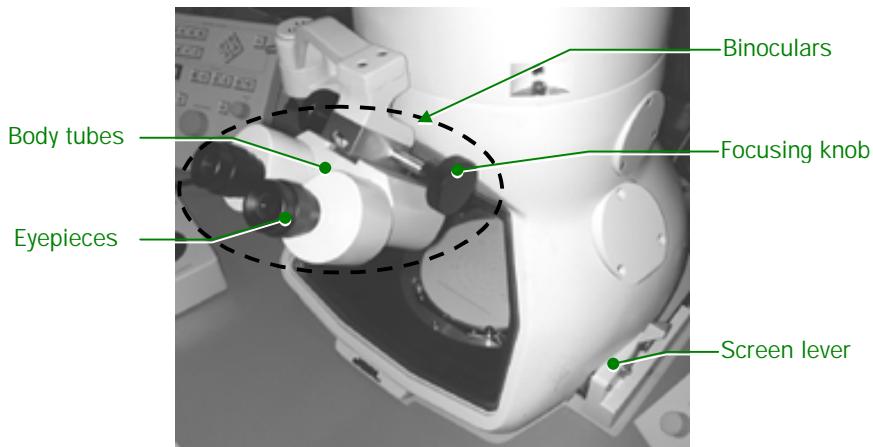


Fig. 5.21

8. Select the magnification to be used with the MAG-CAM L knob (R1-⑤).
9. Focus the image using the OBJ FOCUS knob (R1-⑥).
 - a. Press the fluorescent screen lever to place the small screen in the beam path.

**Fig. 5.22**

- b.** Manipulate the focusing knob of the binoculars to focus the binoculars on the small screen.
☞ First, focus the whole binoculars with the focusing knobs, and adjust, if necessary, the interocular distance by changing the distance between the body-tubes, and focus the eyepieces by turning the knurled ring (**☞** Fig. 5.18).
- c.** Turn on the IMAGE EOB X or Y (R1-①).
- d.** If the beam oscillates or divides into two, manipulate the Z CONT (R1-⑪) to obtain a single stable beam.
- e.** Observe an image with clear contours on the small fluorescent screen through the binoculars.
- f.** If the image appears as a double image, adjust the Z CONT switch (R1-⑪) so as to obtain a single stationary image. The image will appear as a double image if the image is under-focused or over-focused.
- g.** Turn off the IMAGE WOBB X or Y switch (R1-①).
- 10.** Manipulate the BRIGHTNESS knob (L1-⑥) to set the exposure time shown on "Exp. Time" on the center main screen (**☞** Sect. 4.4.4b) to an optimum value.
- 11.** Depress the PHOTO switch (R1-⑧) with the small screen placed in the electron beam path after the built-in lamp in the PHOTO switch lights up (that is, the film moves to the photographing position).
☞ The EXP lamp opens while the shutter opens. The PHOTO switch built-in lamp lights up when the exposed film moves into the receiving magazine.
- 12.** If the built-in lamp in the PHOTO switch is not lit, depress the switch again. The film is exposed.
☞ The lamp will not light up if no film is in the dispensing magazine.
☞ The exposure time is determined by an amount of entire electrons either on the small or large fluorescent screen. Therefore, removing the small screen out of beam path, when the large screen is entirely illuminated, does not affect the correct exposure time determination. The small screen therefore should be placed in the beam path when the large screen is partially illuminated.

5.2.8 Film Processing

1. Unload the receiving magazine from the camera chamber (☞ Sect. 5.2.3).
2. Adjourn to a darkroom and remove the lid from the receiving magazine and the cassettes from the magazine under a safelight (red lamp).
3. Carefully remove the film from the cassette.

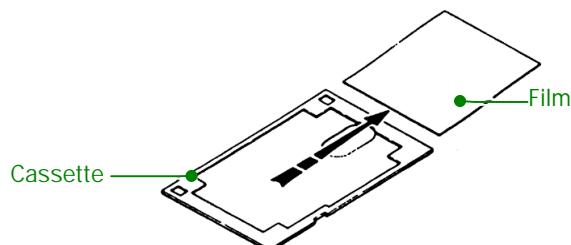


Fig. 5.23 Removing the film from the cassette

4. Immerse the film in a developer ($20 \pm 0.5^\circ\text{C}$); and leave it in until the exposed latent image becomes sufficiently visible (☞ usually three or four minutes; Fig. 5.22).
During the developing process, agitate the developer or move the film in order to avoid developing marks.
~~✓~~ If only a few films are to be processed, developing trays may be used. However, if many films are to be processed at one time, it is recommended to use suitable tanks and hangers (stainless steel tanks, polyvinyl chloride tanks, etc. are the best).
5. Immerse the film in a stop bath (2 to 3% glacial acetic acid solution, 18 to 21°C) and leave it in for approx. 30 seconds.
This is to suspend development so as to prevent the film from becoming blotchy and to prolong the effectiveness of the fixer.
6. Immerse the film in a rapid acid hardening fixer (18 to 21°C) 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 negative to clear).
This is to dissolve the photosensitive silver halide (white part of the film) and thereby make the unexposed part of the film transparent. Thereafter, processing can be carried out under an ordinary light.
7. Wash the film in running water (15 to 20°C) for 30 to 60 minutes.
This removes the complex salt and fixing solution. The washing time can be considerably reduced by immersing the film in a rinse accelerator prior to washing it in running water.
8. Immerse the film in a final rinse bath (weak solution of anionic surfactant, 18 to 21°C) and leave it in for approx. 30 seconds (or wipe both surfaces of the film carefully with a soft sponge).
By so doing, film drying time is reduced and film blisters are prevented.
9. Dry the film in a drying cabinet (the cabinet need not be large); or dry it naturally by hanging it in a well-ventilated, dust-free place away from direct sunlight.

Store the dried film in a negative bag (polyethylene, cellophane, etc.) and keep the bag in a dry place away from direct sunlight.

 Consequences of faulty film processing, etc. are listed in Table 1 (assuming that the exposure is in order).

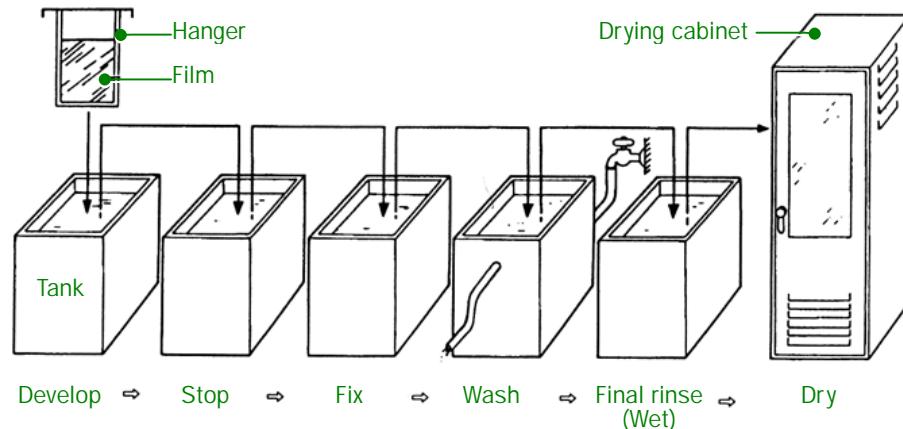


Fig. 5.24 Film processing

Table 5.1 Consequence of faulty film processing

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

5.3 METHOD B

5.3.1 Conditions for High Resolution Microscopy

■ The electron beam divergence angle must be small

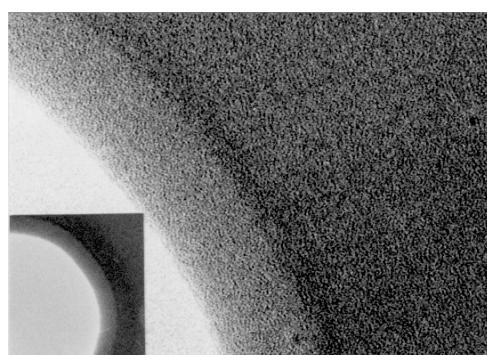
High resolution micrographs will be difficult to obtain due to low coherence when the electron beam divergence angle is large. Therefore, use a small condenser aperture (100 or 40 micron meters in diameter), manipulate the BRIGHTNESS knob to obtain 2 to 4 seconds of exposure time and set the beam divergent angle as follows using the

The α -SELECTOR No. is displayed on the left main screen (☞ Sect. 4.4.4a). The No. can be varied using the α -SELECTOR knob (L1-③). No. 3 covers all the range of magnification except when very high resolution photographs are required. No.2 and 1 are recommended for microscopy at very high magnifications required small divergence angle. The smaller the divergence angle (i, e, the smaller the α -SELECTOR No.), the higher the image quality with smaller field of view. Refer to the following when selecting the α -SELECTOR No.

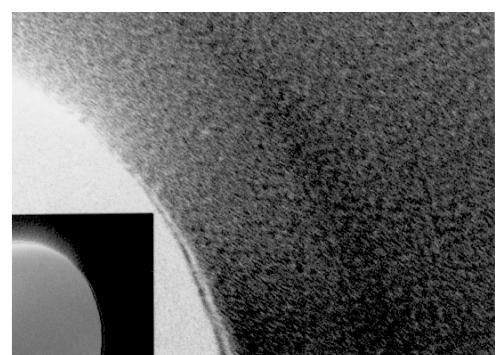
- α -SELECTOR No. 3: For any magnification
- α -SELECTOR No. 2: For 100,000 times or higher
- α -SELECTOR No. 1: For 500,000 times or higher

■ The voltage center must be properly aligned.

Fig. a shown below shows a hole image when the voltage center is properly aligned. In this figure, the background structure (phase contrast) is readily discernible, and the edge of the hole can be clearly observed all the way round. On the other hand, Fig. b shows a hole image when the voltage center is misaligned. In this figure, the image is indistinct, the background structure appears unidirectional, and the edge of the hole is blurred as if astigmatism exists.



a: Hole image when voltage center is aligned



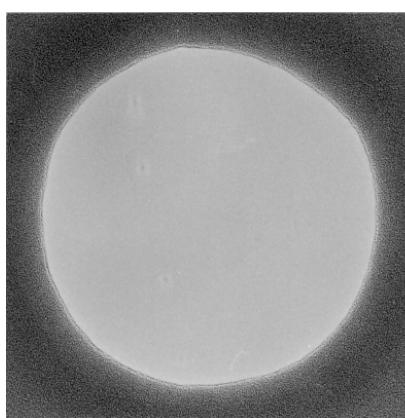
b: Hole image when voltage center is misaligned

Fig. 5.25 Effect of voltage center alignment

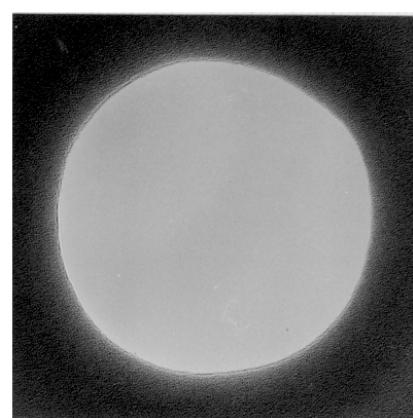
For high magnification photography, realign the voltage center at the photographing magnification by using the HT-WOBBLER switch (R1-①).

■ **The objective aperture must be properly inserted.**

Fig. a shows a hole image when the objective aperture is properly inserted into the electron beam path. In this figure, the background structure is readily discernible, and the edge of the hole can be clearly observed all the way round. On the other hand, Fig. b shows a hole image when the aperture is improperly inserted. In this figure, the image is indistinct, the background structure exhibits unidirectional blurring, and the edge of the hole appears as if astigmatism exists.



a: Hole image when objective aperture is aligned



b: Hole image when objective aperture is misaligned

Fig. 5.26 Effect of objective aperture insertion

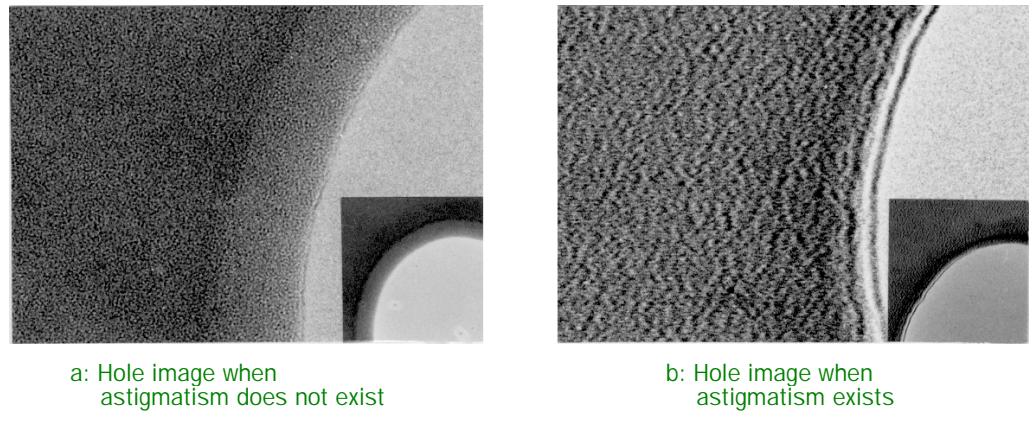
■ **The objective lens astigmatism correction must be complete.**

If astigmatism exists in the objective lens, the focusing becomes unidirectional, and it will be impossible to focus the image correctly in all directions. To illustrate the point, Fig. a shows a hole image when the lens is free from astigmatism, and Fig. b shows the same image when lens astigmatism is present.

It will be seen that when the lens is free from astigmatism, the background structure is clear and the edge of the hole can be readily observed all the way round; and that when lens astigmatism is present, the image is blurred and the Fresnel fringe is asymmetrical around the edge of the hole.

Astigmatism correction should be carried out at a magnification higher than that used for actual photography. However, once astigmatism correction is complete, photography can be carried out at lower magnifications without the need to repeat astigmatism correction. If the amount and direction of astigmatism vary as time goes by, a dirty objective aperture or dirty specimen holder is indicated. In this case, clean the contaminated part/parts as per the maintenance manual.

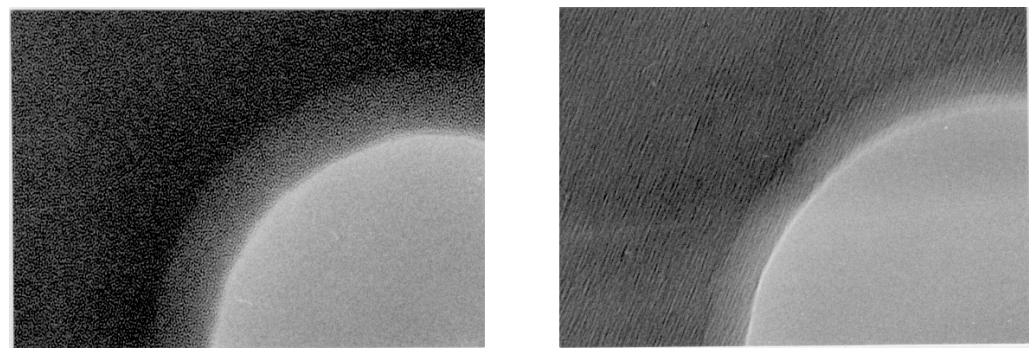
Utilizing the background structure in conjunction with the Fresnel fringe (at slightly over-focus) is extremely effective when correcting objective lens astigmatism at magnifications of 100,000 times or more. That is to say, after first of all removing the astigmatism as much as possible using the Fresnel fringe, focus the image and then remove any remaining astigmatism so as to make the background structure as clear as possible.

**Fig. 5.27 Effect of objective lens astigmatism**

■ **The specimen must be tightly secured.**

If the specimen is not tightly secured, it will result as time passes in a gradual shift of the specimen (image). This phenomenon is referred to as “image drift”. Fig. a shows a hole image under drift-free conditions, and Fig. b shows the same image when image drift exists. In the former, the background structure is distinct, and the edge of the hole can be clearly discerned all the way round.

In the latter case, the background structure appears to be unidirectional, and the edge of the hole exhibits one-way blurring.

**Fig. 5.28 Effect of image drift**

The chief causes of image drift and the countermeasures to be taken are as follows:

- Damaged, wrinkled, improperly secured and/or insufficiently strong supporting film
Exercise great care when preparing the supporting film. Use adequate adhesive when securing the film to the grid, and reinforce the film using the carbon coating method.
- Bent specimen grid
Discard and replace with new (unbent) grid.
- Electrically charged specimen and/or supporting film
Enhance conductivity by coating the specimen and/or supporting film with carbon.

■ Others

If the specimen is contaminated, it is difficult to focus the image correctly, and photographs obtained will be obscure even though the image is properly focused. In order to prevent contamination by the electron beam, avoid irradiating the specimen for a long time.

Do not use a magnification higher than that necessary for resolving the feature of interest adequately, and photograph the image with an exposure time as short as possible (two to four seconds will be adequate).

5.3.2 Illumination System Alignment

1. Select "Maintenance" on the "TEN Controller" main menu to display the "Alignment Panel for Maintenance" screen.

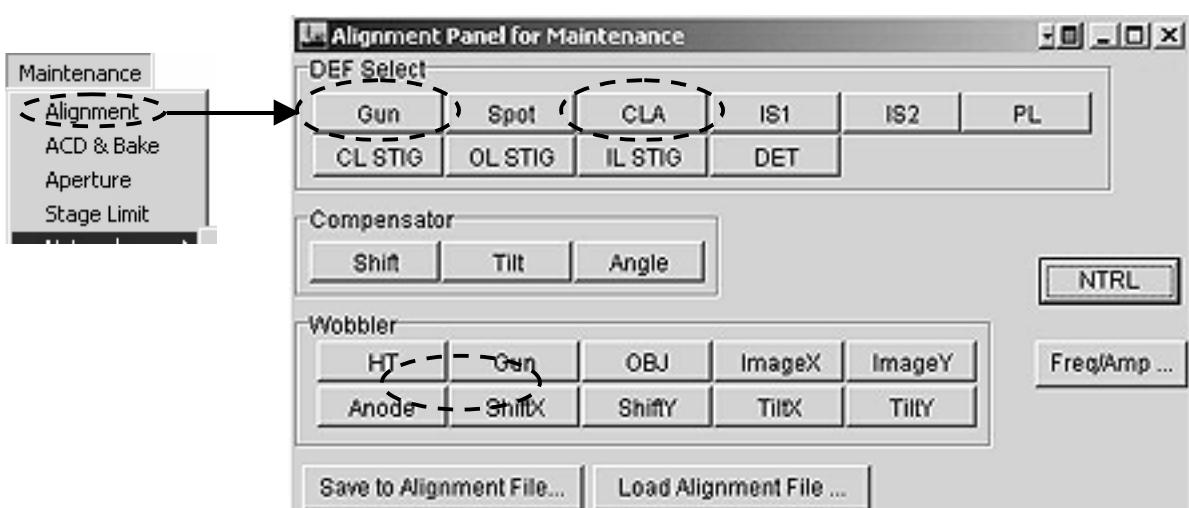


Fig. 5.29 "Alignment Panel for Maintenance" screen

2. Set the magnification to 5,000 times.
3. Set the SPOT SIZE knob (L1-③) to 1.
4. Converge the electron beam using the BRIGHTNESS knob (L1-⑥).
5. Select "Gun" on the "Alignment Panel for Maintenance" screen.
6. Manipulate the SHIFT knobs (L1-⑧, R1-③) or DEF/STIG knobs (L1-⑩, R1-④) to center the beam.
7. Depress the "Wobble-Anode" button on the "Alignment panel for Maintenance" screen.
8. Manipulate the SHIFT knobs and DEF-STIG knobs so that the beam converges and diverges concentrically.
9. Set the SPOT SIZE knob (L1-③) to 5.
10. Depress the BRIGHT TILT switch (L1-⑥) or set the "DEF Select" switch on the "Alignment Panel for Maintenance" screen.
11. Center the beam using the SHIFT knobs (L1-⑧, R1-③).
12. Repeat step 2 to 8 above until the beam deviation from the screen center when the SPOT SIZE knob setting is changed becomes minimum.

5.3.3 Condenser Lens Astigmatism Correction

When astigmatism exists in the condenser lens, the shape of the electron beam when converged maximally on the screen is elliptical and image brightness is insufficient. Making the converged electron beam circle performs astigmatism correction.

1. Select "Maintenance" on the "TEN Controller" main menu to display the "Alignment Panel for Maintenance" screen.
2. Insert a condenser aperture in the beam path.
3. Converge the beam as small as possible using the BRIGHTNESS (L1-⑥).
4. Depress the COND STIG switch (L1-⑤) or Depress the "DEF Select-CL STIG" button on the "Alignment Panel for Maintenance" screen.
5. Manipulate the DEF/STIG knobs (L1-⑩, R1-⑤) to make the beam circle appearing just before and after the beam is converged.

 When the BRIGHTNESS (L1-⑦) is turned slowly back and forth from the position where the beam is maximally converged, the electron beam appearing just before and after the beam is converged is elliptical if astigmatism exists in the condensed lens.

5.3.4 Beam Deflector Adjustment

5.3.4a Tilt adjustment

This is to adjust the ratio of the current in the condenser lens beam deflector upper coil and lower coil so that the electron beam deviation when tilting the beam is minimum.

1. Select "Maintenance" on the "TEN Controller" main menu to display the "Alignment Panel for Maintenance" screen.
2. Set the magnification to 10,000 times.
3. Converge the beam as small as possible using the BRIGHTNESS (L1-⑥).
4. Center the beam using the SHIFT knobs (L1-⑧, R1-③).
5. Depress the "Wobbler-TiltX" button on the "Alignment Panel for Maintenance" screen.

The beam spot is divided into two now.

6. Depress the "compensator-Tilt" button on the "Alignment Panel for Maintenance" screen.
7. Make the divided spot a single spot using the DEF/STIG X knob (L1-⑩).
8. Turn off the "compensator-Tilt" button on the "Alignment Panel for Maintenance" screen by depressing the button.
9. Center the beam using the SHIFT knobs (L1-⑧, R1-③).
10. Depress the "Wobbler-TiltY" button on the "Alignment Panel for Maintenance" screen.

The beam spot is divided into two now.

11. Depress the "compensator-Tilt" button on the "Alignment Panel for Maintenance" screen.
12. Make the divided spot a single spot using the DEF/STIG Y knob (L1-⑩).
13. Turn off the "compensator-Tilt" button on the "Alignment Panel for Maintenance" screen by depressing the button.

5.3.4b Shift adjustment

This is to adjust the ratio of the current in the condenser lens beam deflector upper coil and lower coil so that the electron beam deviation when tilting the beam is minimum.

1. Select "Maintenance" on the "TEN Controller" main menu to display the "Alignment Panel for Maintenance" screen.
2. Depress the SA DIFF button (R1-②) to obtain the DIFF mode.
3. Turn the BRIGHTNESS knob (L1-⑦) fully counterclockwise.
4. Manipulate the DIFF FOCUS knob (R1-⑦) to obtain a caustic spot.
5. Depress the "compensator-Tilt" button on the "Alignment Panel for Maintenance" screen.
6. Depress the "Wobbler-TiltX" button on the "Alignment Panel for Maintenance" screen.

The beam spot is divided into two now.

7. Make the divided spot a single spot using the DEF/STIG X knob (L1-⑪).
8. Depress the "Wobbler-ShiftX" button on the "Alignment Panel for Maintenance" screen.
9. Depress the "Wobbler-ShiftY" on the "Alignment Panel for Maintenance" screen.
10. Make the divided spot a single spot using the DEF/STIG Y knob (R1-④).
11. Turn off the "Wobbler-ShiftY" on the "Alignment Panel for Maintenance" screen by depressing the button.

5.3.5 Voltage/current Center Adjustment

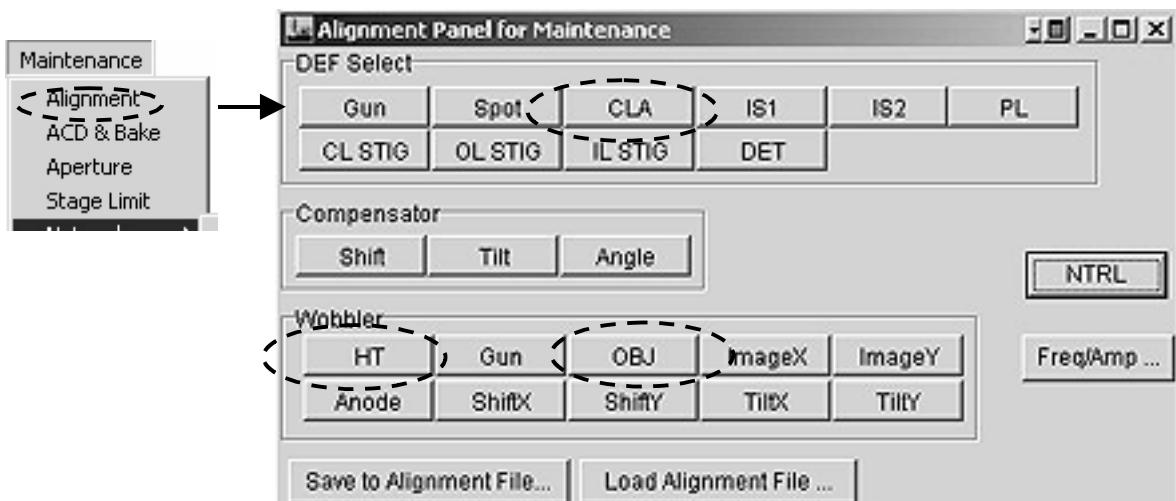


Fig. 5.30

5.3.5a Current center adjustment

1. Select "Maintenance" on the "TEN Controller" main menu to display the "Alignment Panel for Maintenance" screen.
2. Obtain an image in the MAG mode.
3. Focus the image using OBJ FOCUS (R1-⑥).
4. Diverge the beam to the extent of the entire fluorescent screen.
5. Bring a conspicuous image to the screen center.
6. Depress "Wobbler-OBJ" on the "Alignment Panel for Maintenance" screen.
The image now starts to expand and contract periodically.
7. Depress the BRIGHT TILT switch (L1-⑥) or depress "DEF Select-CLA" on the "Alignment Panel for Maintenance" screen.
8. Manipulate DEF/STIG (L-⑩, R1-④) to bring the image expansion/contraction center to the screen center.
9. Turn off "Wobbler-OBJ" on the "Alignment Panel for Maintenance" screen by depressing "Wobbler-OBJ".

5.3.5b Voltage center adjustment

1. Select "Maintenance" on the "TEN Controller" main menu to display the "Alignment Panel for Maintenance" screen.
2. Obtain an image in the MAG mode.
3. Focus the image using OBJ FOCUS (R1-⑥).
4. Diverge the beam to the extent of the entire fluorescent screen.
5. Bring a conspicuous image to the screen center.
6. Depress the HT WOBB switch (R1-①) or "Wobbler-HT" on the "Alignment Panel for Maintenance" screen.
The image now starts to expand and contract periodically.
7. Depress the BRIGHT TILT switch (L1-⑤) or depress "DEF Select-CLA" on the "Alignment Panel for Maintenance" screen.
8. Manipulate DEF/STIG (L-⑩, R1-④) to bring the image expansion/contraction center to the screen center.
9. Turn off the HT WOBB switch or depress "Wobbler-HT" on the "Alignment Panel for Maintenance" screen to turn off by depressing "Wobbler-HT".

5.3.6 Objective Lens Astigmatism Correction

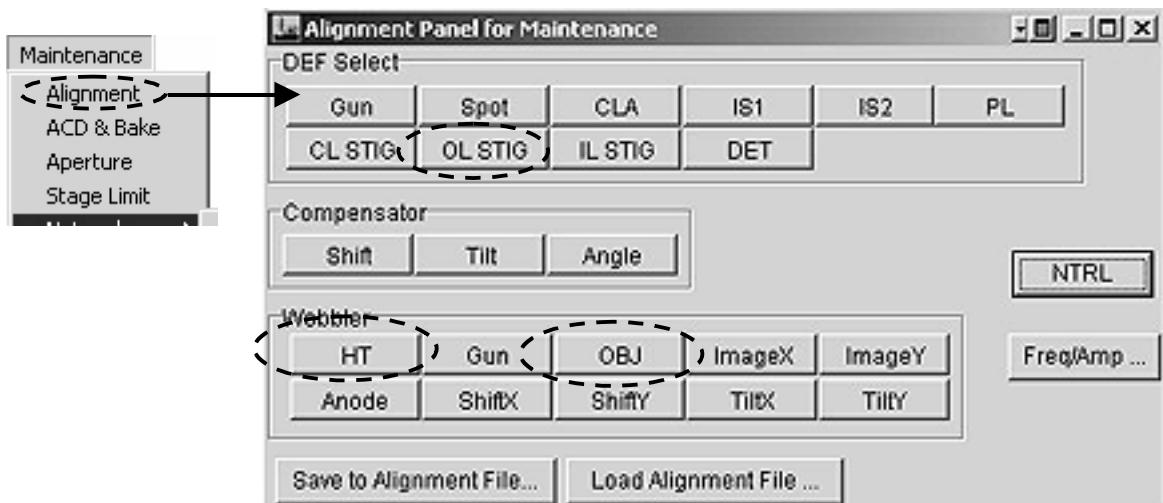
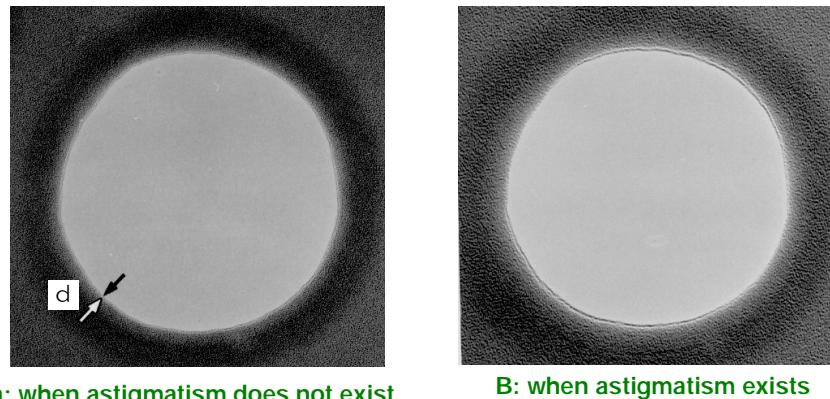


Fig. 5.31

5.3.6a At Middle Magnifications

A perforated, thin plastic film reinforced with carbon is recommended as a test specimen for astigmatism correction.

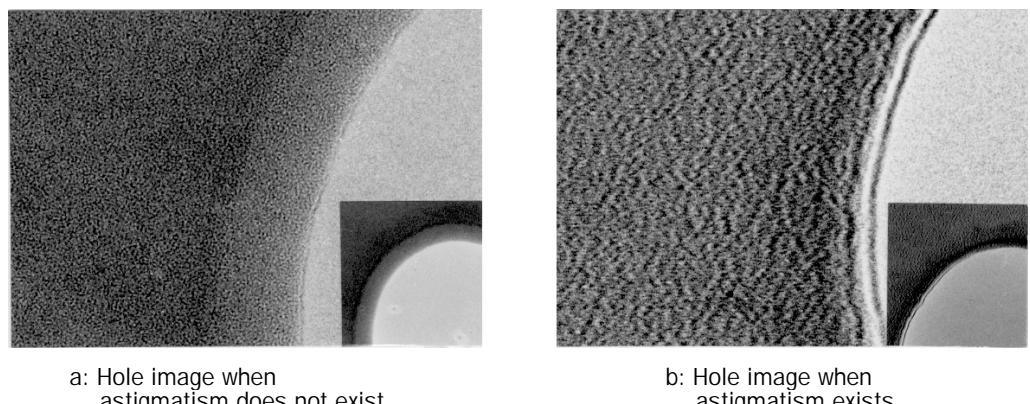
1. Select "Maintenance" on the "TEN Controller" main menu to display the "Alignment Panel for Maintenance" screen.
2. Set the magnification to 20,000 times in the MAG mode.
3. Use BRIGHTNESS (L1-⑦) to adjust the image brightness and SHIFT (L1-⑧, R1-③) to adjust the beam position.
4. Focus the image using OBJ FOCUS (R1-⑥).
5. Use the trackball (SC-②) or X,Y buttons (SC-①) to bring a suitable hole on the specimen to the screen center.
6. Press OBJ STIG (L1-⑥) or "DEF Selector-OL" on the "Alignment Panel for Maintenance" screen.
7. Manipulate OBJ FOCUS (R1-⑥) so that a fresnel fringe (A white line seen along the hole edge when slightly over-focused) appears along the edge of the hole.
 - ☒ The distance between the line and hole edge (☞ "d" in Fig. 5.32a) is uneven when astigmatism exists in the objective lens.
8. Manipulate DEF/STIG (L1-⑩, R1-④) so that the image contrast and distance between the line and hole edge (☞ "d" on the figure shown below) becomes even in all directions.
 - ☒ If the objective aperture or the specimen is dirty, or the objective aperture is not correctly inserted in the beam path, or the voltage center is not properly set, it may be impossible to correct astigmatism completely.

**Fig. 5.32 Astigmatism in the objective lens**

5.3.6b At High Magnifications

An amorphous specimen (the specimen supporting film itself or specimen itself) is used for astigmatism correction at high magnifications.

1. Select "Maintenance" on the "TEN Controller" main menu to display the "Alignment Panel for Maintenance" screen.
2. Set the magnification to 100,000 times or higher in the MAG mode.
3. Obtain suitable image brightness using BRIGHTNESS (L1-⑦) and SHIFT (L1-⑧, R1-④).
4. Manipulate OBJ FOCUS (R1-⑦) to focus the image.
5. Use the trackball (SC-②) or X,Y buttons (SC-①) to obtain an amorphous specimen on the screen using the .
6. Depress OBJ STIG (L1-⑤) or select "DEF select-OL" on the "Alignment Panel for Maintenance" screen.
7. Slowly turn OBJ FOCUS back and forth from the in-focus position to observe a phase image.
8. Manipulate DEF/STIG (L1-⑩, R1-④) so as to make the phase image as separated tiny spots (Fig. 5.33a shown below).

**Fig. 5.33 Effect of objective astigmatism**

5.3.7 Image Focusing

Image focusing at low magnifications is easy when the image wobbler is used. Focusing at high magnifications however, is not easy with the image wobbler. Image focusing with Fresnel fringe is recommended at high magnifications. At very high magnifications, micro particles on the specimen are used for image focusing.

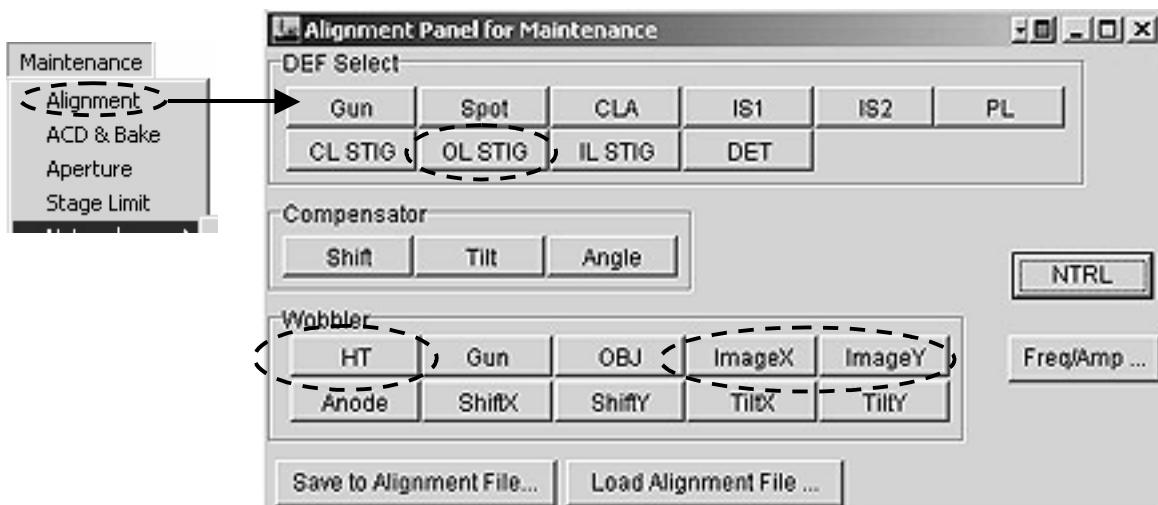
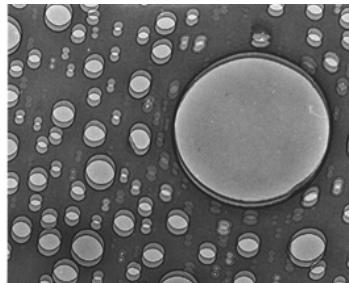
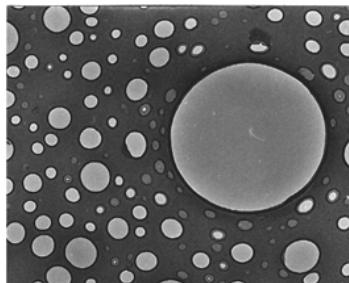
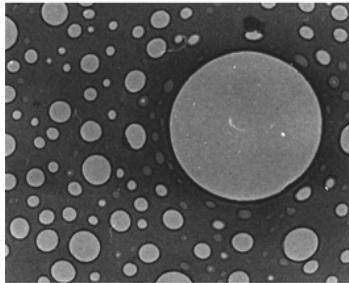
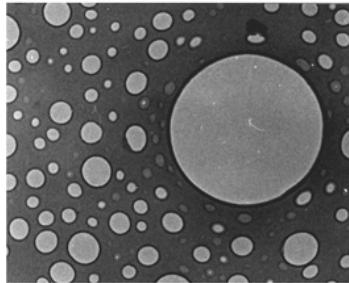
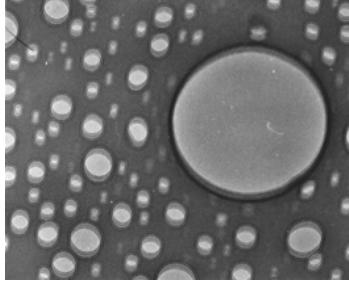
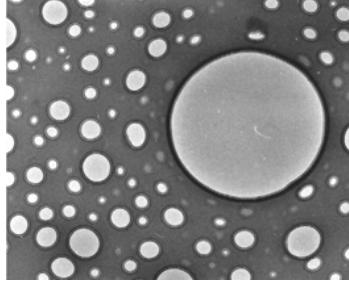


Fig. 5.34

5.3.7a Using Image Wobbler

1. Select "Maintenance" on the "TEN Controller" main menu to display the "Alignment Panel for Maintenance" screen.
2. Set the microscope to the MAG mode.
3. Depress IMAGE WOBBLER X or Y (R1-②) or depress "Wobbler-Image X or Y" on "Alignment Panel for Maintenance" screen.
A doubled-image appears on the screen..
 If an objective aperture and/or the slit is/are in the beam path, the field of view will be obstructed. To avoid the obstruction, use the larger aperture or remove both the aperture and slit from the beam path.
4. Manipulate OBJ FOCUS (R1⑦) so as to make the doubled-image a single stationary image.
5. Turn off the IMAGE WOBBLER X or Y (R1-②) or depress "Wobbler-Image X or Y" on "Alignment Panel for Maintenance" screen to turn off "Wobbler-Image X or Y".

Table 5.2

	IMAGE X or Y switch	
	ON	OFF
Under-focus		
In-focus		
Over-focus		

5.3.7b Using Fresnel Fringe

1. Manipulate the OBJ COARSE (R1-⑥) to obtain the sharpest possible image (coarse focusing).
2. While observing a portion of the image having the greatest contrast (a film hole or dust particle is ideal for practice purpose) through the binoculars, turn the OBJ FOCUS-FINE knob (R1-④) slightly counterclockwise and clockwise and obtain an in-focus.

If a film hole is used, a bright, high contrast fringe (Fresnel fringe) forms around the edge of the hole, as shown in Fig. a below, when the FINE knob is turned counterclockwise. This is referred to as the under focus condition, a condition in which the contour width increases as the amount of under focus is increased. When the FINE knob is turned clockwise, a dark fringe (Fresnel fringe) appears slightly apart from the edge of the hole as shown in Fig. c below. This is referred to as the over-focus condition, a condition in which the distance between the fringe and the edge of the hole increases as the amount of over-focus is increased. In-focus lies between under-focus and over-focus. As the knob is gradually turned clockwise from the under-focus condition, the width of the bright fringe forming the hole contour decreases. When the fringe disappears and contour contrast is minimum as shown in Fig. b below, the image is in-focus. As the knob is turned further clockwise, the image assumes an ambiguous state and appears as either an in-focus or over-focused image. Immediately after the image has assumed such a state, a dark fringe appears slightly away from the edge of the hole (over-focus), as the knob is turned further clockwise.

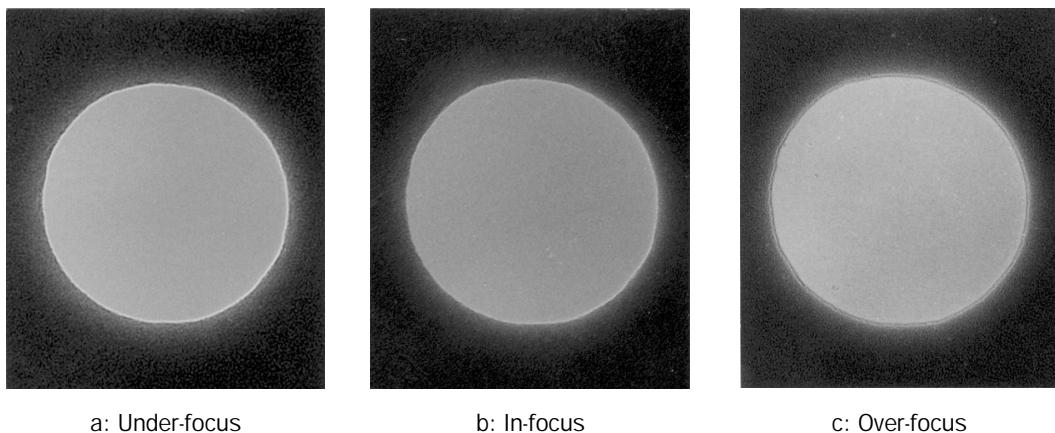


Fig. 5.35

3. Set the OBJ FOCUS-FINE knob (R1-④) to the in-focus position or slightly under-focus position (obtained by turning the knob slightly counterclockwise from the in-focus position).

In the case of low-contrast specimens (such as very thin biological sections), the image should be slightly under-focused in order to obtain a sufficiently sharp image. In order to distinguish the focus suitable for photography from in-focus, it is called ‘optimum’ focus.

5.3.8 Focusing with Fine Structure

Utilizing the background structure in conjunction with the Fresnel fringe (over-focus or under-focus) is very effective for increasing the focusing accuracy when focusing images at magnifications of 100,000 times or more. that is to say, focus the image as precisely as possible with the fringe at under-focus, and then finely focus the image (in-focus) so as to minimize background structure contrast.

A further point to keep in mind when focusing images at high magnifications is that, since the possibility of mistaking the apparent fine structure for the actual structure is large, it is necessary to photograph several images while changing the focus very slightly (through-focus method) and to select the optimum-focus image from among the ones photographed (☞ Sect. 5.5.3).

Fig. 5.31 shows micrographs of perforated film obtained by the through-focus method. These micrographs clearly indicate that the background structure varies according to defocusing (Fresnel fringe variation).

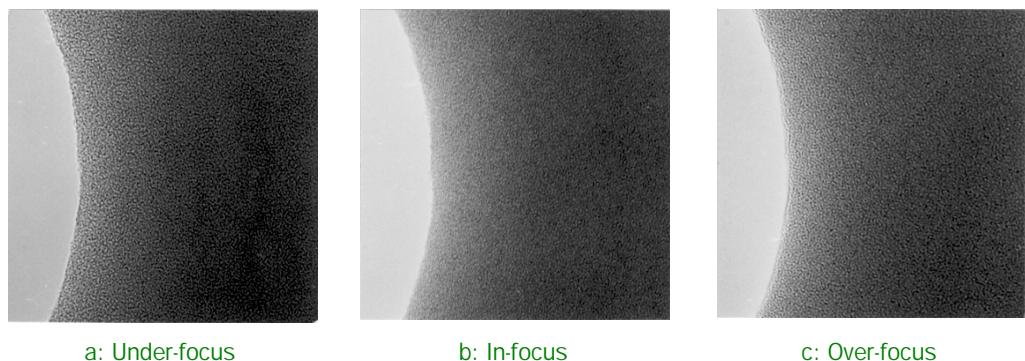


Fig. 5.36 Fresnel fringe and background structure variation

5.4 SPECIAL OBSERVATION

5.4.1 Bright Field Image

When the incident electron beam passes through the specimen, it splits chiefly into unscattered electron beam and scattered (diffracted) electron beam; the former forms a bright field image.

1. Obtain a selected area image (☞ Sect. 5.5.1).
2. Insert an objective aperture into the electron beam path (☞ Sect. 5.2.9b).
3. Adjust the objective aperture position using the aperture assembly knob 2 and 3 so that the direct spot paths through the aperture.
☞ The center spot in the diffraction diagram is called as “direct spot” and other spots are called as “Diffraction spots”.
4. Depress the MAG1 switch (R1-②) to obtain the MAG mode.
5. Select the desired magnification using the MAG/CAM L knob (R1-⑤).

A bright field image (Fig. 5.37-a) appears on the screen.

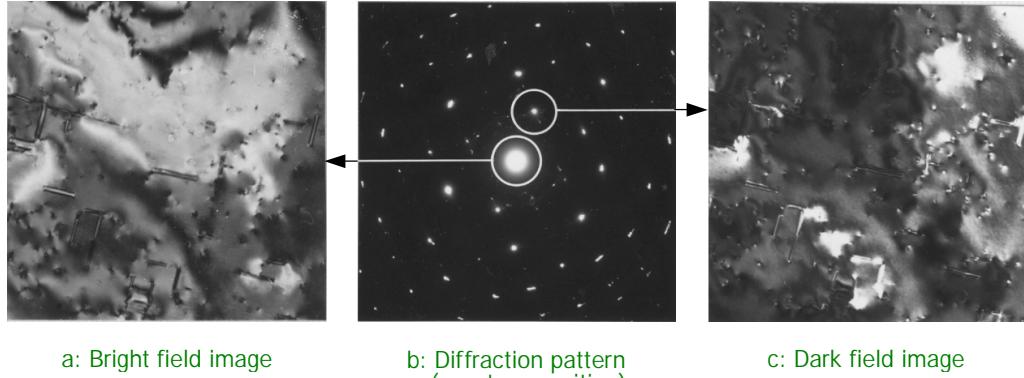


Fig. 5.37 Bright/dark field images

5.4.2 Dark Field Image

When the incident electron beam passes through the specimen, it splits chiefly into unscattered electron beam and scattered (diffracted) electron beam; the former forms a bright field image, and the latter a dark field image. Though the dark field image does not provide sufficient image brightness, it has an advantage that image contrast is much greater than that of a bright field image.

1. Obtain a selected area image (☞ Sect. 5.5.1).
2. Insert an objective aperture into the electron beam path (☞ Sect. 5.2.9b).
3. Adjust the objective aperture position using the aperture assembly knob 2 and 3 so that the direct spot paths through the aperture.
☞ The center spot in the diffraction diagram is called as “direct spot” and other spots are called as “Diffraction spots”.
4. Depress the DARK TILT switch (L1-⑤).
5. Adjust the objective aperture position using the DEF/STIG knobs (L1-⑩, R1-④) so that the desired diffraction spot paths through the aperture.

 The center spot in the diffraction diagram is called as “direct spot” and other spots are called as “Diffraction spots”.

6. Depress the MAG1 switch (R1-②) to obtain the MAG mode.
7. Adjust the image brightness using the BRIGHTNESS knob (L1-⑥).
A dark field image (Fig. 5.37-c) appears on the screen.
-  Use the SHIFT knobs (L1-⑧, R1-③) to center the beam if necessary.

5.4.3 Low Magnification Image

This mode is useful when searching the field of view in the wide area and also useful for searching the field at low magnifications. Since the objective aperture cannot be used in this mode, the field limiting aperture is used to enhance the image contrast.

5.4.3a Low magnification image observation

1. Select “Maintenance” on the “TEN Controller” main menu to display the “Alignment Panel for Maintenance” screen.
2. Carry out column alignment ( Sect. 5.3.2).
3. Remove the objective and field limiting apertures from the beam path ( Sect. 5.2.9).
4. Depress the LOW MAG switch (R1-②).
5. Select the desired magnification with the MAG/CAM L knob (R1-⑤).
A selected magnification appears on screen.
6. Adjust the image brightness using the BRIGHTNESS knob (L1-⑥).
A dark field image appears on the screen.
-  Use the SHIFT knobs (L1-⑧, R1-③) to center the beam if necessary.
7. Perform the current center adjustment ( Sect. 5.4.3b).

5.4.3b Current center adjustment

1. Select “Maintenance” on the “TEN Controller” main menu to display the “Alignment Panel for Maintenance” screen.
2. Depress the BRIGHT switch (L1-⑥) or turn on “Wobbler-OBJ” on the “Alignment Panel for Maintenance” screen.
 The image rotates around a point on the screen. This center is called “Current center”.
3. Depress on the BRIGHT TILT switch (L1-⑥) or turn on “DEF Select-CLA” on the “Alignment Panel for Maintenance” screen.
4. Bring the current center to the screen center using the DEF/STIG knobs (L1-⑩, R1-④).
5. Turn off “WOBBLER-OBJ” on the “Alignment Panel for Maintenance” screen.
6. Carry out the astigmatism correction ( Sect. 5.4.4).

5.4.3c Astigmatism Correction

1. Depress the OBJ STIG switch (L1-⑤) or turn on "DEF Select-OL STIG" on the "Alignment Panel for Maintenance" screen.
2. Depress the IMAGE WOBBLER X switch (R1-①) to turn on the switch.
3. Focus the image using the OBJ FOCUS knob (R1-⑥).
4. Turn off the IMAGE WOBBLER X switch (R1-①).
5. Turn on the IMAGE WOBBLER Y switch (R1-①).
 ☒ A doubled-image appears on the screen.
6. Manipulate the DEF STIG Y knob (R1-④) to make the doubled-image as a single image.
7. Turn off the IMAGE WOBBLER Y switch (R1-①).
8. Turn on the IMAGE WOBBLER X switch (R1-①).
 ☒ A doubled-image appears on the screen.
9. Manipulate the DEF STIG Y knob (R1-④) to make the doubled-image as a single image.
10. Repeat above steps until the image does not become doubled.

☞ Sect. 5.3.7a for the image focusing using the image wobbler.

5.4.4 Minimum Dose Exposure (MDS)

This operation reduces considerably the electron beam irradiation on the specimen. The electron beam illuminates the specimen while photographing is performed only. Three modes are provided (SEARCH FOCUS and PHOTO SET).

1. Carry out the initial setting.

- Select "Option" on the main menu TEM Controller screen (☞ Sect. 4.4.2) to display the MDS screen (☞ Sect. 4.4.6j).

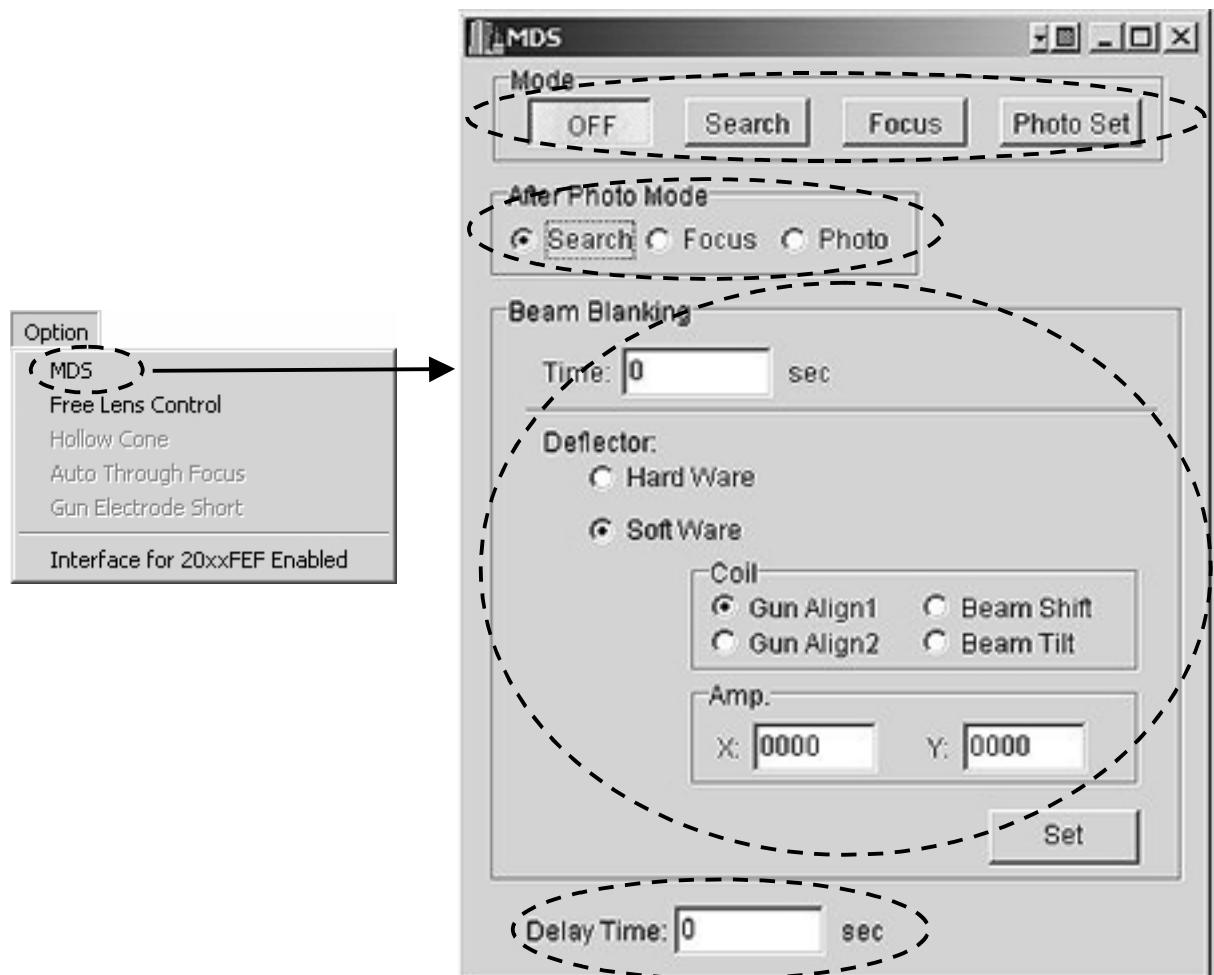


Fig. 5.38 MDS screen

- Set the After Photo mode (☞ Item ② in sect. 4.4.6j), beam blanking time, beam blanking method (☞ Item ③ in Sect. 4.4.6j) and delay time (☞ Item ④ in Sect. 4.4.6j).

- ☞ The electron beam is cut off for a specific period of time, called the blanking time, just before the shutter opens.
- ☞ The electron beam is cut off for a specific period of time, called the delay time, is the period of time just before the shutter opens after the blanking time has elapsed.
- ☞ The "Enter" key should be depressed to enter all the information set in this step.

3. Set the PHOTO SET mode.
 - a. Select "Photo Set" on the MDS screen.
 - b. Set the image brightness, magnification and photographing condition.

 Generally, the electron beam is converged and the field of view is narrowed as much as possible and the manual exposure mode is used for photographing in this mode.
4. Set the SEARCH mode.
 - a. Select "search" on the MDS screen.
 - b. Set the image brightness, magnification and photographing condition for field searching.

 Generally, a low magnification is selected, the electron beam is diverged to make the beam density on the screen minimum and the manual exposure mode is used for photographing in this mode.
 - c. Select the DIFF mode.

 A low magnification image appears when the DIFF FOCUS is shifted largely after diverging the beam as much as possible.
5. Set the FOCUS mode.
 - a. Select "Focus" on the MDS screen.
 - b. Set the focusing condition.

 The magnification higher than that used for in the PHOTO SET mode is selected. The beam should be converged as much as possible (converged to the area where the image focusing is narrowly carried out).
6. Repeat the condition setting in the SEARCH→FOCUS→PHOTO SET modes in this order to make the beam deviation minimum.
7. Select "Focus" on the MDS screen to obtain the FOCUS mode.
8. Depress the IMAGE SHIFT switch (L1-⑤) or "DEF Select-IS1" on the "Alignment Panel for Maintenance" screen.
9. Bring the electron beam to the position where image focusing is performed using the SHIFT knobs (L1-⑧, R1-③).
10. Bring the field of view for focusing to the screen center using the DEF/STIG knobs.

 The field of view for focusing should not overlap the field of view for beam illumination area selected in the PHOTO SET mode.
11. Make sure that the condition in each mode is correctly set.
12. Search the field of view to be photographed in the SEARCH mode.
13. Focus the image in the FOCUS mode.
14. Carry out photographing.
 - a. Depress the PHOTO switch (R1-⑧).

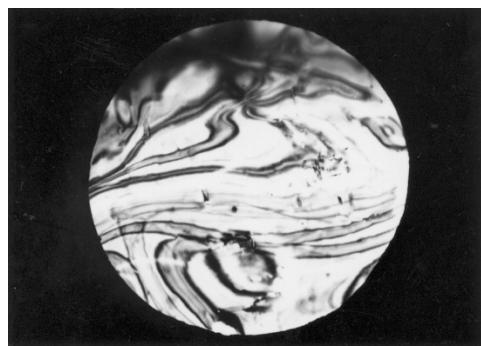
The PHOTO mode is automatically selected and photographing is performed. The "After Photo" mode is automatically selected after completion of the photographing.
 - b. Select "OFF" on the MDS screen to obtain the conventional photographing mode.

5.5 ELECTRON DIFFRACTION

5.5.1 Selected Area Diffraction

An electron beam passing through the small area limited by a field limiting aperture forms a selected area diffraction pattern.

1. Obtain a conventional image on the screen.
2. Depress the SA MAG switch (R1-②) to obtain the SA MAG mode.
3. Manipulate the MAG/CAM L knob (R1-⑤) to select a magnification to be used.
4. Bring a field of view to be used to the screen center using the triangle buttons or trackball ( Sect. 4.2.5).
5. Insert a field limiting aperture into the electron beam path.
A selected area image appears on the fluorescent screen.
6. Turn the BRIGHTNESS knob clockwise to darken the image as much as possible.
7. Depress the SA DIFF switch (R1-②) to obtain the SA DIFF mode.
A diffraction diagram appears on the screen.
8. Manipulate the MAG/CAM L knob (R1-⑤) to select a camera length to be used.
9. Manipulate the DIFF FOCUS knob to make the diagram clear.



a: Selected area image



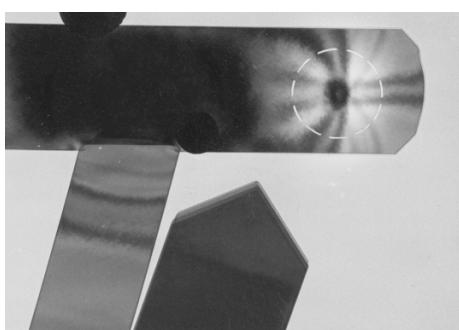
b: Selected area diffraction image

Fig. 5.39 Selected area diffraction

5.5.2 Microbeam Electron Diffraction

A finely converged electron beam, illuminating only a very small area on the specimen, forms a diffraction pattern in this method (also called “microarea”, “nanoarea”, or “converged” electron diffraction).

1. Obtain a conventional image on the screen.
2. Depress the MAG1 (R1-③), and select the desired magnification in the TEM mode.
3. Select a magnification to be used using the MAG-CAM L knob (R1-⑤).
4. Bring a field of view to be used to the screen center using the triangle buttons or trackball (☞ Sect. 4.2.5).
5. Focus the image using the OBJ FOCUS knob (R1-⑥).
6. Carry out the multiple-exposure (☞ Sect. 5.2.6d) to carry out the first photograph.
7. Depress the NBD switch (L1-③) to obtain the NBD mode.
8. Converge the beam using the BRIGHTNESS knob (R1-⑥).
9. Manipulate the SPOT SIZE knob (L1-③) to select the spot size value.
10. Move the electron beam to the field to be studied using the left and right SHIFT (L1-⑧, R1-③).
11. Depress the SA DIFF (R1-②).
12. Select a camera length using the MAG-CAM L knob (R1-⑤).
13. Adjust the size of the diffraction spot by varying the α -SELECTOR knob (L1-③) and changing the condenser aperture size.
14. Depress the MAG1 switch (R1-②) to obtain the MAG mode.
15. Carry out the second exposure in the multiple-exposure mode.
16. Depress the SA DIFF switch (R1-②).
17. Record the pattern in the manual exposure mode (the exposure time of about 30 seconds will be suitable).



a: Beam spot and image



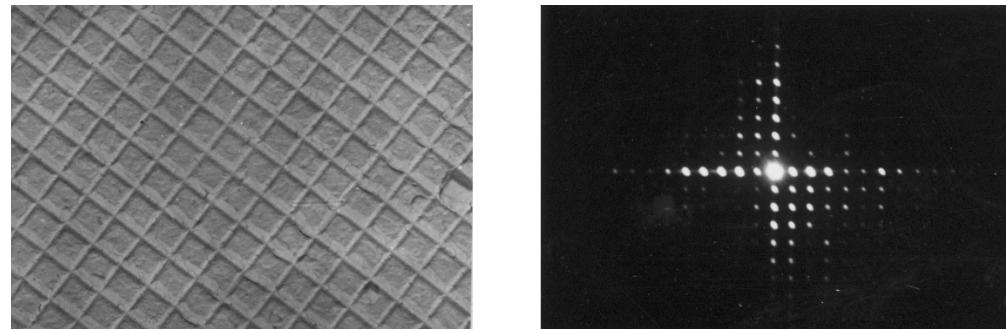
b: Microbeam diffraction pattern

Fig. 5.40 Microbeam electron diffraction

5.5.3 High Dispersion Electron Diffraction

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

1. Obtain a conventional image on the screen.
2. Depress the MAG1 (R1-③), and select the desired magnification in the TEM mode.
3. Select a magnification to be used using the MAG-CAM L knob (R1-⑤).
4. Select a field of view to be studied.
5. Carry out the photographing.
6. Depress the LOW MAG switch (R1-②) to obtain the LOW MAG mode. 4.2.5).
7. Set the magnification to about 500 times.
8. Focus the image using the OBJ FOCUS knob (R1-⑥).
9. Manipulate the BRIGHTNESS knob (L1-⑥) to diverge the beam to the extent where the entire specimen image appears.
10. Bring the field of view to be studied to the screen center.
11. Insert a small condenser aperture (10 or 20 μm in dia.).
12. Insert the objective aperture of 5 μm into the beam path and center it.
13. Carry out photographing if necessary.
14. Depress the SA DIFF switch (R1-②).
15. Select a camera length (longer than 400 cm) using the MAG/CAM L knob.
 -  The camera lengths that can be varied are 8 to 200 cm, 400 cm and longer and 3303 cm. The 8 to 200 cm camera lengths are for selected area electron diffraction, the 400 cm and longer camera lengths are for high dispersion electron diffraction, and the 33.3 cm camera length is for high resolution electron diffraction.
16. Make sure that a direct spot is on the screen. If the spot cannot be found, fined it as follows.
 - a. Turn the BRIGHTNESS knob (L1-⑥) clockwise.
 - b. Center the spot using the SHIFT knobs (L1-⑧,R1-③).
 - c. Depress the SA DIFF knob (R1-②) again.
 - d. Manipulate the DIFF FOCUS knob (R1-⑦) to clarify the spot.
17. Carry out the photographing in the manual exposure mode.



a: Micrograph of optical replica

b: Corresponding high dispersion diffraction pattern

Fig. 5.41 High dispersion diffraction

5.6 USE OF THE ANTICONTAMINATION DEVICE

Use of the anticontamination device reduces specimen contamination caused by electron beam irradiation. Therefore, this device is useful in that valuable specimens can be preserved after the completion of microscopy. Also, specimens can be observed at high resolving power and at high magnification.

5.6.1 Filling the Refrigerant Tank

1. Make sure that the column pressure is lower than 0.1 Pa (10^{-3} Torr) and that the yellow lamp on the connector box does not light when the check button on the box is depressed
 - The state of the column vacuum is shown on the “Valve Status” screen (☞ Sect. 4.4.6g).
 - If the refrigerant tank is cooled with liquid nitrogen when the gauge reading is more than 0.1 Pa (that is, when the column pressure is not sufficiently low), the residual moisture in the column air will condense into water and settle on the trap. This will cause oxidation of the trap and charging with electrons, resulting in an increase of objective lens astigmatism and fluctuation of the electron beam.
 - If the yellow lamp on the connector box lights up when the check button is depressed, stop the instrument operation and contact the JEOL service representative.
2. Protect the viewing window glass with the covers provided.

CAUTION

Do not proceed to the next step without covering the window. Proceeding to the next step with uncovered window may crack the window glass due to liquid nitrogen splashing, causing serious damage to the microscope column interior.

3. Insert the funnel into the tank.
4. Fill the tank with liquid nitrogen and wait for 15 minutes.

CAUTION

- The room should be well ventilated while filling the refrigerant tank with liquid nitrogen in order to avoid any oxygen shortage.
- Always wear goggles and anti-frostbite gloves while filling the refrigerant tank with liquid nitrogen and discharging the tank, since the liquid nitrogen may gush from the tank and splash on the operator during filling and discharging.
- Use a steady step when filling the tank with liquid nitrogen and discharging the tank to avoid accidents.

5. Replenish the tank once again.

6. Remove the funnel from the refrigerant tank and place the cap on the opening.

 **Do not admit air into the column unless the trap temperature has risen to room temperature (☞ Sect. 5.6.2).**

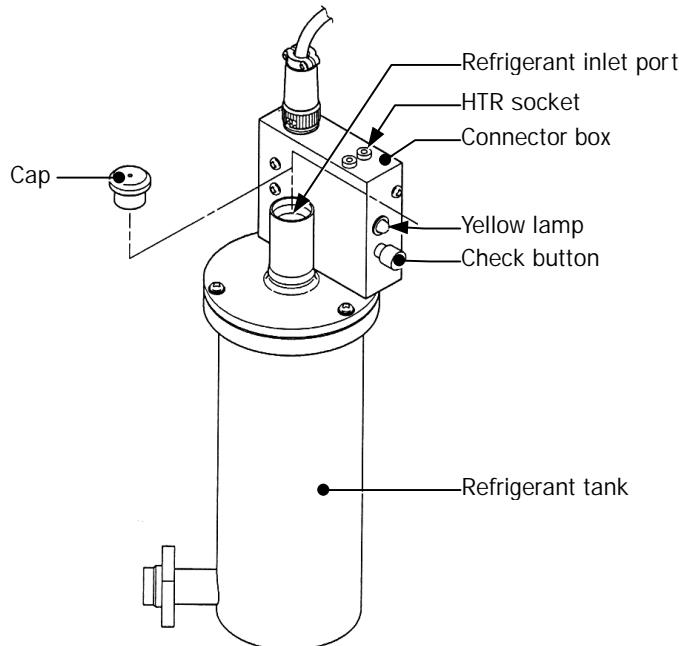


Fig. 5.42 Refrigerant tank

5.6.2 Raising the Trap Temperature to Room Temperature

If the microscope is turned in the day and night evacuation mode before returning the anticontamination device temperature to room temperature, a large amount of gases absorbed on the device cooling trap will be released during column evacuation. Such gas releases adversely affect the evacuation system.

Furthermore, if air is admitted into the column when the trap is cooled down, moisture in the air will condense and ice will form, the latter enveloping the trap. It is, therefore, necessary to raise the trap temperature to room temperature before admitting air into the column and turning the microscope in the day and night evacuation mode.

1. Place the cover provided on the viewing chamber window to protect the window glass from splashing liquid nitrogen on it.
2. Remove the refrigerant tank cap and put on goggles and anti-frostbite gloves.
3. Wear goggles and anti-frostbite gloves and refrigerant into the tank.
 - a. Lowering completely the protective cylinder.
 - b. Place the cylinder end over the fitting port on the tank.
 - c. Insert the refrigerant drainer and connect the drainer cable to the HTR socket on the tank.
4. Open the "Bake Out/ACD Heat" screen by selecting "Maintenance" on the "TEM Controller" main menu.
5. Select "ACD Heat" on the screen.
6. Click the ACD button on the screen.

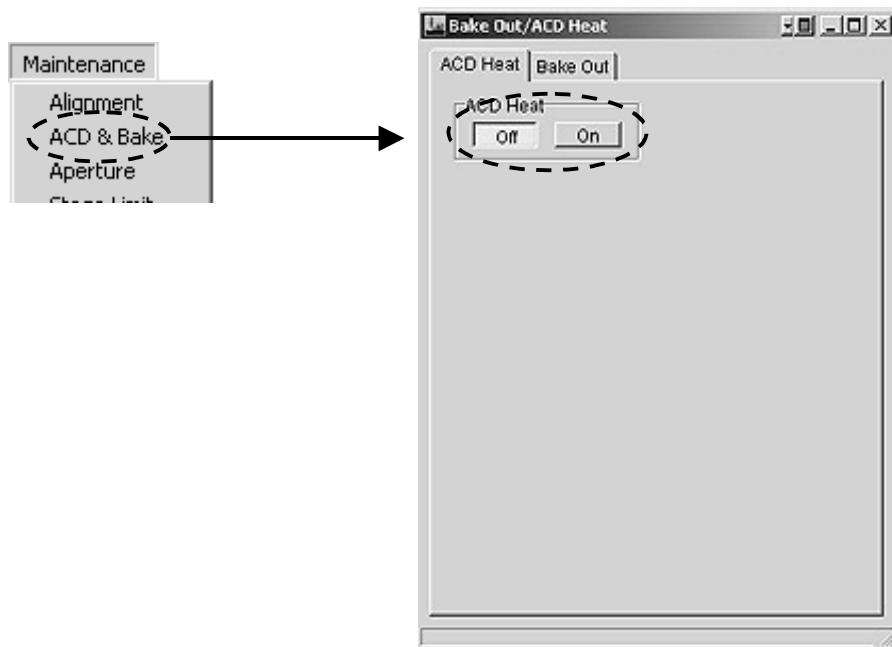


Fig. 5.43 Bake Out/ACD Heat screen

- ☞ If the refrigerant drainer cable is disconnected while the ACD HEAT button lamp is lit, the lamp will remain lit. In this case, connect the cable to the tank again, and wait for the lamp to go out.
- ☞ In order to terminate trap heating before the trap reaches room temperature, depress the "Off" button for few seconds on the screen.

⚠ CAUTION

Do not remove the drainer just after the ACD HEAT built-in lamp goes out. You may get burnt if you touch the drainer just after the lamp goes out, since the drainer is not cooled down.

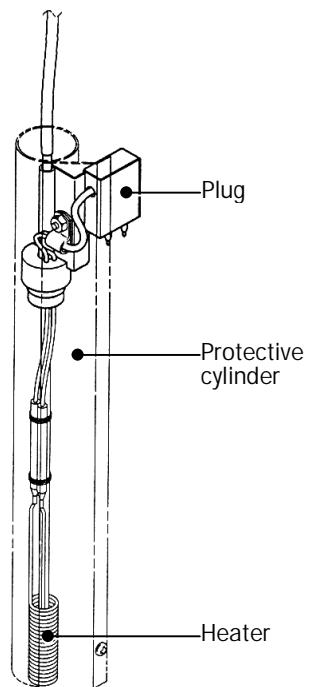


Fig. 5.44 Refrigerant drainer

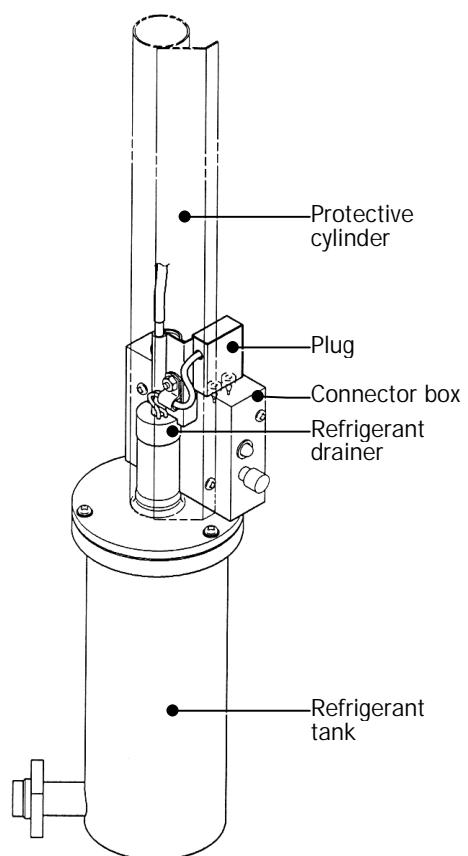


Fig. 5.45 Tank with drainer

5.7 SPECIAL OPERATION

5.7.1 Alignment Data Saving

The present alignment data can be saved and produced the condition by reading the saved data. This is useful to save the data of the alignment in the special condition. The saved data will be useful for accidental situation such as losing the beam.

5.7.1a Saving

1. Select "Maintenance" on the main menu on the "TEM Controller" screen to open the "Alignment Panel for Maintenance" screen.

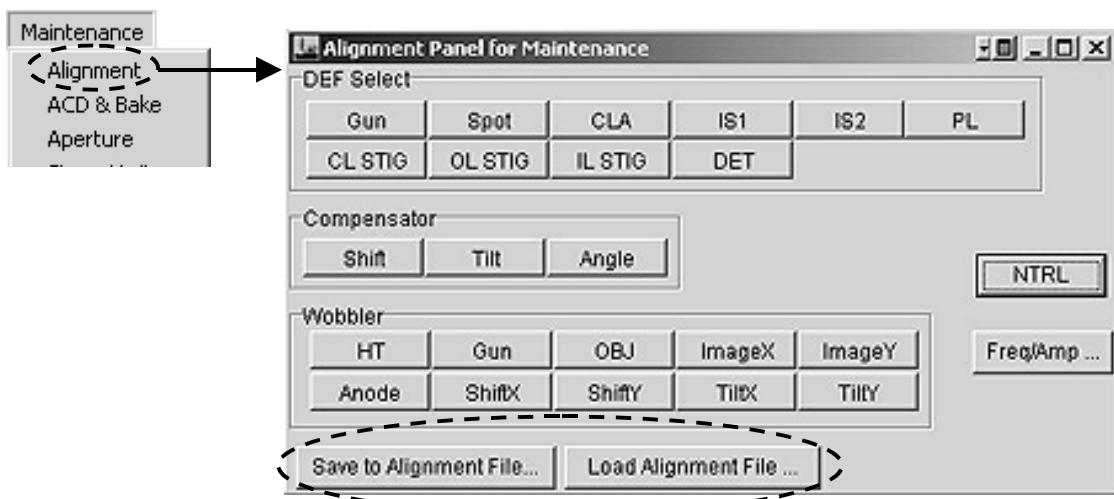


Fig. 5.46 Alignment Panel for Maintenance" screen

2. Depress "Save Alignment File..." button on the screen.
3. Determine the file name and save it.

5.7.1b File Reading

1. Select "Maintenance" on the main menu on the "TEM Controller" screen to open the "Alignment Panel for Maintenance" screen.
2. Depress "Load Alignment File...." button on the screen.
3. Select the file name and read it.

5.7.2 Free Lens Control (FLC)

You can freely vary each lens individually and create special lens conditions of use. Also, you can record and save the lens conditions that you created in FLC FILE.

1. Select "Option" on the main menu on the "TEM Controller" screen to open the "FLC Panel" screen (☞ Fig. 5.47).
2. Give a check mark to "On" for the lens to be controlled or "ALL".
3. Move the scroll bar on the screen to vary the lens current.
4. Click the "Save" button on the screen to save the file and click the "Load" button to read the file.

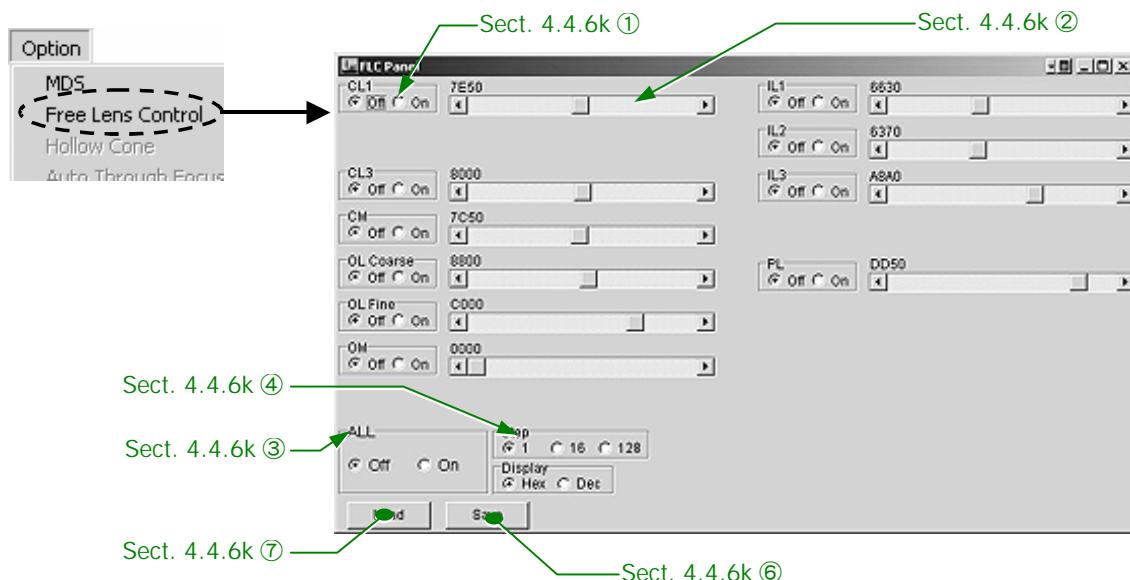


Fig. 5.47 FLC Panel screen

5. Give a check mark to "Off" for the lens to be turned off or give to "ALL-Off" to terminate the FLC (Free Lens Control) mode operation.

When the screen is closed without giving a check mark to "ALL-Off", the FLC is left functioning.

5.8 APPENDIX

All the parts to be exchanged periodically are listed in this section. Consult a JEOL service representative at the time limit of the part(s) exchanging.

5.8.1 Microscope Console and Column

 The parts marked with an asterisk are not required exchanging if no abnormality is found on them.

Part name	Specification	Exchanging frequency
Condenser aperture	$\phi 10 \mu\text{m}$ (PT)	Every 5 years*
Condenser aperture	$\phi 40 \mu\text{m}$ (PT)	Every 5 years*
Condenser aperture	$\phi 100 \mu\text{m}$ (PT)	Every 5 years*
Condenser aperture	$\phi 200 \mu\text{m}$ (PT)	Every 5 years*
Field limiting aperture	$\phi 10 \mu\text{m}$ (VMP)	Every 5 years*
Field limiting aperture	$\phi 20 \mu\text{m}$ (VMP)	Every 5 years*
Field limiting aperture	$\phi 50 \mu\text{m}$ (VMP)	Every 5 years*
Field limiting aperture	$\phi 100 \mu\text{m}$ (VMP)	Every 5 years*
Nylon tubes	AS-4-50-06(4×6)	Every 5 years
Urethane tubes	UF-25-08-08(5×8)	Every 5 years
Nylon tubes	AS-4-35-08(6×8)	Every 5 years
Vinyl hoses	TR-12(12×18)	Every 5 years
HT EVAC LINE	18×42×1000	Every 5 years
Solenoid valves	AD11-10A-03A-24V	Every 5 years
Regulating valve	INA-13-956-A-00	Every 5 years
Pressure meter	S-130	Every 5 years

5.8.2 Objective Aperture

The specification of the objective apertures differs depending on the instrument configuration.

5.8.2a UHR, HR and HT configurations

Part name	Specification	Exchanging frequency
Aperture	$\phi 5-30-40-60 \mu\text{m}$ (CU)	Every 5 years*

5.8.2b CR and HC configurations

Part name	Specification	Exchanging frequency
Aperture	$\phi 5-15-30-50 \mu\text{m}$ (CU)	Every 5 years*

5.8.3 Vacuum Pumps

The specification of the parts to be exchanged differs depending on the evacuation system used in the instrument.

5.8.3a EM-23075 evacuation system

Part name	Specification	Exchanging frequency
Nylon tube	AS4-50-04(2.5×4)	Every 5 years
Gum hose	(603×13.4, black)	Every 5 years
Nylon tube	AS4-50-06(4×6)	Every 5 years

5.8.3b EM-23078 evacuation system

Part name	Specification	Exchanging frequency
TMP damper	PM006492-X	Every 3 years
PEG gauge head	PR25, DN25KF	Every 1 year
Nylon tube	AS4-50-04 (2.5×4)	Every 5 years
Gum hose	6.3×13.4	Every 5 years
Nylon tube	AS4-50-04 (4×6)	Every 5 years
Regulating valve	INA-13-956-A-00	Every 5 years
Pressure meter	S-130	Every 5 years
Urethane tube	6.5×10, UF-25-10 blue	Every 5 years
Oil mist filter	DT-250-25A	Every 5 years
Gum hose	18×42×1000	Every 5 years

5.8.3c EM-23080 evacuation system

Part name	Specification	Exchanging frequency
Gum hose	18×42×1000	Every 5 years
Regulating valve	INA-13-956-A-00	Every 5 years
Pressure meter	S-130	Every 5 years
Urethane tube	6.5×10, UF-25-10 blue	Every 5 years
Oil mist filter	DT-250-25A	Every 5 years
Gum hose	18×42×1000	Every 5 years
RP oil	MR-100-IL	Every 2 years
V-belt		Every 2 years

5.8.3d EM-23085 evacuation system

Part name	Specification	Exchanging frequency
TMP damper	PM006459-X	Every 3 years
Nylon tube	AS4-50-06 (4×6)	Every 5 years
Oil mist filter	DT-250-25A	Every 5 years
Gum hose	18×42×1000	Every 5 years
RP oil	MR-100-1L	Every 2 years
V-belt		Every 2 years