INSTRUCTIONS

JEOL

JSM-T200

SCANNING MICROSCOPE

No.ISM-T200-1
〔EP165001〕

JEOL LTD./JEOL TECHNICS LTD.

Tokyo Japan

7912003KP

The Model T200 Scanning Microscope has been developed under the design philosophy of combining simple operation, simple maintenance, and high performance. Accordingly, quality micrographs comparable to those obtainable by a large instrument can be readily obtained without any special skill.

These features together with the various advantages peculiar to the scanning microscope, such as very large depth of focus, wide magnification range, and minimal specimen preparation, make the T200 a most effective instrument for research work, quality control, and as a visual education aid.

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CHAPTER 1 INTRODUCTION

1.1 GENERAL

The scanning electron microscope is a comparatively recent addition to the microscope family and is proving to be very popular along with the long established light and transmission type electron microscopes.

In spite of their merits and demerits, each type of microscope has its role to play depending on the field of application. For example, if a high resolving power and large depth of focus is not called for, a light microscope would be ideal. Where a very high resolving power is required, a transmission electron microscope would be necessary. However, when using a transmission electron microscope, the specimen must be very thin (less than 1 μm (10,000 Å) in thickness), a factor which requires a great deal of skill on the part of the user in order to prepare such specimens.

The scanning electron microscope, on the other hand, offers a fairly high resolution and moreover, since it is possible to use bulk specimens (specimen thickness being of no consequence), specimen preparation is easy. In addition to which, the depth of focus is large, thereby enabling 3-D observation.

The operational principle of the scanning electron microscope is illustrated in Fig. 1.1. A finely focused electron probe is made to scan the specimen, resultant upon which, secondary and backscattered electrons, etc. (Fig. 1.2) are emitted from the surface of the specimen. These signals are then detected by a detector and outputted via an amplifier to a synchronously scanned CRT as an intensity variation signal. The CRT raster width divided by the electron probe scanning width gives the image magnification.

By adding an appropriate detector (optional) to the standard T200, transmitted electron images, cathodoluminescence images, etc. can be observed in addition to secondary and backscattered electron images. Further, by incorporating an X-ray detector, X-ray analysis becomes possible.

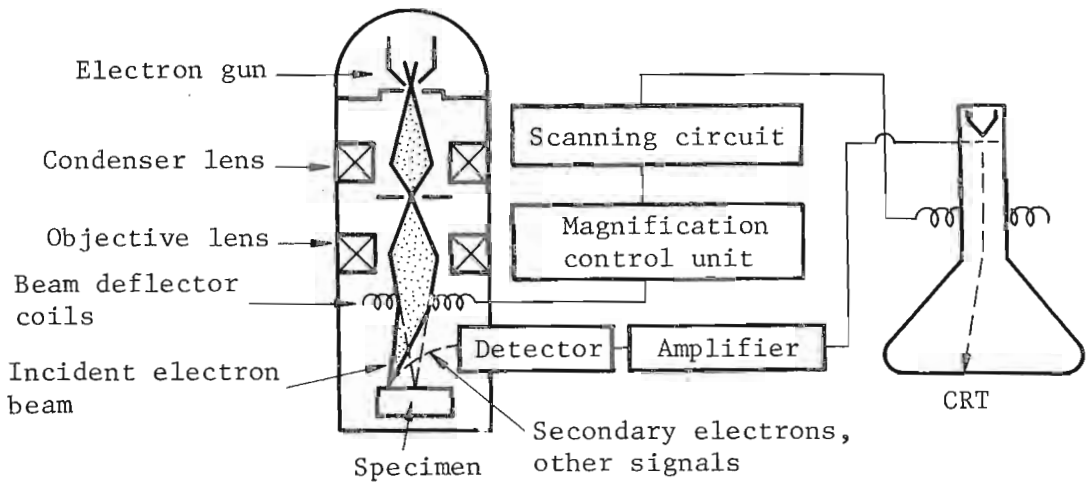


Fig. 1.1 Principle of scanning electron microscope

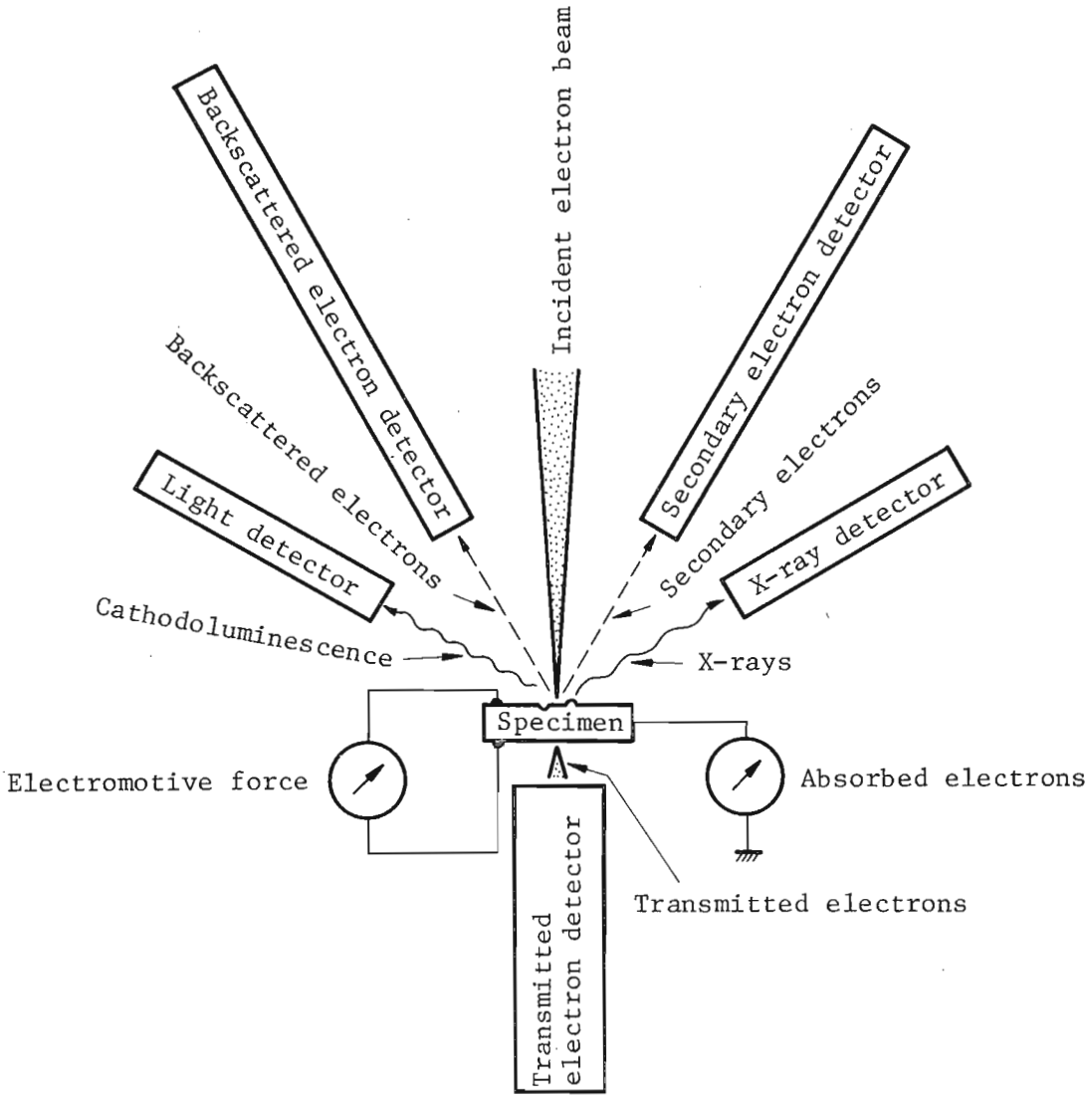


Fig. 1.2 Signals emitted by specimens

1.2 Specifications

1. Technical data

■ Performance

Resolution:	10 nm (100 Å) at 25 kV and 20 mm working distance.
Magnification:	15× to 100,000× (15× available at working distance 48 mm only).

■ Electron optical system

Accelerating voltage:	2, 5, 10, 15, 25 kV.
Electron gun filament:	Precentered cartridge tungsten filament.
Lens system:	3-stage demagnifying system (2-stage condenser lens and objective lens).
Alignment:	Mechanical.
Stigmator:	8-pole electromagnetic type.
Image fine shift:	Up to ±10 μm (25 kV) in any direction; electromagnetic, joystick control.

■ Specimen stage (twin stage)

Specimen stage	I (Eucentric specimen stage)	II (Large specimen stage)
Specimen accomodation	Up to 10 dia. × 10 thick*(mm)	Up to 76.5 dia. × 25.5 thick** (mm)
Range of movement	X: 10 mm Y: 20 mm	X: 40 mm Y: 40 mm
Tilt	-40° to +90°***	—
Rotation	360°	—
Working distance	20 mm	48 mm
Specimen exchange	By drawing out the stage	
Signal terminal	Optional (max. 48 pins)	

* 32 dia., 51 dia., 76.5 dia. (mm) optionally available.
** Up to 127.5 dia. × 25.5 thick (mm) possible.
*** 220° possible.

■ Scanning system

Secondary and backscattered electron detection*:	By a detector (comprizing a scintillator, a light pipe, a photomultiplier and a collector).
* Backscattered electron detector, which is capable of obtaining topographic and composition images, transmitted electron detector, cathodoluminescence detector, specimen current detector, X-ray detector:	Optionally available.
Scanning modes:	Frame scan (including TV scan), line scan and Y modulation.
Scanning speeds:	Visual ··· TV scan; 0.2, 0.33, 10 sec/frame. Line scan ··· 0.2, 0.33, 10 sec/frame. Record ··· 60 sec/frame.
Magnification:	35× to 100,000× (23 steps; series of 35, 50, 75, 100, 150, 200, 350, ·····). (15× available at WD = 48 mm).
Viewing area:	135 mm × 180 mm.
Cathode ray tube:	230 mm, green phosphor CRT (used for viewing and recording*). * A CRT exclusively used for recording is optionally available.

■ TV signal output terminal: BNC-R connector; VTR available; composite video signal output; positive polarity; output voltage 1 Vp-p; use of 75 ohm coaxial cable; scanning frequency — horizontal: 15.75 kHz, vertical: 60 Hz.

■ Recording system (complete with electromagnetic shutter and shutter button)

CSI-1:	Standard; Brownie roll film; 1 to 1/2 photographing ratio.
CSI-2:	Polaroid pack film; 1 to 3/4 photographing ratio (optional).
CSI-3:	35 mm roll film; 1 to 1/4 photographing ratio (optional).
CSI-4:	Polaroid sheet film; 1 to 1 photographing ratio (optional).

■Vacuum system

Operation:	Fully automatic.
Ultimate pressure:	7×10^{-4} Pa (5×10^{-6} Torr).
Vacuum gauge:	Pirani gauge.
Pump-down time:	About 30 minutes (from cold).
	Specimen exchange: About 2.5 minutes.
Oil rotary pump:	100 ℓ/min — 1 unit.
Oil diffusion pump:	420 ℓ/sec — 1 unit.
■Safety devices:	Devices for power failure, water failure and vacuum deterioration: built-in.
■Miscellaneous:	Service outlet: built-in (100 V, 2 A; used for operating optional attachments).
	The instrument can be wheeled on its own casters.

2. Installation requirements

■Power and water

Power:	100 V, 50/60 Hz, single phase, 2 kVA (basic instrument: 1.2 kVA; attachments: 0.8 kVA).
	Starting current 60 A (0.2 sec.)
	Fluctuation: less than ±10% (that also includes initial operation).
Ground terminal:	1 terminal, less than 100 Ω.
Cooling water:	Flow rate ··· 2 ℓ/min at 0.05 — 0.2 MPa ($0.5 - 2$ kg/cm^2).
	Temperature ··· 20 ±5 °C (water temperature at the outlet: not greater than 35 °C).
	Faucet ····· 1, 12 mm O.D.
	Drain ····· 1.

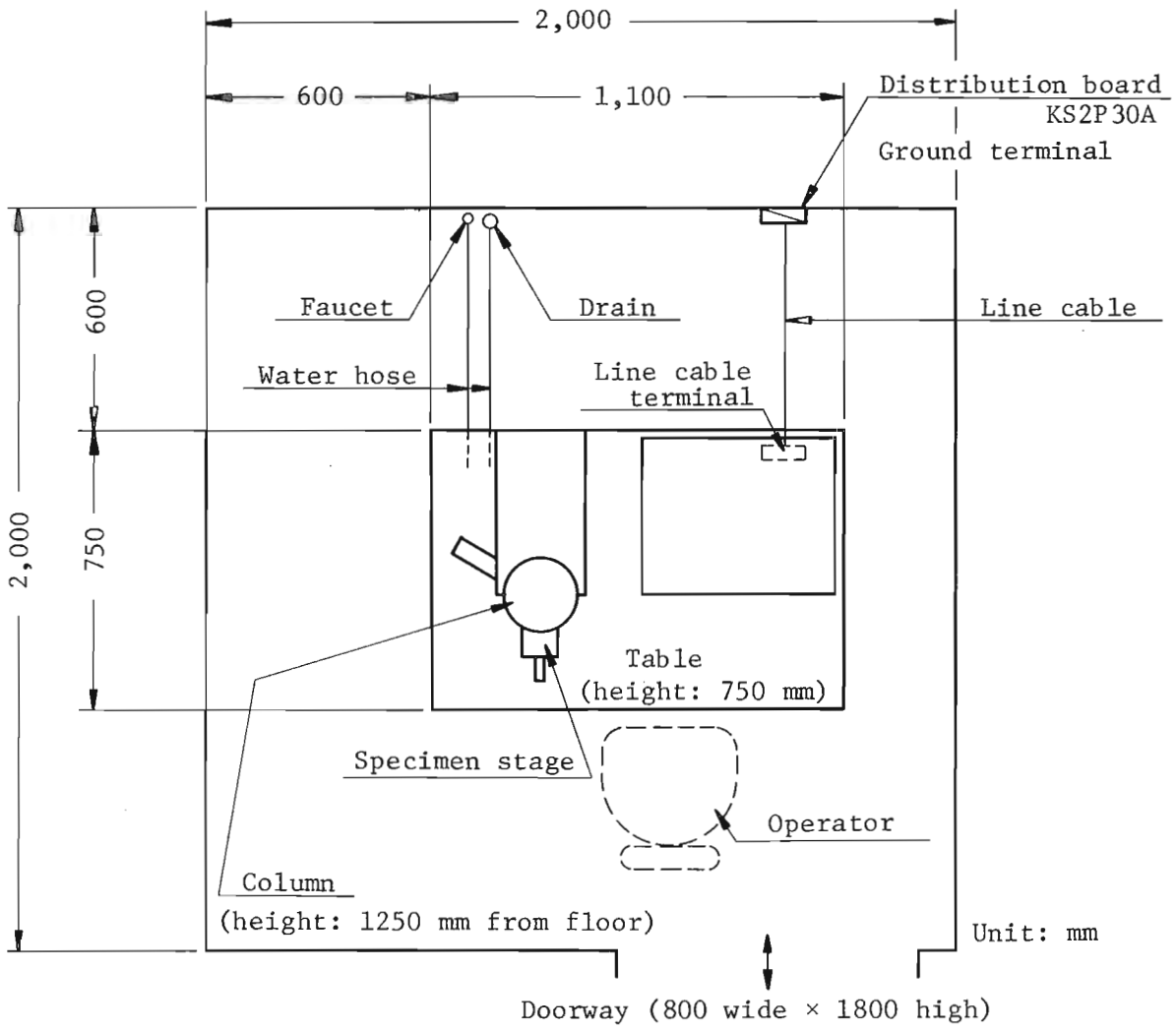
■Installation room

Room temperature:	20 ±5 °C.
Relative humidity:	Less than 80%.
Floor vibration:	Less than 2 μm p-p (5 Hz) in the X, Y and Z directions, less than 3 μm p-p (10 Hz) in the X, Y and Z directions, and less than 8 μm p-p (50 Hz) in the X, Y and Z directions (with the instrument installed).

Stray magnetic fields: Less than 0.3 μT (3 mG).

Note: The above specifications are subject to change without notice.

1.3 Layout, dimmensions and weight



Overall weight (basic instrument: about 280 kg)

CHAPTER 2 DESCRIPTION OF MAIN UNITS

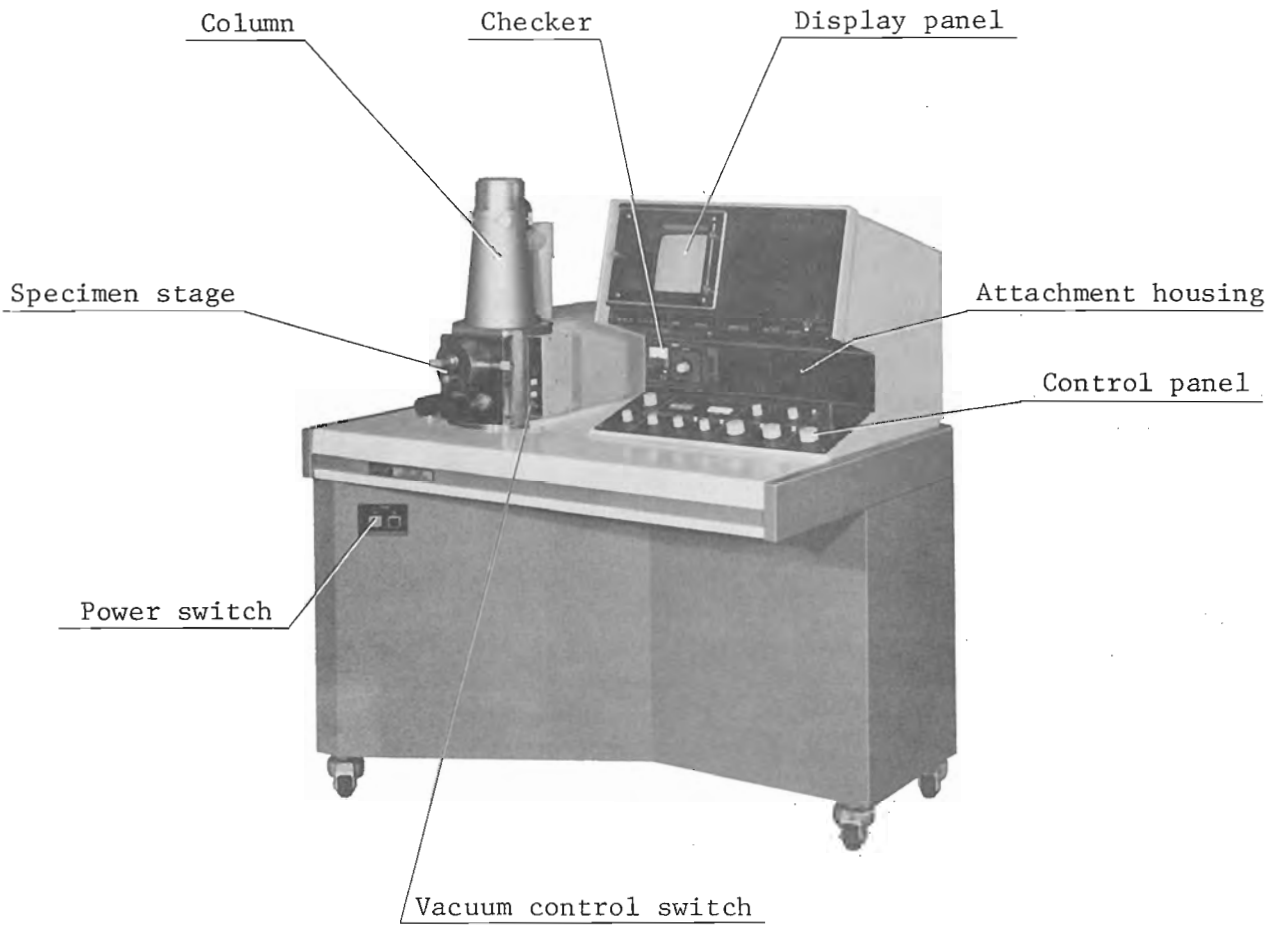


Fig. 2.1 General view of T200

2.1 Column and specimen stage

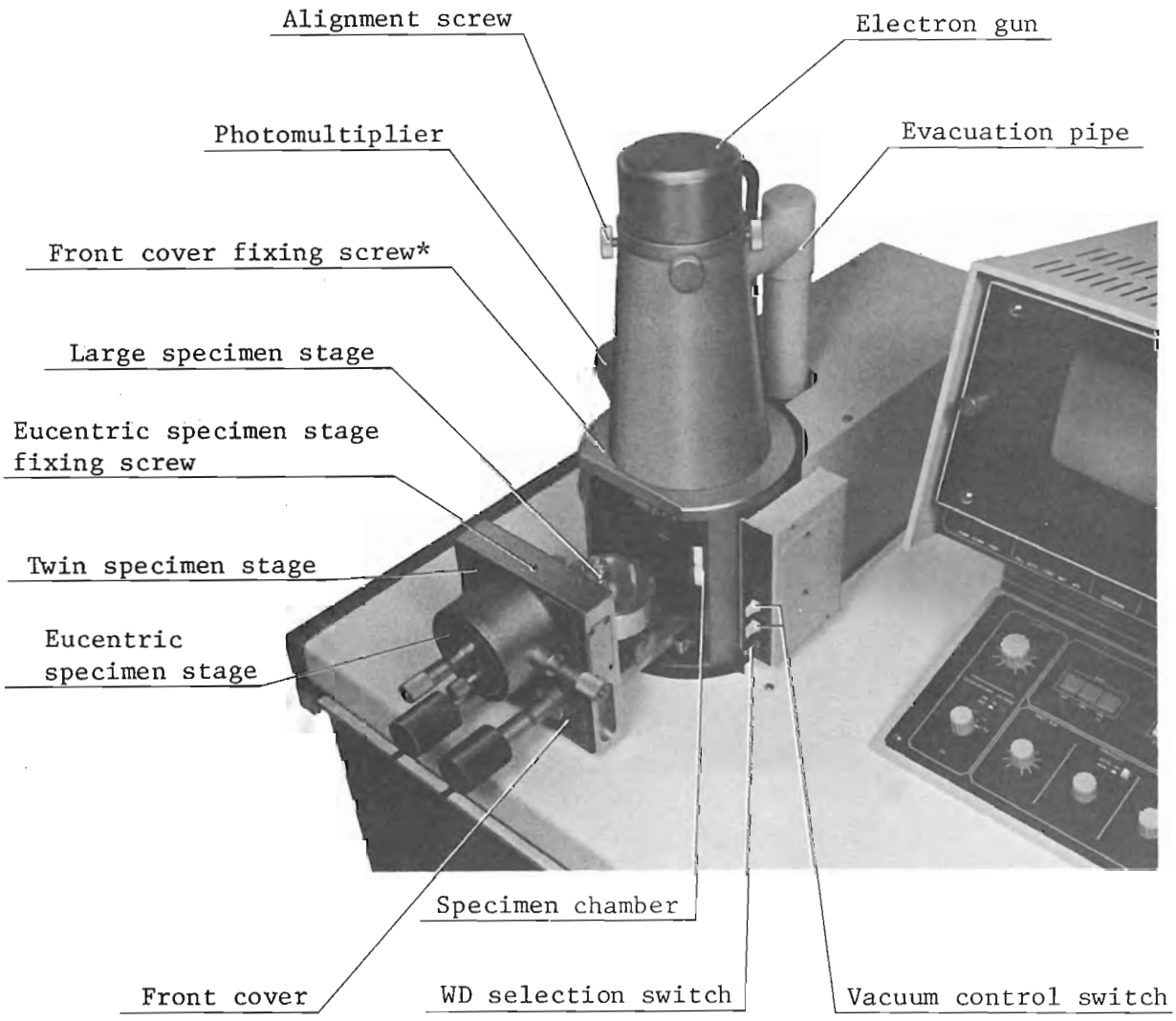


Fig. 2.2 Column and specimen stage

* *Used during transportation and when an attachment is attached.*

2.2 Display panel

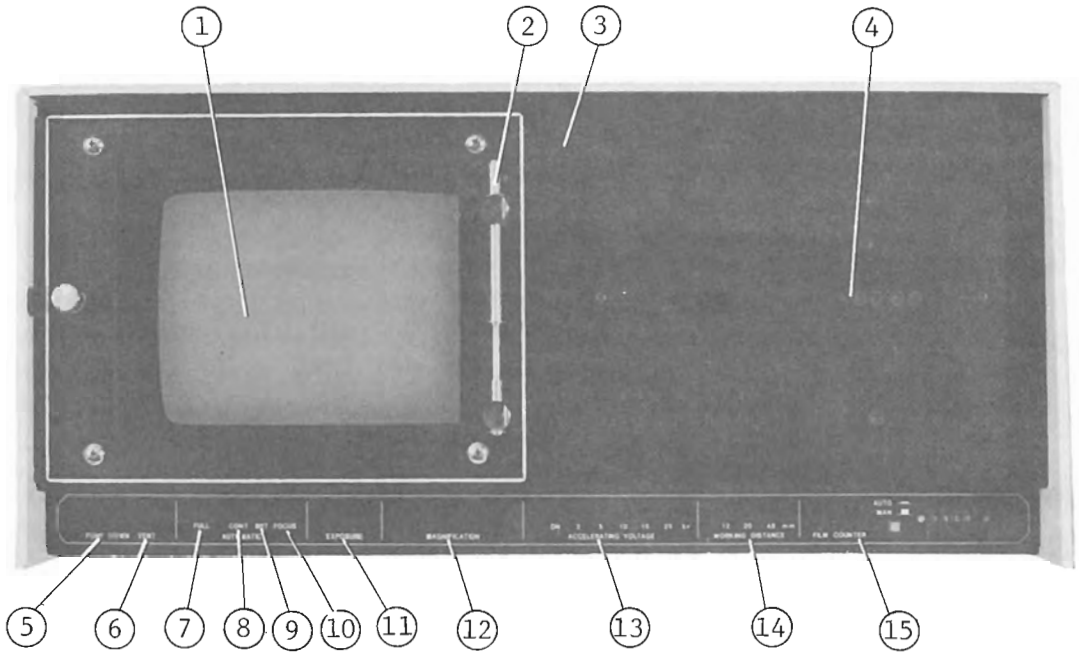


Fig. 2.3 Display panel

(1) CRT

(2) CSI photographic recording system mounting pin

(3) Connector for CSI

(4) Blank plate (to be removed when mounting an optional CRT for photography)

The display panel lamps indicate the operating state, etc. of the microscope as follows:

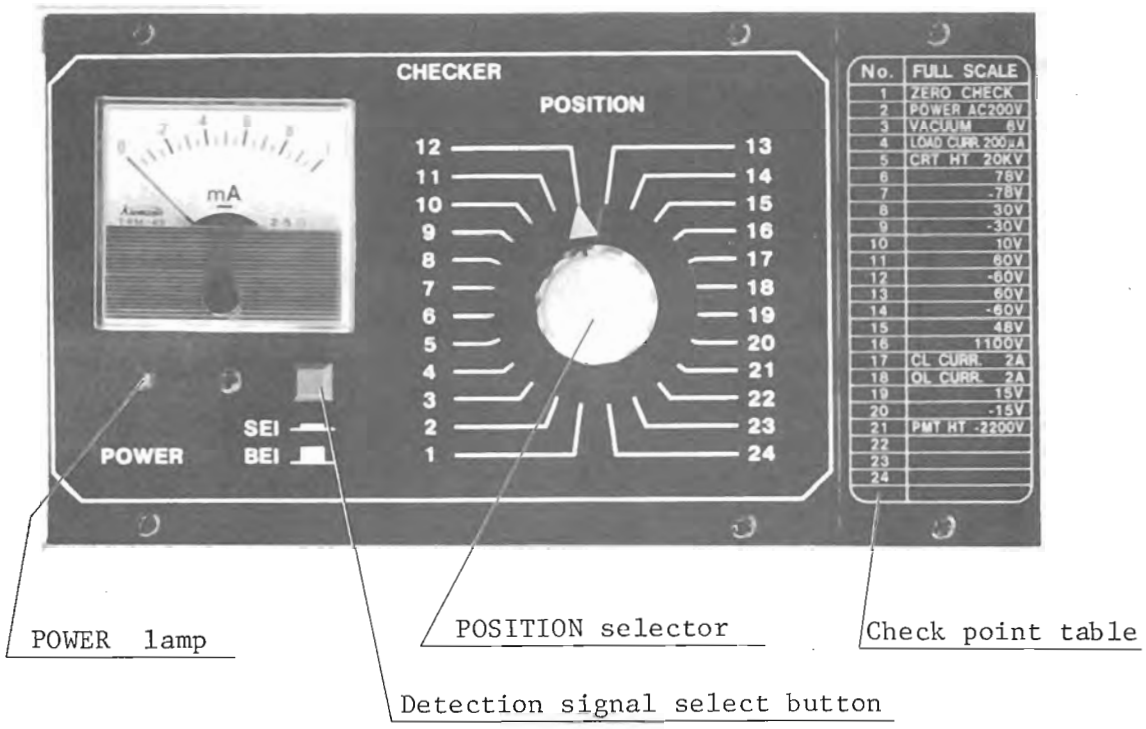
(5)	PUMP DOWN	Lights up and remains lit during column evacuation.
(6)	VENT	Lights up when the specimen chamber is exposed to the atmosphere.
	AUTOMATIC	The following lamps light up, indicating that the related function is being automatically controlled, when the respective buttons are depressed as indicated.
(7)	FULL	Lights up when the [ACCELERATING VOLTAGE] [ON/OFF] button is depressed.
(8)	CONT	Lights up when the [CONTRAST] [AUTO/MAN] button is depressed.

⑨ BRT	Lights up when the [BRIGHTNESS] [AUTO/MAN] button is depressed.
⑩ FOCUS	Lights up when the [FOCUS] [AUTO/MAN] button is depressed.
⑪ EXPOSURE	Lights up and remains lit during photography.
⑫ MAGNIFICATION	These LEDs (5), which do not function unless the microscope is in vacuo, are for digitally displaying the magnification of the CRT image. If the displayed magnification includes a decimal point, the displayed value is incorrect.
⑬ ACCELERATING VOLTAGE	The ON lamp lights up when an accelerating voltage is applied to the electron gun, and the respective lamps light up in accordance with the selected voltage. The selected voltage is printed out on the film.
⑭ WORKING DISTANCE	The respective lamps light up in accordance with the selected working distance. The selected working distance is printed out on the film.
⑮ FILM COUNTER	In the [MAN] mode, all four digits of the film identification number must be set manually by means of the four thumbwheels as provided. In the [AUTO] mode, however, the last two digits (displayed by LEDs) of the film identification number increase automatically each time a film is exposed until the displayed number reaches 99. However, the first two digits must be set manually.

2.3 Checker

This checker enables the operator to pinpoint a faulty circuit or unit by monitoring 21 voltages and currents.

1. Auto checker
   The auto checker automatically makes known a failure in any of the six main power supplies (check points 6, 7, 8, 9, 10 and 15 in Fig. 2.4). That is, if any of the voltages deviate by ±10% or more from the value listed, the POWER lamp goes off to indicate an abnormality. The actual power supply at fault is identified by positioning the POSITION selector at the above check points and noting the meter reading at each position.
2. The POSITION selector enables the operator to monitor 21 voltages and currents, including the above six main power supply voltages and various other operational parameters such as 0 V, mains power voltage, vacuum, load current, CRT and PMT high tensions, and CL and OL exciting currents. Check points 22 to 24 have been allotted for attachments.
   Note: When calling in your nearest JEOL Service Center in connection with the above, please indicate the check point/points at fault and the voltage or current reading/readings in question.



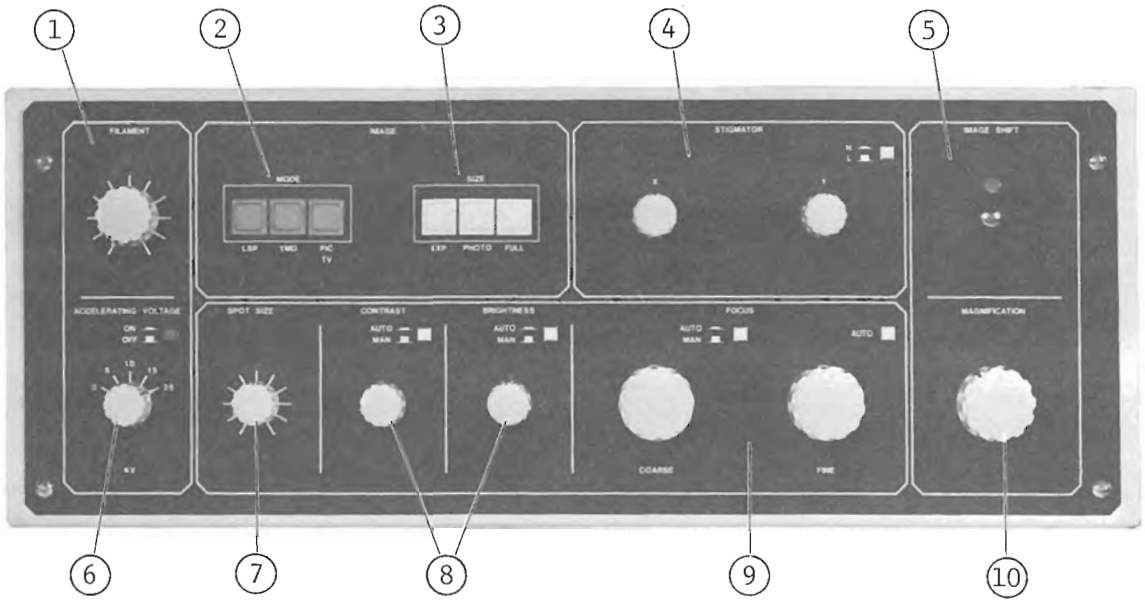
SEI: For observation of secondary electron images
BEI: For observation of backscattered electron images

Fig. 2.4 Checker panel

Check point table

No.	FULL SCALE	Measured value
1	ZERO CHECK	
2	POWER AC 200 V	
3	VACUUM 6 V	
4	LOAD CURR 200 μA	
5	CRT HT 20 kV	
6	78 V	
7	-78 V	
8	30 V	
9	-30 V	
10	10 V	
11	60 V	
12	-60 V	
13	60 V	
14	-60 V	
15	48 V	
16	1100 V	
17	CL CURR 2 A	
18	OL CURR 2 A	
19	15 V	
20	-15 V	
21	PMT HT -2200 V	
22	For attachments	
23		
24		

2.4 Control panel



(1) FILAMENT control

Controls the electron gun filament heating current.
Caution: To prevent overheating the filament which curtails the filament service life, avoid turning the control excessively.
When the filament burns out, the monitor lamp goes out.

(2) IMAGE MODE buttons

LSP : For observation of signal waveforms (slow scan only).
YMD : For observation of Y-modulated images (slow scan only).
PIC TV : For observation of slow-scan and TV-scan images.

(3) IMAGE SIZE buttons

EXP : For image focusing, astigmatism correction and exposure determination (by Rapid Exposure Marker).
PHOTO : For checking the photographing area.
FULL : For selecting the field of view.

(4) STIGMATOR controls

Used to correct astigmatism (that is, to obtain a perfectly round electron probe). When the astigmatism is corrected, the defocused image does not exhibit directional blurring. It is recommended that correction be carried out at a magnification of 10,000× or higher.

(5) IMAGE SHIFT joystick

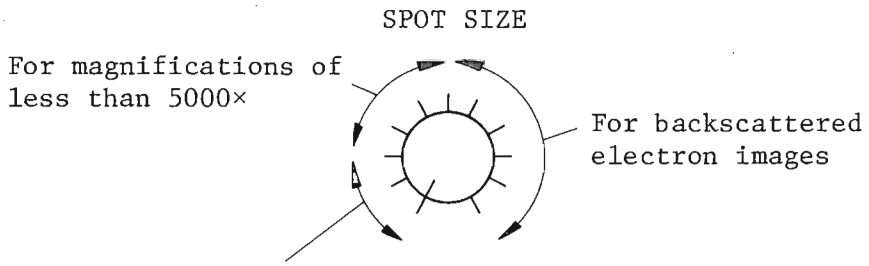
The joystick allows the image to be shifted electromagnetically up to ±10 μm.

⑥ [ACCELERATING VOLTAGE] control

Selects the accelerating voltage.

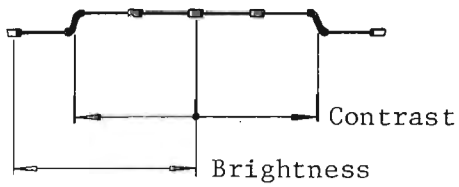
⑦ [SPOT SIZE] control

Changes over the size of the electron probe. Normally, this control is set at the 9 o'clock position. However, if the image appears grainy, turn the control clockwise until the graininess disappears.



⑧ [CONTRAST] and [BRIGHTNESS] controls

These controls adjust the image contrast and brightness. When the IMAGE [SIZE] [EXP] button is depressed, a rapid exposure marker appears on the CRT screen. By optimizing the exposure marker (as illustrated below) with the [CONTRAST] and [BRIGHTNESS] controls, an optimum image is obtained when the respective [AUTO] buttons are depressed.



⑨ [FOCUS] controls

These controls are for focusing the image on the CRT screen. By depressing the center and right [AUTO] buttons, the automatic focusing mode is established.

⑩ [MAGNIFICATION] cotnrol

Selects the magnification of the CRT screen image. The magnification is displayed on the display panel.

CHAPTER 3 OPERATION

3.1 Startup and shutdown

3.1.1 Startup

1. Open the water faucet to supply cooling water to the microscope (water flowrate: 1.5 to 2 ℓ/min).
   Caution: If the flowrate is increased beyond 2 ℓ/min, overcooling of the diffusion pump, for example, may take place.
2. After first turning on the mains power switch on the distribution board, depress the [POWER][ON] switch on the console front, left-side panel. By so doing, the [CHECKER] panel [POWER] lamp and display panel [PUMP DOWN] lamp light up and the rotary pump comes into operation.
   Note: Within 15 to 30 minutes, the [MAGNIFICATION] panel displays a magnification reading, indicating that the column vacuum has reached a degree sufficient for beam generation and specimen observation.

3.1.2 Shutdown

1. Depress the [POWER][OFF] switch.
   Notes: 1. If the column is not under high vacuum, evacuate the column by pushing the [PUMP DOWN] switch before depressing the [POWER][OFF] switch.
   2. If the microscope is going to be out of use for a prolonged period of time, be sure to evacuate the column to prevent corrosion.
2. Turn off the mains power switch, wait 10 to 15 minutes for the diffusion pump to cool down to room temperature, then close the water faucet.
   Note: Although it is preferable to wait 10 to 15 minutes for the diffusion pump to cool down to room temperature, shutting off the cooling water immediately after turning off the power switch has no adverse effect on the microscope.

3.1.3 Power failure

The microscope stops automatically. When power is restored, however, it is necessary to manually reactivate the microscope by depressing the [POWER][ON] switch.

3.1.4 Water failure

The microscope stops automatically. As in the case of power failure, when water is restored, it is necessary to manually reactivate the microscope by depressing the [POWER][ON] switch.

Note: Even when the cooling water is restored, depressing the [POWER][ON] switch will not reactivate the microscope unless the diffusion pump thermostat has cooled down to its normal operating temperature.

3.2 Specimen mounting

3.2.1 Specimen preparation

Although specimen preparation for scanning microscopy is fairly simple, satisfactory result will not be obtained unless the specimen are prepared according to their types and the purpose of observation. Refer to Appendix, Specimen preparation.

3.2.2 Eucentric specimen stage

1. Push the [VENT] switch to admit air into the column.
2. Wait about 40 seconds for the column to become fully exposed to the atmosphere, then draw out the front cover after first setting the tilt control to 0°.
3. Insert the specimen stub, complete with specimen, into the specimen holder, adjust the specimen height adjust screw so as to make the specimen flush with the holder rim, and secure the stub with the stub fixing screw (Figs. 3.2 and 3.3).
   Caution: If the specimen surface is not flush with the holder rim, the actual and displayed magnifications will differ, difference increasing as the working distance is reduced.
4. Return the specimen stage to the specimen chamber and push the [PUMP DOWN] switch.
5. Wait 2 to 3 minutes for the [MAGNIFICATION] indicator to display a reading. Almost immediately thereafter (10 — 20 seconds later), the image can be observed.

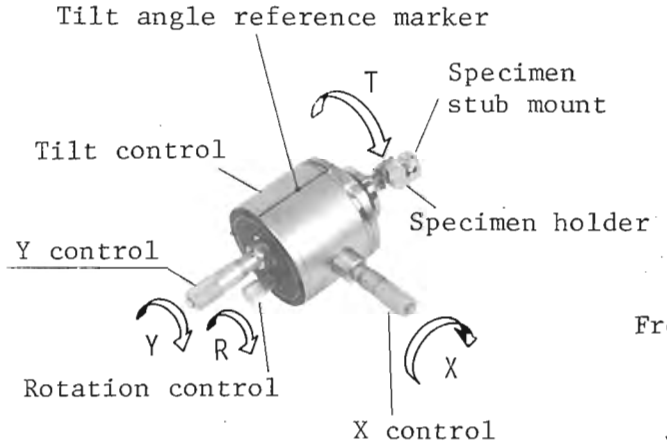
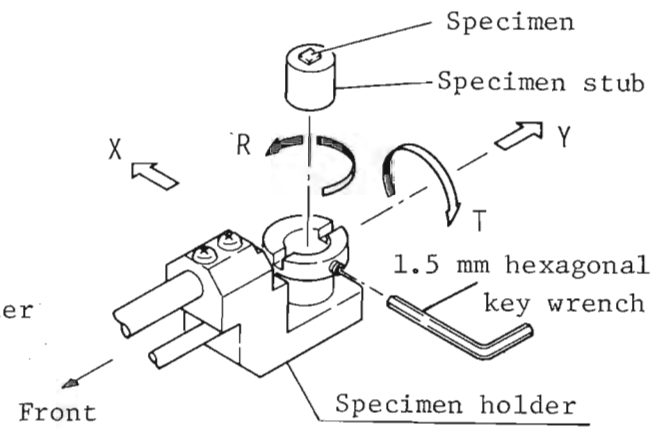
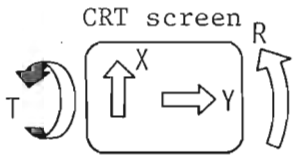


Fig. 3.1 Eucentric specimen stage





When both the X and Y controls read 5 mm, the electron beam is incident to the center of the specimen stub.

The directions of X, Y, T, and R arrows correspond to the respective rotated directions of the X, Y, T, and R controls (Fig. 3.1).

Fig. 3.2 Image movement on CRT screen

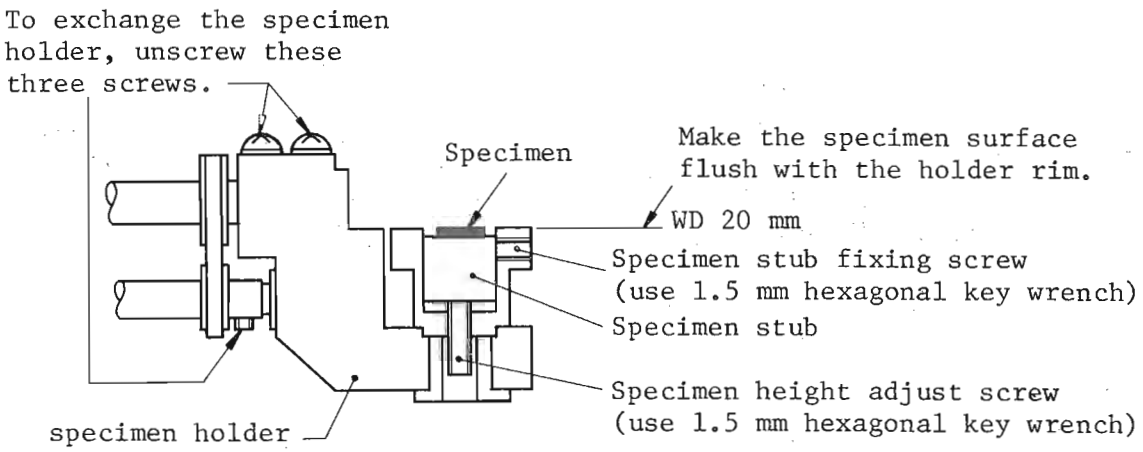
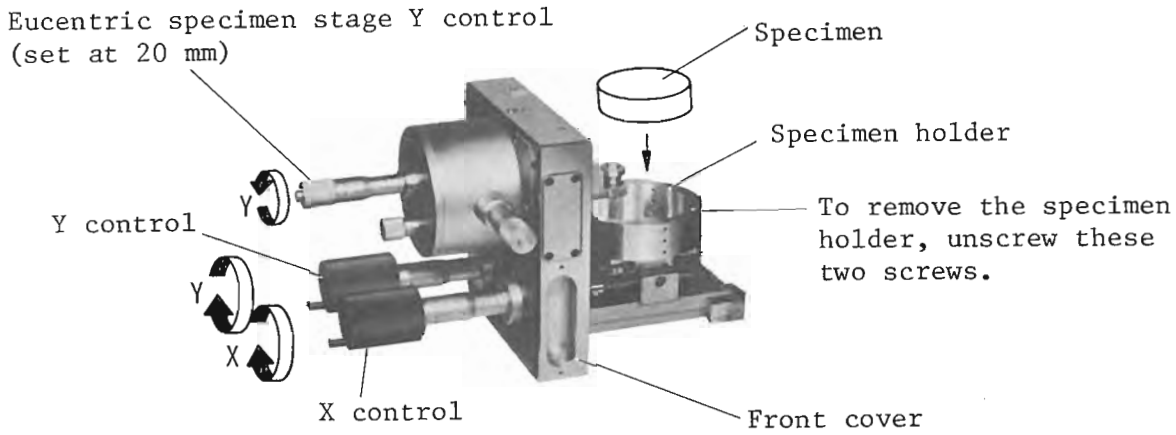


Fig. 3.3 Specimen height adjustment

3.2.3 Large specimen stage

1. Push the VENT switch.
2. Wait about 40 seconds for the column to be completely exposed to the atmosphere, then draw out the front cover after first setting the tilt control to 0°.
3. Set the eucentric stage Y control to 20 mm.
4. Insert the specimen in the holder, adjust the specimen height adjust screw so as to make the specimen flush with the holder rim, and secure the specimen with the specimen fixing screws (Figs. 3.4 and 3.5).
5. Return the specimen stage to the specimen chamber and push the PUMP DOWN switch.
6. Wait 2 to 3 minutes for the MAGNIFICATION indicator to display a reading. Almost immediately thereafter (10 — 20 seconds later), the image can be observed.

   Note: If the specimen is porous or prone to gas evolution, it will take longer to evacuate the column.



When both the X and Y controls read 20 mm, the electron beam is incident to the center of the specimen holder.

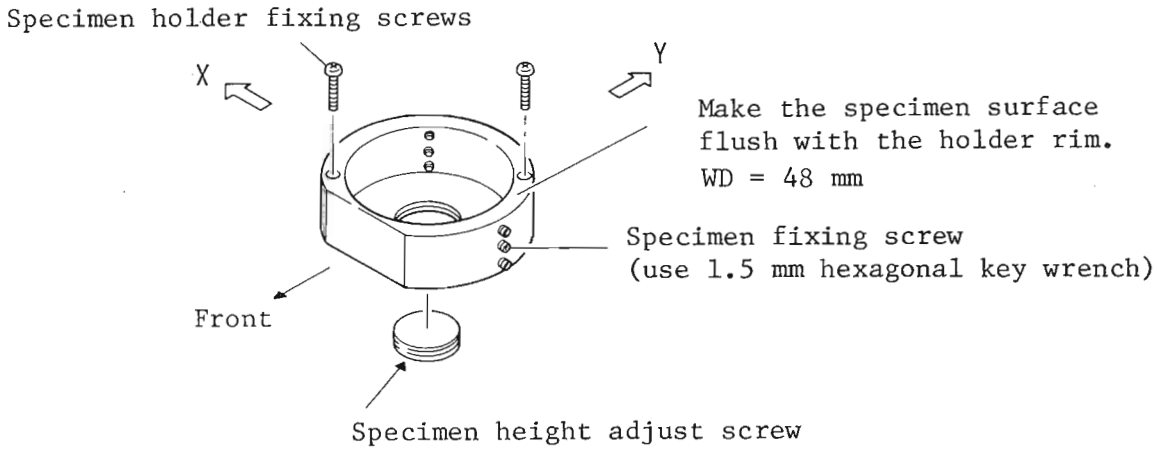
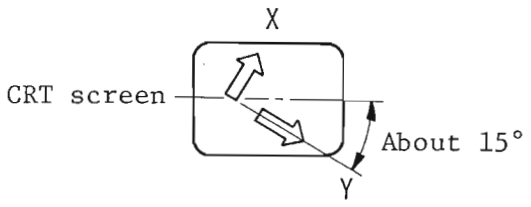


Fig. 3.4 Large specimen stage



The directions of X and Y arrows correspond to the respective rotated directions of the X and Y controls (Fig. 3.4).

Fig. 3.5 Image movement on CRT screen

3.3 Image observation

3.3.1 Secondary electron image (SEI)

Initial setting

1. Set the following specimen stage controls and WD selector as indicated.
   - Eucentric specimen stage
     - X control ..... 5 mm.
     - Y control ..... 5 mm.
     - Tilt control ..... Normally, about 30° (varies according to specimen topography).
   - WD selector ..... 20.
2. Set the following checker panel and control panel controls as indicated:
   - Checker panel
     - [SEI] switch ..... Depress.
   - Control panel
     - [FILAMENT] control ..... Fully counterclockwise.
     - [ACCELERATING VOLTAGE] control ..... 25 (kV).
     - [SPOT SIZE] control ..... 7 o'clock position.
     - [CONTRAST] control ..... Set so that the checker meter reads 0.22 with the [POSITION] selector at 21.
     - [BRIGHTNESS] control ..... Midway position.
     - [FOCUS FINE] control ..... Midway position.
     - [MAGNIFICATION] control ..... 35× — 500×.
     - [IMAGE SHIFT] joystick ..... Center.
     - [STIGMATOR] [X] and [Y] controls ..... Midway position. (If astigmatism correction has already been completed, leave these controls set where they are.)
     - [CONTRAST], [BRIGHTNESS] and [FOCUS] panel [AUTO/MAN] buttons ..... [MAN].

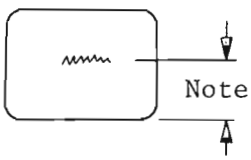
Observation

1. Depress (ON) the [ACCELERATING VOLTAGE] button. The raster now appears over the entire CRT screen.
2. Depress the [IMAGE][MODE] [LSP] and [IMAGE][SIZE] [EXP] buttons. A line should now appear on the lower part of the CRT screen. If not, gradually turn the [BRIGHTNESS] control clockwise until the line appears.

A line appears.

3. Turn the [FILAMENT] control to about the 11 o'clock position. The monitor lamp should now light up. If not, a burnt-out filament is indicated. In this event, replace it with a new one.
4. Gradually turn the [FILAMENT] control to about the 2 o'clock position. By so doing, the line referred to in step 2 above changes into a waveform and moves up towards the center of the CRT screen.
   Note: If the resultant waveform goes beyond the screen area, lower the waveform by turning the [BRIGHTNESS] and/or [CONTRAST] control(s) counterclockwise.

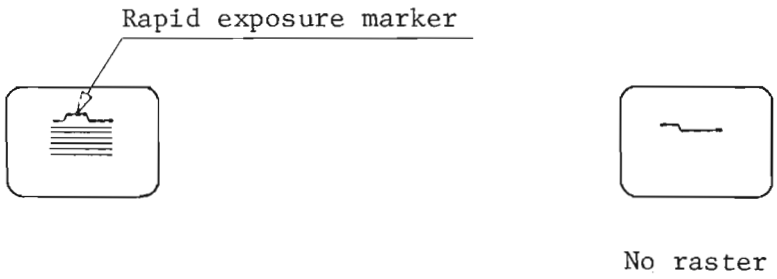
No electron beam



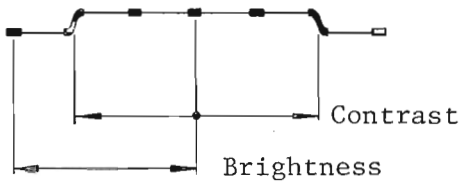
With electron beam

5. Turn the [FILAMENT] control beyond the 2 o'clock position until the waveform remains stationary regardless of how much further the control is turned.
   Note: As the control is turned beyond the 2 o'clock position, it will be noted that the waveform first moves down and then moves up before reaching the stationary state.
6. Once the stationary position has been established, slowly turn the [FILAMENT] control counterclockwise until the waveform starts to move down abruptly. Stop turning the control counterclockwise at this point and turn the control clockwise (just slightly) so as to position the control at the point just prior to where the waveform starts to fall (for details on the [FILAMENT] control setting procedure, see Sect. 3.6.1).

7. Depress the IMAGE MODE PIC button. The rapid exposure marker together with a raster should now be visible on the CRT.
   Note: If only the rapid exposure marker is visible, turn the BRIGHTNESS and/or CONTRAST controls clockwise until the raster appears.



8. Increase the magnification with the MAGNIFICATION control and focus the image with the FOCUS COARSE control.
9. Adjust the BRIGHTNESS and CONTRAST controls so as to obtain the rapid exposure marker pattern as shown below.
   Note: Adjust the CONTRAST control first so as to obtain five bars at the upper level. Then adjust the BRIGHTNESS control so as to make the center bar accord with the center of the rapid exposure marker.



10. Increase the magnification to the desired value and focus the image with the MAGNIFICATION and FOCUS controls.
    Note: When the magnification is considerably changed, the rapid exposure marker changes. In this case, readjust the related controls.

3.3.2 Backscattered electron image (BEI)

The initial settings and observation procedure in the case of BEI observation are the same as for SEI observation. However, in the initial settings, depress the BEI button instead of the SEI button and set the SPOT SIZE control to between 12 and 3 o'clock.

Note: If it is desired to observe an SEI during BEI observation, be sure to set the SPOT SIZE control at the 7 o'clock position before depressing the SEI button.

3.3.3 Adjusting the rapid exposure marker

This marker has been adjusted for optimum exposure, using ASA75 film and with the lens opening set at f/11, prior to factory dispatch. Accordingly, under normal circumstances, so long as the film speed and lens opening remain at ASA75 and f/11, respectively, it is unnecessary to adjust the rapid exposure marker. However, since optimum exposure varies somewhat depending on the condition and nature of the specimen, occasional adjustment may be necessary. Furthermore, adjustment will be necessary when it is required to take high and low contrast micrographs.

1. High contrast images
   In order to obtain a high contrast image, turn the [CONTRAST] control clockwise until the exposure marker bar appears beyond the standard white level bar as shown in Fig. 3.6. Since increasing the image contrast also increases the image brightness, it will be necessary to decrease the brightness by turning the [BRIGHTNESS] control counterclockwise until the extreme left bar (at the upper level) aligns with the black level bar.
2. Low contrast images
   In order to obtain a low contrast image, turn the [CONTRAST] control counterclockwise. Adjust the [BRIGHTNESS] control to compensate for the loss of image brightness (see Fig. 3.7).
3. Automatic image brightness and contrast control
   After first obtaining optimum image brightness and contrast at a magnification of about 1000×, establish the automatic control mode by depressing the AUTO/MAN buttons on the control panel. By so doing, the [CONT] and [BRT] lamps on the display panel light up.
   To set the image contrast and/or brightness as you desire, release the [AUTO/MAN] button on the [CONTRAST] and/or [BRIGHTNESS] panel(s) and adjust the related control(s).

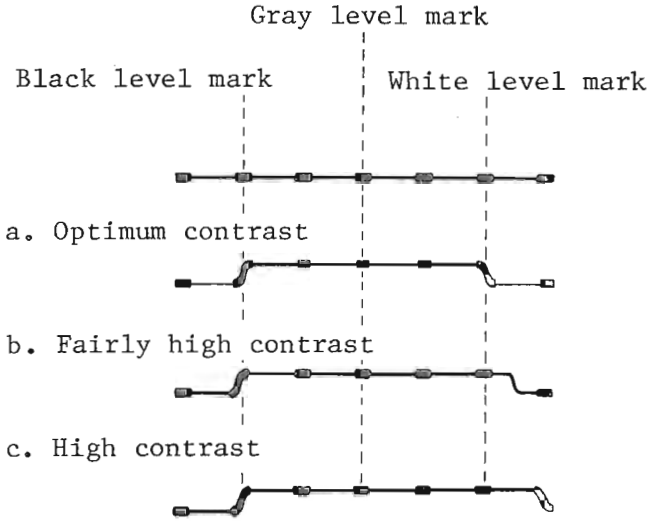


Fig. 3.6

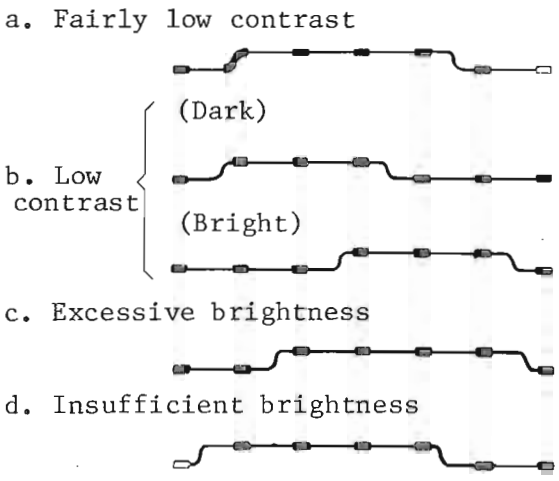


Fig. 3.7

3.3.4 Astigmatism correction

If the image exhibits directional blurring when the [FOCUS] [COARSE] (or [FINE]) control is turned about the in-focus position and, if when turning the control further the image exhibits blurring in a direction at right angles to said directional blurring, it will be necessary to correct the astigmatism as follows.

1. Depress the [L] button.
2. Set the two [STIGMATOR] controls to the 12 o'clock (i.e. neutral) position.
3. Turn the [FOCUS] [COARSE] (or [FINE]) control until the image blurring direction is clearly identifiable.
4. Turn the [STIGMATOR] [X] control clockwise and counterclockwise and ascertain the positions where the image blurring directions are mutually perpendicular. Once ascertained, set the control to midway between the two positions. That is, position the control so that the new image blurring direction bisects the orthogonal blurring directions (see Fig. 3.8 a, b, c).
5. Repeat the above procedure with the [STIGMATOR] [Y] control. The above procedure completes astigmatism correction (see Fig. 3.8 d).
6. Focus the image with the [FOCUS] [COARSE] and/or [FINE] controls.

Notes: 1. If any directional image blurring remains, repeat Steps 4 to 6.

2. If the image is in-focus, the presence of directional image blurring cannot be ascertained.

3. When checking for the presence of astigmatism, use a magnification higher than 10,000×.

4. If the above procedure fails to correct the astigmatism, use the [H] button instead of [L] button and repeat the same procedure.

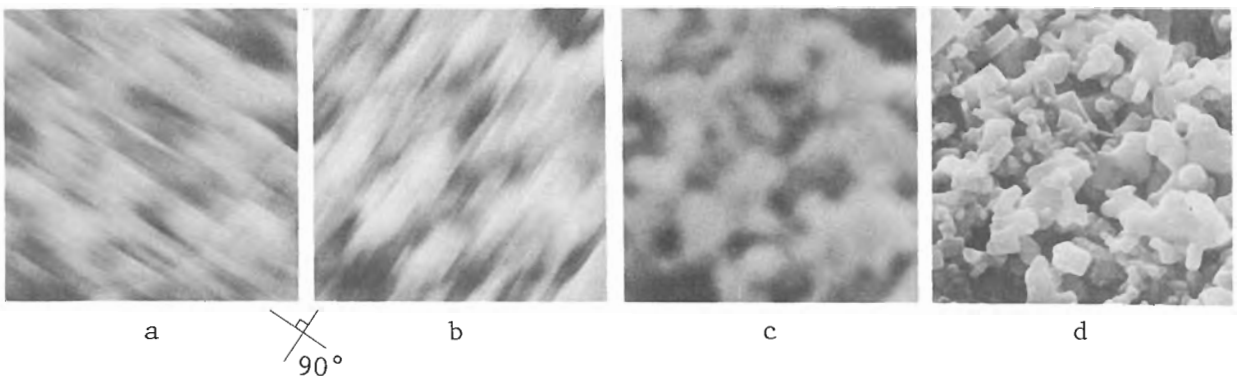


Fig. 3.8 Astigmatism correction

3.3.5 Automatic focus mode

1. Set the [FOCUS] [FINE] control to midrange.
2. Set the magnification to 10,000× and roughly focus the image with the [FOCUS] [COARSE] control.
3. Depress the [FOCUS] panel [MAN/AUTO] button. The display panel FOCUS lamp lights up.
4. When the magnification and/or field of view are/(is) changed, depress the right side [AUTO] button on the [FOCUS] panel.

Notes: 1. The automatic focus control circuit operates each time the [AUTO] button is depressed and the image is automatically brought into focus.

2. If the image does not come into focus, re-depress the [AUTO] button or change the field of view. If the image still remains out of focus, the field of view in question is outside the operating range of the automatic focus control circuit. In this case, use the [FOCUS] [COARSE] (or [FINE]) control to focus the image.

3. If the specimen surface is rough, only the high points or crests are brought into focus.

4. For high magnifications, correct the astigmatism fully prior to focusing.

3.4 FULL AUTO SEM images

When the following controls are set as indicated, the image automatically appears when the power switch is depressed.

- [FILAMENT] control: Optimum operating position (adjust the control once a day).
- [ACCELERATING VOLTAGE] button: Depressed.
- [MAGNIFICATION] control: Approx. 500×.
- [BRIGHTNESS] and [CONTRAST] controls: Optimum image positions.
- [AUTO] buttons: Depressed.

Note: Each time a used specimen is replaced by a new one, it will be necessary to push the [PUMP DOWN] switch.

3.5 Photography

3.5.1 Photographic recording systems

The photographic recording system must be selected according to the type of film intended for use. The various recording systems and available film are listed below.

Photographic recording system	Photographing ratio	Available film and number of exposures
CSI-1 (Fig. 3.9)	1 : 0.5	Brownie roll film; J120 ASA50, 100, 200, etc. (negative); 10 exposures per roll. Brownie roll film; 220 ASA100, 400, etc. (negative); 20 exposures per roll.
CSI-2 (Fig. 3.10)	1 : 0.75	Polaroid Land film pack; Type 105 or 665 ASA75 (positive/negative); 8 sheets per pack. Polaroid Land film pack; Type 107 ASA3000 (positive); 8 sheets per pack
CSI-3 (Fig. 3.11)	1 : 0.25	35 mm roll film; J135 ASA50, 100, 200, 400, etc. (negative); 12, 20, 24, or 36 exposures per roll
CSI-4 (Fig. 3.12)	1 : 1	Polaroid Land sheet film Type 51 (high contrast), ASA200 Type 52 (wide latitude) ASA400 Type 55 (positive/negative) ASA50 Type 57 (ultrahigh speed) ASA3000 20 sheets per pack

Available film holders

CSI-1: Mamiya Roll Film Holder (Type 2)

CSI-2: Polaroid Film Holder (Type 2)

CSI-3: Yashica RF Reflex (ML macro-lens, f = 55 mm; with viewfinder)

CSI-4: Polaroid Film Holder (#545).

Note: It is possible to use the Mamiya Roll Film Holder (Type 2) in conjunction with the CSI-2 as well as the CSI-1. In this case, however, it will only be possible to photograph part of the screen image. It is also possible to use the Polaroid Film Holder (Type 2) in conjunction with the CSI-1 as well as the CSI-2. In this case, however, the entire image will only occupy part of the film.

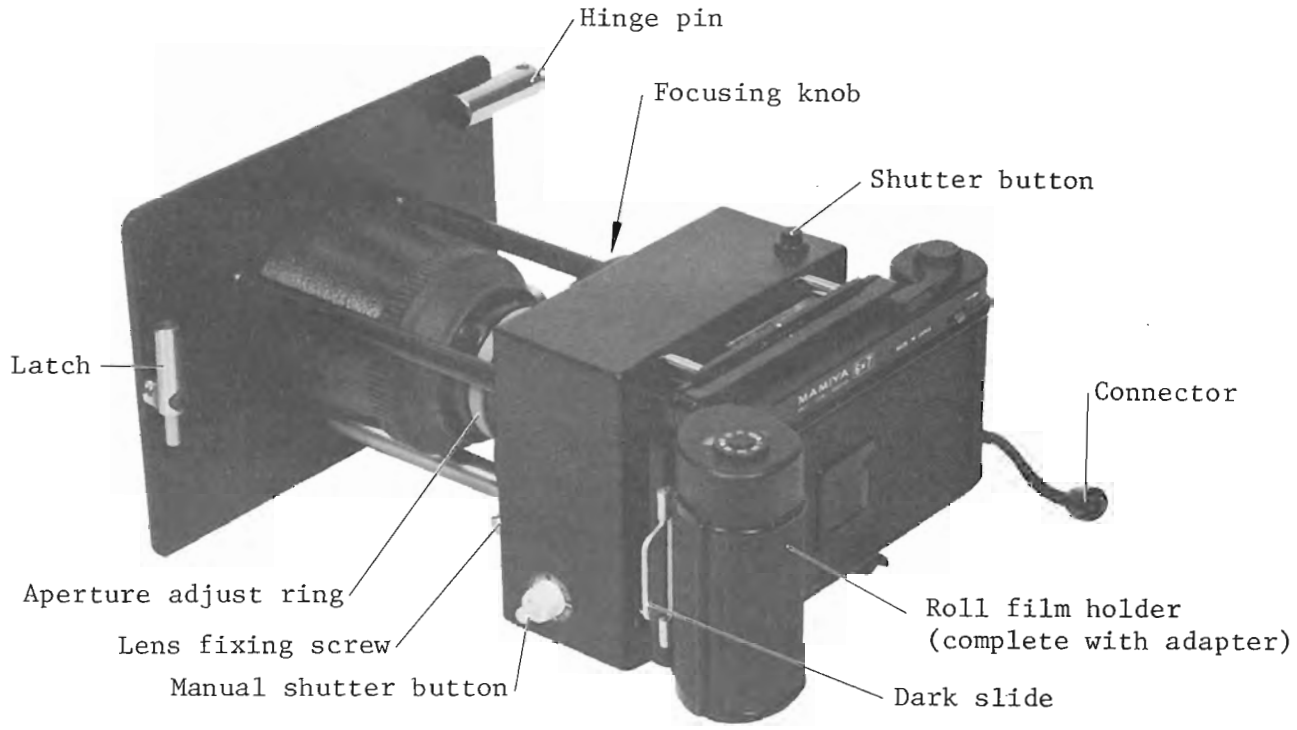


Fig. 3.9 CSI-1

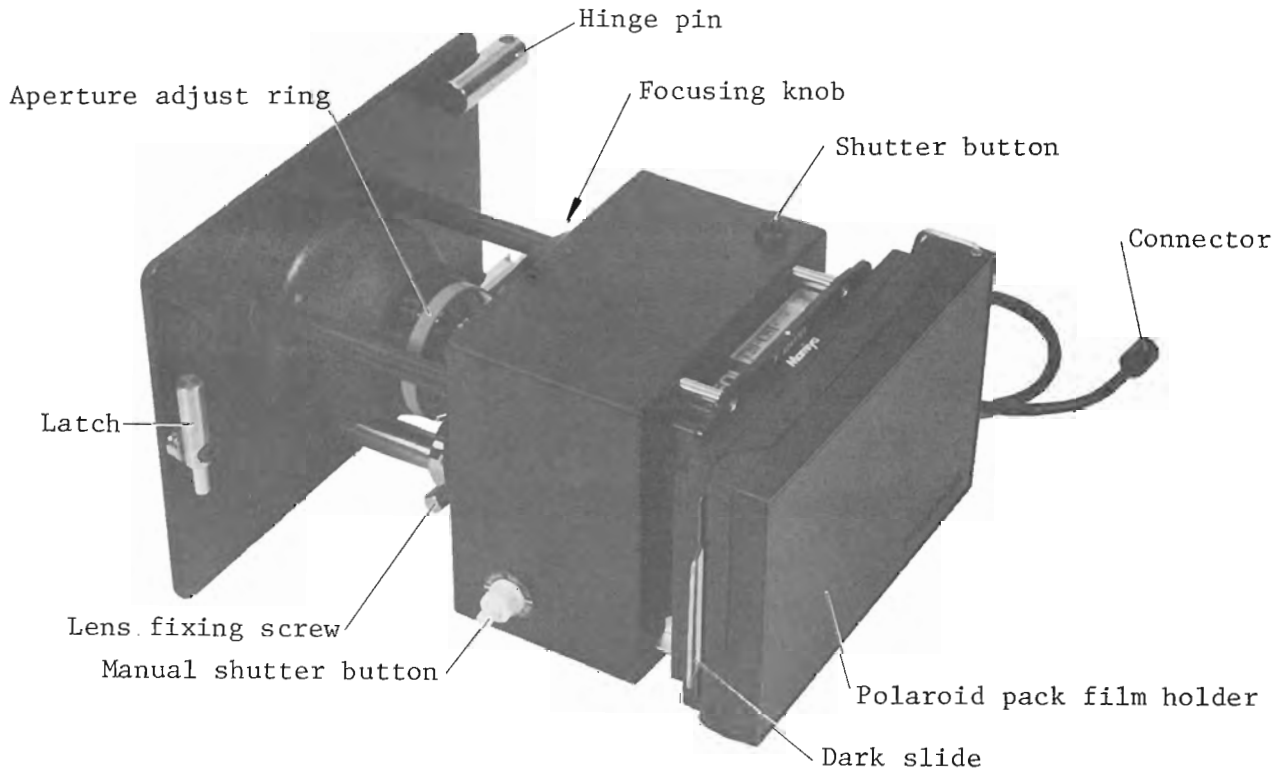


Fig. 3.10 CSI-2

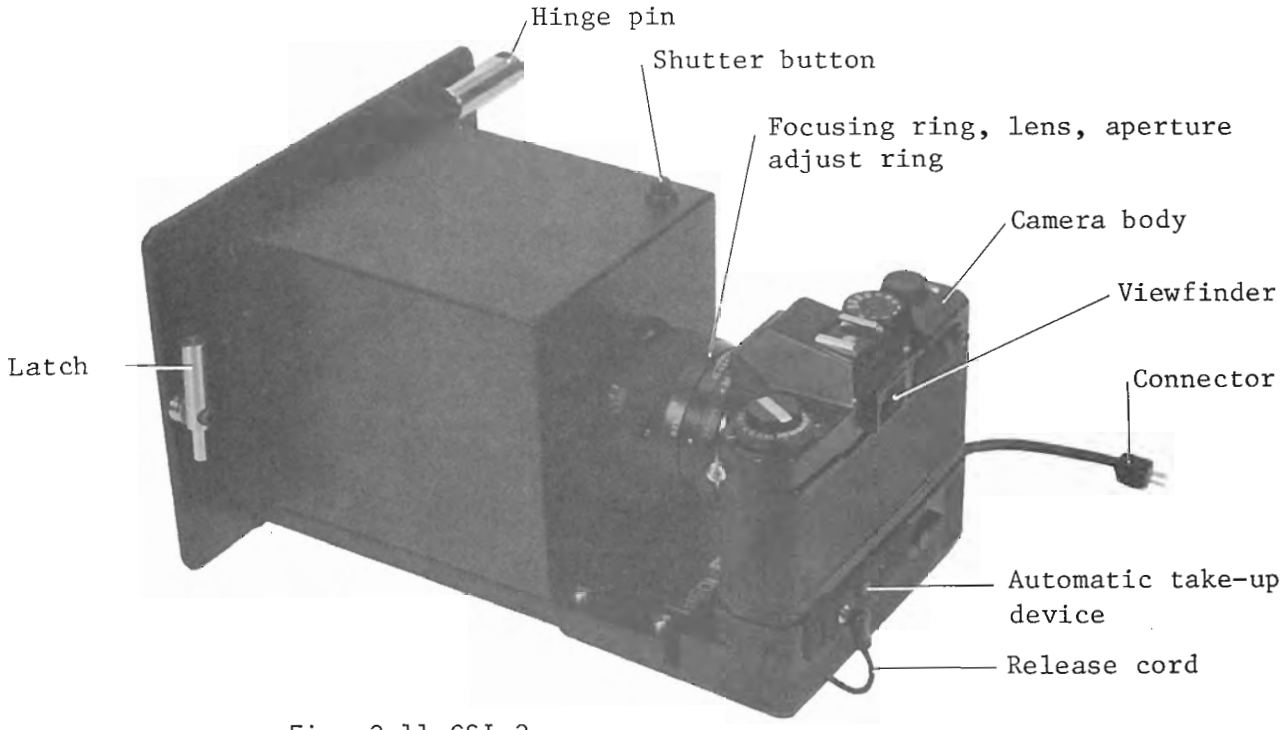


Fig. 3.11 CSI-3

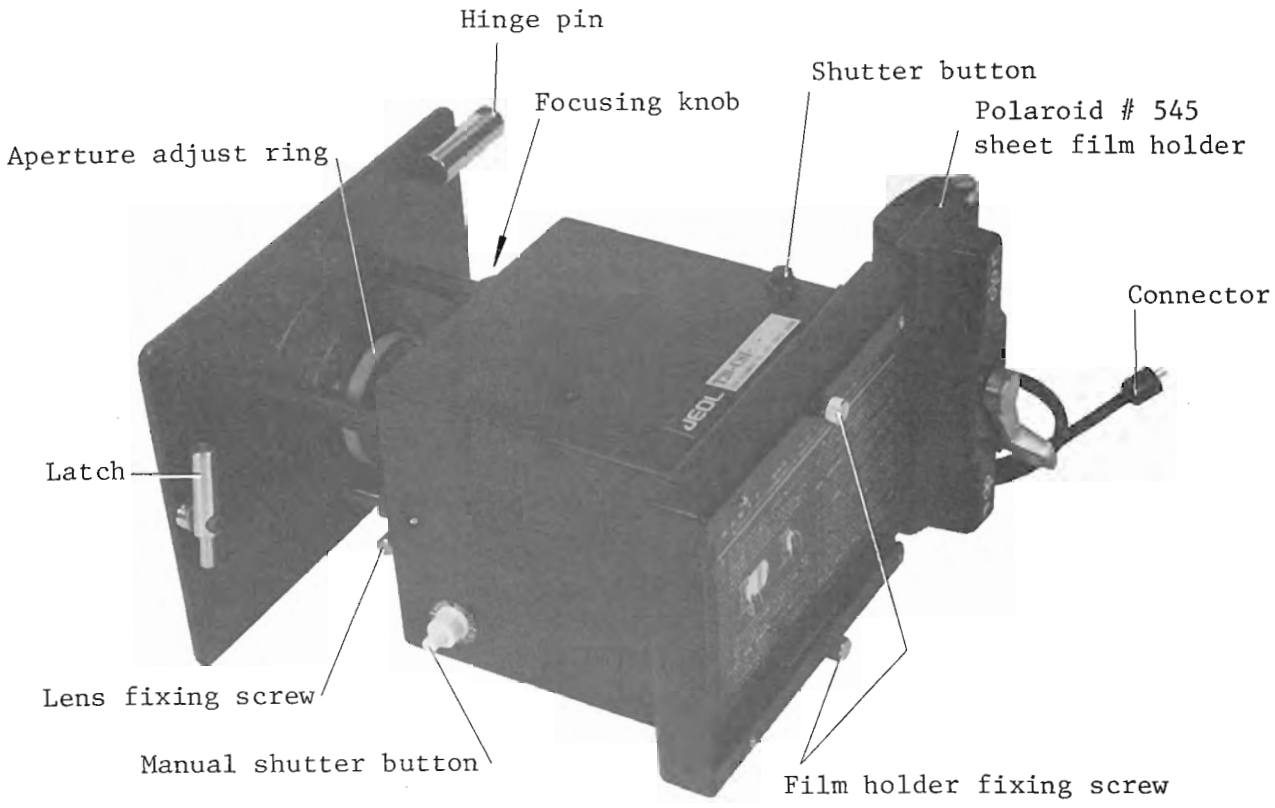


Fig. 3.12 CSI-4

3.5.2 Photographing the scanning image

Photographing procedure in the case of recording systems CSI-1, -2, -3, and -4 is practically the same.

1. Mount the recording system (hereafter referred to as the CSI) on the CRT and secure it with the hinge pin. Afterwhich, insert the CSI connector in the socket on the display panel.
2. Obtain an image on the CRT, swing the CSI to the CRT and fasten it in place with the latch lever.
   Note: In order to enhance scanning line visibility, it is recommended to use an LSP or TV image.
3. Open the camera shutter by depressing the manual shutter button.
   Note: The CSI-3 is a single-lens reflex camera, so the shutter does not open. In this case, the image is observed through the viewfinder.
4. Set the lens opening to 5.6 (max).
5. Attach the focus screen to the CSI.
   Note: In the case of the CSI-3, the focus screen is not required.
6. Using a magnifying glass, focus the scanning lines with the focus knob and then secure the lens with the fixing screw as provided.
7. Remove the focus screen and replace it with a loaded film holder.
   Caution: Be sure not to forget to insert the dark slide in the film holder.
   Note: In the case of the CSI-3, the dark slide is not required.
8. Close the shutter by depressing the shutter button.
9. Set the lens opening appropriately in accordance with the film speed*.
10. In the case of the CSI-3, set the shutter control to B.

The above procedure completes preparation for photography.

11. Set the film number with the thumbwheel switches on the display panel. In the [MAN] mode, the film number remains unchanged so long as the thumbwheel switches are not preset. On the otherhand, in the [AUTO] mode, once the film number is set, the last two digits (displayed by LEDs) of the film number automatically advance one by one as each film is exposed.
12. Select the desired field of view and adjust the image brightness and contrast in conjunction with the exposure marker.
13. Remove the dark slide from the film holder.
14. After checking the image focus, press the shutter button. After 3 seconds, the shutter opens and exposure commences; 60 seconds later, the shutter closes.
15. Advance the film.
    Notes: 1. In the case of the CSI-3, the film is automatically advanced.
    2. After each exposure, be sure to replace the dark slide except in the case of the CSI-3.
    3. In the case of the CSI-2 and -4, refer to the instructions of Polaroid film holder.
    4. In the case of the CSI-3, refer to the camera instructions.

---

* See Sect. 3.5.3.

3.5.3 Film speed and f-number

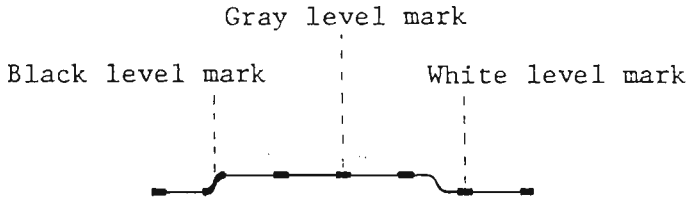
The exposure marker has been adjusted so as to match a film speed of ASA75. For other film speeds, re-adjust the exposure marker and then set the f-number as follows:

Film speed		f-number
ASA	DIN	
50	18	5.6 - 8
75, 100	21	8 - 11
200	24	11 - 16
400	27	16 - 22

3.5.4 Use of ultrahigh speed Polaroid Land sheet film (type 107, 57, etc.)

Ultrahigh speed film (ASA3000) is normally unsuitable for image recording due to its rather poor resolution and narrow latitude. Accordingly, the use of this type of film should be restricted to special purpose photography such as when recording dynamic behavior.

1. Attach a commercially available ND4 filter (dia. 52 mm) to the lens.
2. Set the lens opening to f22.
3. Adjust the rapid exposure marker so as to slightly reduce the image contrast as shown below.



3.5.5 Data readout on micrograph

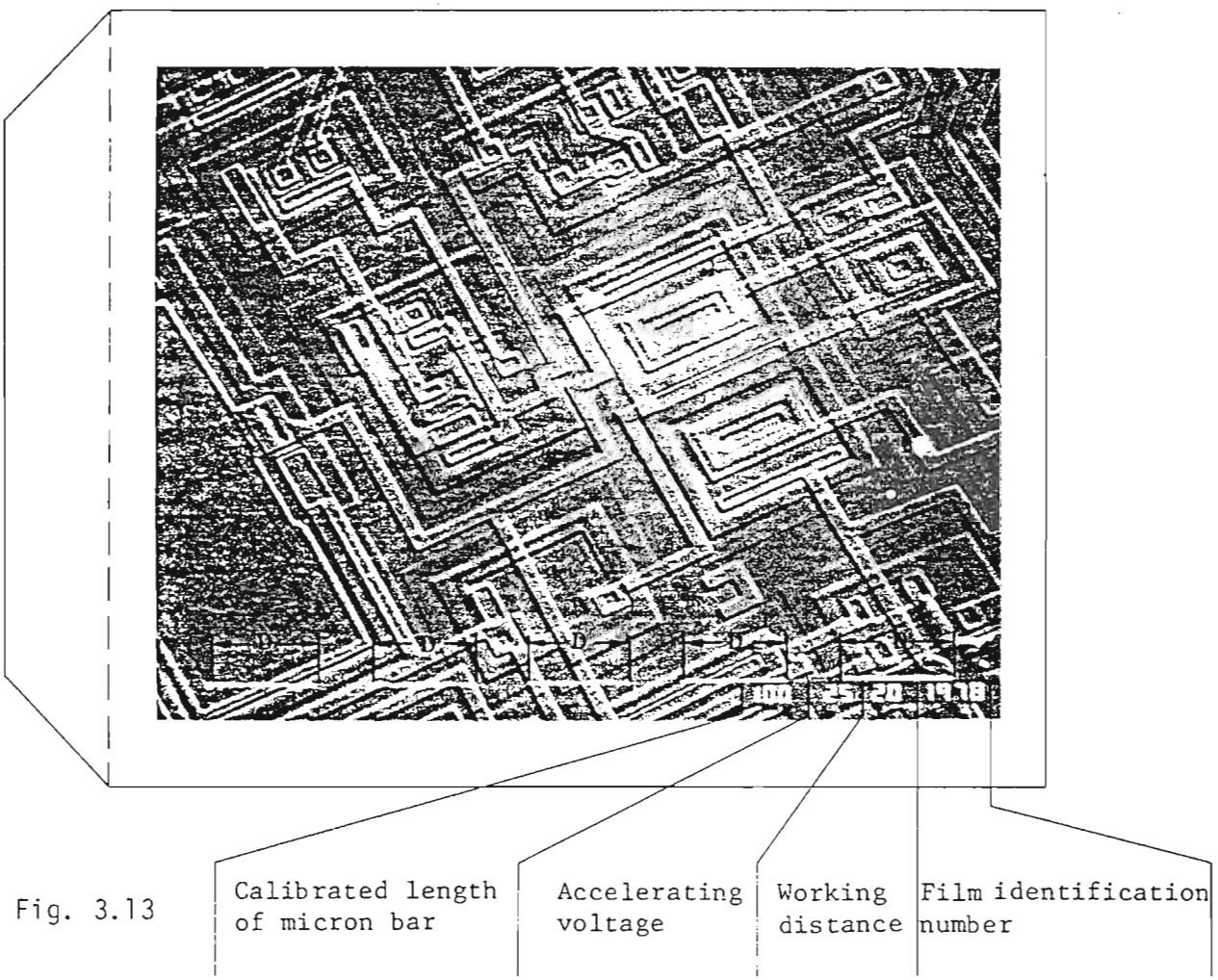


Fig. 3.13

- Calibrated length of micron bar

  Example: 1000 ··· D = 1000 µm, 50 ··· D = 50 µm, 1 ··· D = 1 µm,
  01 ··· D = 0.1 µm, 005 ··· D = 0.05 µm

- Accelerating voltage (up to 2 digits)

  25 kV, 15 kV, 10 kV, 5 kV, 2 kV.

- Working distance

  8 mm, 20 mm, 48 mm.

- Film identification number (up to 4 digits)

- Magnification

$$(\text{Magnification}) = \frac{(\text{Length of D (mm)})}{(\text{Calibrated length of micron bar (}\mu\text{m)}}$$

Ex. $\frac{15 \text{ mm}}{1000 \ \mu\text{m}} = \frac{15 \text{ mm}}{1 \text{ mm}} = 15$

Note: The central micron bar should be used to ascertain the length of the micron bar.

3.6 Aligning the microscope

Axis alignment is necessary in the following cases:

1) After replacing or cleaning the electron gun filament, condenser lens aperture, or objective lens aperture.
2) After dismantling and reasembling the column.

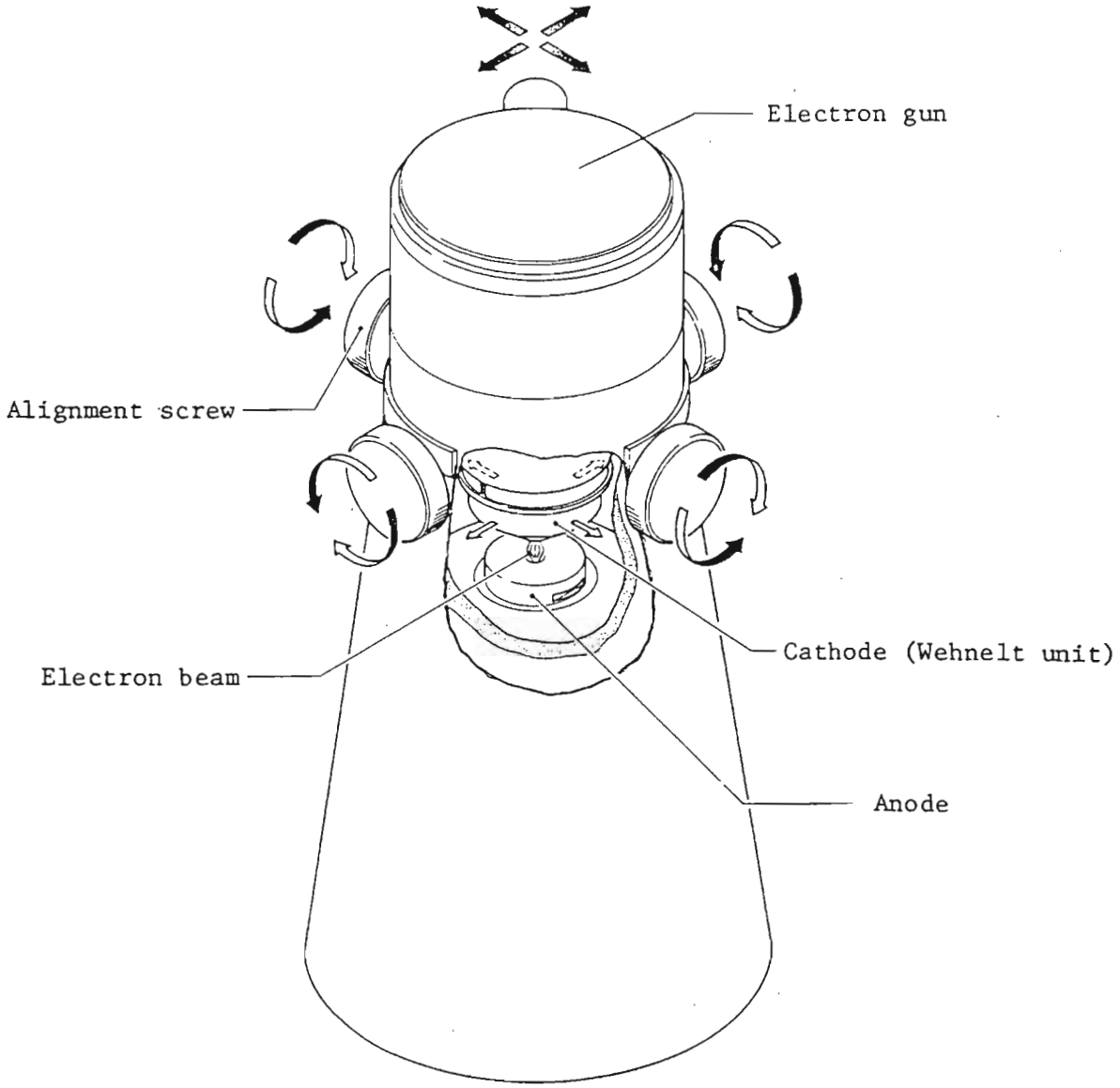
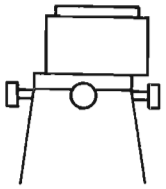
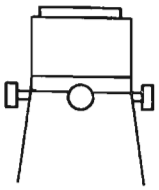


Fig. 3.14 Electron gun alignment

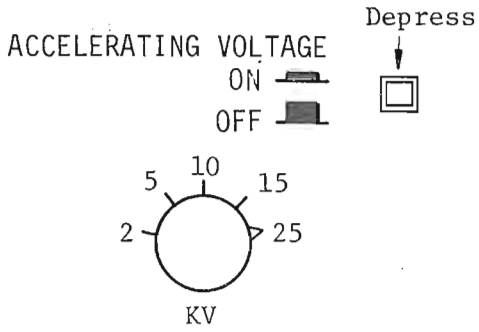
1. Evacuate the column and check that the MAGNIFICATION indicator displays a reading.
2. Set the working distance to 20 mm.
3. Bring the electron gun to the mechanical center with the alignment screws.
4. Set the ACCELERATING VOLTAGE switch at 25 kV and turn on the accelerating voltage by depressing the button.
5. Depress the LSP and EXP buttons. A line now appears on the CRT screen.
   Note: If a line fails to appear, adjust the BRIGHTNESS control so as to bring the line to the bottom of the screen.
6. Set the FILAMENT control to around the 11 o'clock position. The FILAMENT monitor lamp will light up.
   Note: If the lamp fails to light up, a burntout filament is indicated. In this event, replace the filament.
7. While monitoring the CRT waveform, slowly turn the FILAMENT control to about the 2 o'clock position; i.e., so as to maximally heighten the waveform. This is referred to as the first peak position (see Fig. 3.15).
   Note: If when carrying out Step 7 the waveform shows little inclination to move upward or conversely moves upward to such an extent that the trace disappears off the screen, adjust the

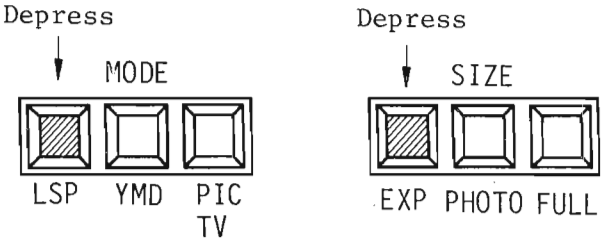


Electron gun misaligned

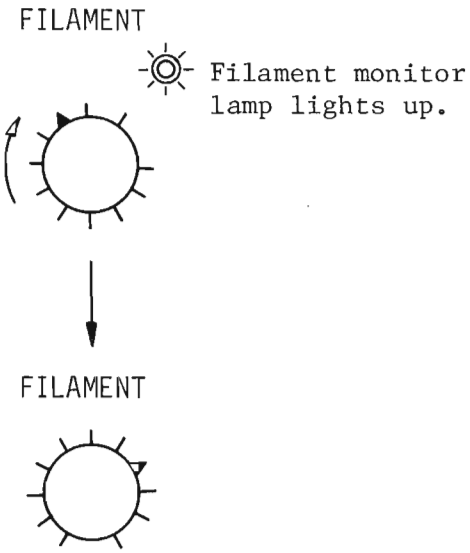


Bring electron gun to mechnical center.





A line appears on CRT screen.

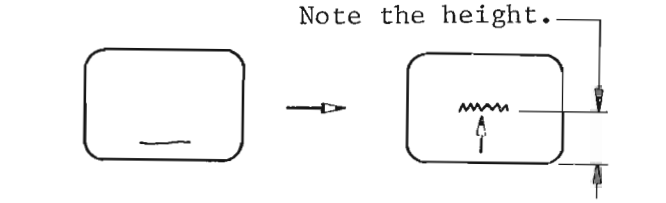


CONTRAST or *BRIGHTNESS* *control so as to normalize the situation.*

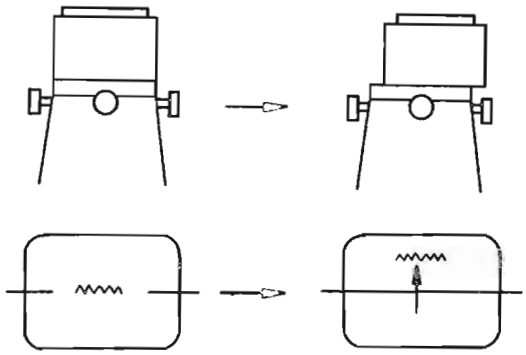
8. Re-adjust the axis alignment screws so as to maximally heighten the waveform.
9. Further turn the FILAMENT control to about the 3 o'clock position; i.e., to the point where saturation commences. This is referred to as the second peak position (see Fig. 3.15).

   Notes: 1. When turning the FILAMENT control from the 2 o'clock position to the 3 o'clock position, the waveform will lose height and then regain its lost height as it approaches 3 o'clock.

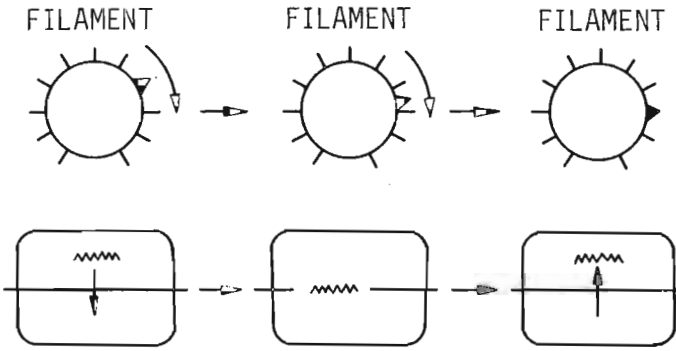
   2. If the waveform fails to saturate and lose height when the FILAMENT control is turned beyond the saturation position, repeat Steps 6 — 8.
10. Re-adjust the axis alignment screws so as to maximally heighten the waveform.
11. Check that the waveform level follows the pattern as shown in Fig. 3.15 by returning the FILAMENT control to the fully counterclockwise position and turning it clockwise through the 11 o'clock, 2 o'clock and 3 o'clock positions. Then, if all is in order, turn the



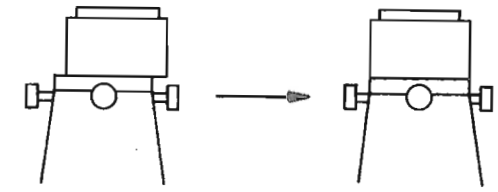
No electron beam Set FILAMENT control to maximally heighten the waveform.

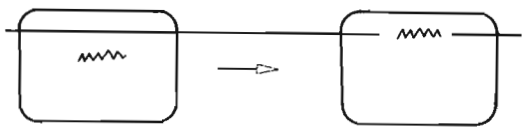


Maximally heighten the waveform with the alignment screws.



Set FILAMENT control at the saturation position.





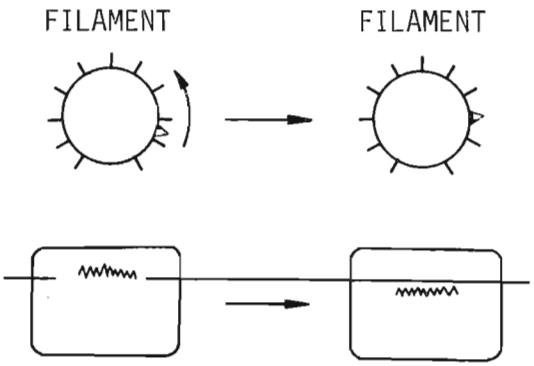
Maximally heighten the waveform with the alignment screws

control slightly counterclockwise and set it at the position just prior to where the waveform starts to fall abruptly (point A in Fig. 3.15).

Caution: Operating the gun filament in the over-saturated state may curtail the service life of the filament or cause it to warp.

Notes: 1. The first and second peak heights vary slightly from filament to filament.

2. With some new filaments, the first peak is higher than the second peak.



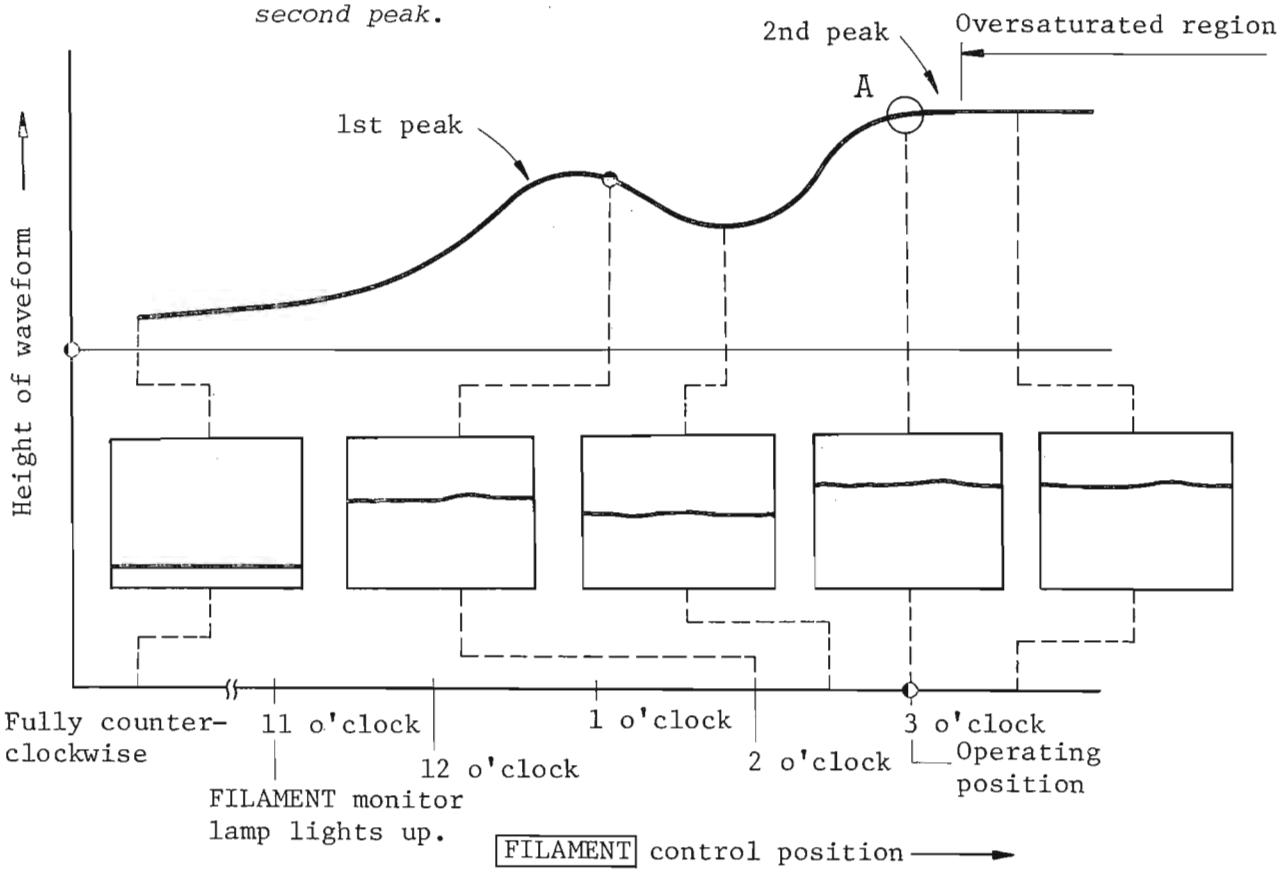
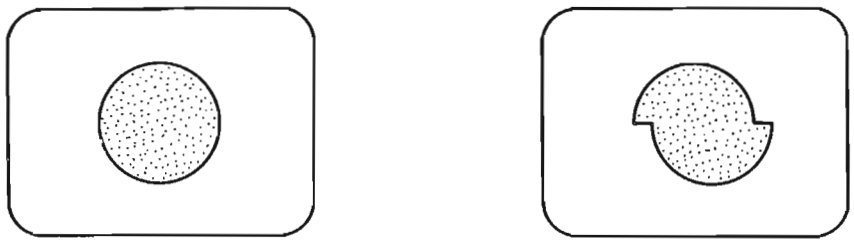


Fig. 3. 15 FILAMENT control setting

CHAPTER 4 MAINTENANCE I (General Precautions)

After prolonged operation, the column interior becomes contaminated by electron beam bombardment, evaporated materials, and very fine dust particles. If this contamination is allowed to remain, astigmatism may increase, image resolution may deteriorate, the probe current may become unstable, or it may not be possible to obtain a normal image due to probe skipping (Fig. 4.1).

Accordingly, the column should be disassembled at regular intervals and the various contaminated parts cleaned or replaced.



Normal image

Image resulting from probe skipping

Fig. 4.1 Normal and abnormal images

Precautions to be taken during column disassembly (reassembly) and component replacement

Handling the component parts

Since the component parts housed inside the column are precision-machined, they must be handled with great care. Always wear clean cotton or nylon gloves to avoid contamination by perspiration, etc. (especially during reassembly), which could lead to corrosion. Prior to removing any of the parts, prepare a stout work bench and suitable mats and covers. Gauze or rayon paper, for example, is suitable for those parts from which lint can be easily removed, while plastic sheeting or saran film is appropriate for small complex components. The plastic sheeting, however, should be insoluble in organic solvents. Plastic sheeting, saran film or aluminum foil is suitable as a cover. In the case of heavy components, cushioning material (plastic foam, etc.) is recommended to act as a buffer. When using wrenches, screwdrivers, tweezers or other tools necessary for removing the various parts, be extremely careful not to abrase or scratch the parts being removed. Moreover, be careful not to bend or force the parts when inserting or removing them. Do not cut any lead wires.

Parts storage and placement

If the disassembled parts are not to be reassembled immediately after cleaning, do not leave them on the table exposed to the atmosphere, but

store them in a desiccator. If a desiccator is not available, wrap the component parts in rust-proof paper, then cover the rust-proof paper with saran film, not forgetting to insert a desiccant between the rust-proof paper and the saran film. Then cover the saran film with aluminum foil and store in a suitable place where the humidity is low. Arrange the removed parts in an orderly fashion, especially small parts, screw, etc., to make reassembly easier and to avoid misplacement or loss of screws.

Proper usage of screwdrivers and tools

The proper tool must be employed for the particular job at hand. Also, when using screwdrivers, wrenches, etc. to remove and reassemble the various component parts, be sure not to apply undue stress or try to force removal of the screws, etc., otherwise screw heads and screw threads will be damaged.
When reinstalling a component part after cleaning, screw in the screws in a diagonal rotary fashion to prevent imbalance, strain and/or vibration.

CHAPTER 5 MAINTENANCE II (Parts Replacement)

5.1 Electron gun filament replacement

If the filament monitor lamp remains unlit when the FILAMENT control is turned beyond the 11 o'clock position, a burntout filament is indicated. In this case, replace the filament as follows:

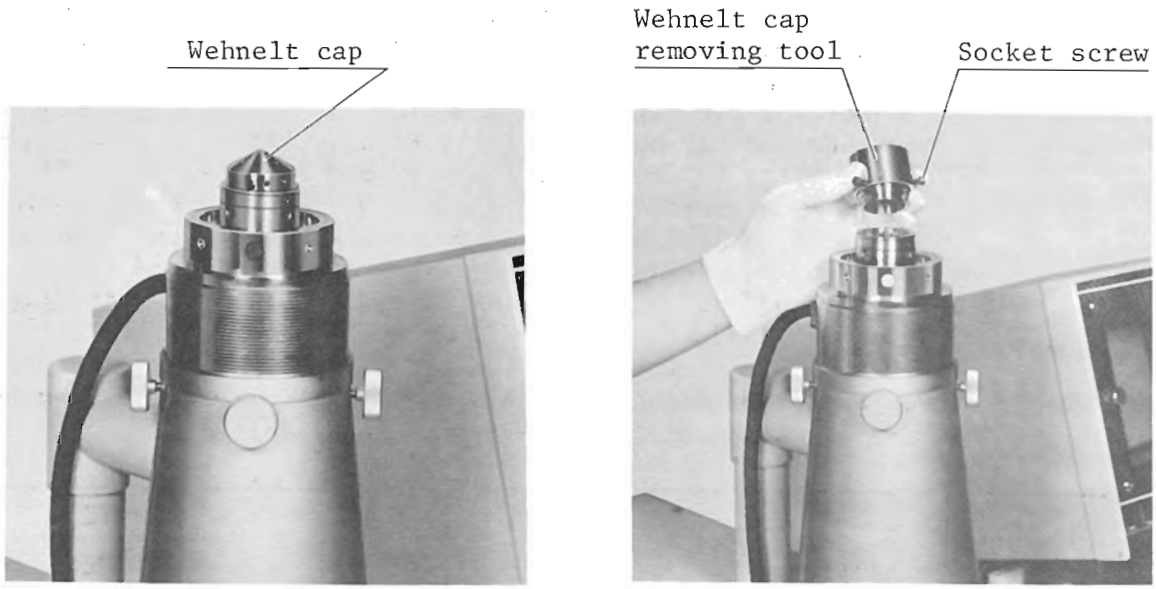
1. Admit air into the column by pushing the VENT switch.
2. Loosen the alignment screws (4 pcs.), remove the electron gun by lifting it straight up, turn it upside down and then place it on the column (see Figs. 5.1 and 5.2).

Cautions: 1. Allow a few minutes for the Wehnelt unit to cool down before handling it.

2. When carrying out the following steps, be sure to observe the precautions described in Chap. 4. Furthermore, make it a rule not to leave the column exposed to the atmosphere for longer than necessary.

Fig. 5.1 Removing the electron gun

3. Place the Wehnelt cap removing tool (hereafter referred to as the Wehnelt tool) over the Wehnelt cap, tighten the screws (see Figs. 5.2 and 5.4), and remove the Wehnelt cap from the Wehnelt unit base by pulling the tool.

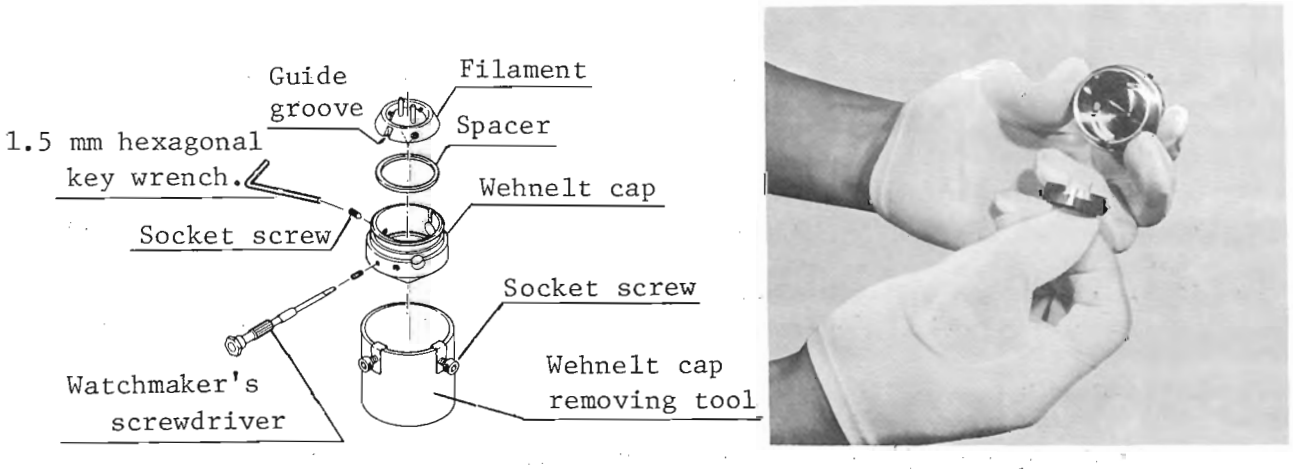


a. Securing the electron gun

b. Removing the Wehnelt cap

Fig. 5.2

4. Loosen the screws and remove the cap from the Wehnelt tool.
5. Remove the filament by loosening the filament fixing screws (3 pcs.) with the hexagonal key wrench and the setscrew with the screwdriver (Fig. 5.3).



a

b

Fig. 5.3

6. Clean the Wehnelt cap.
7. If the high voltage insulator is discolored, clean it.
8. Align the new filament guide groove with the guide pin, insert the filament into the Wehnelt cap and secure the filament by tightening the filament fixing screws.

   Notes: 1. Usually use the 2 mm spacer and only when the instrument is to be operated under the high resolution work used the 1.9 mm spacer.

   2. Do not let the tip of the electron gun filament protrude outside the tip surface of the Wehnelt cap or indication of the CHECKER "4" meter does not exceed 0.7 (140 μA). If the indication exceeds 0.7, replace the spacer by the 2 mm one. When the indication still exceeds 0.7 even if the 2 mm spacer is used, replace the filament by a new one.

   3. If the indication of CHECKER "4" fluctuates when the FILAMENT knob is readjusted, clean the Wehnelt cap. If, at that time, a whiskerlike substance is observed on the filament, replace it by a new filament. (This whisker like substance can be seen when a magnifying glass is used.)

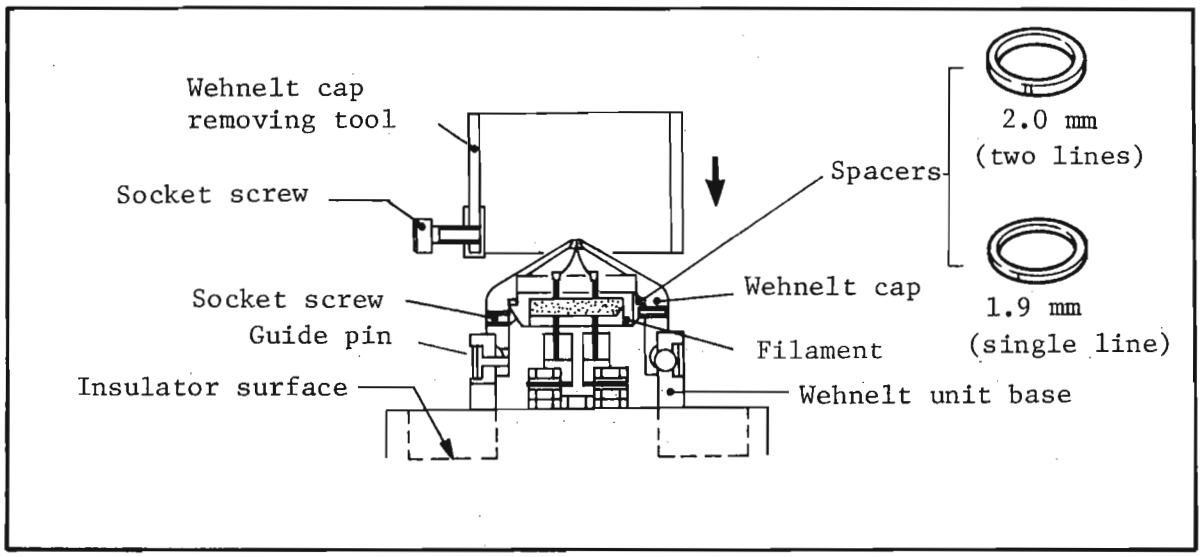


Fig. 5.4

9. Orientate the Wehnelt cap so as to align the cap guide groove with the Wehnelt unit base guide pin and push the cap down onto the Wehnelt unit base.
10. After applying the handblower to the Wehnelt unit and environs so as to remove all traces of lint, dust, etc., return the electron gun to the column.

    Caution: When returning the electron gun, be sure not to twist the electron gun cable.
11. Re-evacuate the column by pushing the PUMP DOWN switch.
12. Wait for the MAGNIFICATION indicator to display a reading, then turn ON the accelerating voltage by pressing the ACCELERATING VOLTAGE button and carry out axis alignment (for details, see Sect. 3.6).

5.2 Removing the condenser lens aperture

1. Admit air into the column by pushing the [VENT] switch.
2. Press the [POWER] [OFF] button.
3. After first removing the electron gun, unscrew the anode with the pole-piece removing tool (see Fig. 5.5) and carefully remove the pole piece assembly by lifting it straight up.
   Cautions: 1. Be sure not to drop the pole pieces or to bump them against adjacent parts.
   2. Cover the column with aluminum foil to prevent dust entering therein.
4. Remove the anode fixing screws (3 pcs.) (Fig. 5.6).
5. Detach the spacer [1] from the pole piece [1] by turning the spacer counterclockwise and remove the aperture holder [1] with the pole-piece assembling tool.
   Caution: Do not attempt to remove the aperture holder, etc. while the pole piece is still hot; otherwise the threaded portion of the holder may be damaged.
6. Unscrew the aperture fixing screw [1] with the pole-piece assembling tool and remove the aperture [1] from the aperture holder [1].
7. Remove aperture [2] as per aperture [1] removal.
8. Clean apertures [1] and [2] in accordance with cleaning method C (Sect. 6.2.3) or if uncleanable, replace with new ones.
9. Reassemble the pole piece, aperture holders, etc. by following the above steps in reverse order.
10. Replace the condenser lens pole-piece assembly, anode, and electron gun and re-evacuate the column.
    Caution: Since the pole pieces and parts made of iron easily oxidize, do not leave them exposed to the atmosphere for longer than necessary.
    Notes: 1. Aperture [1] is held in aperture holder [1] by aperture fixing screw [1].
    2. Aperture [2] is held in aperture holder [2] by aperture fixing screw [2].

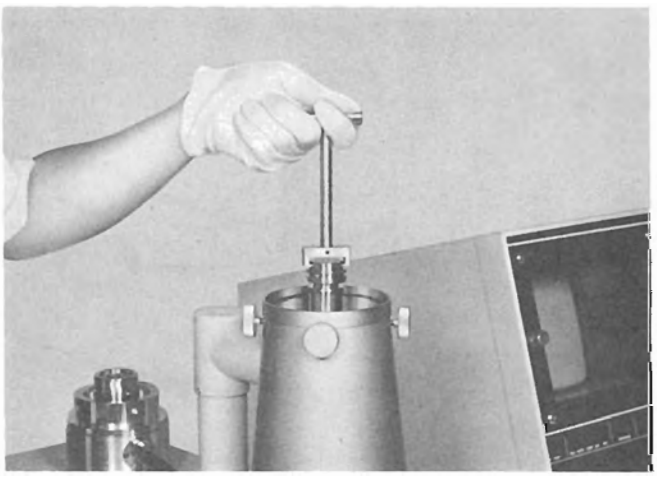


Fig. 5.5 Removing the condenser lens pole-piece assembly

3. *Apertures [1] and [2], aperture holders [1] and [2] and aperture fixing screws [1] and [2] are identical and therefore interchangeable. However, be sure when assembling the apertures that they are orientated correctly (see Fig. 5. 6).*
4. *Although spacer [2] and pole pieces [2] and [3] can be used upside-down, IT IS RECOMMENDED to reassemble them as they were before disassembly.*

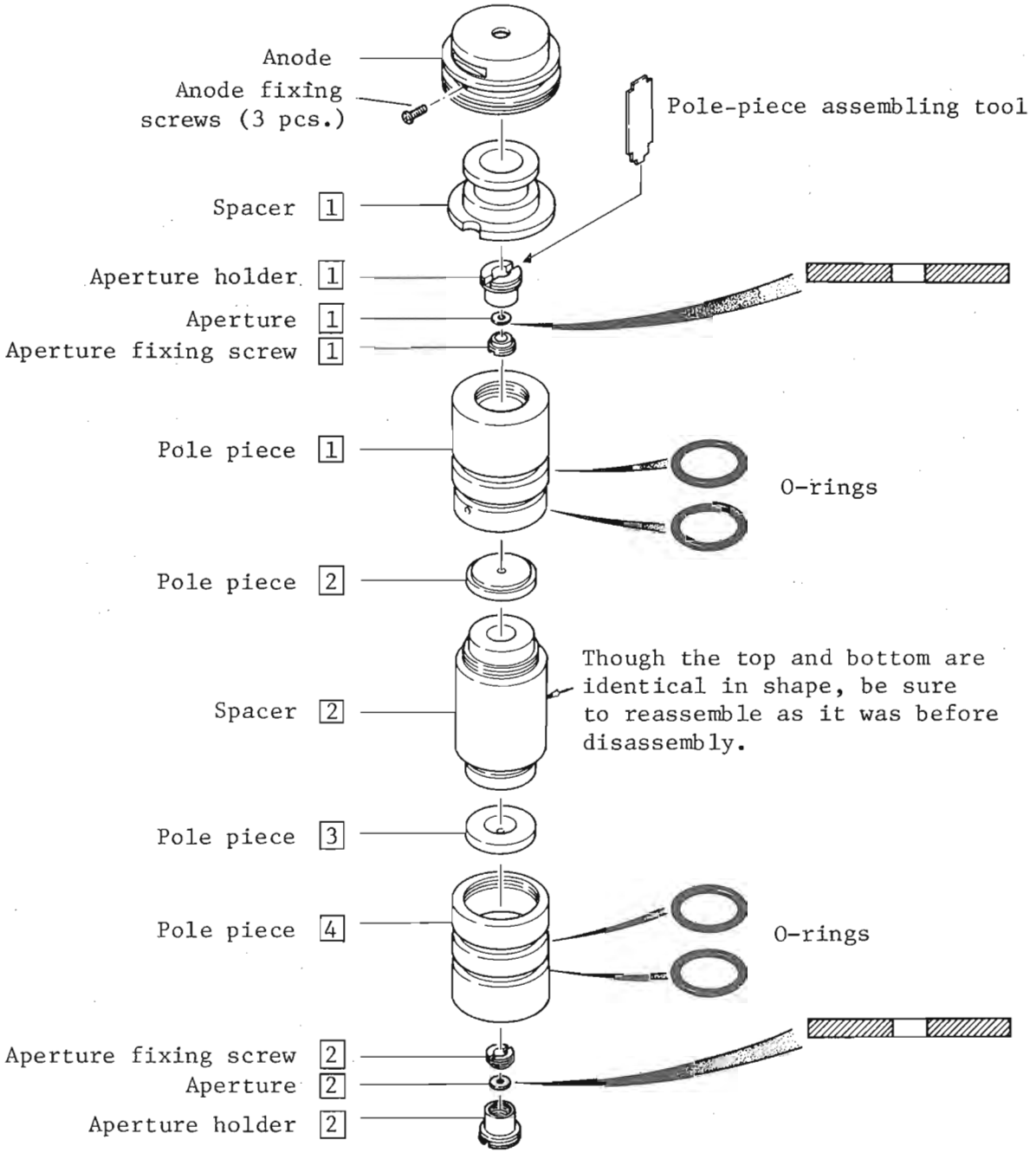


Fig. 5.6 Disassembling the condenser lens pole-piece assembly

5.3 Removing the objective lens aperture*

1. Admit air into the column by pushing the VENT switch.
2. Remove the specimen stage.
3. Remove the objective lens aperture holder with the aperture holder removing tool (see Fig. 5.7).
4. Cover the aperture holder cap with aluminum foil and remove the cap by turning it counterclockwise. Then remove the aperture and spacer (Fig. 5.8).

   Notes: 1. If it proves difficult to remove the cap by hand, use tweezers (see Fig. 5.8).

   2. If it proves difficult to remove the aperture from the holder, push the underside of the aperture with a toothpick or the like.

   Caution: Be careful not to scratch, nick, bend or lose the aperture and spacer.
5. Clean the aperture in accordance with cleaning method C (see Sect. 6.2.3).
6. Check that there are no traces of polish, lint, etc. on the cap, spacer and aperture holder.
7. Carefully insert the aperture and spacer into the aperture holder using tweezers and secure them with the cap.

   Cautions: 1. Do not handle the cleaned cap, spacer, aperture, etc. with bare hands.

   2. Clean the tweezers, aperture holder removing tool, etc. with solvent before using them.
8. Return the aperture holder to the objective lens pole piece (Fig. 5.7).
9. Return the specimen stage to the specimen chamber and evacuate the column.

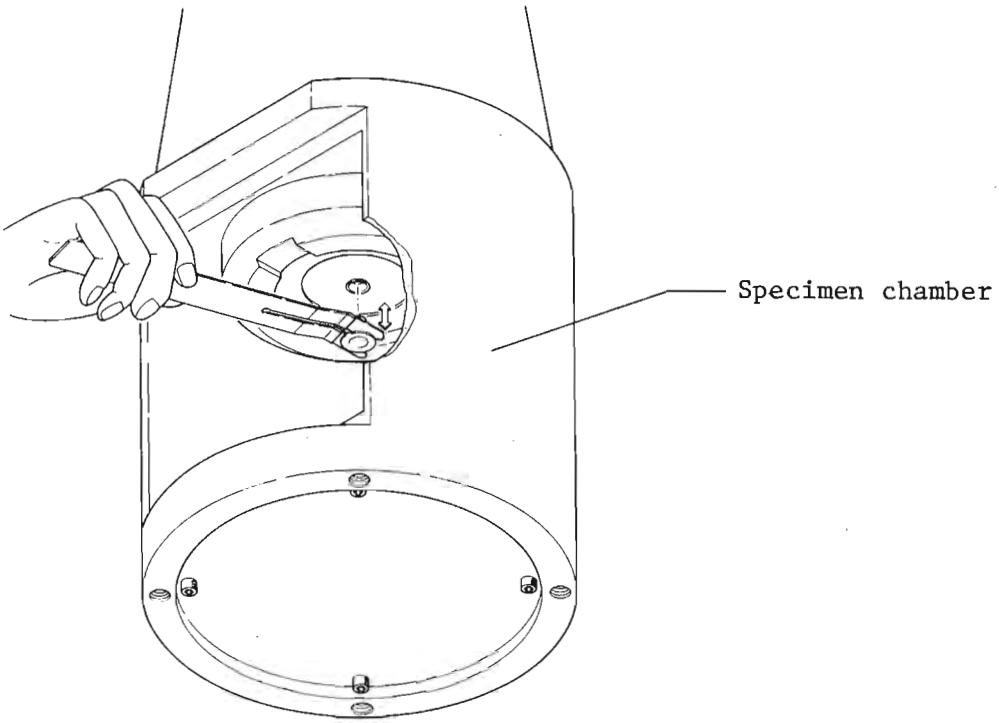


Fig. 5.7 Removing the objective lens aperture

* *Objective lens aperture diameter is 300 μm.*

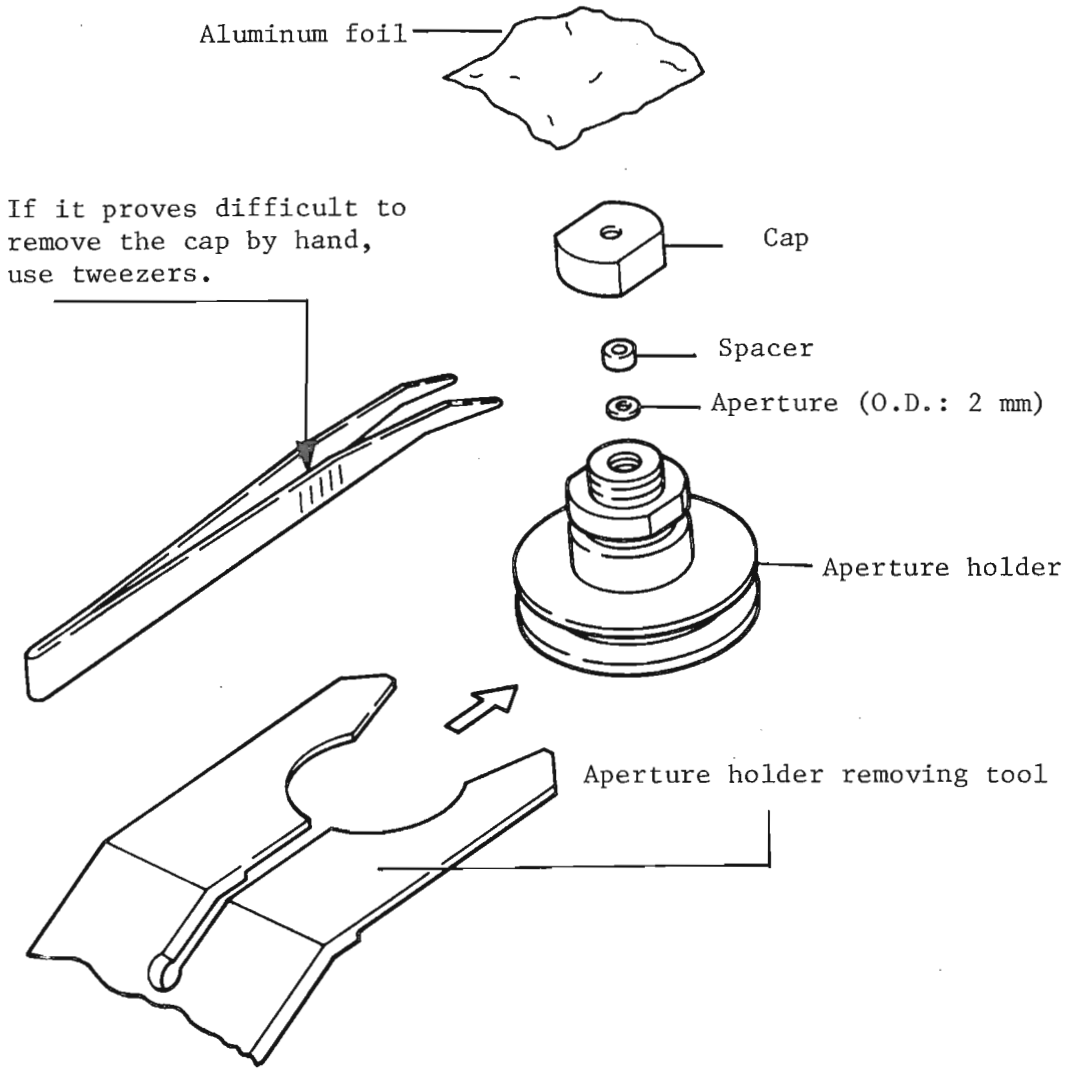


Fig. 5.8 Exploded view of the objective lens aperture assembly and means for removing it

5.4 Disassembling the beam deflector

When removing the beam deflector, take care not to knock the deflector against the adjacent parts and not to break the deflector lead wires.

1. Screw screws (M4 × 25, 2 pcs.) into the threaded holes on the beam deflector flange and using the screws as handles, lift the deflector straight up.
2. Remove the coil spring, the screw (pipe holder) securing the metal pipe, and the metal pipe itself (Fig. 5.9).
3. If the electrode is dirty, remove it and clean.

Caution: When reassembling the beam deflector, screw in the pipe holder firmly so as to be sure of properly grounding the metal pipe (Fig. 5.9). If the pipe is not properly grounded, dark spots may appear.

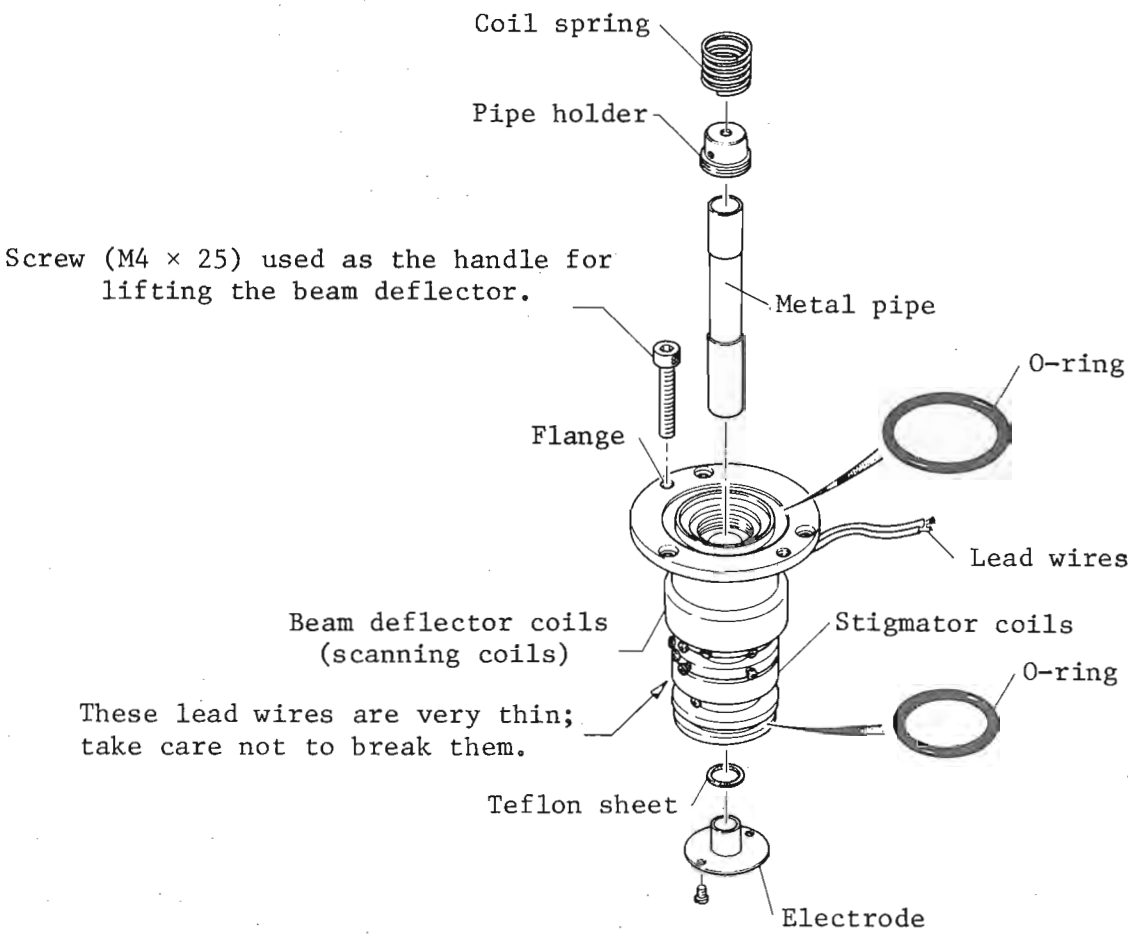


Fig. 5.9 Exploded view of the beam deflector

5.5 Replacing the scintillator

The scintillator will require replacing when the image becomes noisy (i.e., when the CHECKER meter reads 0.32 or over at an optimum exposure with the CHECKER POSITION selector at 21), or when the aluminum foil has peeled off. To replace the scintillator, proceed as follows:

1. Turn OFF the accelerating voltage by pressing the ACCELERATING VOLTAGE button and vent the column by pushing the VENT switch.
2. Unscrew the detector securing screws (4 pcs.) and remove the detector (Fig. 5.10).
3. Remove lead wire A from the collector by loosening off screw A. then unscrew screws B (2 pcs.) and remove the shield pipe (Fig. 5.11).
4. Remove the corona ring and scintillator from the light pipe by loosening off screws C (2 pcs.).

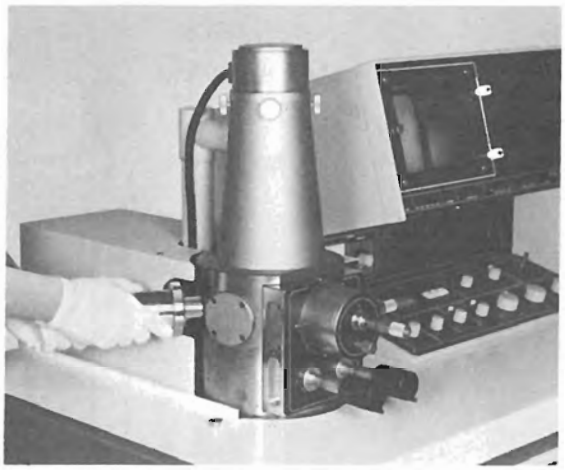


Fig. 5.10 Removing the detector

5. Apply a thin coat of silicone oil to the exposed end of the light pipe.
   Caution: When cleaning the light pipe, use gauze lightly soaked in alcohol. Do not use solvents other than alcohol because the light pipe is extremely sensitive to nonalcoholic solvents.
6. Mount a new scintillator on the exposed end of the light pipe (excercising great care not to damage the scintillator), then attach the corona ring and secure it with screws C.
   Caution: Do not scratch or permit dust to settle on the scintillator or light pipe. NEVER touch the surface of the scintillator.
7. Replace the collector and secure it with screws B.
8. Replace the detector and secure it with the four screws as provided.
9. Push the PUMP DOWN switch to re-evacuate the column.

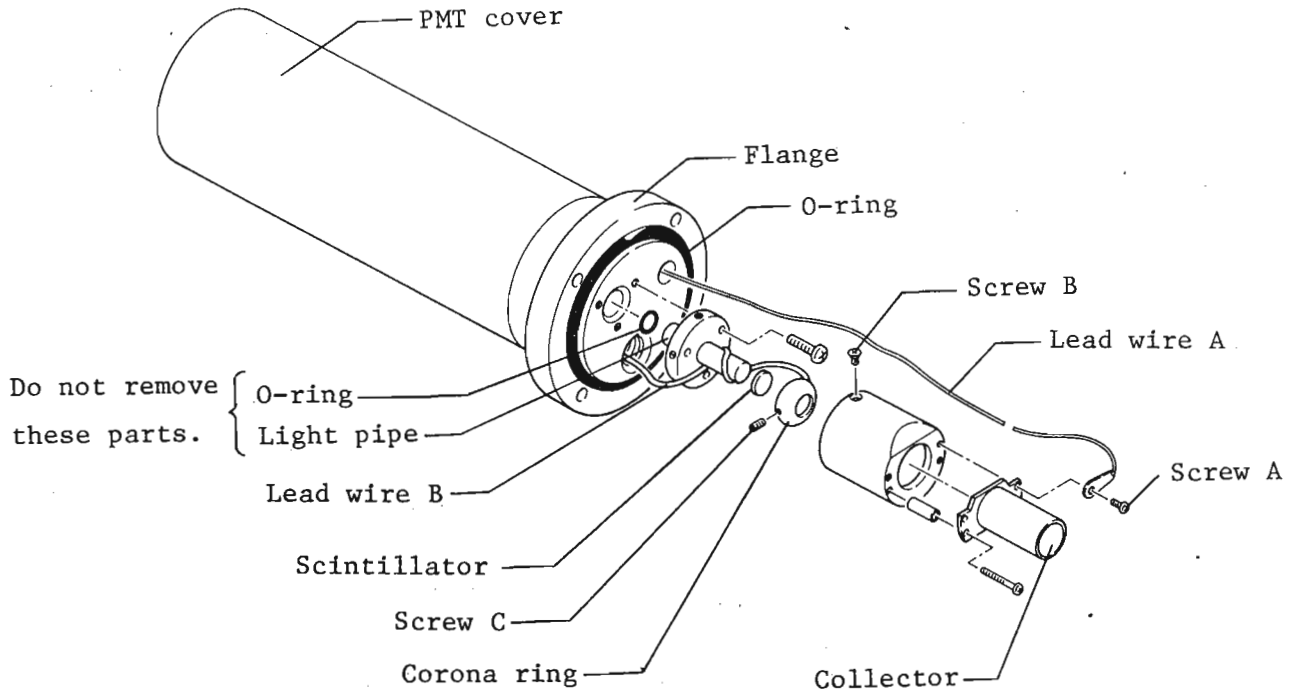


Fig. 5.11 Disassembling the detector

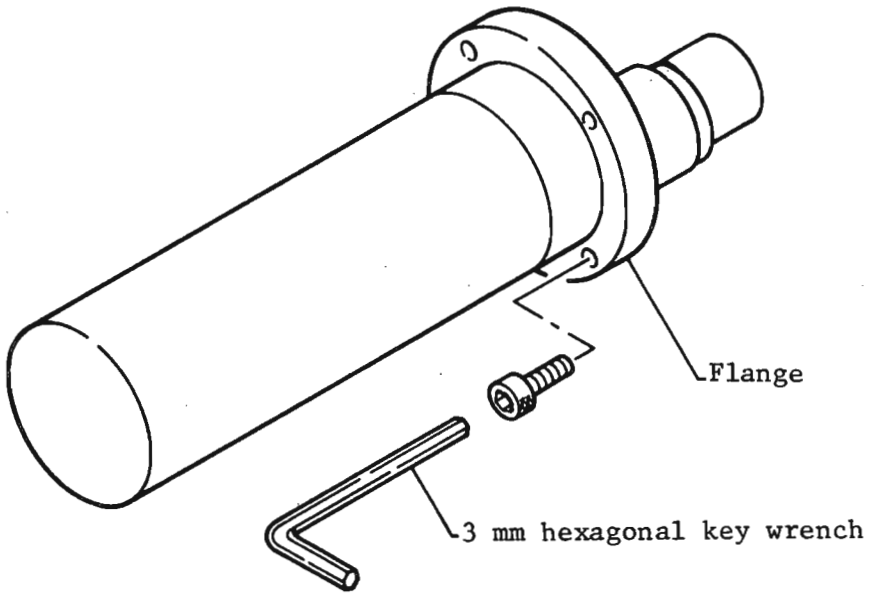
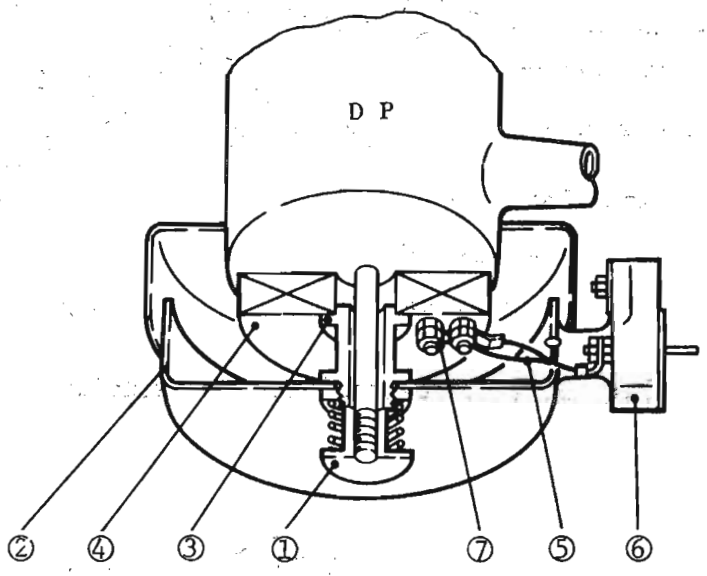


Fig.5.12 Detector and PMT

5.6 Replacing the oil diffusion pump heater

1. Turn off the power switch (i.e., push the POWER OFF button) and the mains power switch on the distribution board.
2. Remove the rear panel by loosening off the panel fixing screws (6 pcs.).
3. Allow the heater assembly to cool down.
4. Unscrew the heater assembly holding nut ① and remove the heater assembly (comprising cover ②, adapter ③, heater ④, lead wires ⑤ and socket ⑥).
5. Remove heater ④ from cover ②.
6. Unscrew nuts ⑦, disconnect the lead wires from the heater and remove the heater.
7. Attach a new heater.
8. Reassemble the heater assembly parts.



① Heater assembly holding nut
② Cover
③ Adapter
④ Heater
⑤ Lead wires
⑥ Socket
⑦ Nuts

Fig. 5.13 Diffusion pump heater assembly

5.7 Oil rotary pump maintenance

Check the pump oil level from time to time and replenish as necessary.

Caution: Prior to removing the rear panel, be sure to turn off the mains power switch on the distribution board.

Notes: 1. If the oil level has fallen below the (·) mark on the oil level indicator, replenish is necessary. To replenish, use the pump exhaust port.

2. Only use the grade and type of oil as specified. If in doubt, contact your nearest JEOL Service Center.

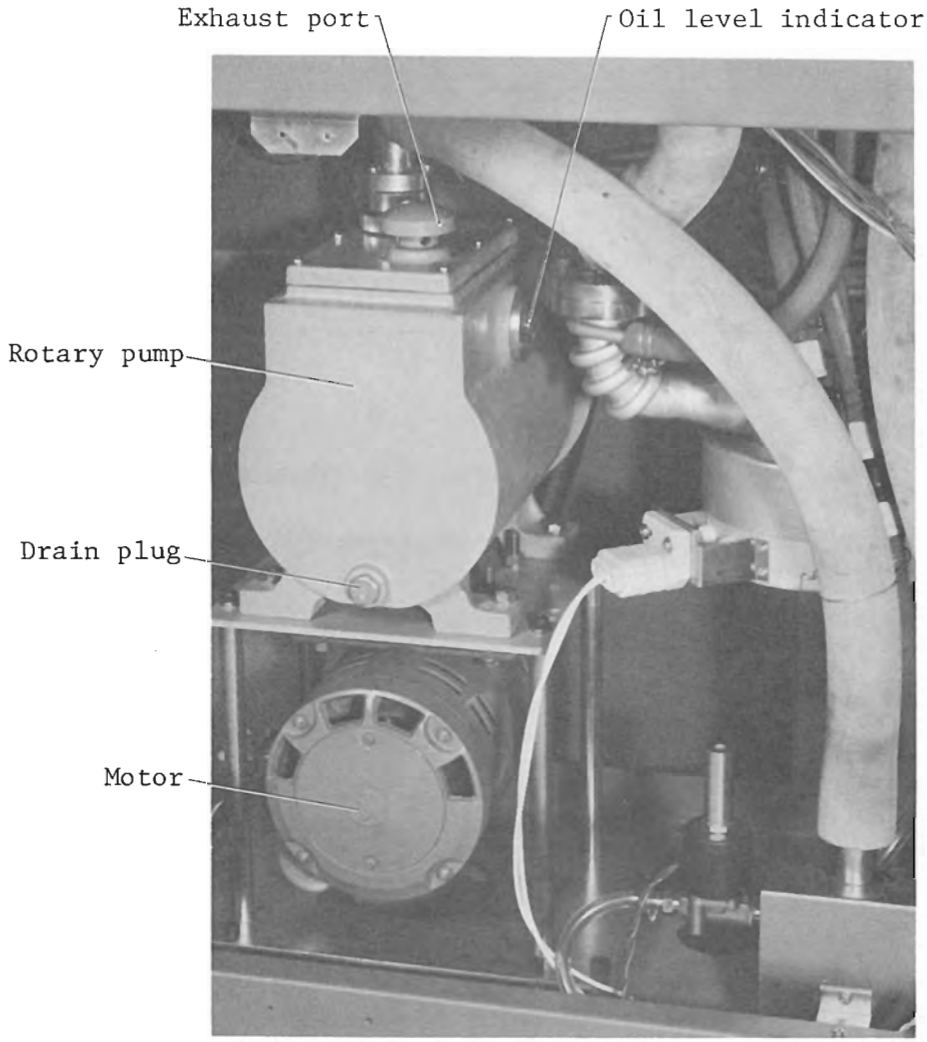


Fig. 5.14

5.8 Fuse replacement

1. Turn off the mains power switch on the distribution board.
2. Remove the rear panel by loosening off the panel fixing screws (6 pcs.).
3. Check for blown fuses and replace as necessary.
   Note: The replacement fuse/fuses should be the same type and have the same rating as the blown fuse/fuses.

Fuse No.	Related cct.	Rating	(JIS)
F1A	Not used		
F1B	Service outlet	3 A, glass tube	(MF03NM-3A)
F1C	T1 transformer	8 A, glass tube	(MF03NM-8A)
F2A	T2 transformer	2 A, glass tube	(MF03NM-2A)
F2B	Oil diffusion pump	8 A, glass tube	(MF03NM-8A)
F2C	Vacuum system	20 A, glass tube	(MF03NM-20A)
F3A	Master power supply	30 A, enclosed	(CF2-30A)
F3C	Master power supply	30 A, enclosed	(CF2-30A)

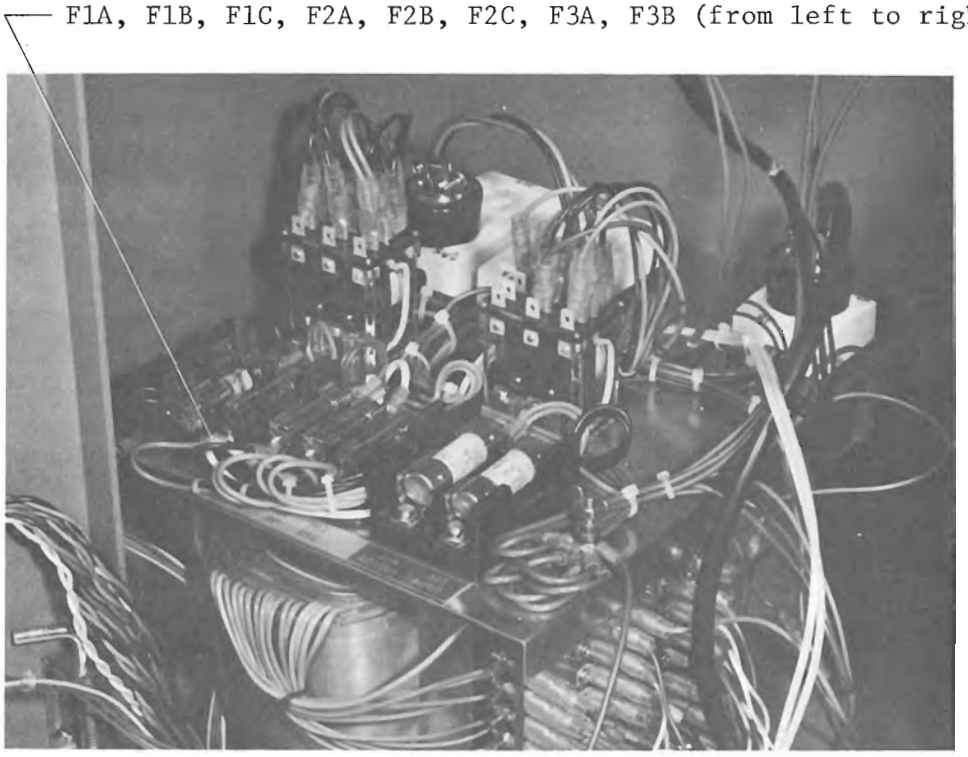


Fig. 5.15 Location of fuses

CHAPTER 6 MAINTENANCE III (Column Disassembly, Reassembly and Cleaning)

6.1 Column

When disassembling or reassembling the column, be sure to observe the precautions described in Chap. 4. Moreover, avoid unnecessary disassembly (avoid removing parts not related to the disassembly procedure or parts which do not require cleaning, as this not only complicates reassembly but also leads to the possibility of such parts being damaged).

Use saran film or aluminum foil to cover exposed portions of the column not requiring disassembly.

6.1.1 Disassembly and reassembly

1. Turn off the mains power supply switch on the distribution board and wait at least 30 minutes for the instrument to cool down.
2. Remove the alignment screws and remove the electron gun from the condenser lens by lifting the gun straight up.
   Caution: When handling internal parts which are exposed to vacuum, be sure to wear clean, thin gloves. However, exercise care so that traces of lint, etc. from the gloves do not remain in the column as this is a cause of image deterioration.
3. Remove and disassemble the condenser lens pole pieces, and remove the apertures (see Sect.5.2).
4. Remove the evacuation pipe and column magnetic shield.
5. Loosen off the four condenser lens holding screws and remove the condenser lens by lifting it straight up.
   Caution: When lifting the condenser lens, be careful as it is very heavy.
6. Remove the metal pipe from the beam deflector (see Sect. 5.4).
   Caution: Take care not to drop the metal pipe.
7. Remove the beam deflector from the objective lens (see Sect. 5.4) and remove the electrode.
8. Clean the parts specified in Table under Sect. 6.2.2 and then reassemble them.
   Note: When reassembling the specified parts, observe the following precautions.

   ◦ Dust removal
   As each component part is being reassembled, use a hand blower to remove any traces of dust or lint which may have readhered to the part. Also, if the reassembly operation is temporarily suspended prior to completion, be sure to cover the exposed parts with saran film or aluminum foil to prevent contamination. If these precautions are neglected, the entire cleanup procedure will have been to no avail. In some cases, high voltage discharge or image quality deterioration may occur.

   • O-ring and mating surface check
   Inspect the O-rings and their mating surfaces for scratches, lint, etc.

When applying vacuum grease, apply it sparingly so as to avoid column and/or specimen contamination.
In the case of mating surface scratches, if these scracthes are extremely shallow, no treatment is necessary. If necessary, rub the surface with emery paper (tangentially with respect to the groove). If the scratches are deep, contact your nearest JEOL Service Center for assistance. If these precautions are not observed, it may be impossible to attain a good vacuum.

9. Re-evacuate the column.

6.2 Cleaning

6.2.1 Cleaning materials, tools, etc.

- Cleaning liquid (organic solvent such as trichloroethylene and alcohol)
  The cleaning liquid should be of high cleaning quality, high purity, preferably non-inflammable and volatile, and should have a high safety factor.
  Ensure adequate ventilation when using the cleaning liquid and do not allow prolonged contact with the skin.
- Fine grain metal polish
  The polish should be paste-like and easy to remove with organic solvent. It is used for removing persistent contamination.
- Gauze or rayon paper (crepe or gauze type)
  Should be of high quality and not release impurities when moistened with organic solvent.
- Absorbent cotton
  Should be of high quality.
- Toothpicks, cotton swabs (about 5 mm dia.) or cotton buds.
- Brushes
  Saran fiber brushes or brushes whose bristles are unaffected by organic solvent.
- Tweezers (supplied as accessory)
  Used to handle small parts. When using the tweezers, take care not to scratch or bend the parts.
- Screwdrivers and standard tools (supplied as accessory)
- Beaker
  This should be made of stainless steel or aluminum, or enamel-coated. Glass beakers are not recommended as they are easily broken.
- Work gloves
  Any commercially available cotton, nylon, or polyethylene gloves are suitable. Work gloves should always be worn when handling internal parts exposed to vacuum.
- Ultrasonic cleaner
- Mini-drill

6.2.2 Cleaning frequency and procedures

Under normal circumstances, the cleaning frequency listed in the Table below should be sufficient to keep the instrument in a reasonably contamination-free condition at all times. If, however, contaminated parts are noted, clean such parts irrespective of the cleaning frequency listed in the Table.

Parts	Cleaning frequency	Cleaning method
Wehnelt cap	When replacing the filament	B
Anode	Every 12 months	B
Condenser lens aperture	Every 6 months	C
Pole piece	Every 12 months	A
Objective lens aperture	Every 6 months	C
Objective lens aperture holder, cap, and spacer	Every 6 months	B
Metal pipe	Every 24 months	B

For details on the cleaning method, see Sect. 6.2.3.

6.2.3 Cleaning methods

- Cleaning method A

  Application: Cleaning of lightly contaminated parts
  For flat surfaces, wipe with gauze, rayon paper or absorbent cotton soaked in cleaning liquid. In the case of parts which scratch easily, use absorbent cotton only. For holes, the interior of cylindrical parts, etc., use cotton swabs or toothpicks wrapped in absorbent cotton. To remove oil, etc. from intricate or threaded parts, immerse the parts in a beaker of solvent, or brush off the oil. If the parts are easily scratched, avoid using a brush. An ultrasonic cleaner is highly effective for cleaning small parts. After removing the parts from the beaker, dry them with a hand blower so as to prevent residue from accumulating.
  When cleaning the pole piece, be extremely careful not to deform or scratch the edge of the bore. Never use a brush except for threaded parts.

- Cleaning method B

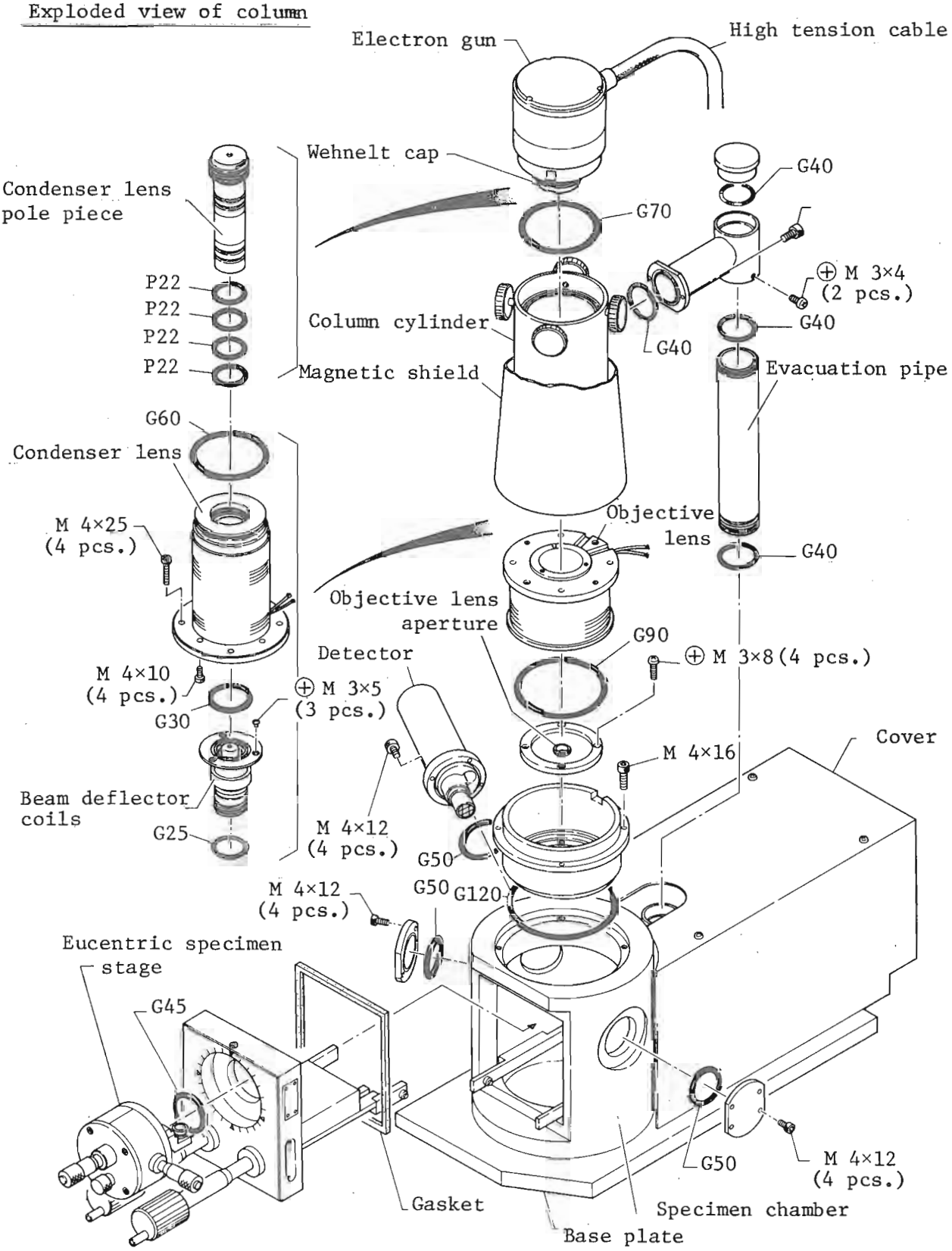
  Application: Cleaning of heavily contaminated parts (Wehnelt cap, anode, objective lens aperture holder, metal pipes, etc.)

For flat surfaces, wipe with gauze, rayon paper or absorbent cotton lightly smeared with fine grain metal polish. For holes, the interior of cylindrical parts, etc., use cotton swabs or toothpicks wrapped in absorbent cotton. Avoid applying polish to intricate, threaded, or synthetic resin parts. Also, when cleaning the parts, refrain from applying excessive rubbing force.
Visual inspection is sufficient for determining the adequacy of contamination removal. Remove any traces of polish with solvent. If polish is allowed to remain, it will in itself become a contaminant, completely defeating the object of the task in hand. Finally, keep the cleaned parts covered until ready for reassembly.

- Cleaning method C

Application: Apertures (tantalum or molybdenum apertures, etc.)
Place the apertures in a vacuum evaporator employing a tungsten wire (0.5 — 0.8 mm dia.) basket heater, helical heater or high-melting point thin metal foil boat that has been cleaned by preheating under high vacuum, and subject the apertures to a temperature of about 1500°C (white heat) for about 15 minutes. Avoid excessive heating as this may cause the apertures to melt. At the same time, insufficient heating will not provide adequate removal of the contamination. After heating, allow the apertures in the evaporator to cool down to room temperature before exposing them to the atmosphere (it takes about one hour). This is to prevent oxidation. When handling the apertures, take care not to nick or bend them.

Exploded view of column



APPENDICES

A.1 Specimen preparation

Unfortunately, there is no one universally applicable specimen preparation technique, since the preparation method varies according to the type and nature of the specimen being examined.

The following, however, lists certain basic requirements, etc. common to all specimens. For specific details regarding the various preparation techniques, refer to the bibliographies given in books dealing with the subject of scanning electron microscopy.

■ Common basic requirements for all specimens

1. The specimen must be shaped so as to fit the specimen holder and must be secured firmly in the specimen holder.
2. The specimen must be conductive. Therefore, non-conductive specimens require to be coated with a conductive agent.
3. Since the specimen is examined in vacuo and is subject to electron beam bombardment, the specimen must be treated before being introduced into the microscope. Otherwise, satisfactory micrographs cannot be ontained. Moreover, the microscope will be contaminated by the specimen itself or gases evolving from the specimen.
   Note: The following specimens must be handled with great care:

   Volatile specimens
   Radioactive specimens
   Wet specimens; that is, thick plant leaves, bulky soft animal tissues, etc.
   Fine particles
   Magnetic materials
   Porous specimens (especially gas-absorbed specimens).

■ Securing the specimen

Use conductive paint to secure the specimen to the specimen stub.

Note: In addition to conductive paint, double-faced adhesive tape, vacuum compound, methyl cellulose solution, manicuring solution and various other adhesives can also be used for securing the specimen to the stub.

■ Specimen coating

In the case of non-conductive specimens, coat the specimens by vacuum evaporation or sputtering in order to avoid any buildup of surface charge and reduce damage by thermal effects of the electron beam and further to improve the secondary electron yield ratio.

• Vacuum evaporation

Coating materials: Carbon (continuous; not in aggregate form; uniform; highly adhesive),
Gold (non-oxidization; extremely fine particles; low melting point; high secondary electron emission),
Platinum-palladium alloy, aluminum, etc.

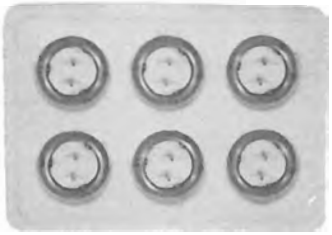
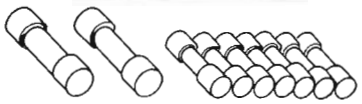
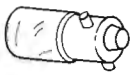
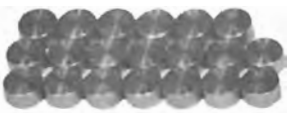
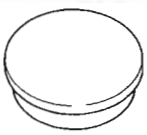
Coating thickness: 100 – 200 Å.
The double coating method (e.g., one thin coat of carbon topped by one coating of gold) is widely used for various specimens.

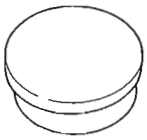
- Sputtering

  Materials: Gold, platinum-palladium alloy, chromium, silver, copper, etc.

A.2 Standard tools and accessories

Name	Appearance	Quantity
Container		1
Screwdriver, Phillips-headed		1 set (3 pcs.)
Screwdriver, watchmaker's		1 set (6 keys)
Hexagonal key wrench		1 set (6 pcs.)
Tweezers		1 set (2)
Pole-piece removing tool		1
Pole-piece assembling tool		1
Wehnelt cap removing tool		1

Name	Appearance	Quantity
Hand blower		1
Objective aperture		1 set
Magnifying lens		1
Gun filament		1 case (6 pcs.)
Fuse		1 set (9 pcs.)
Lamp		1
Specimen stub (10 dia. × 5 thick mm)		20
Specimen stub (10 dia. × 10 thick mm)		20
Vacuum grease		1 vial (5 g)
Conductive paint		1 vial

Name	Appearance	Quantity
Fine grain metal polish		1 vial (10 g)
Fixed aperture holder removing tool		1
Teflon sheet (Beam deflector coil spacer)		1