INSTRUCTIONS

JSM-35CF

SCANNING MICROSCOPE

JEOL

No. IEP35CF-1
(EP156091)

JEOL LTD. / 日本電子

Tokyo Japan

8103633HP

2.5 Detector

■ Detector system:	Scintillator-photomultiplier system complete with pre-amplifier and collector.
■ Imaging signals:	Secondary electrons, backscattered electrons.
■ Signal control	
● Contrast (waveform amplitude):	Photomultiplier gain control.
● Brightness (waveform level):	Preamplifier DC level control.

2.6 Image Display System

■ Image polarity:	Normal and inverse.
■ Video signal control	
● Contrast:	CRT input signal amplitude control.
● Brightness:	CRT input signal level control.
■ Y-modulation device:	Built-in (Y-modulated image display).
■ Waveform monitor:	Built-in (video signal waveform display).
■ Image display	
● For viewing:	High resolution, long persistence 10″ CRT (135 mm × 180 mm).
● For recording:	Ultra-high resolution, short persistence 5″ CRT (69 mm × 92 mm, 42° deflection, flat-face type).

2.7 Photographic Recording System

■ Camera	
● Focal length:	77.3 mm.
● Lens opening (f-number):	f/5.6, 8, 11, 16, 22.
● Automatic shutter mechanism:	Built-in (synchronized electromagnetic).
■ Exposure meter:	Independently displays contrast and brightness.
■ Multi-exposure mechanism:	Built-in.
■ Film number:	0000 to 9999 (first 2 digits are set manually and last 2 digits are set automatically or manually), digitally displayed and recorded on film.
■ Data recording (direct display on CRT with white or black characters, or white characters on black background)	
● Accelerating voltage:	□□ kV.
● Magnification:	× □□□□□□

Index number	Part name	Function/Operation
		controls clockwise, the scale reading increases and the specimen and image move in the direction indicated by the arrow as shown in Fig. 4.6 (WD: 15 mm). The X control should be set to 7.5 (mm) for the airlock system specimen exchange.
	Rotation control	This control (360° full turn, with a stop) rotates the specimen so as to orient it as desired. This control is very convenient for aligning a directional specimen with the tilt axis or orienting it at right angles to the tilt axis and also for orienting a specimen image vertically or horizontally on the CRT. When this control is turned clockwise, the counter reading (000 – 999) increases, and the specimen on the stage and the image on the CRT rotate in the direction indicated by the arrow (clockwise) as shown in Fig. 4.6. The rotation angle θ_R can be calculated from $\theta_R = 0.36N$, where N is the counter reading. The rotation control must be set to 000 (0°) when exchanging the specimen via the airlock system.
	Tilt control	This control tilts the specimen and changes the viewing angle (refer to Table 4.1). With a flat specimen, the yield of the secondary electrons can be increased by increasing the tilt angle. When the control is turned clockwise, [illegible] and the specimen tilts in the direction indicated by the arrow as shown in Fig. 4.6. For full focusing of the tilted specimen, depress the FULLY FOCUS pushbutton on the LENS panel and adjust the AMPLITUDE knob on the LENS panel so that the probe focuses along the tilting surface. Distortion of the image caused by tilting can be corrected using the scan rotation and tilt correction unit (attachment SRT). When exchanging the specimen, this control must be set to 0°.
⑦	Specimen exchange chamber airlock knob	This knob operates airlock valve AV2 (Fig. 3.8), so as to separate the specimen exchange chamber from the specimen chamber (Fig. 4.7). To open the airlock valve, pull the knob out as far as it will go; to close the valve, push in the knob as far as it will go. When exchanging the specimen, open the airlock valve after the specimen exchange chamber has been evacuated, move the specimen holder from the specimen exchange chamber to the specimen chamber by the specimen exchange rod, then mount the specimen holder on the specimen stage.

Table 5.1 lists specimen sizes, applicable combinations of specimen holders and specimen pedestals, and specimen exchange methods. This should be used in conjunction with Table 4.1.

Table 5.1 Specimen mounting

Specimen size		Specimen holder	Specimen pedestal	Specimen exchange method
Diameter	Thickness			
10mm or less	Thin	WD15 specimen holder	10mm dia. × 10mm hgt.	Airlock system*2
↓	5mm or less	↓	10mm dia. × 5mm hgt.	↓
↓	5mm–10mm	↓	———	↓
28mm or less	15mm or less	WD39 specimen holder	———	↓
28mm–33mm	15mm–20mm	↓	(Remove cylinder)	↓
76mm or less	20mm or less	Large-size specimen holder*1	———	Hinge system

*1 *An LSH type specimen holder available upon special order.*
*2 *Though both airlock and hinge systems are used to exchange specimens, the airlock system is most common.*

5.2.3a Specimen mounting (removal) on (from) the specimen holder

■ WD15 specimen holder (see Fig. 5.2)

1. Loosen the specimen pedestal screw, insert a screwdriver in the bottom of the specimen holder, raise the specimen by turning the specimen height adjusting screw, then remove the pedestal with the specimen from the cylinder (Fig. 5.2–A and –B). If the specimen pedestal is not used (Fig. 5.2–C), loosen the specimen height adjusting screw and remove the used specimen with the screw.

   Notes: 1. The specimen can be exchanged with the specimen cylinder attached to the holder. However, if it is difficult to do so, remove the specimen cylinder by loosening the cylinder screw, and replace it after the specimen has been exchanged.

   2. Use organic solvent to remove specimens secured with silver conductive paint. Polish the upper surfaces of the specimen pedestal and specimen height adjusting screw (before re-use), if necessary.

2. After checking the combination of specimen size and pedestal (see Table 5.1), secure the specimen horizontally to the specimen pedestal or specimen height adjusting screw with silver conductive paint. Then, if necessary, perform metallic coating with a vacuum evaporator (conductive processing).
3. Insert the specimen pedestal or specimen height adjusting screw to which the specimen is secured into the specimen cylinder. Adjust the specimen height with a screwdriver to make the specimen surface flush with the top of the specimen cylinder.
4. If the specimen pedestal is used (Fig. 5.2–A and –B), secure it by screwing the specimen pedestal screw into the upper or lower threaded hole in the specimen cylinder. Screws are not required if the specimen pedestal is not used (Fig. 5.2–C).

Clean the outer surface with gauze soaked in liquid detergent. If the contamination is difficult to remove, use a small amount of metal polish. Be sure to wipe off all traces of polish as in cleaning method A after cleaning. Take care not to get any polish on the threaded portion.

6.6.3c Parts and column reassembly

When carrying out reassembly, observe the precautions listed in Section 6.6.1. The assembly procedure is divided into four parts, viz., parts assembly, specimen chamber and objective lens assembly, 2nd deflection system and condenser lens assembly, and intermediate cylinder, anode chamber and electron gun assembly. Upon completion of assembly, check the assembled parts to make sure all is in order and then evacuate the assembled column as quickly as possible.

When carrying out O-ring replacement, refer to Section 6.6.4.

■Parts reassembly

1. Attach the objective lens aperture foil to the aperture selector as follows (see Figs. 6.18 and 6.19):
   a. Place the insulator leaf, aperture foil, and fixing plates A and B on the aperture holder in that order and then lightly screw in screws G (with washer) and H.
   b. Use the aperture foil holder tool to align the aperture holes with those of the aperture holder. After alignment, tighten screws G and H.

   Caution: Take care not to bend or otherwise deform the aperture foil.
2. Assemble the 2nd deflection system cylinder as follows (see Fig. 6.17):

   Caution: Take care not to break lead wires.
   a. Insert the pipe into the cylinder, connect the stigmator coil assembly (with the coil assembly pin aligned with the cylinder slot) and secure the stigmator coil assembly to the cylinder with the ring nut.
   b. Insert the lower aperture into the stigmator coil assembly and secure it with the cap nut.
3. Assemble the condenser lens pole piece as follows (Fig. 6.17):
   a. Screw the upper pole piece in the spacer.
   b. Insert the upper and lower apertures in the aperture holder in that order and secure them with the cap nut.

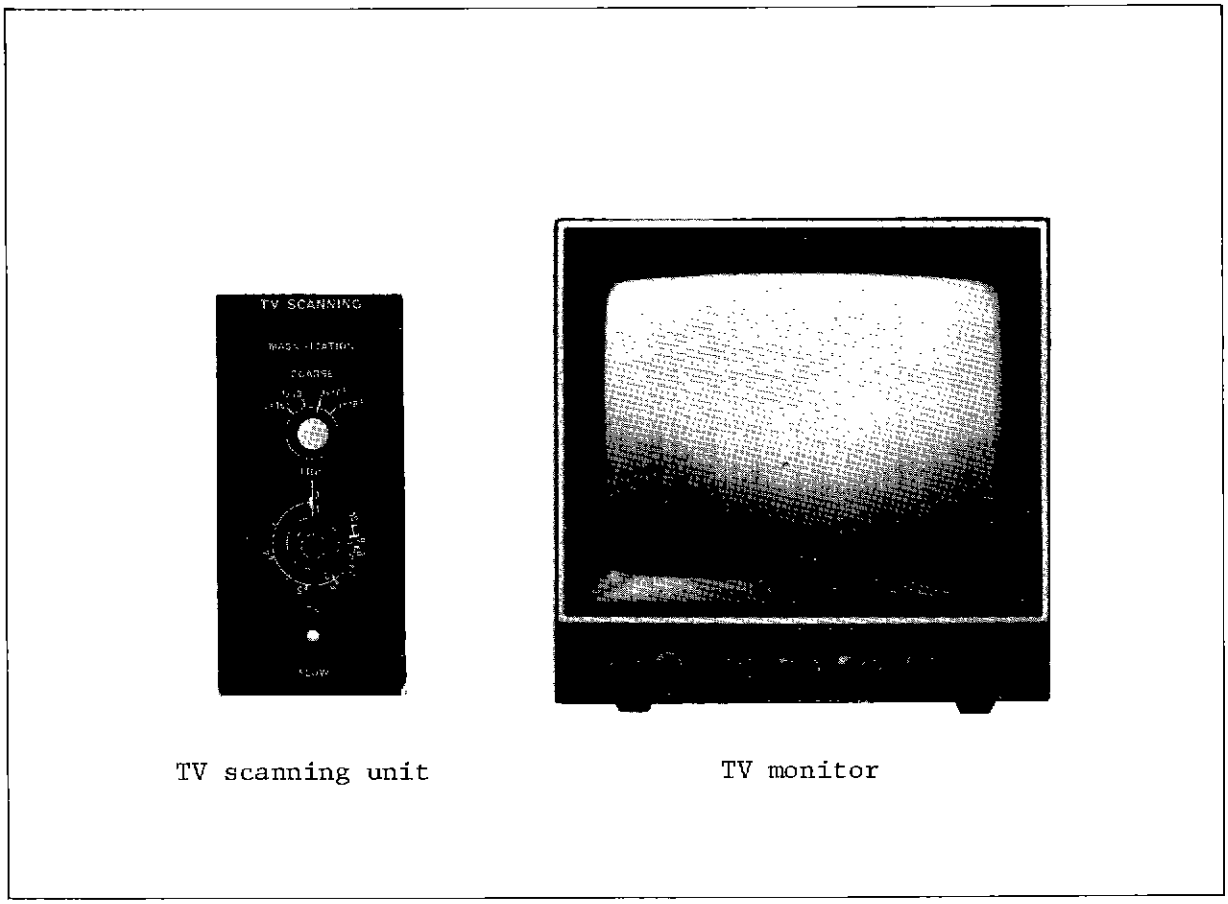
      Caution: Make sure that the apertures are seated flush in the holder. Failing to observe this precaution may result in damage to the apertures and holder when the cap is screwed onto the holder. When inserting the apertures in the holder, take care not to mistake the top and bottom of each aperture.
   c. Screw the aperture holder in the pole piece and secure it with the tool.
4. Replace the Wehnelt cap onto the Wehnelt unit base according to Section 6.2.

INSTRUCTIONS

35-TVS

TV SCANNING DEVICE

No. IEP35C-TVS
(EP730043)



TV scanning unit

TV monitor

Fig. 1 TV scanning device

INSTRUCTIONS

35-IMS

IMAGE SELECTOR

No. IEP35C-IMS
(EP422001)

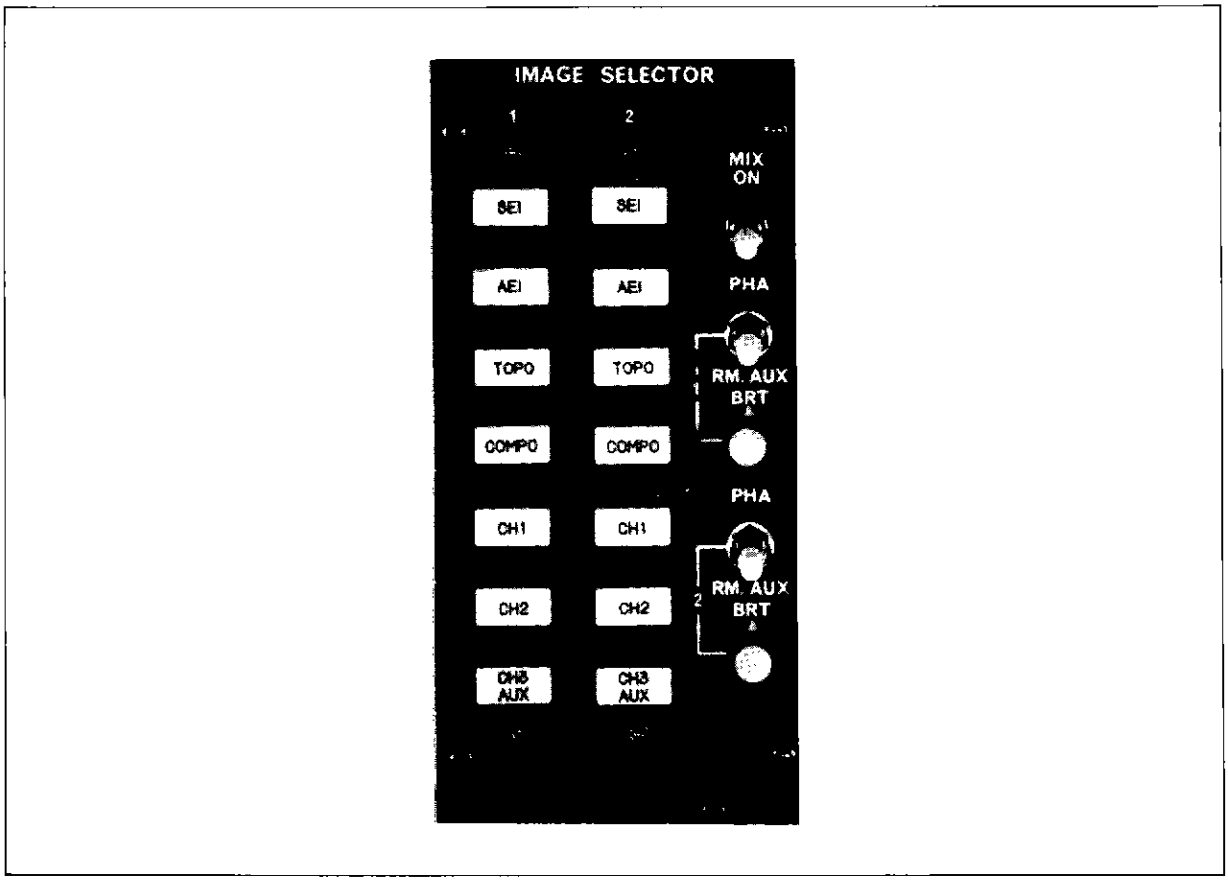


Fig. 1 Image selector unit

1. GENERAL

This unit is designed for use in conjunction with a JSM-35C Scanning Microscope incorporating a variety of attachments so as to enable various types of specimen image to be selected and displayed on the CRT.

The unit panel is provided with two sets of identical pushbuttons so as to permit an extra CRT to be used and thereby enable two different kinds of images to be compared at the same time. Another extremely useful feature of this unit is the facility provided for signal mixing. That is to say, any two kinds of signal can be mixed and the resultant image displayed on the CRT.

5.2 Specimen holder insertion and removal

5.2.1 Inserting the specimen holder in the specimen chamber

1. Set the goniometer stage controls as indicated in Table 1 (A).

Purpose \ Controls	WD (mm)	X (mm)	Y (mm)	Z (mm)	Rotation	Tilt	Remarks
A. Specimen holder insertion and removal	15 or 39	2.5	0 to 25	0	0°	0°	
B. Specimen selection	15 or 39	7.5	0 to 25	0	0°	0°	
C. Specimen center observation	15 or 39	7.5	12.5	-	-	0°	Field of view: 1.8mm dia.

Table 1 Goniometer stage control setting chart

2. Screw the threaded part of the adapter (Fig. 9) into the specimen holder screw hole.
3. Mount the specimen holder on the specimen stage as per the normal procedure. For WD 39 mm, first attach the exchange chamber adapter to the specimen exchange chamber.

5.2.2 Removing the specimen holder from the specimen chamber

1. Set the goniometer stage controls as indicated in Table 1 (A).
2. Remove the specimen holder from the specimen chamber as per the normal procedure. For WD 39 mm, first attach the exchange chamber adapter to the specimen exchange chamber.

5.3 Specimen selection

1. Set the goniometer stage controls as indicated in Table 1 (B).
2. Attach the specimen exchange chamber cap to the specimen exchange chamber*, rough the chamber, and open the airlock valve.
3. While observing the chamber interior through the viewing window, insert the specimen exchange rod adaptor into the specimen holder pedestal rotating shaft, making sure that the adaptor pin aligns with the shaft guide slot.
4. Rotate the specimen holder pedestal by turning the specimen exchange rod so as to select the specimen for intended observation.

Notes: 1. Make sure that the specimen number (1 to 4) inscribed on the side wall of the holder pedestal coincides precisely with the ▲ mark.

2. To observe the specimen center, set the goniometer stage controls as indicated in Table 1 (C).
When using the OM (optical microscope) attachment and/or LNT (liquid nitrogen trap) attachment in conjunction with the JSM-35C Scanning Microscope, the range of the goniometer stage

*For WD 39 mm, first attach the adapter to the specimen exchange chamber.

controls is limited as shown in Table 2. On no account should these limitations be exceeded.

Controls / Combinations	WD (mm)	X (mm)	Y (mm)	Z (mm)	Rotation	Tilt	Remarks
T E D	15	0 - 15	0 - 25	-1.5 - +1.5	±180°	0 - 45°	
	39	0 - 15	0 - 25	-1.5 - +1.5	±180°	0 - 60°	
TED + LNT	15	0 - 15	0 - 25	-1.5 - +0.5	±180°	0 - 45°	
	39	0 - 15	0 - 25	-1.5 - +0.5	±180°	0° (Fixed)	
TED + OM	15	0 - 10	0 - 25	-1.5 - +1.5	±180°	0 - 45°	With the OM withdrawn from the optical axis.
	39	0 - 15	0 - 25	-1.5 - +1.5	±180°	0 - 60°	
TED + LNT + OM	15	0 - 10	0 - 25	-1.5 - +0.5	±180°	0 - 45°	
	39	0 - 15	0 - 25	-1.5 - +0.5	±180°	0° (Fixed)	

Table 2 Goniometer stage control range chart

6. OPERATION

6.1 Bright field image (see Fig. 2a)

1. Set the TED unit controls as follows (see Fig. 1).
   - MODE knob ..... PICTURE
   - X-SHIFT knob ..... about 30° either side of midway position
   - Y-SHIFT knob ..... Midway position
2. Set the control unit control knobs as follows (see Fig. 11).
   - WINDOW control ..... OPEN
   - FIELD control ..... BRIGHT
   - DIFFRACTION control ..... OUT

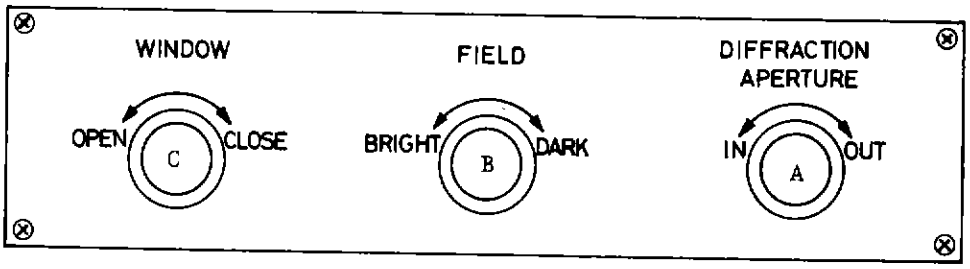


Fig. 11 Control unit controls

3. Insert the 100 or 240 μm diameter (setting number 1 or 2) objective lens aperture into the beam path.
4. Set the GUN BIAS thumbwheel switch, according to accelerating voltage, as follows:

Accel. voltage (kV)	GUN BIAS
35	2 or 3
25	1 or 2

Note: Use 35 kV in the case of thick specimens.

5. Set the CONTRAST knob at 2.0, 3.0, or 4.0.
6. Set the OBJECTIVE LENS (MEDIUM) knob at 5.0.
7. Position the CONDENSER LENS knob at the 2 or 3 graduation from the fully clockwise position.
8. Minimize the magnification by depressing the magnification selection 10^1 COARSE button and turning the FINE knob fully counterclockwise, and then position the PROBE SCAN/EXT switch at PROBE SCAN.
9. After making sure that the electron beam illumination is visible on the fluorescent screen, turn the CONDENSER LENS knob so as to obtain an absorbed current of 10^{-10} to 10^{-12} A.

Note: Avoid turning the CONDENSER LENS knob too far, otherwise the resultant flow of excess current may damage the detector.

10. Manipulate the X, Y-SHIFT knobs around their midway positions so that the incident electron beam passes through the center hole on the fluorescent screen.
    Note: If the beam shifts off center (i.e., fails to pass through the center hole) during the remaining part of this procedure, re-center it immediately with the X, Y-SHIFT knobs.
11. Close the viewing window light proof cover A by positioning the WINDOW control at CLOSE
12. Set the SEI/BEI switch (SEI unit) to BEI.
13. Adjust the CONTRAST and BRIGHTNESS knobs (SEI unit) for a quality image.
14. Obtain the desired magnification by depressing the appropriate magnification selection COARSE button and adjusting the FINE knob as necessary. Then select the field of view with the goniometer stage X, Y controls.
15. Focus the image with the OBJECTIVE LENS, MEDIUM and FINE knobs.
16. If necessary, correct out the astimatism.
17. Take a micrograph.

6.2 Dark field image I (see Fig. 2b)

1. Carry out Steps 1 to 10 in Sect. 6.1, disregarding the note under Step 10.
2. Set the FIELD control at DARK.
   Note: The direct beam should now be visible on the fluorescent screen B. If the beam goes off the screen during the remaining part of this procedure, bring it back with the X, Y-SHIFT knobs.
3. Carry out Steps 11 to 17 in Sect. 6.1.

6.3 Dark field image II (see Fig. 2c)

1. Depress the LENS unit AUTO FOCUS button to cease the autofocusing function (the button lamp goes out).
2. Carry out Steps 1 to 5 in Sect. 6.1.
   Note: Use the 600 μm diameter (setting number 3) objective lens aperture.
3. Set the CONDENSER LENS knob around the midway position.
4. Minimize the magnification by depressing the magnification selection 10^1 COARSE button and turning the FINE knob fully counterclockwise, and then position the PROBE SCAN/EXT switch at EXT.
5. Decrease the direct beam intensity with the CONDENSER LENS knob within an extent that the electron diffraction pattern can be observed on the fluorescent screen.
6. Turn the OBJECTIVE LENS MEDIUM knob slowly counterclockwise until the pattern is in focus.
7. Repeat Steps 5 and 6 until the sharpest diffraction pattern is obtained.
8. Set the X-, Y-SHIFT knobs around their midway positions and observe the diffraction pattern.
9. Manipulate the X-, Y-SHIFT knobs so that the desired diffracted beam passes through the center hole of the fluorescent screen.

Note: If the beam shifts off center (i.e., fails to pass through the screen hole) during the remaining part of this procedure, re-center it with the X-, Y-SHIFT knobs.

10. After setting the PROBE SCAN/EXT switch to PROBE SCAN, carry out Steps 11 to 17 in Sect. 6.1.

6.4 Scanning electron diffraction pattern

1. Carry out Steps 1 to 7 in Sect. 6.3.
2. Set the DIFFRACTION APERTURE control at IN, then the X-SHIFT knob to the midway position.
3. Set the TED unit MODE selection switch to DIFF.
4. Carry out Steps 11 and 12 in Sect. 6.1.
5. Obtain a scanning diffraction pattern suitable for photography with the CONTRAST and BRIGHTNESS knobs. The CONTRAST knob is used for adjusting the diffraction pattern intensity and the BRIGHTNESS knob is used for adjusting the background intensity.
6. Set the camera length by referring to Sect. 7.
7. Locate the diffraction pattern as desired with the X-, Y-SHIFT knobs.
8. Photograph the pattern.

[Scanning electron diffraction line profile (LSP)]

a. After completing Steps 1 to 7 above, position the SCAN GENERATOR unit scanning mode selection switch at - (line scanning) and then the modulation mode selection switch at the upper position (amplitude modulation).
b. Adjust the peak of the diffracted or direct beam with the CONTRAST knob and the zero level with the BRIGHTNESS knob.
c. Maximize the peak of the direct beam with the Y-SHIFT knob and optionally shift the direct beam horizontally with the X-SHIFT knob.

Notes: 1. If necessary, shift the diffraction pattern vertically with the Y-SHIFT knob.

2. By using the Y-modulation device (YMD) in conjunction with this device, the intensity profile can be displayed on the CRT. In this case, position the SCAN GENERATOR unit scanning mode selection switch at □ (frame scanning) and push the Y-MOD button on the DISPLAY unit.*

** Operation procedure for the YMD is given in the JSM-35C instruction manual.*

7. CAMERA LENGTH FOR SCANNING ELECTRON DIFFRACTION

Fig. 12a shows the ray diagram for high resolution diffraction in the case of a conventional transmission electron microscope. The interplanar spacing d_{hkl} is given by the following equation:

$$d_{hkl} \fallingdotseq \frac{L}{r_{hkl}} \lambda e \ (\text{Å}) \quad \cdots\cdots\cdots\cdots \quad (1)$$

where L is the camera length which is determined mechanically, λe is the electron wavelength which varies according to the accelerating voltage E (volt): $\lambda e = \sqrt{\frac{150.4}{E(1 + 0.978 \times 10^{-6}E)}}$ Å, and r_{hkl} is the distance between the central spot and the diffraction spot.

However, since the scanning electron diffraction pattern is obtained by scanning the diffraction pattern with deflection coil A and displaying the pattern on the CRT synchronized with coil A, the camera length L' in the scanning electron diffraction mode varies with the beam deflection angle or, in other words, L' varies according to the magnification setting. This device is designed so that the diameter ($2r_{111}$) of the diffraction ring of spacing d_{111} in Au is 35 mm at 35 kV, so long as the magnification is minimum (the magnification selection 10^1 COARSE button depressed and the FINE knob set fully counterclockwise) and the working distance is 39 mm. Accordingly, the camera length L' is given as follows:

$$L' \fallingdotseq \frac{41.1}{\lambda e} \ (\text{mm}) \quad \cdots\cdots\cdots\cdots\cdots \quad (2)$$

For example, at an accelerating voltage of 35 kV ($\lambda e \fallingdotseq 0.0643$ Å), L' is about 639 mm (refer to Camera Length Calibration Chart). Further, even if the working distance is varied, the camera length remains unchanged so long as the $2r_{111}$ in Au is 35 mm on the CRT. At a working distance of 39 mm, an accelerating voltage of 35 kV and the minimum magnification setting, the interplanar spacing is readily given by the following expression.

$$d_{hkl} = \frac{41.1}{r'_{hkl}}$$

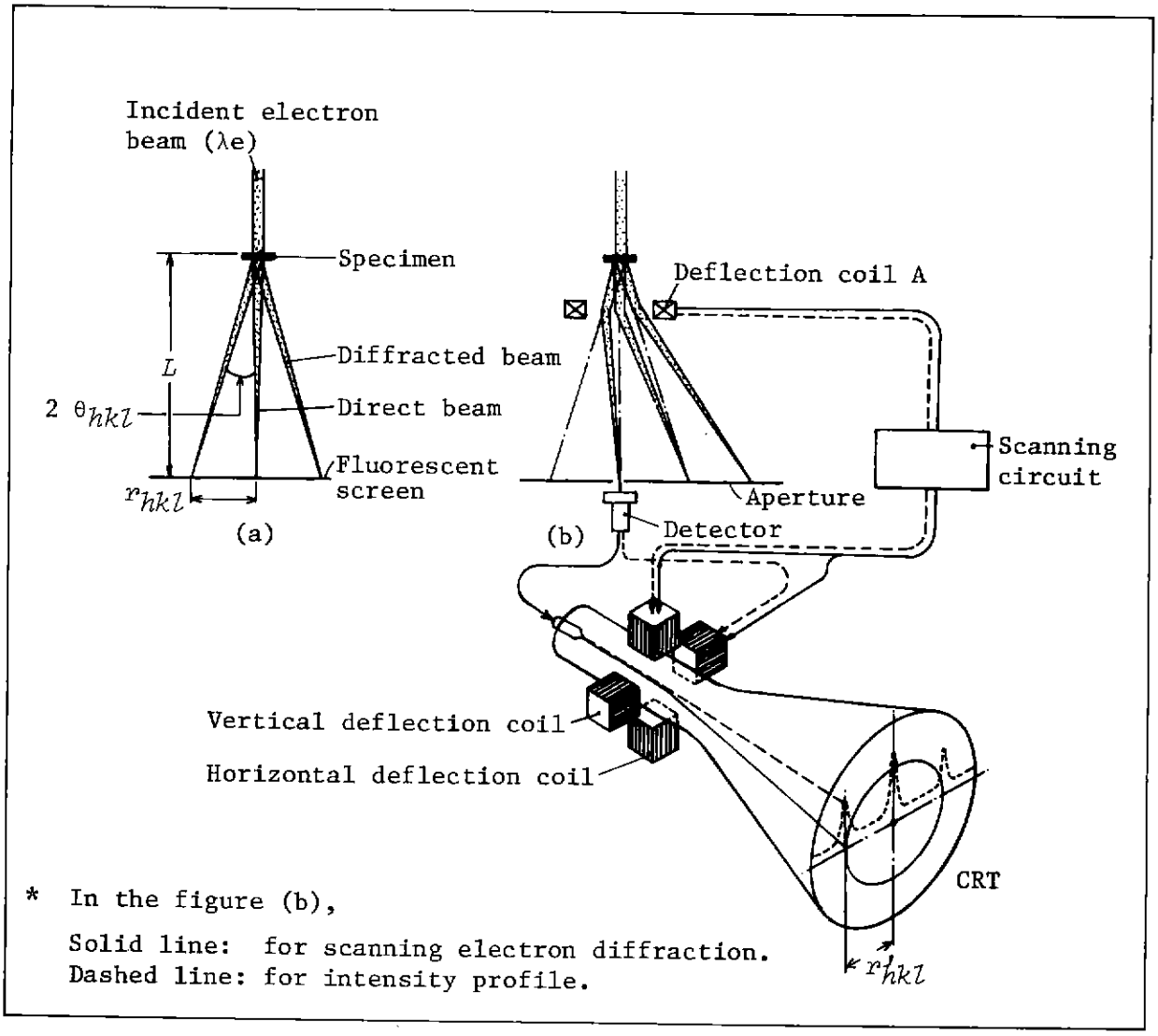
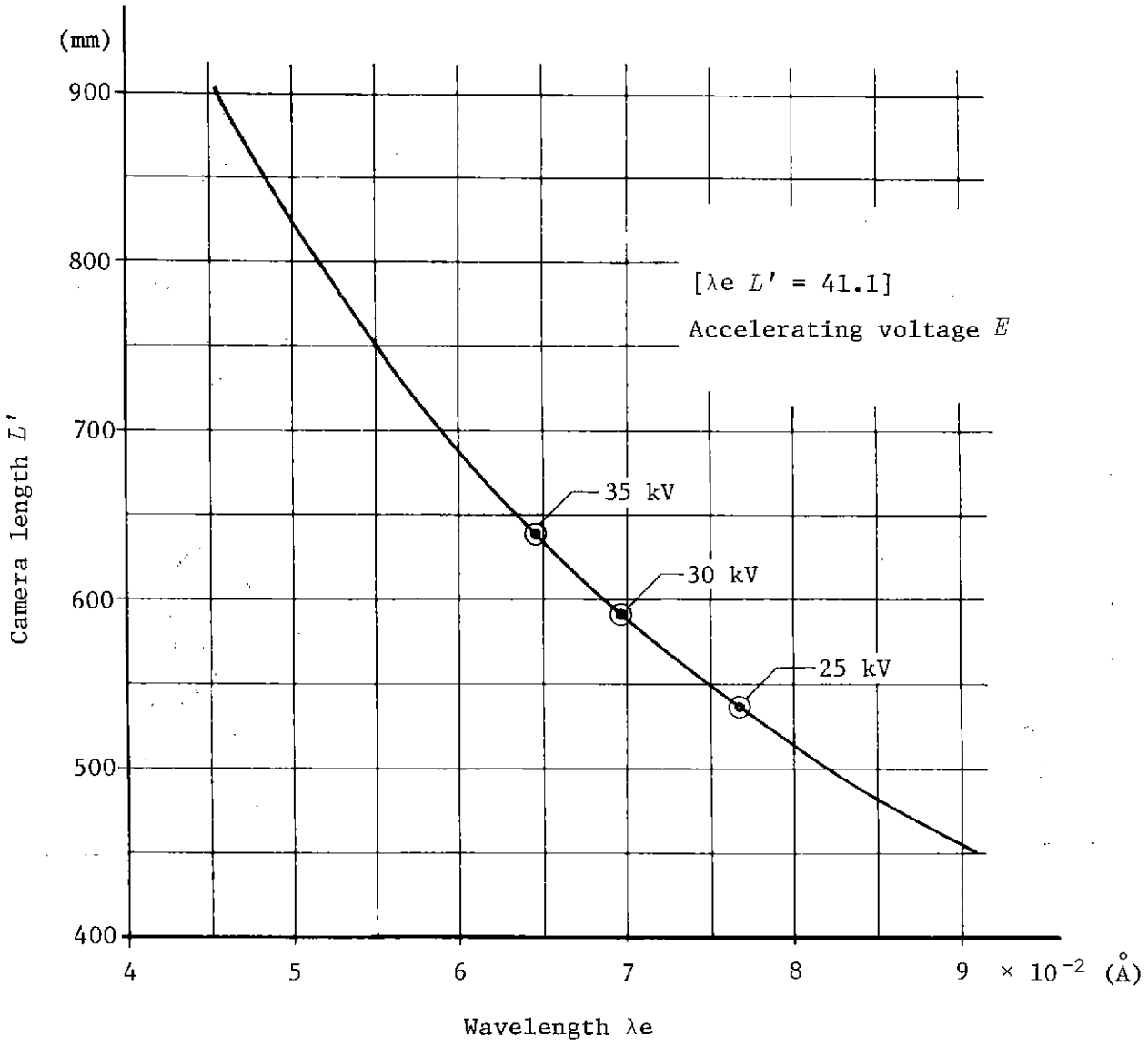
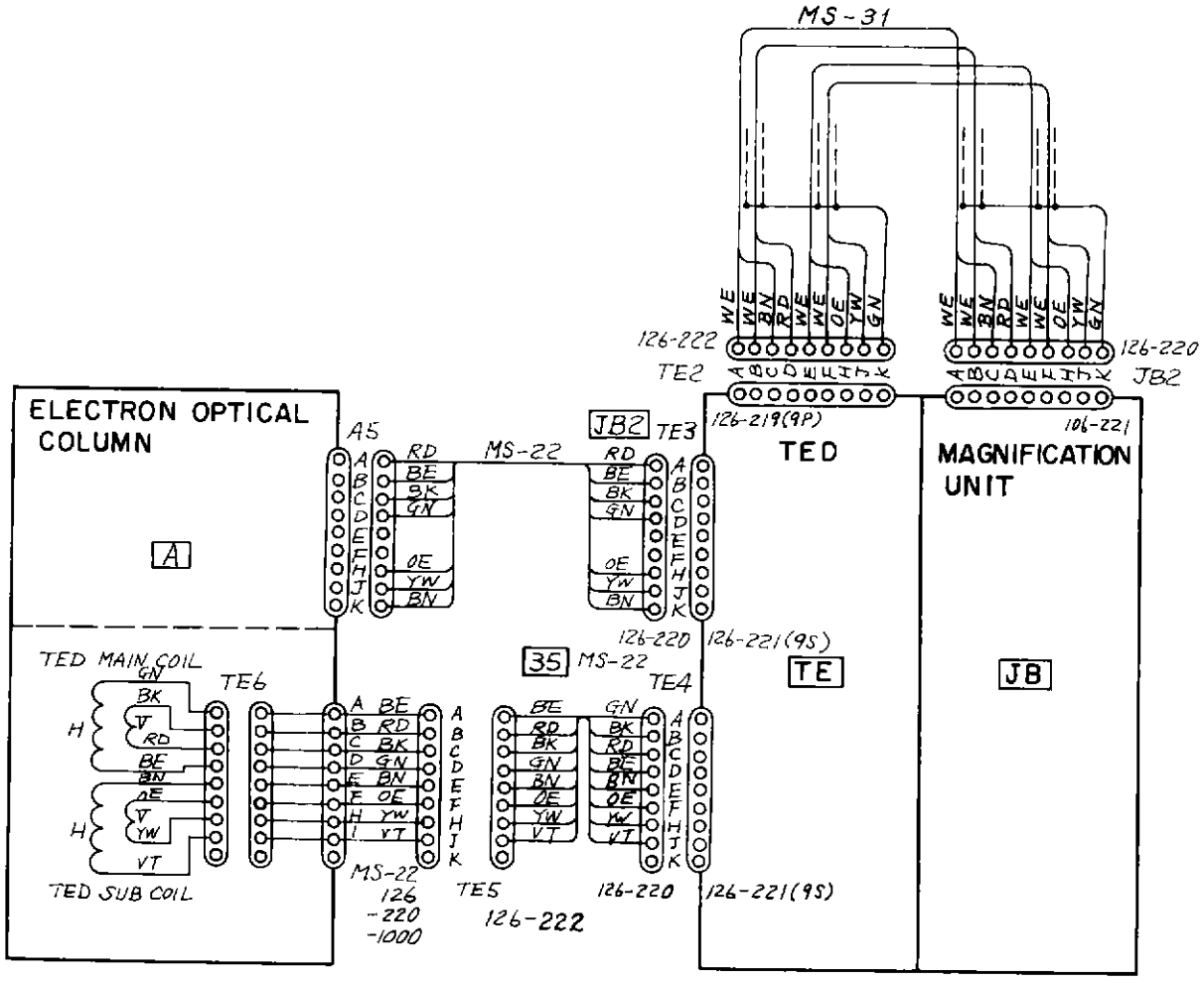


Fig. 12 Camera length

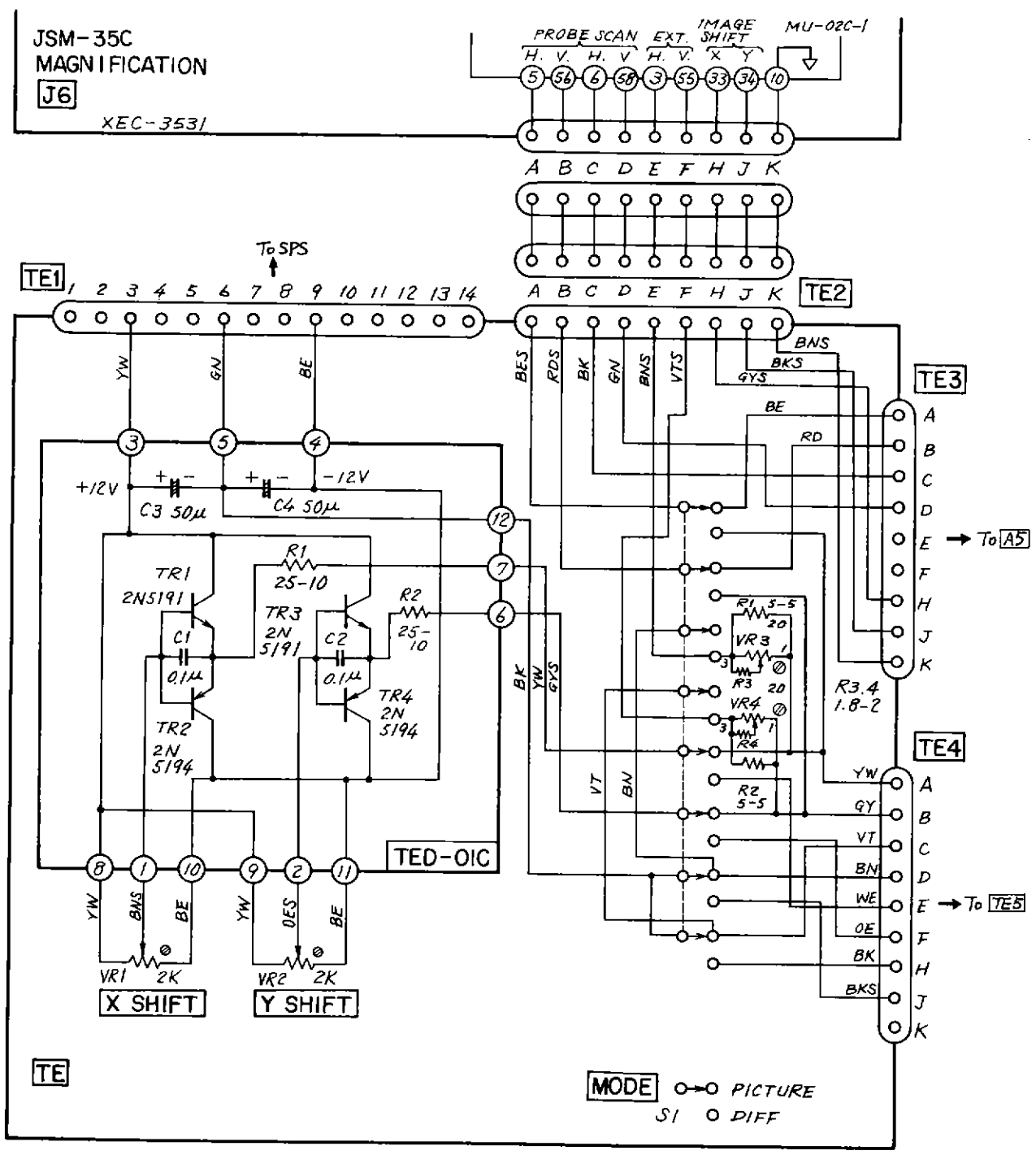


Camera length calibration chart



INTERCONNECTION DIAGRAM

XEC-3839


JSM-35C
MAGNIFICATION
J6
XEC-3531
PROBE SCAN
H. V. H. V
EXT.
H. V.
IMAGE SHIFT
X Y
MU-02C-1
5 56 6 58 3 55 33 34 10
A B C D E F H J K
To SPS
TE1
1 2 3 4 5 6 7 8 9 10 11 12 13 14
TE2
A B C D E F H J K
YW
GN
BE
BES
RDS
BK
GN
BNS
VTS
BNS
BKS
GYS
TE3
BE
RD
A
B
C
D
E
F
H
J
K
To A5
+12V
C3 50μ
C4 50μ
-12V
TR1
2N5191
R1
25-10
TR3
2N
5191
R2
25-10
C1
0.1μ
C2
0.1μ
TR2
2N
5194
TR4
2N
5194
TED-OIC
R1 5-5
20
VR3
1
R3 20
VR4
1
R4
R2
5-5
R3.4
1.8-2
TE4
YW
GY
VT
BN
WE
OE
BK
BKS
To TE5
YW
BNS
BE
YW
OES
BE
VR1 2K
VR2 2K
X SHIFT
Y SHIFT
TE
MODE
PICTURE
S1
DIFF

INSTRUCTIONS

35-SRT

SCAN ROTATION & TILT CORRECTION UNIT

No. IEP35C-SRT
(EP696053)

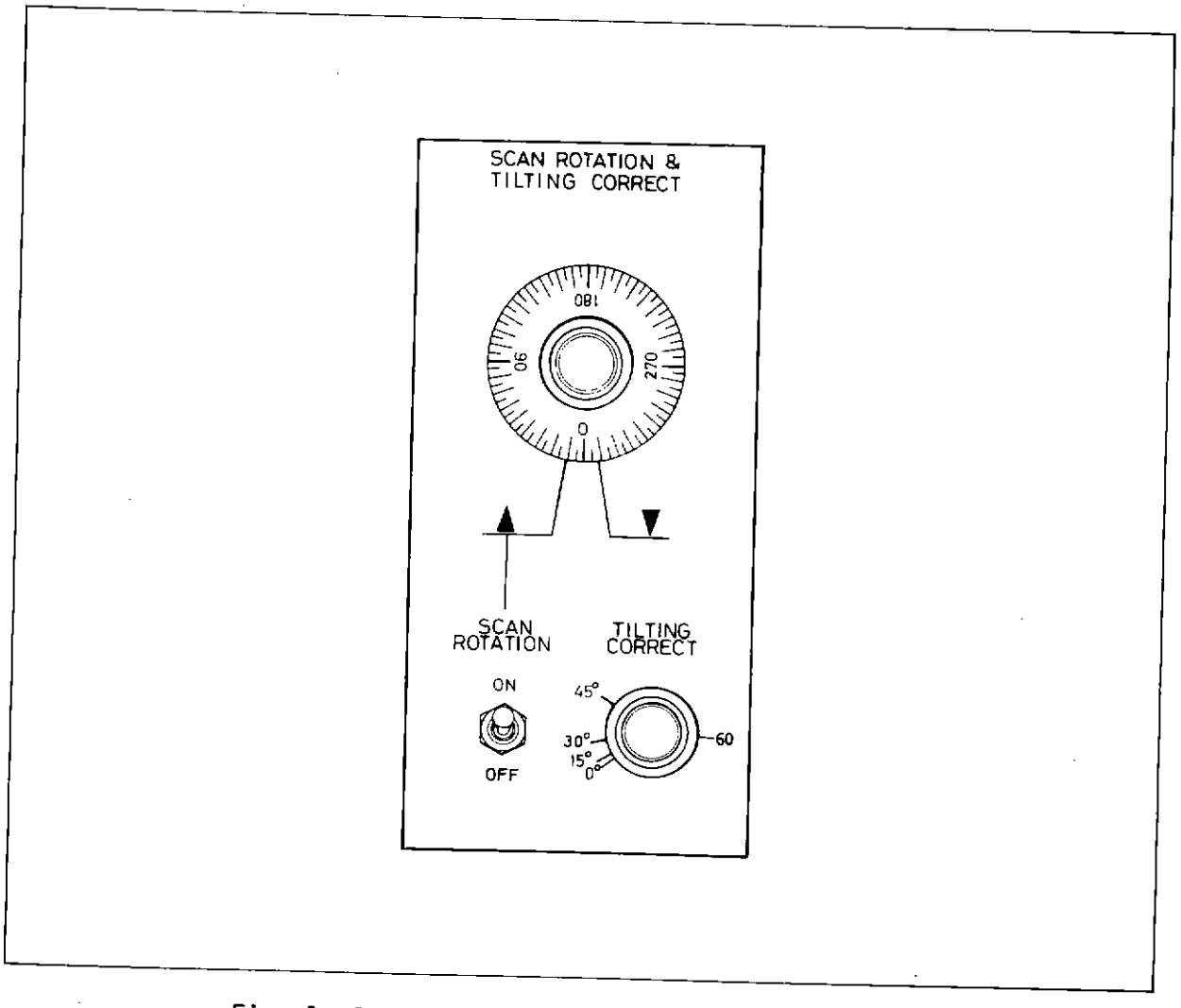


Fig. 1 Scan rotation & tilt correction unit

1. GENERAL

This unit permits 360° continuous rotation of the scan raster on the specimen surface and correction of the beam deflection angle. Accordingly, the specimen image can be optionally orientated without having to change the orientation of the specimen. Furthermore, image foreshortening due to specimen tilting can be corrected by reducing the beam deflection angle in a direction perpendicular to the tilt axis; i.e., by increasing the magnification in said direction.

2. SPECIFICATIONS

- Scan rotation: 360°, continuously variable.
- Tilt correction: 0 to 60°, continuously correctable (distortion: less than 5%).
- Power: DC ±20 V, 60 mA; DC ±10 V, 150 mA.
- Operating temperature: 0 to 50°C.
- Dimensions: 70 mm (W) × 300 mm (D) × 150 mm (H).

3. COMPOSITION

- Scan rotation & tilt correction unit 1

4. PANEL DESCRIPTION

- ON/OFF switch
  Scan rotation circuit switch.
- SCAN ROTATION knob
  Changes the direction of the electron probe scanning. Depending on the specimen height (working distance), the knob is set at ▲ or ▼. The ▲ setting is for the higher specimen position and the ▼ setting for the lower specimen position.
- TILTING CORRECT knob
  Corrects image distortion due to specimen-tilting.

5. INSTALLATION

1. Confirm that the power switch on the operation and display section panel is off.
2. Insert the scan rotation and tilt correction unit into the operation and display section of the scanning microscope.

Note: Power for the unit is supplied from the power supply built into the rack.

3. Turn on the power switch.

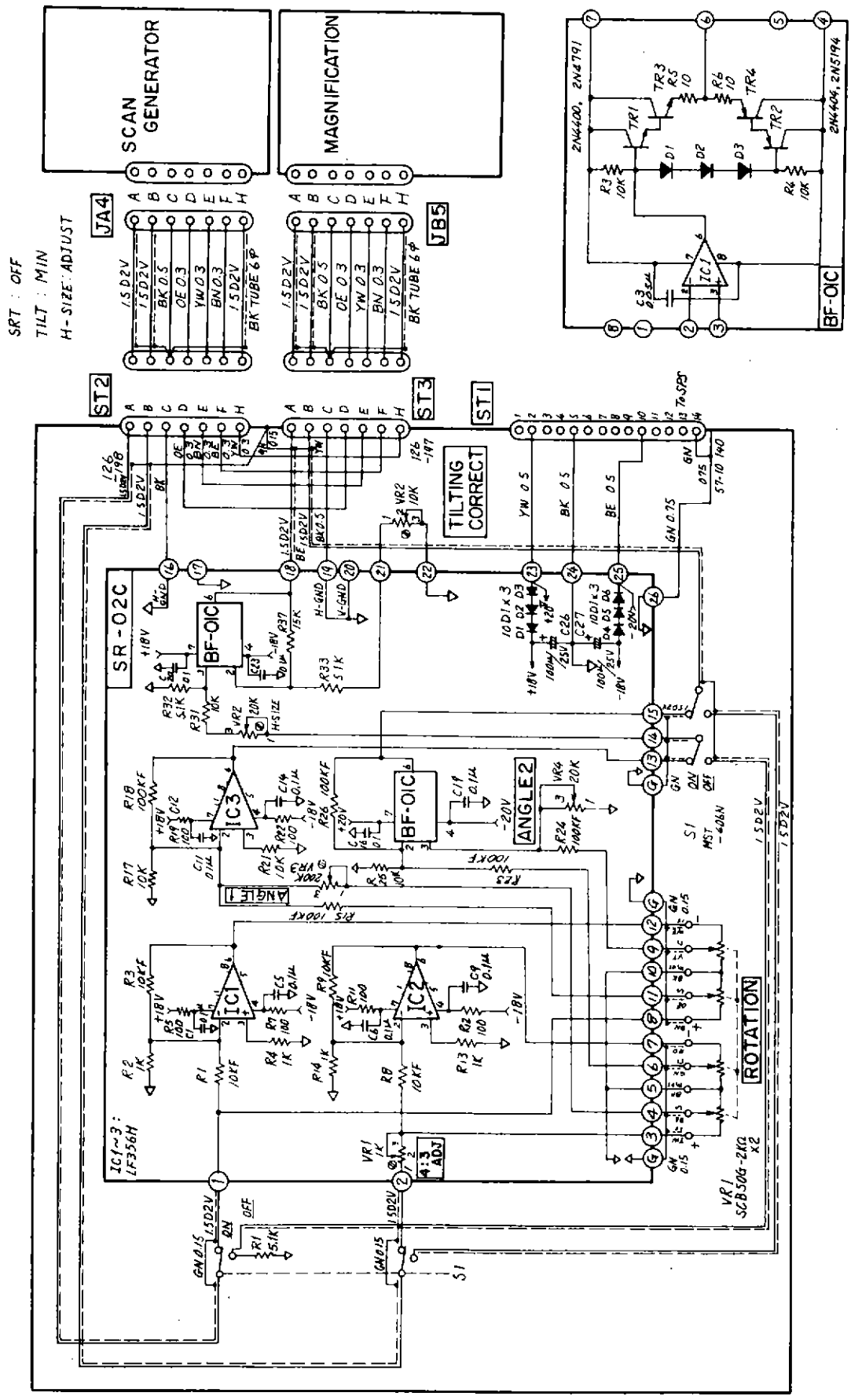
6. OPERATION

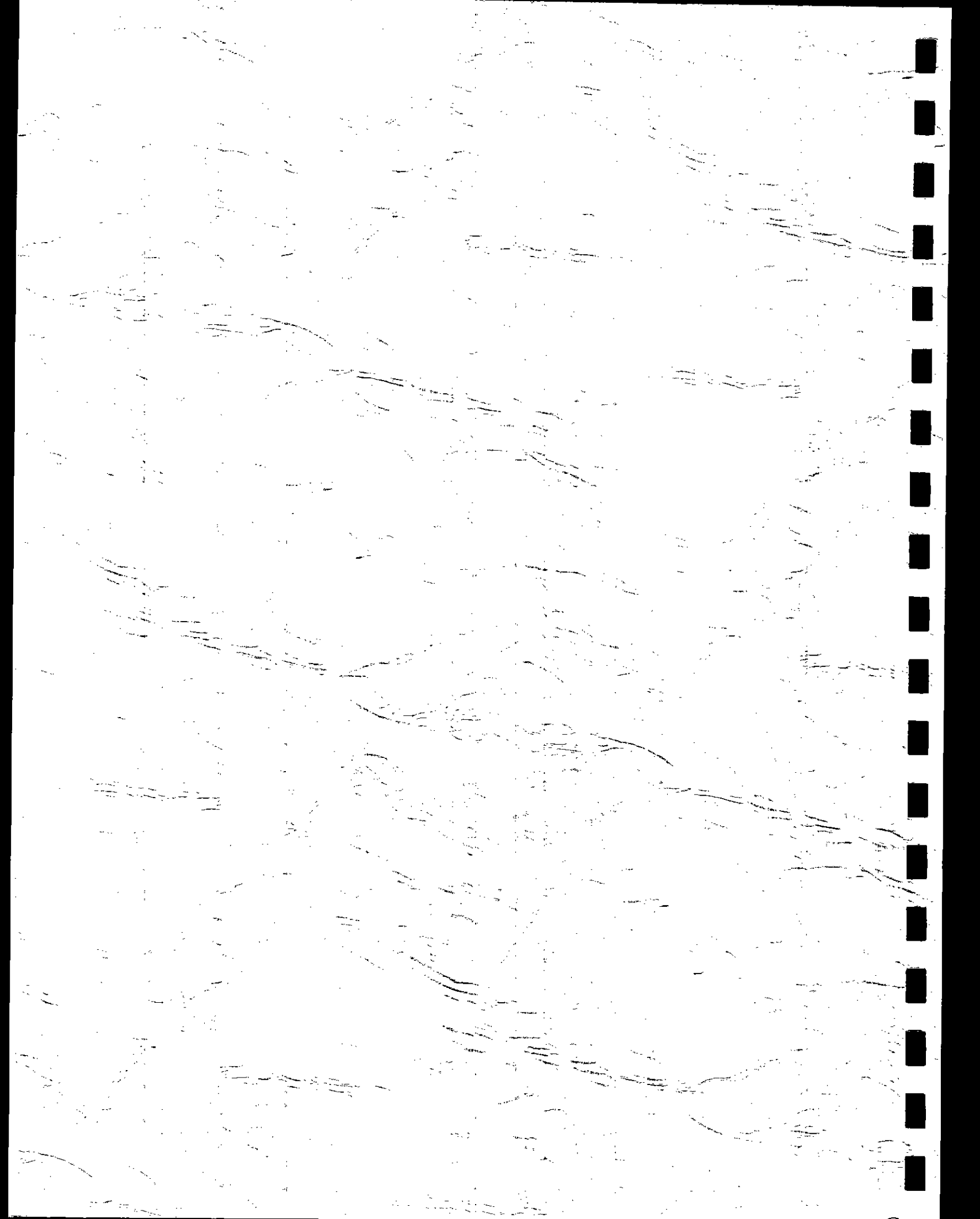
6.1 Scan rotation

1. Set the ON/OFF switch at ON.
2. Use the SCAN ROTATION knob to change the CRT image as desired.

6.2 Tilt correction

Turn the TILTING CORRECT knob so that the graduation on the knob corresponds to the tilt control setting (that is, the specimen tilt angle) of the specimen stage (goniometer stage).


SCAN GENERATOR
MAGNIFICATION
JA4
JB5
ST2
ST3
ST1
SRT : OFF
TILT : MIN
H-SIZE: ADJUST
SR-02C
BF-OIC
TILTING CORRECT
ANGLE2
ANGLE1
ROTATION
IC1-3: LF356H
VR1 SCB504-2KΩ X2
2N4400, 2N4791
2N4404, 2N5194



MECHANICAL PARTS LIST

JSM-35CF

SCANNING MICROSCOPE

JEOL

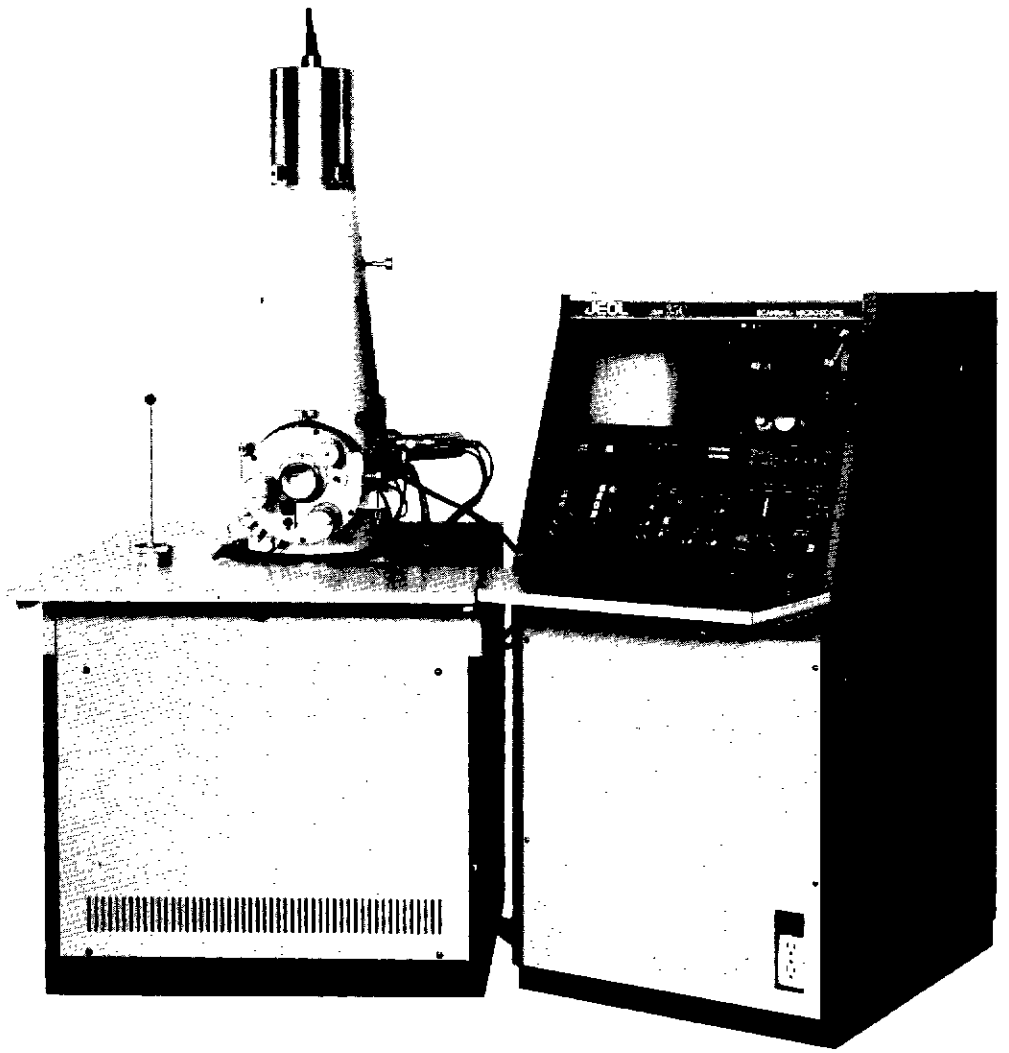
No. MPLEP35CF-1
(EP156091)

JEOL LTD. / 日本電子

Tokyo Japan

8102833HP

JSM-35CF SCANNING MICROSCOPE



Notice

This is a mechanical parts list providing parts information needed to be referred to by the user during routine operation or maintenance. Please use this list when contacting a JEOL service engineer or during maintenance inspection.

COMPONENTS LIST (BE520)

K-NO. AG110133(04) MODEL JSM-35C (M) EP156091~

	PART NO.	DESCRIPTION		QTY
I	804900361		ELEC.OPTIC.SYS.	1
[1A]	804700494	AA111035(06)-07 2	H.V.CABLE	1
[1B]	804700508	AA111030(01)-01 2	ANODE CHAMBER	1
[1C]	804500665	AA112015(04)-04 3	WEHNELT UNIT	1
[2A]	804700516	AA113048(03)-04 2	ALIGNMENT COIL	1
[2B]	804500673	AA113045(02)-01 3	INTMD.CYLINDER	1
[2C]	804500681	UA314101(05)-03 3	AIR LOCK VALVE	1
[3A]	804500690	UA321101(07)-06 3	CONDENSER LENS	1
[3B]	804300160	UA323101(03)-03 4	CL POLE PIECE	1
[4A]	804700443	AA114034(01)-02 2	OBJECTIVE LENS	1
[4B]	804700524	AA115031(08)-09 2	DEFLECTION COIL	1
[4C]	804500703	UA362101(13)-11 3	STIGMATOR	1
[5A]	804500576	UA316101(04)-02 3	MAGNETIC SHIELD	1
[3C]	804500584	UA321102(02)-02 3	AXIS ALIGNMENT	1
[6A]	804700435	UA361101(05)-06 2	APERTURE SELCTR	1
[6B]	804500592	UA361109(07)-03 3	APERTURE HOLDER	1
II	804900370		SPEC.CHMBR SYS.	1
[5B]	804700427	UA331103(02)-02 2	SPECIMEN CHMBR	1
[7]	804800090	UA332102(12)-18 1	SPEC.STAGE/CONT	1

COMPONENTS LIST

K-NO. AG110133(04) MODEL JSM-35C (M) EP156091~

	PART NO.	DESCRIPTION		QTY
[8,9]	8048001111	UA333125(08)-10 1	STAGE FRONT CVR	1
[5C]	8047005322	UA336110(06)-09 2	DETECTOR	1
[5H]	8045007466	UA336116(00)-00 3	PMT HOLDER	1
[5D]	8043001788	AA237003(02)-01 4	LAMP HOLDER	1
[5E]	8045007111	UA331105(01)-01 3	HINGE	1
[5F]	8045007200	UA331106(03)-03 3	EXCH.PRE-EVAC.	1
[5G]A	8043001866	UA334108-00 4	SPEC.HOLDER(A)	1
[5G]A-1	8043001944	UA334109(00)-00 4	SPEC.MOUNT	1
[5G]A-2	8049004188	(00)	HOLDER	1
[5G]B	8045007388	UA334110(00)-00 3	SPEC.HOLDER(B)	1
III	8049003888		VACUUM SYSTEM	1
[10A]	8047004600	UA371121(03)-04 2	ELEC.GUN EVAC.	1
[10B]	8047004788	UA371105(06)-05 2	COLUMN EVAC.PIP	1
[10C]	8045006144	UA371109(02)-02 3	SPEC.CHMBR EVAC	1
[11A]	8048001033	AA142049(00)-00 1	PRE-EVAC PIPE	1
[11B]	8045006577	AA145043(01)-01 3	SOL.VALVE MOUNT	1
[11C]	8045006499	AA142046(01)-01 3	EXCH.CHMBR EVAC	1
[12A]	8047004866	UA370101(09)-10 2	EVAC.SYS.CONNEC	1
[10D]	8045006222	UA372101(00)-00 3	THERMOSTAT MNT.	1

COMPONENTS LIST

K-NO. AG110133(03) MODEL JSM-35C (M) EP156085~

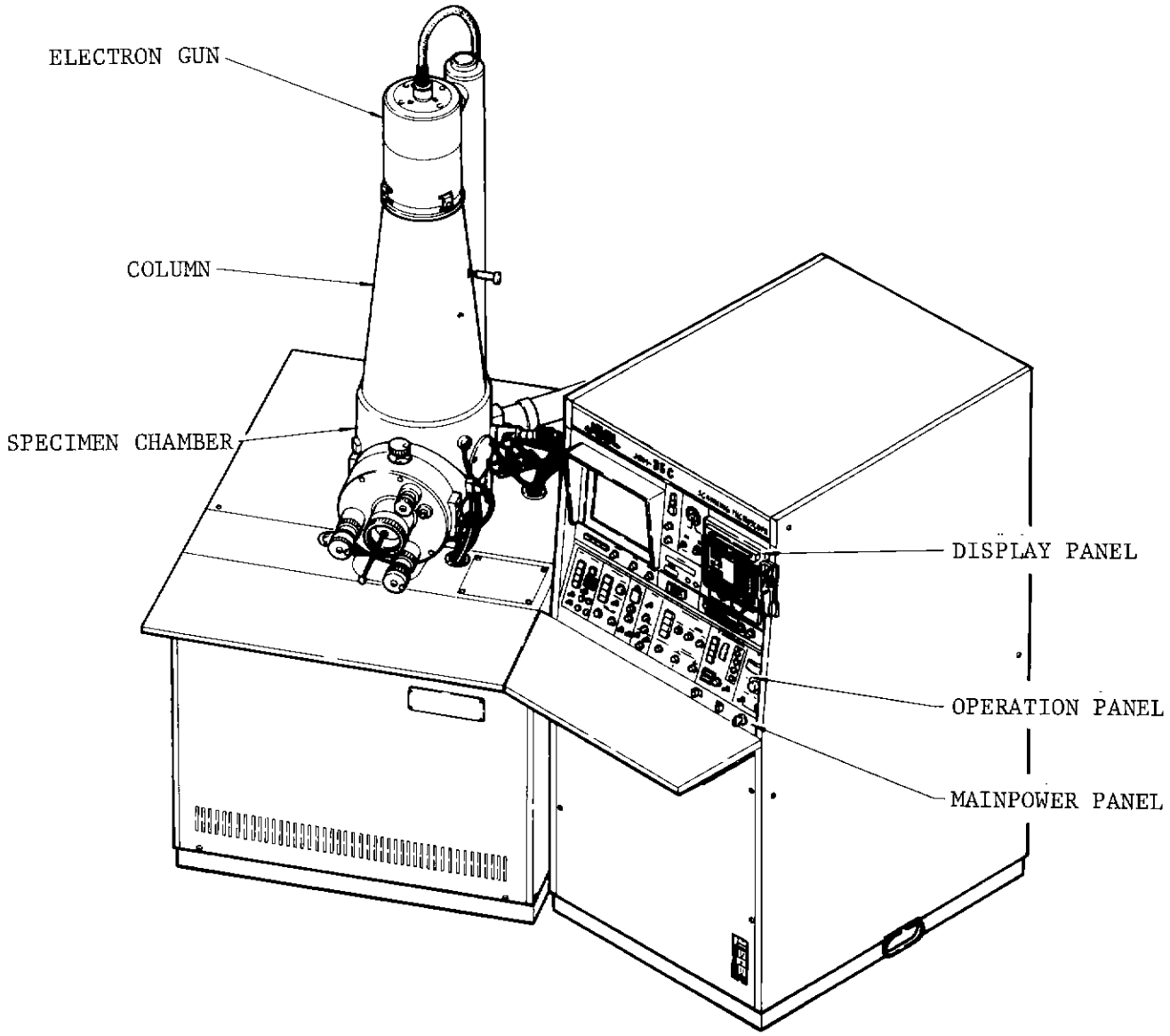
	PART NO.	DESCRIPTION		QTY
【10E】	804500631	AA247001(02)-03 3	COOL.WATER SYS.	1
【12B】	804300011	MA174004(02)-02 4	PIRANI TUBE MNT	2
【12C】	804700010	MA014001(04)-06 2	RP-100G	2
	804700028	MA013008-01 2	DP-4E	1
【12D】-1	804700419	MA013009(04)-04 2	DP-4E JET	1
【12D】-2	804300135	MA013010(01)-01 4	BP BAFFLE	1
【12D】-3	804900272	804900272(00)	DP-4E PARTS	1
	804700036	MA012001-04 2	WTR-COOL BAFFLE	1
【12E】-1	804500568	MA012002(02)-02 3	BAFFL.ASSMBLNG	1
【12E】-2	804900281	804900281(00)	BF-4 PARTS	1
【10B】B-1	804700044	MA011012(05)-08 2	4"BTTRFLY VALVE	1
【10B】B-2	804700052	MA011013(05)-10 2	2"BTTRFLY VALVE	1
【11D】	804500011	AA145035(02)-02 3	1"PNEU.L-VALVE	2
【11E】	804500029	AA145036(02)-02 3	PNEU.VENT VALVE	2
【11F】	804500037	AA145037(00)-00 3	VENT VALVE	1
【12F】	804500045	UA171119(00)-00 3	AIR FILTER	1
Ⅳ	804900396	UG111010	ACCSS./SUPPLIES	1
	804900299	UA393106	STD.ACCESSORIES	1

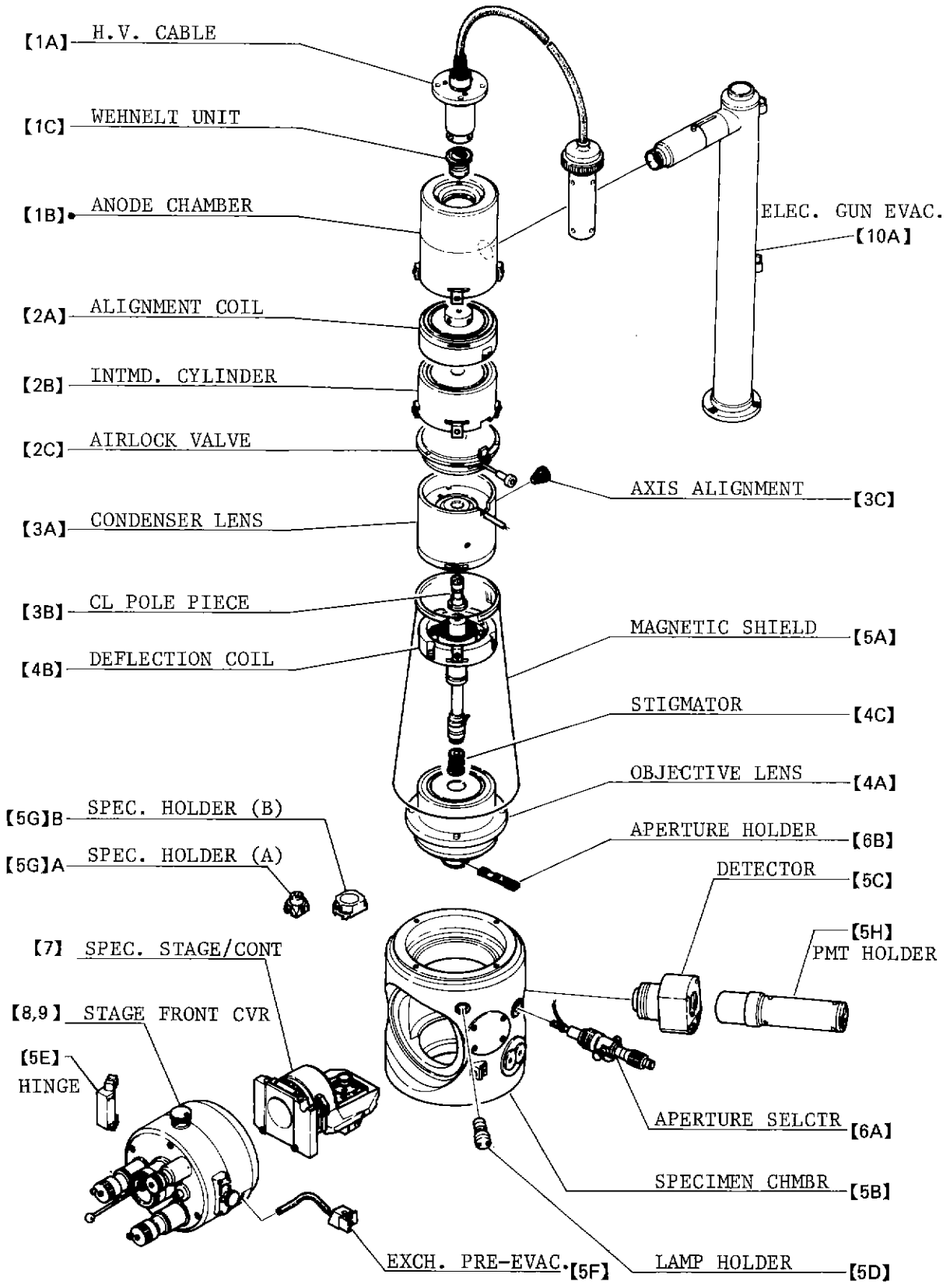
COMPONENTS LIST

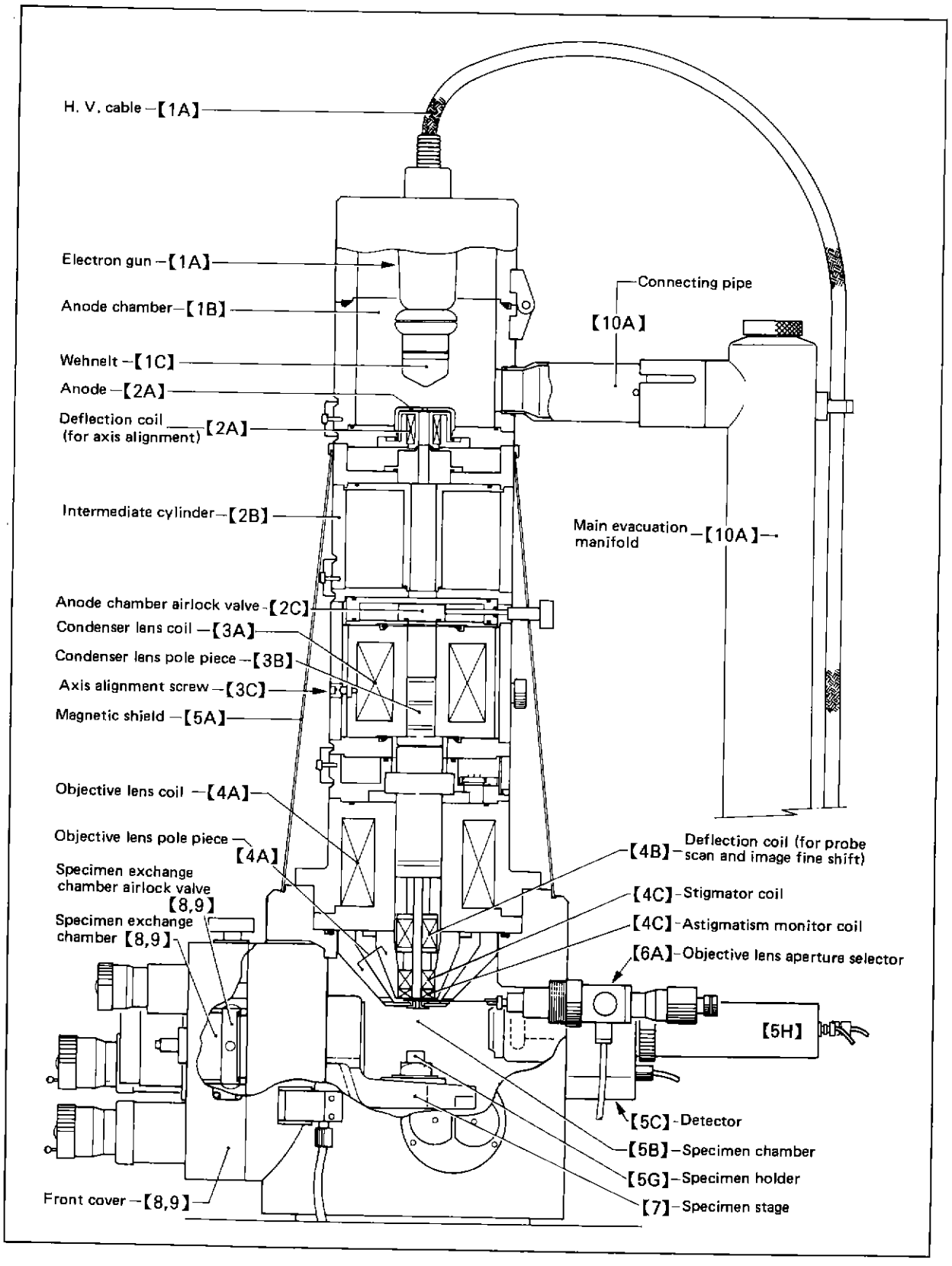
K-NO. AG110133(03) MODEL JSM-35C (M) EP156085~

	PART NO.	DESCRIPTION		QTY
[0]-1	8049003293	(00)	ACCESSORIES	1
[0]-2	8043001434	MA99-ANO-4(02)-02 4	FILAMENT BOX	2
[0]-3	8043001511	UA393113(02)-02 4	STORE CASE	1
[0]-4	8049003533	UA395102(00)	SPECIAL TOOLS	1
[00]	————	————	O-RING LIST	

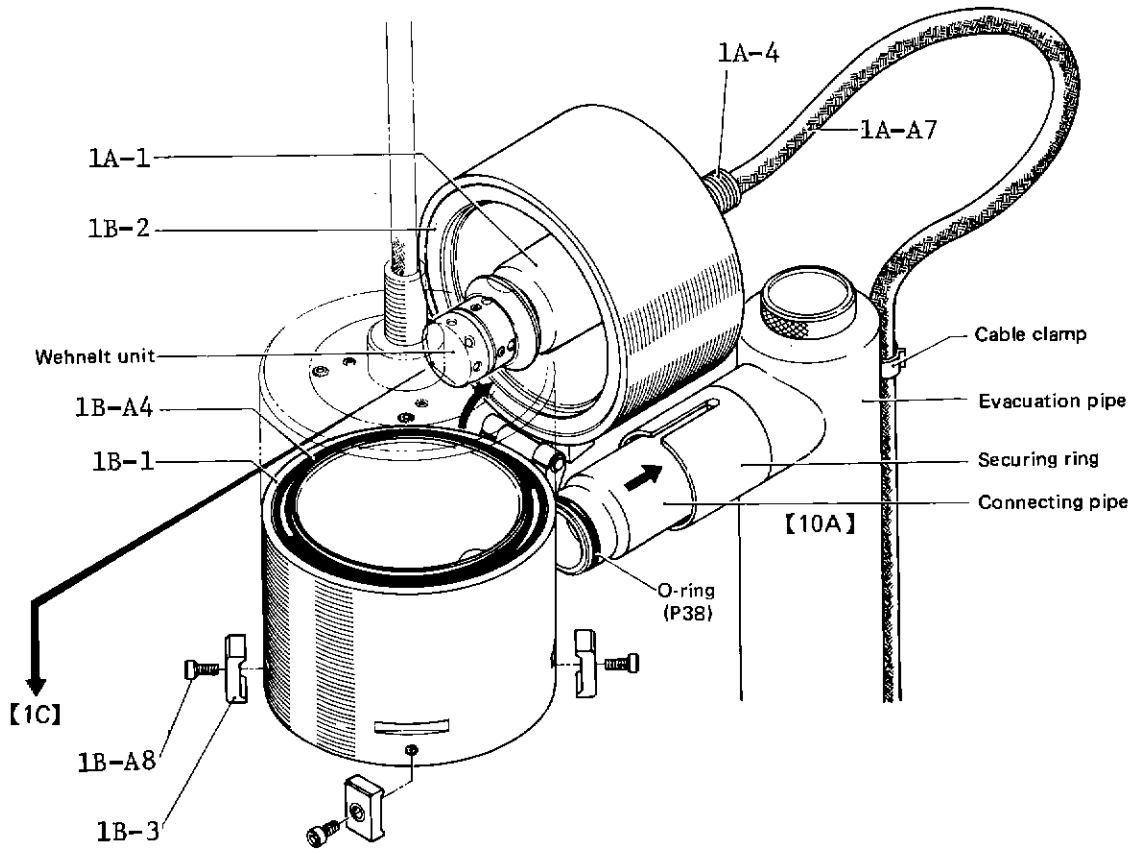
STANDARD CONFIGURATION




【1A】H.V. CABLE
【1C】WEHNELT UNIT
【1B】ANODE CHAMBER
【2A】ALIGNMENT COIL
【2B】INTMD. CYLINDER
【2C】AIRLOCK VALVE
【3A】CONDENSER LENS
【3B】CL POLE PIECE
【4B】DEFLECTION COIL
ELEC. GUN EVAC. 【10A】
AXIS ALIGNMENT 【3C】
MAGNETIC SHIELD 【5A】
STIGMATOR 【4C】
OBJECTIVE LENS 【4A】
APERTURE HOLDER 【6B】
DETECTOR 【5C】
【5H】 PMT HOLDER
【5G】B SPEC. HOLDER (B)
【5G】A SPEC. HOLDER (A)
【7】 SPEC. STAGE/CONT
【8,9】 STAGE FRONT CVR
【5E】 HINGE
APERTURE SELCTR 【6A】
SPECIMEN CHMBR 【5B】
EXCH. PRE-EVAC. 【5F】
LAMP HOLDER 【5D】



Cross-section of column



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* PARTS LIST *
****

【1A】

MODEL	804000069	AG110133(03)	JSM-35C (M)	EP156085-
COMPO	804700494	AA111035(06)	H.V.CABLE	800902

SEQ	PART-NO.	DESCRIPTION		QTY
☞ 1	327000708	INSULATOR	AB710296-03 3	1
☞ 4	800101880	SPRING,PRESSURE	UB311007-00 4	1
7	600002501	CONTACT	MB101850-03 4	2
8	600082296	CONTACT	AB710299-01 4	2
10	600082342	HOLDER	AB110548-01 4	1
11	800101791	BOARD	AD121875-01 4	1
12	600003451	CONTACT	AD120192-00 4	3
13	800101804	PIPE	AD121876-02 4	1
14	800101812	HOLDER	AD121877-01 4	1
15	800101821	HOLDER	AD121878-01 4	1
16	800101839	HOLDER	AD121879-01 4	1
17	800101782	NUT	AD120196-00 4	1
18	800503112	CAP	AB110635-01 3	1
19	800100948	HOLDER	AB110636-01 4	1

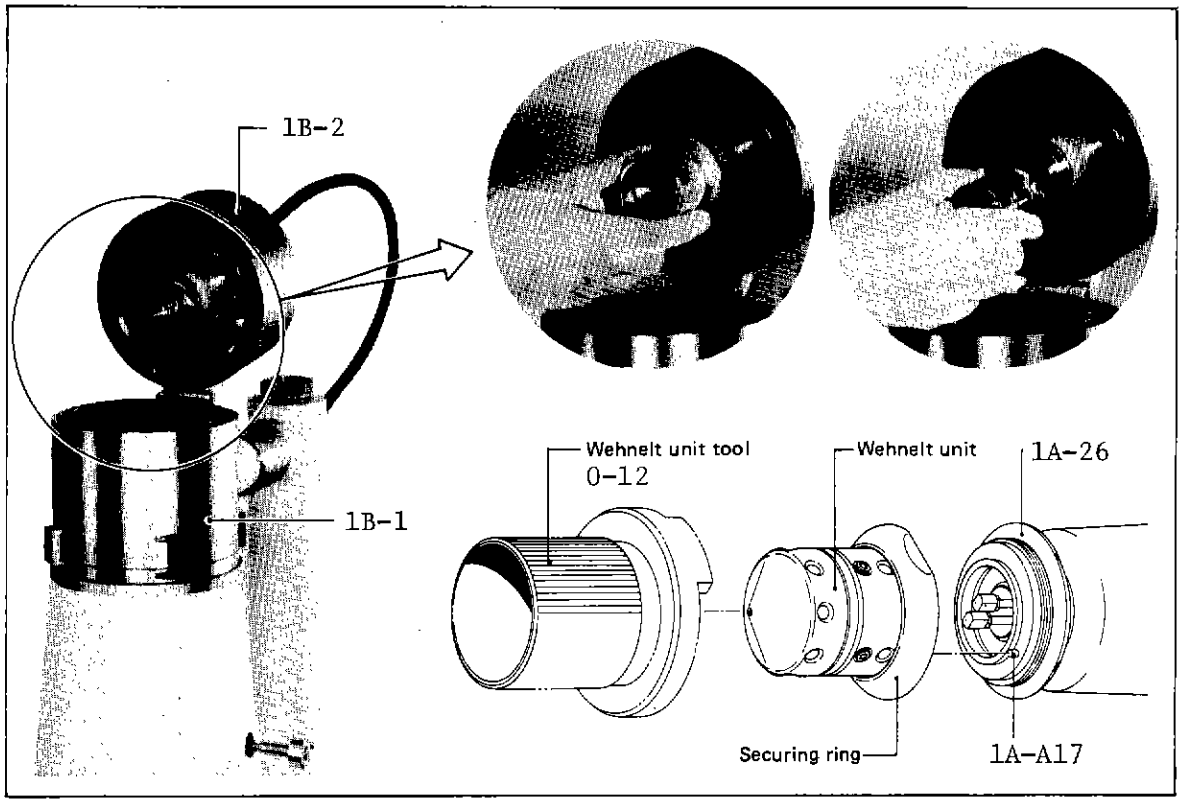
	SEQ	PART-NO.	DESCRIPTION		QTY
	20	800100956	HEAT CONDUCTOR	AB110638-00 4	1
	21	600103153	HEAT CONDUCTOR	AB110639-02 4	1
	22	800100964	RING	AB110640-00 4	1
	23	800100972	RING	AB110641-01 4	1
	25	800100981	HOLDER	AB110643-01 4	1
☞	26	800101774	HOLDER	AB710301-02 4	1
	27	800100999	HOLDER	AB110650-00 4	1
	28	800120477	EXPLANATION	AG530068-02 4	1
	29	600177645	INSULATOR	MB110778-00 4	1
A	1	409005169	+PAN HEAD SCREW	3*5 BSW2 NIP3	1
A	2	409002003	+PAN HEAD SCREW	3*6 BSW2 CRP1	3
A	3	412000504	SPRING WASHER	2ｺﾆｳ 4 PBP NIP3	2
A	4	412000121	HEXAGONAL NUT	M 2 SUS304 1ｼｭ	2
A	6	416000967	JOINT	B-5.5	3
☞A	7	360004466	HI-VOLT CABLE	XES-0274 (3Cﾌｱｲｺﾝｼｰﾙﾄﾞｶｺｳ	
A	8	409001601	+PAN HEAD SCREW	4*12 BSW2 NIP3	2
A	10	409006807	HEXSOCKET SCREW	ﾋﾗ 3*3 SUS304	2
A	11	406000115	O-RING	JISB2401 P 10 4D	1
A	12	406001341	O-RING	JISB2401 G 50 4D	1
A	13	409006815	HEXSOCKET SCREW	ﾋﾗ 4*4 SUS304	1
A	14	423005529	OIL	KF96 500CS 1KGｲﾘ	
A	16	409008486	HEXSOCKET SCREW	ﾄｶﾞﾘ 3*10 SUS304	4
☞A	17	415001897	PARALLEL PIN	H7B 2*5 SUS	1
A	18	126101566	LEAD (Pb) TAPE	0.1T*15*50	1

【1B】

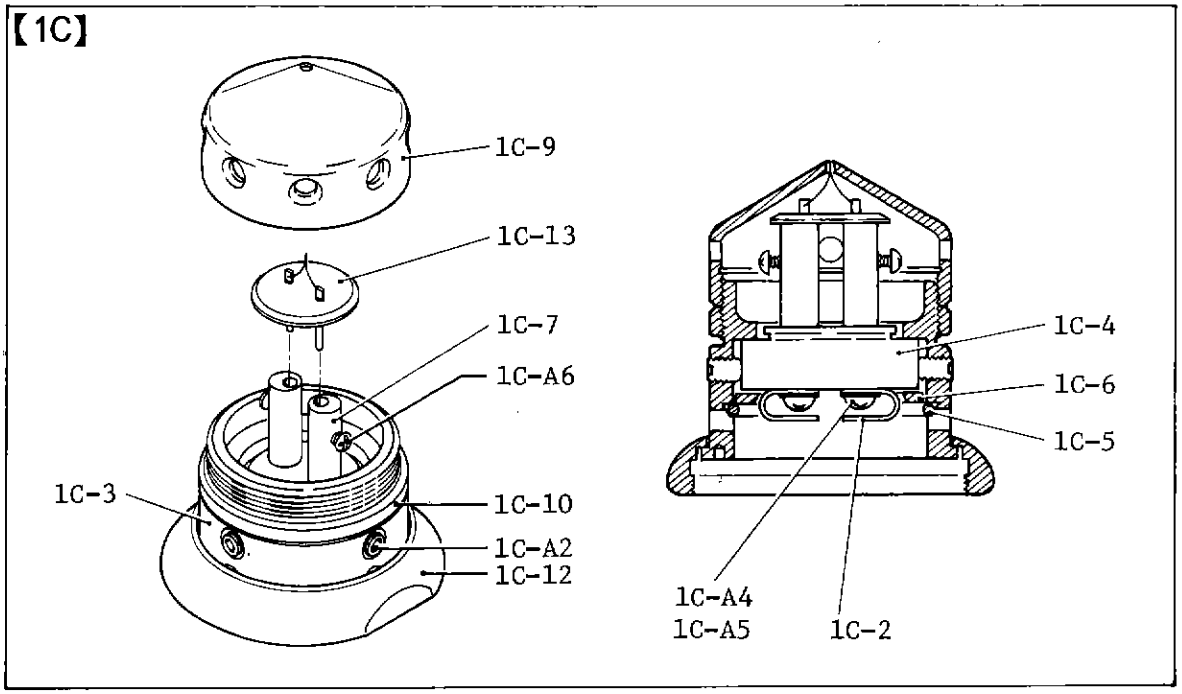
MODEL	804000069	AG110133(03)	JSM-35C (M)	EP156085-
COMPO	804700508	AA111030(01)	ANODE CHAMBER	800902

****

	SEQ	PART-NO.	DESCRIPTION		QTY
☞	1	800700295	CHAMBER	UB311004-07 2	1
☞	2	800501977	HOLDER	UB311032-03 3	1
☞	3	800100654	HOOK	UB311010-05 4	4
	4	800100905	BRACKET	AB110044-02 4	1
	5	800100913	BRACKET	AB110045-02 4	1
	6	800101898	SCREW	UB311021-01 4	1
	7	800100921	SHAFT	AB110046-00 4	1
A	2	415001811	PARALLEL PIN	H7B 5*6 S45C	1
A	3	406000654	O-RING	JISB2401 P 67 4D	1
☞A	4	406000808	O-RING	JISB2401 P 125 4D	1
A	5	414001630	CIRCLIP(E-TYPE)	4 SK5	2
A	7	411001060	HEXSOCKET BOLT	4*12 SCM3	4
☞A	8	411001116	HEXSOCKET BOLT	5*12 SCM3	8



Removing the Wehnelt unit

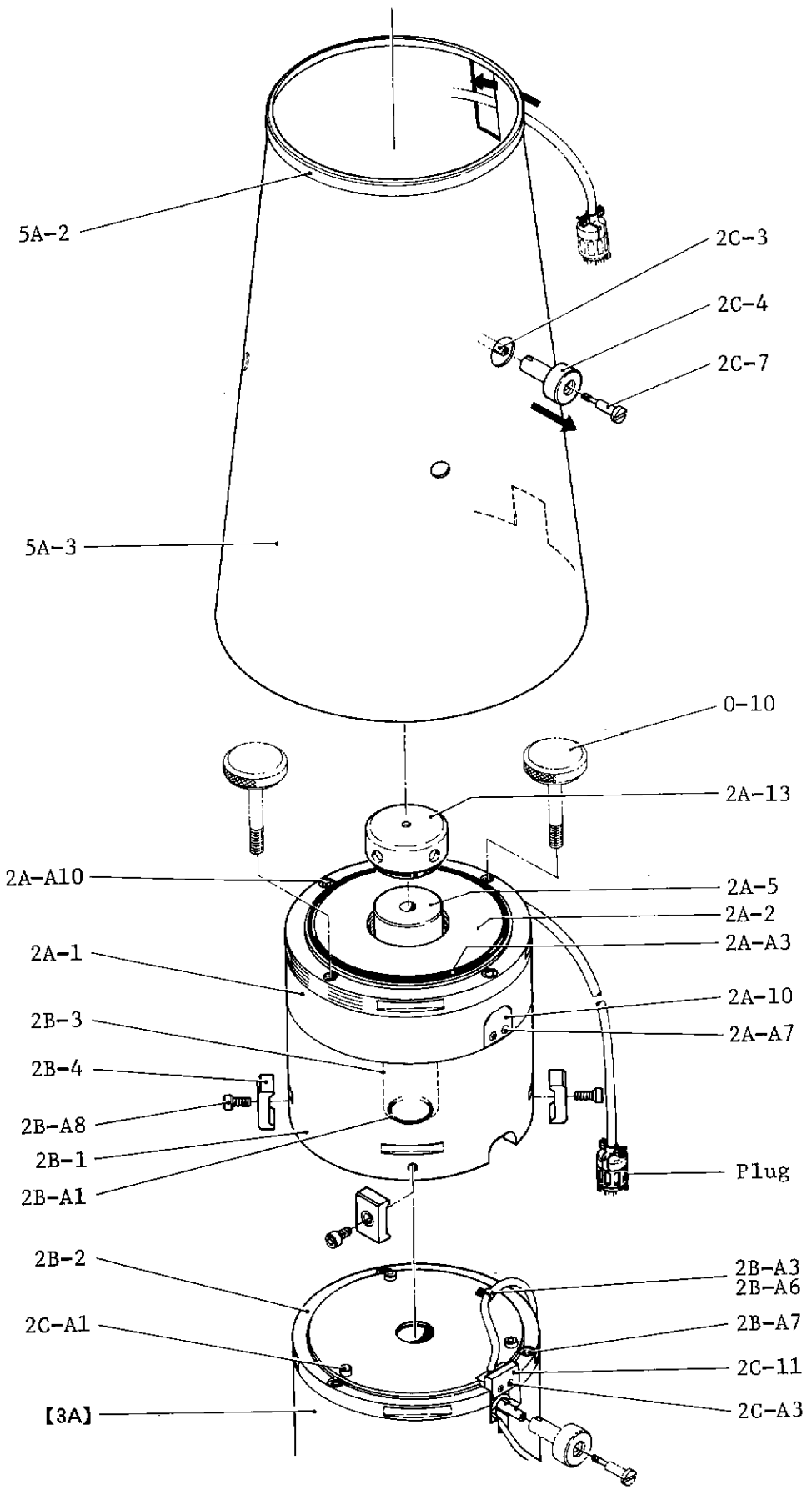


Wehnelt unit

【1C】

MODEL	804000069	AG110133(04)	JSM-35C (M)	EP156091-
COMPO	804500665	AA112015(04)	WEHNELT UNIT	800902

	SEQ	PART-NO.	DESCRIPTION		QTY
☞	2	800101006	SPRING,LEAF	AB120008-04 4	2
☞	3	800101928	HOLDER	UB311038-00 4	1
☞	4	600006255	INSULATOR	AB120010-00 4	1
☞	5	800101022	RING	AB120011-01 4	1
☞	6	800101936	WASHER	UB311039-00 4	1
☞	7	800101031	HOLDER	AB120013-00 4	2
☞	9	800101049	GRID	AB120015-02 4	1
☞	10	800101944	NUT	UB311040-00 4	1
☞	12	800101910	NUT	UB311037-01 4	1
☞	13	800500199	FILAMENT	AB120058-00 3	1
☞A	2	409006823	HEXSOCKET SCREW	ﾋﾗ 4*5 SUS304	4
☞A	4	412004003	SPRING WASHER	2ｺﾞｳ 3 SWRH ZNP3C	2
☞A	5	409006831	+PAN HEAD SCREW	3*14 SUS304	2
☞A	6	409004561	+PAN HEAD SCREW	2*5 SUS304	2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2B-3
2A-A7
2B-4
2B-A8
2B-1
2B-A1
Plug
2B-2
2B-A3
2B-A6
2C-A1
2B-A7
2C-11
【3A】
2C-A3

【2A】

MODEL	804000069	AG110133(03)	JSM-35C (M)	EP156085-
COMPO	804700516	AA113048(03)	ALIGNMENT COIL	800902

	SEQ	PART-NO.	DESCRIPTION		QTY
☞	1	800700066	FLANGE	AB130476-01 2	1
☞	2	800500300	FLANGE	UB361002-08 3	1
	4	800101111	SPACER	AB130477-01 4	1
☞	5	800101120	CASING	AB130478-01 4	1
	6	800101073	SUPPORT	AB130143-02 4	1
	7	800101081	CORE	AB130144-01 4	2
	8	800101154	SPACER	AB140031-01 4	2
	9	800101138	NUT	AB130479-01 4	1
☞	10	800101103	PLATE	AB130469-03 4	1
	11	800101146	SPACER	AB130510-00 4	1
	12	800124553	COIL	XES-0277-00 4	2
☞	13	800131762	ANODE	AB710242-00 4	1
A	1	406000174	O-RING	JISB2401 P 14 4D	1
A	2	406001332	O-RING	JISB2401 G 45 4D	2
☞A	3	406001481	O-RING	JISB2401 G 120 4D	1
A	4	415002524	PARALLEL PIN	H7B 1*5 PB	8
A	5	409001881	+PAN HEAD SCREW	2*4 BSW2 CRP1	12
☞A	7	409006840	+PAN HEAD SCREW	2*16 BSW2 CRP1	2
A	8	409006858	+PAN HEAD SCREW	3*5 BSW2 CRP1	3
A	9	409002089	+PAN HEAD SCREW	4*10 BSW2 CRP1	6
☞A	10	411001108	HEXSOCKET BOLT	5*10 SCM3	2
A	11	411003062	HEXSOCKET BOLT	5*35 SCM3	3
A	12	416000622	RUG TERMINAL	2	12
A	13	430000171	NYLON CLIP	HP-2N	3

【2B】

MODEL	804000069	AG110133(03)	JSM-35C (M)	EP156085-
COMPO	804500673	AA113045(02)	INTMD.CYLINDER	800902

	SEQ	PART-NO.	DESCRIPTION		QTY
☞	1	800700015	YOKE	AB130467-03 2	1
☞	2	800500024	FLANGE	AB130466-03 3	1
☞	3	800500016	YOKE	AB130465-03 3	1
☞	4	800100654	HOOK	UB311010-05 4	4
☞A	1	406001278	O-RING	JISB2401 G 25 4D	1
A	2	406001464	O-RING	JISB2401 G 110 4D	1
☞A	3	409001457	+PAN HEAD SCREW	3*6 BSW2 NIP3	1
A	4	409005061	+PAN HEAD SCREW	4*16 BSW2 NIP3	3
☞A	6	430000171	NYLON CLIP	HP-2N	1
☞A	7	411001108	HEXSOCKET BOLT	5*10 SCM3	3
☞A	8	411001116	HEXSOCKET BOLT	5*12 SCM3	4

【2C】

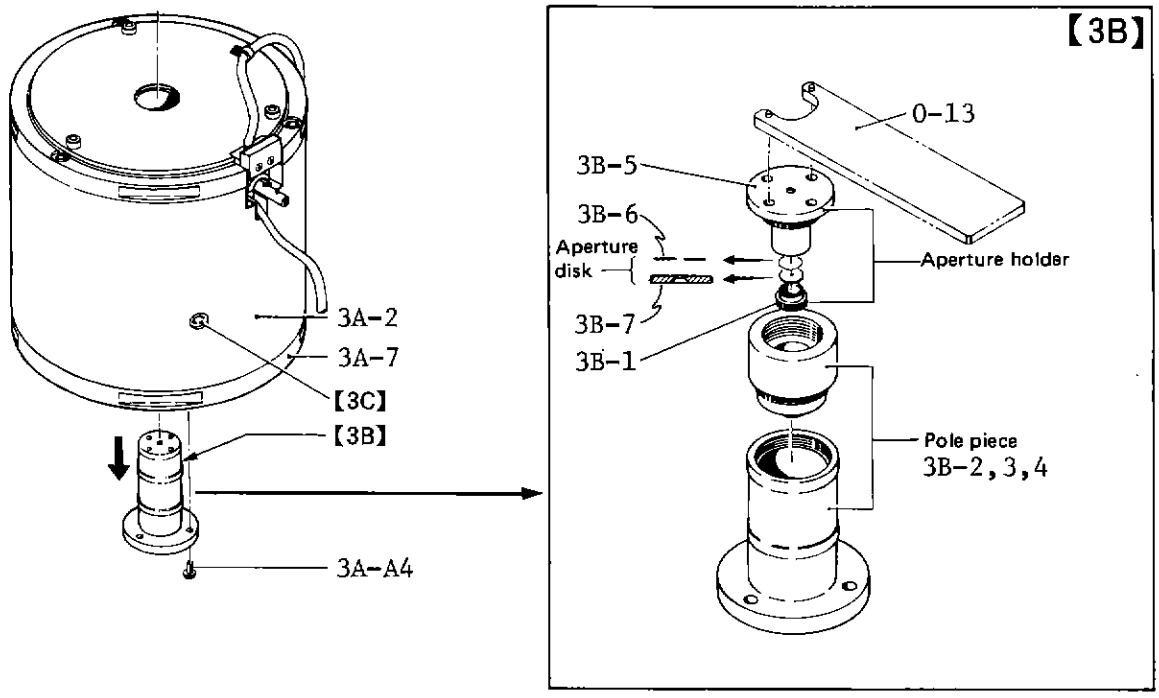
MODEL	804000069	AG110133(03)	JSM-35C (M)	EP156085-
COMPO	804500681	UA314101(05)	AIR LOCK VALVE	800902

	SEQ	PART-NO.	DESCRIPTION		QTY
	1	800500121	PLATE	UB311011-00 3	1
	2	800500130	CASE	UB311012-02 3	1
☞	3	800100662	SHAFT	UB311013-02 4	1
☞	4	800100671	KNOB	UB311014-02 4	1
	5	800100689	VALVE	UB311015-01 4	1
	6	800100697	BRG,PLAIN	UB311016-00 4	1
☞	7	800100701	SCREW	UB311017-00 4	1
	8	800100719	BRG,PLAIN	UB311018-02 4	1
	9	800100042	STOPPER	AB130114-00 4	1
	10	800100735	STOPPER	UB311044-00 4	1
☞	11	800100093	COVER	AB130506-00 4	1
☞A	1	411004107	HEXSOCKET BOLT	4*16 SCM3	3
A	2	409005169	+PAN HEAD SCREW	3*5 BSW2 NIP3	3
☞A	3	409007340	+PAN HEAD SCREW	2*16 BSW2 NIP3	2
A	4	409006866	+FLT HEAD SCREW	2*3 BSW2 NIP3	6
A	6	406000077	O-RING	JISB2401 P 6 4D	1
A	7	406000280	O-RING	JISB2401 P 25 4D	1
A	8	406001464	O-RING	JISB2401 G 110 4D	2
A	9	414002075	CIRCLIP(E-TYPE)	4 PBP	2
A	10	415000459	PARALLEL PIN	H7B 3*8 S45C	1
A	11	409006874	RIVET(ROUND-HD.	2*3 BSW2	1
A	12	415000262	PARALLEL PIN	H7B 2*10 S45C	2

【5A】

MODEL	804000069	AG110133(03)	JSM-35C (M)	EP156085-
COMPO	804500576	UA316101(04)	MAGNETIC SHIELD	800902

	SEQ	PART-NO.	DESCRIPTION		QTY
☞	2	800100727	RING	UB311023-04 4	1
☞	3	800700023	SHIELD PIPE	AB190019-01 2	1



【3A】

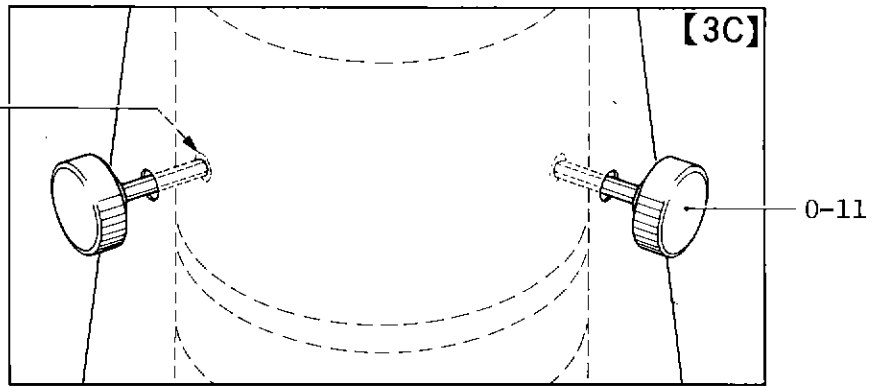
MODEL	804000069	AG110133(03)	JSM-35C (M)	EP156085-
COMPO	804500690	UA321101(07)	CONDENSER LENS	800902

	SEQ	PART-NO.	DESCRIPTION		QTY
☞	2	800700031	CYLINDER	UB321023-03 2	1
☞	7	800500156	FLANGE	UB321028-04 3	1
	8	600010465	BUSH	AB130100-00 4	1
	9	600010473	BUSH	AB130099-02 4	2
	10	800107829	SHEET	AB130112-01 4	3
	11	600010481	BUSH	AB130101-02 4	3
	12	600010490	BUSH	AB130111-03 4	3
	13	800500032	CYLINDER	AB130480-02 3	1
	14	800500041	YOKE	AB130481-06 3	1
	15	800500059	YOKE	AB130482-03 3	1
	16	800100085	HOLDER	AB130483-01 4	1
	17	800124260	COIL	AP000754-02 4	1
	18	800124251	SHEET	AB130745-00 4	1
A	1	411001051	HEXSOCKET BOLT	4*10 SCM3	3
A	2	406000611	O-RING	JISB2401 P 60 4D	2
A	3	411001108	HEXSOCKET BOLT	5*10 SCM3	3
☞A	4	409006882	+PAN HEAD SCREW	3*5 BSW2	3
A	5	406000352	O-RING	JISB2401 P 30 4D	2
A	6	411004107	HEXSOCKET BOLT	4*16 SCM3	3

【3B】

MODEL	804000069	AG110133(03)	JSM-35C (M)	EP156085-
COMPO	804300160	UA323101(03)	CL POLE PIECE	800902

	SEQ	PART-NO.	DESCRIPTION		QTY
☞	1	800100051	HOLDER	AB130147-00 4	1
☞	2	800100069	SPACING RING	AB130148-01 4	1
☞	3	800100751	POLE PIECE	UB321034-01 4	1
☞	4	800100760	POLE PIECE	UB321035-02 4	1
☞	5	800100077	HOLDER	AB130150-04 4	1
☞	6	418000450	APERTURE	AB130151-03 4	1
☞	7	800100611	APERTURE	MB102221-03 4	1
A	1	424005077	PLASTIC CASE	120CC	1
A	2	131100220	POLYURETHANE FOAM	55ﾏﾙ*10T	2
A	3	423001183	SILICA GEL	10Gｲﾘ	1

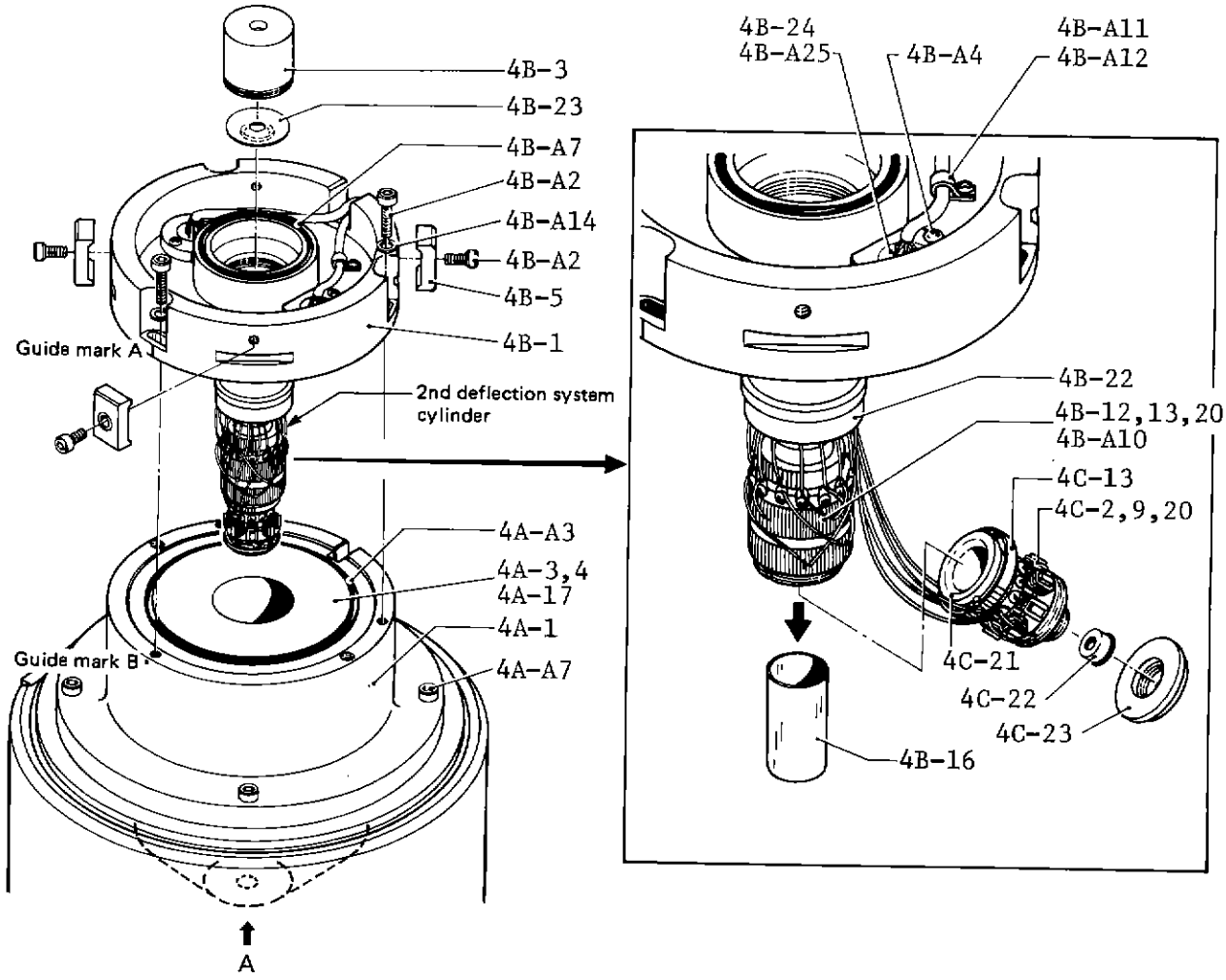


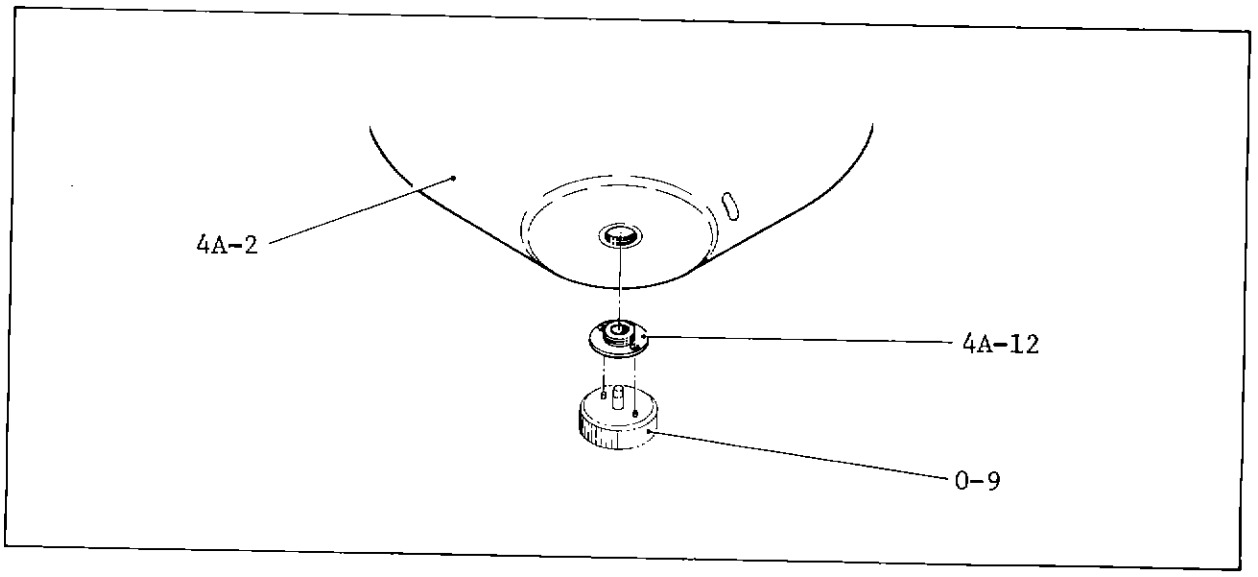
Condenser lens alignment

【3C】

MODEL	804000069	AG110133(03)	JSM-35C (M)	EP156085-
COMPO	804500584	UA321102(02)	AXIS ALIGNMENT	800902

	SEQ	PART-NO.	DESCRIPTION		QTY
	1	800101961	NUT	UB321040-00 4	1
	2	800101979	SPRING,PRESSURE	UB321041-00 4	1
	3	800101987	SLIDER	UB321042-00 4	1
	4	800101995	BRG,PLAIN	UB321043-00 4	1
	5	800101057	ROLLER	AB130090-00 4	1
☞	6	800101090	SCREW	AB130152-02 4	2
A	1	415001820	PARALLEL PIN	H7B 3*4 S45C	1
A	2	401000834	STEEL BALL	6 M/M SUJ2	2
A	3	415000548	PARALLEL PIN	H7B 4*8 S45C	1





Viewed in the A arrow direction

【4A】

MODEL 804000069 AG110133(03) JSM-35C (M) EP156085-

COMPO 804700443 AA114034(01) OBJECTIVE LENS 800902

	SEQ	PART-NO.	DESCRIPTION		QTY
☞	1	800700040	CYLINDER	UB321036-04 2	1
☞	2	800500148	MAGNETIC POLE	UB321017-08 3	1
☞	3	800500067	YOKE	AB140394-04 3	1
☞	4	800500075	FLANGE	AB140395-04 3	1
	5	800500083	YOKE	AB140396-04 3	1
	6	800100743	RING	UB321018-01 4	1
	7	800100131	MAGNETIC POLE	AB140374-05 4	1
	8	800100140	MAGNETIC POLE	AB140375-04 4	1
	9	800100158	SPACER	AB140376-01 4	1
	10	800100174	SPACER	AB140419-00 4	1
	11	800100166	COVER	AB140377-01 4	1
☞	12	800100778	COVER	UB321050-00 4	1
	13	800100824	NUT	UB361146-02 4	1
	14	800100107	CAP	AB140106-01 4	1
	15	800100115	SPRING,LEAF	AB140107-01 4	1
	16	800100123	X RAY ISOLATOR	AB140372-00 4	1
☞	17	800124308	COIL	AP000731-03 4	1
	A 1	406001391	O-RING	JISB2401 G 75 4D	1
	A 2	406001456	O-RING	JISB2401 G 105 4D	1
☞	A 3	406001464	O-RING	JISB2401 G 110 4D	1
	A 4	409006891	+PAN HEAD SCREW	3*10 BSW2	8
	A 5	411001043	HEXSOCKET BOLT	4*8 SCM3	4
	A 6	411001060	HEXSOCKET BOLT	4*12 SCM3	6
☞	A 7	411002422	HEXSOCKET BOLT	5*22 SCM3	4
	A 8	412002566	PLAIN WASHER(SM	M 3 BSP NIP3	4

【4B】

MODEL 804000069 AG110133(04) JSM-35C (M) EP156091-

COMPO 804700524 AA115031(08) DEFLECTION COIL 800902

	SEQ	PART-NO.	DESCRIPTION		QTY
☞	1	800500318	FLANGE	UB361006-05 3	1
☞	3	800103459	SHIELD PIPE	UB361008-07 4	1
☞	5	800100654	HOOK	UB311010-05 4	4
	6	800103467	PIPE	UB361009-02 4	1
	9	800101189	RING	AB150121-02 4	1
	10	800101171	NUT	AB150120-01 4	1
☞	12	800103491	HOLDER	UB361020-03 4	1
☞	13	800101197	SPACER	AB150123-02 4	1
	14	800103505	SUPPORT	UB361023-02 4	1
	15	800101162	PIN	AB150070-00 4	1
☞	16	800101201	PIPE	AB150202-01 4	1

	SEQ	PART-NO.	DESCRIPTION		QTY
☞	20	800124561	COIL	XES-0297-01 4	2
	21	800101235	HOLDER	AB150307-02 4	1
☞	22	800101243	SHIELD PIPE	AB150308-01 4	1
☞	23	800101251	APERTURE	AB150309-01 4	1
☞	24	800186681	HOLDER	800186681-00 4	2
	25	800704177	WIRING LAYOUT	800704177-00 2	1
☞A	2	411001116	HEXSOCKET BOLT	5*12 SCM3	7
A	3	409001490	+PAN HEAD SCREW	3*20 BSW2 NIP3	3
☞A	4	409001473	+PAN HEAD SCREW	3*10 BSW2 NIP3	8
A	5	409006939	+PAN HEAD SCREW	2*5	2
☞A	7	406001359	O-RING	JISB2401 G 55 4D	1
A	8	406000204	O-RING	JISB2401 P 18 4D	2
☞A	10	312000201	CORE	H5C2T 26-32-10	2
☞A	11	430000171	NYLON CLIP	HP-2N	3
☞A	12	409005169	+PAN HEAD SCREW	3*5 BSW2 NIP3	3
A	13	409001309	+PAN HEAD SCREW	2*4 BSW2 NIP3	12
☞A	14	412000326	PLAIN WASHER	M 5 BSP NIP3	3
A	15	416000622	RUG TERMINAL	2	12
A	17	360004121	WIRE	AF04B050 OE	
A	18	360004083	WIRE	AF04B050 BN	
A	19	360004172	WIRE	AF04B050 YW	
A	20	360004113	WIRE	JWD 15KT GN	
A	21	360004067	WIRE	JWD 15KT BE	
A	22	360004075	WIRE	AF04B050 BK	
A	23	360004130	WIRE	AF04B050 RD	
A	24	430001053	ｺﾞｱﾃｯｸｽ YARN	NO.2400	
☞A	25	353002402	HERMTIC SEAL	C-105	2

【4C】

MODEL	804000069	AG110133(04)	JSM-35C (M)	EP156091-
COMPO	804500703	UA362101(13)	STIGMATOR	800902

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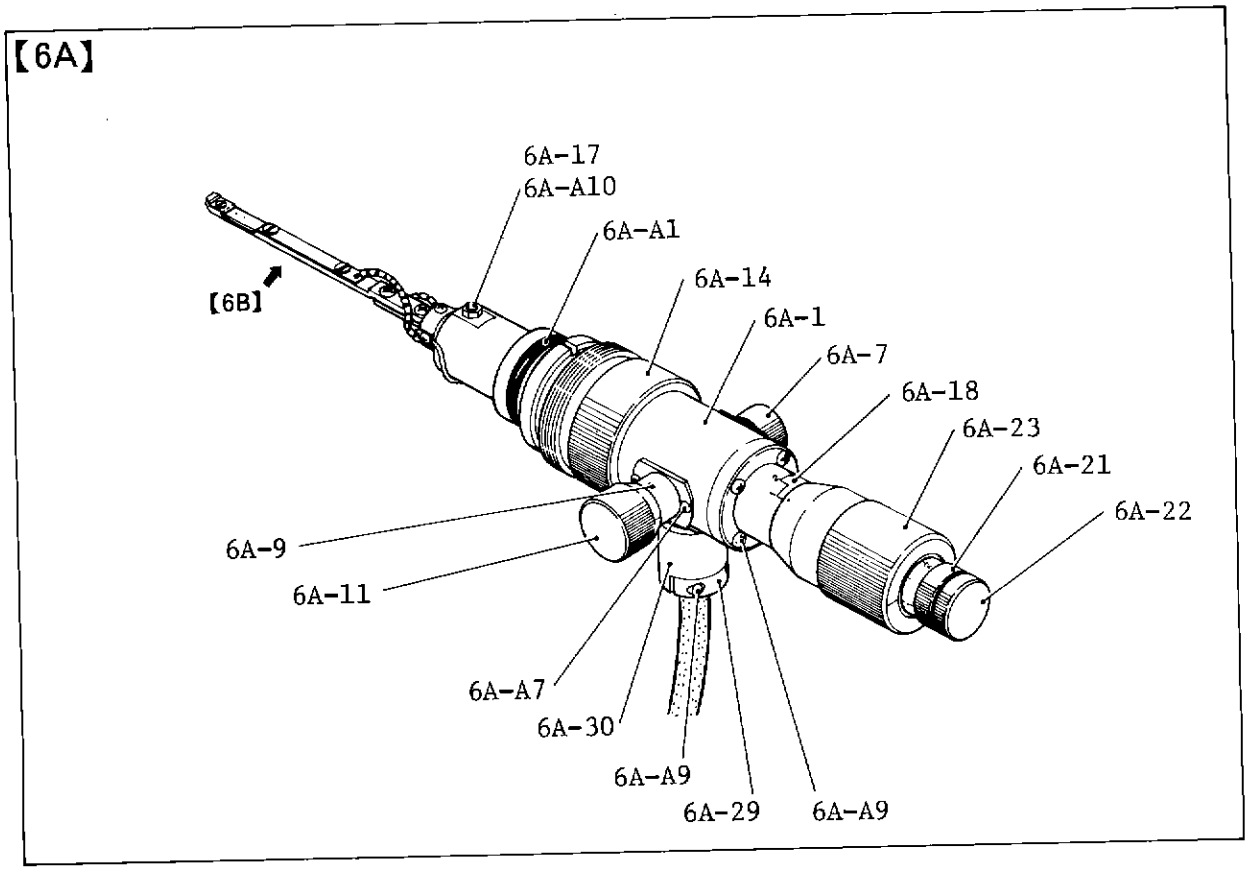
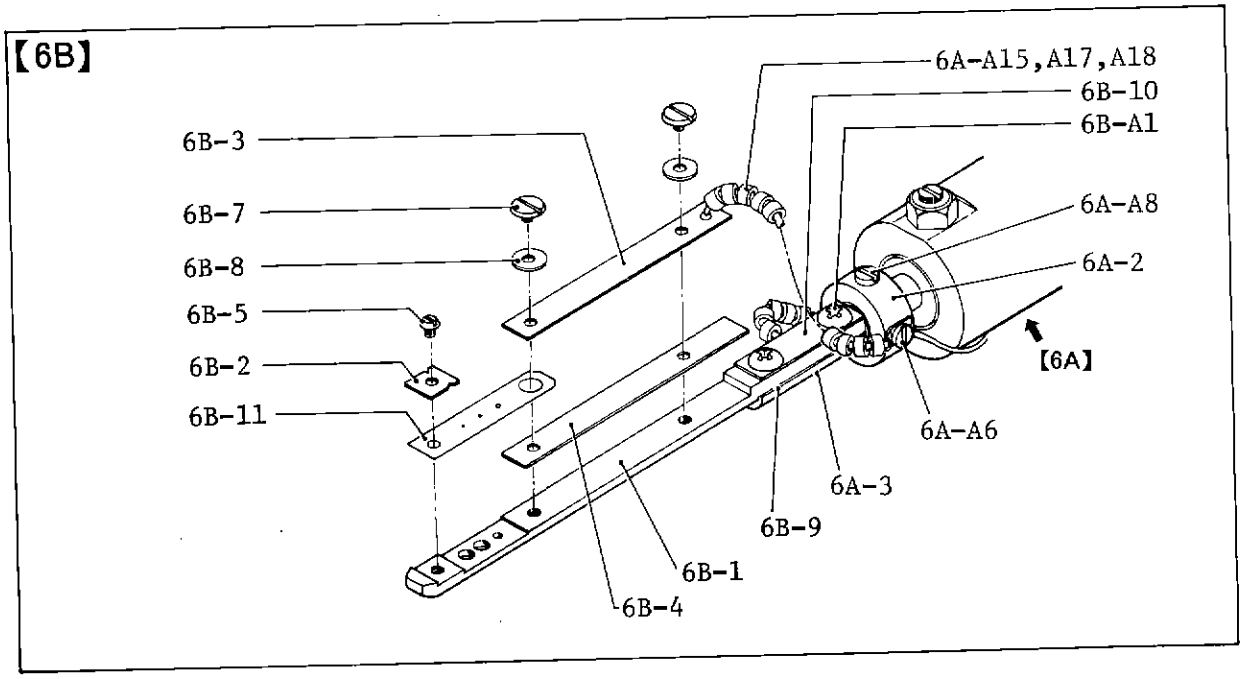
	SEQ	PART-NO.	DESCRIPTION		QTY
☞	2	800103769	BOBBIN	UB361133-05 4	1
	8	800103777	SPACER	UB361139-02 4	1
☞	9	800103475	BOBBIN	UB361016-01 4	1
	12	800101162	PIN	AB150070-00 4	1
☞	13	800103483	NUT	UB361019-01 4	1
	19	800101219	SUPPORT	AB150287-03 4	1
☞	20	800124545	COIL	XES-0272-02 4	1
☞	21	800101227	HOLDER	AB150306-00 4	1
☞	22	800101260	APERTURE	AB150310-02 4	1
☞	23	800101278	CAP	AB150311-01 4	1
A	1	409006939	+PAN HEAD SCREW	2*5	1
A	2	409008699	+PAN HEAD SCREW	2*3 BSW2	11
A	3	416000622	RUG TERMINAL	2	11
A	4	360004130	WIRE	AF04B050 RD	
A	5	360004067	CABLE	JWD 15KT BE	
A	6	360004121	CABLE	AF04B050 OE	
A	7	360004083	CABLE	AF04B050 BN	
A	8	360004172	CABLE	AF04B050 YW	



Objective lens aperture selector



【6A】

MODEL 804000069 AG110133(03) JSM-35C (M) EP156085-

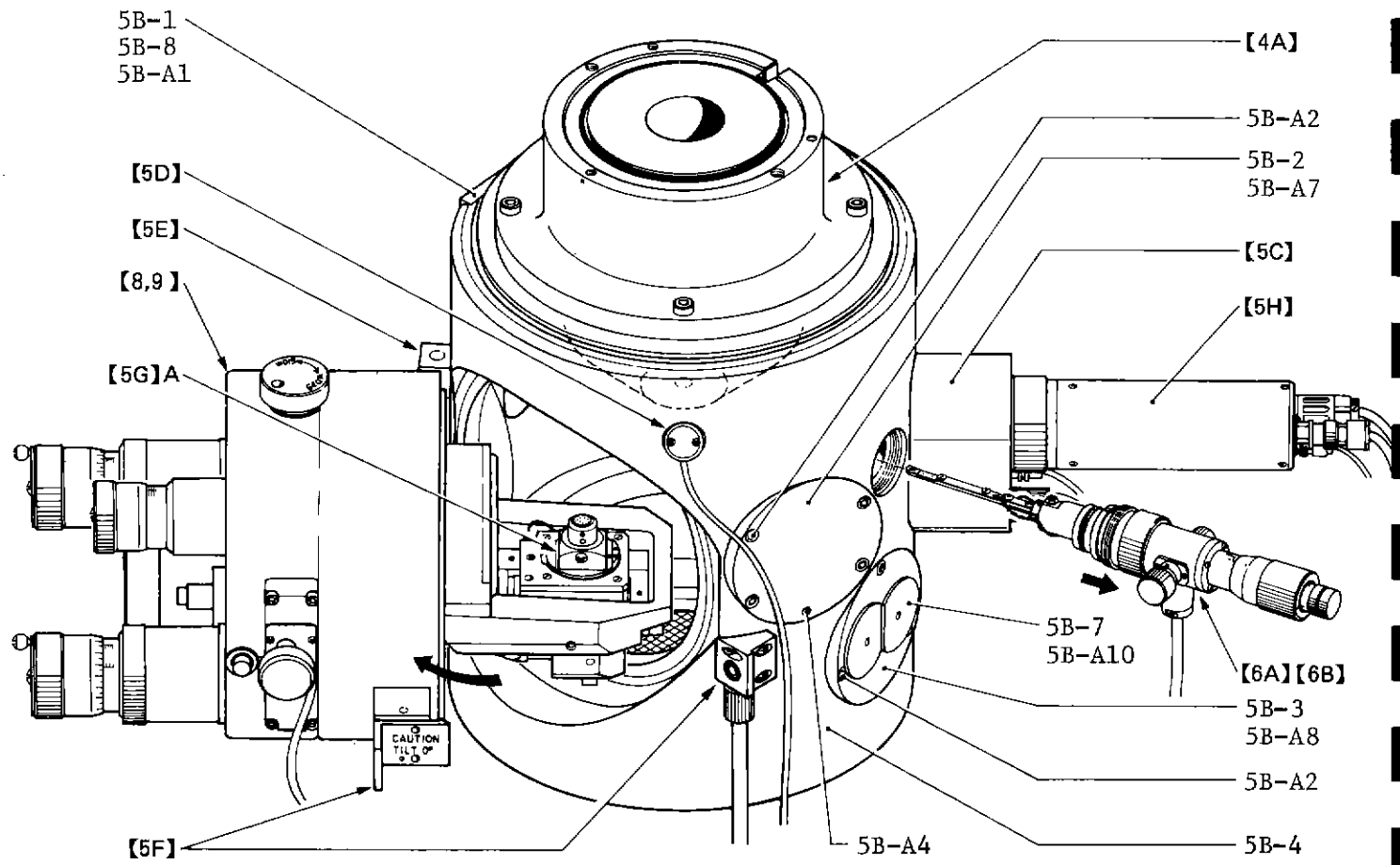
COMPO 804700435 UA361101(05) APERTURE SELCTR 800902

	SEQ	PART-NO.	DESCRIPTION			QTY
☞	1	800500326	BRG,PLAIN	UB361024-02 3		1
☞	2	800103513	SUPPORT	UB361025-00 4		1
☞	3	800103785	SHAFT	UB361145-02 4		1
	4	800103521	BRG,PLAIN	UB361027-00 4		1
	5	800103530	SHAFT	UB361028-00 4		1
	6	800103548	SPRING,PRESSURE	UB361029-00 4		1
☞	7	800103556	NUT	UB361030-00 4		1
	8	800103564	BUSH	UB361031-00 4		3
☞	9	800103572	BRG,PLAIN	UB361032-00 4		1
	10	800103581	SHAFT	UB361033-01 4		1
☞	11	800103599	KNOB	UB361034-00 4		1
	12	800103602	SPRING,PRESSURE	UB361035-00 4		2
☞	14	800103611	HOLDER	UB361037-02 4		1
	15	800103629	SHAFT	UB361038-03 4		1
☞	17	800103637	PIN SCREW	UB361039-01 4		2
☞	18	800103645	BRG,PLAIN	UB361040-02 4		1
	19	800103653	SCREW	UB361041-00 4		3
	20	800103661	SHEET	UB361042-00 4		1
☞	21	800103670	KNOB	UB361043-01 4		1
☞	22	800103688	NUT	UB361044-01 4		1
☞	23	800103696	KNOB	UB361045-00 4		1
	24	800103700	SHAFT	UB361046-02 4		1
	26	800103718	GUIDE	UB361048-00 4		1
	27	800103726	GUIDE	UB361049-00 4		1
	28	800103734	GUIDE	UB361050-00 4		1
☞	29	800103742	SUPPORT	UB361051-00 4		1
☞	30	800103751	SUPPORT	UB361052-00 4		1
	31	800103793	HOLDER	UB361147-00 4		1
	33	800500334	WIRING LAYOUT	UB361148-05 3		1
☞A	1	406000247	O-RING	JISB2401 P 22	4D	1
A	2	406000051	O-RING	JISB2401 P 4	4D	3
A	3	406000115	O-RING	JISB2401 P 10	4D	3
A	4	406000174	O-RING	JISB2401 P 14	4D	1
☞A	6	409004383	FLAT HEAD SCREW	2*3 BSW2		5
☞A	7	409001309	+PAN HEAD SCREW	2*4 BSW2 NIP3		6
☞A	8	409004391	FLAT HEAD SCREW	2*4 BSW2		4
☞A	9	409001325	+PAN HEAD SCREW	2*8 BSW2 NIP3		6
☞A	10	412000202	HEXAGONAL NUT	M 3 BSBM NIP3		2
A	11	401000834	STEEL BALL	6 M/M SUJ2		4
A	13	415001790	PARALLEL PIN	H7B 2*5 S45C		3
A	14	353002496	HERMTIC SEAL	C-133(C-520)		1
☞A	15	416000991	AMP TERMINAL	M23ϑ 0.75SQ		1
☞A	17	327001895	INSULATOR	D1.2*D3.2*2		23
☞A	18	125100540	TIN PLATED WIRE	D0.8*50		2

【6B】

MODEL	804000069	AG110133(03)	JSM-35C (M)	EP156085-
COMPO	804500592	UA361109(07)	APERTURE HOLDER	800902

	SEQ	PART-NO.	DESCRIPTION		QTY
☞	1	800500164	SUPPORT	UB361140-03 3	1
☞	2	800100786	LEAD PLATE	UB361141-02 4	1
☞	3	800100794	LEAD PLATE	UB361142-01 4	1
☞	4	800100808	INSULATOR	UB361143-00 4	1
☞	5	800100182	SCREW	AB160132-01 4	1
☞	7	800100191	SCREW	AB160136-02 4	2
☞	8	800100204	INSULATOR	AB160137-00 4	2
☞	9	800100816	INSULATOR	UB361144-00 4	1
☞	10	800100212	INSULATOR	AB160514-00 4	1
☞	11	418001103	APERTURE	AB720027-02 4	1
☞A	1	409006921	+TRUSS HD SCREW	2*5 BSW2	2



Disassembling the objective lens and specimen chamber

【5B】

MODEL 804000069 AG110133(03) JSM-35C (M) EP156085-

COMPO 804700427 UA331103(02) SPECIMEN CHMBR 800902

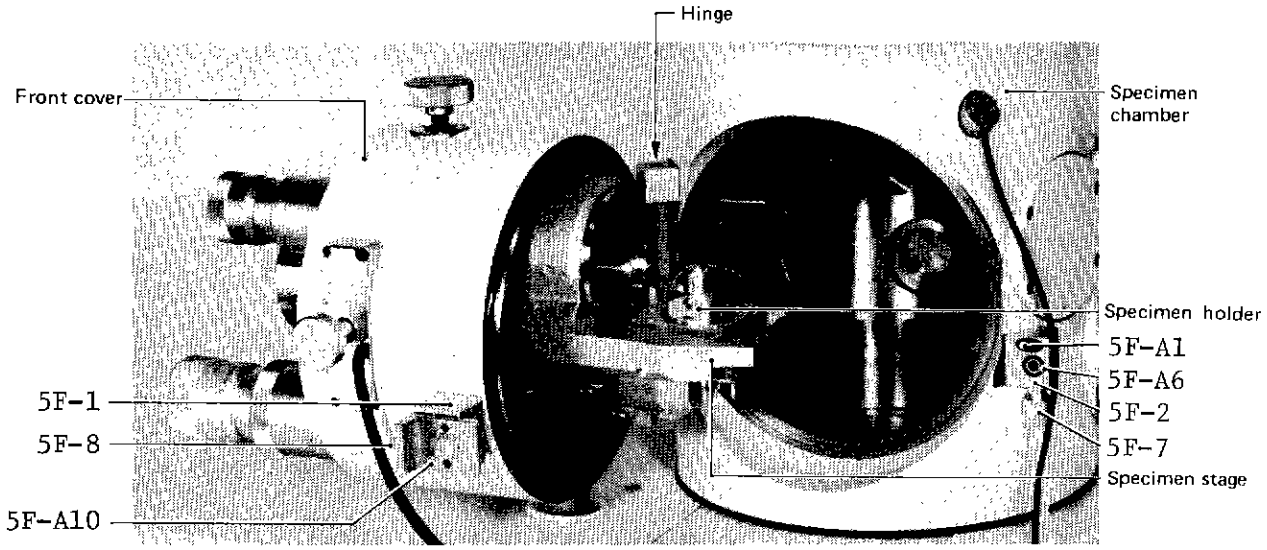
	SEQ	PART-NO.	DESCRIPTION		QTY
☞	1	800500229	CAP	UB331184-00 3	2
☞	2	800500237	CAP	UB331185-00 3	1
☞	3	800500245	FLANGE	UB331186-00 3	1
☞	4	800800010	CHAMBER	UB331187-12 1	1
	5	800102541	CAP	UB331188-00 4	1
	6	800102550	CAP	UB331189-01 4	1
☞	7	800102568	CAP	UB331190-00 4	2
☞	8	600000095	GASKET	AB210027-00 4	2
☞A	1	411001159	HEXSOCKET BOLT	6*10 SCM3	12
☞A	2	411001051	HEXSOCKET BOLT	4*10 SCM3	7
A	3	411000993	HEXSOCKET BOLT	3*8 SCM3	4
☞A	4	415000548	PARALLEL PIN	H7B 4*8 S45C	3
A	5	415001790	PARALLEL PIN	H7B 2*5 S45C	1
A	6	406000859	O-RING	JISB2401 P 145 4D	1
☞A	7	406001383	O-RING	JISB2401 G 70 4D	1
☞A	8	406001375	O-RING	JISB2401 G 65 4D	1
A	9	406000484	O-RING	JISB2401 P 44 4D	1
☞A	10	406001278	O-RING	JISB2401 G 25 4D	3

【5E】

MODEL 804000069 AG110133(03) JSM-35C (M) EP156085-

COMPO 804500711 UA331105(01) HINGE 800902

	SEQ	PART-NO.	DESCRIPTION		QTY
	1	800103017	BRACKET	UB331352-04 4	1
	2	800103025	SHAFT	UB331353-00 4	1
	3	800103033	SPACER	UB331354-00 4	1
	4	800103041	BRG,PLAIN	UB331355-03 4	1
	5	800103050	BRG,PLAIN	UB331356-02 4	1
A	1	411001574	HEXSOCKET BOLT	5*30 SCM3	4
A	2	411001141	HEXSOCKET BOLT	5*20 SCM3	4
A	3	409001457	+PAN HEAD SCREW	3*6 BSW2 NIP3	1

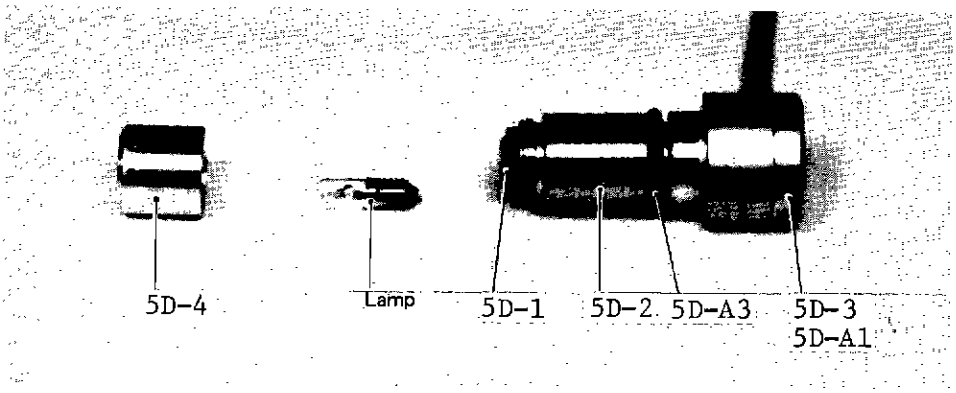


Opening the front cover

【5F】

MODEL	804000069	AG110133(03)	JSM-35C (M)	EP156085-
COMPO	804500720	UA331106(03)	EXCH.PRE-EVAC.	800902

	SEQ	PART-NO.	DESCRIPTION		QTY
☞	1	800500261	BRG,PLAIN	UB331358-03 3	1
☞	2	800500270	BLOCK	UB331359-03 3	1
	3	800103076	SPRING,PRESSURE	UB331360-00 4	1
	4	800103092	PIPE W/FLANGE	UB331362-01 4	1
	5	800101332	PIPE	AB220391-01 4	1
	6	800101341	PIPE FITTING	AB220393-01 4	1
☞	7	800101359	NUT	AB220394-01 4	1
☞	8	800103084	HOOK	UB331361-04 4	1
☞A	1	411001043	HEXSOCKET BOLT	4*8 SCM3	1
A	2	411001060	HEXSOCKET BOLT	4*12 SCM3	2
A	3	411004107	HEXSOCKET BOLT	4*16 SCM3	3
A	5	415001803	PARALLEL PIN	H7B 4*36 S45C	1
☞A	6	406000093	O-RING	JISB2401 P 8 4D	1
A	7	406000123	O-RING	JISB2401 P 10A 4D	1
A	8	490003150	RING	8ﾏﾙ Sｼﾞｮｲﾝﾄﾖｳ	1
☞A	10	409008613	HEXSOCKET SCREW	ﾄｶﾞﾘ 3*5 SCM3	1
A	11	405002416	BYTON TUBE	4.5D*10D*150	



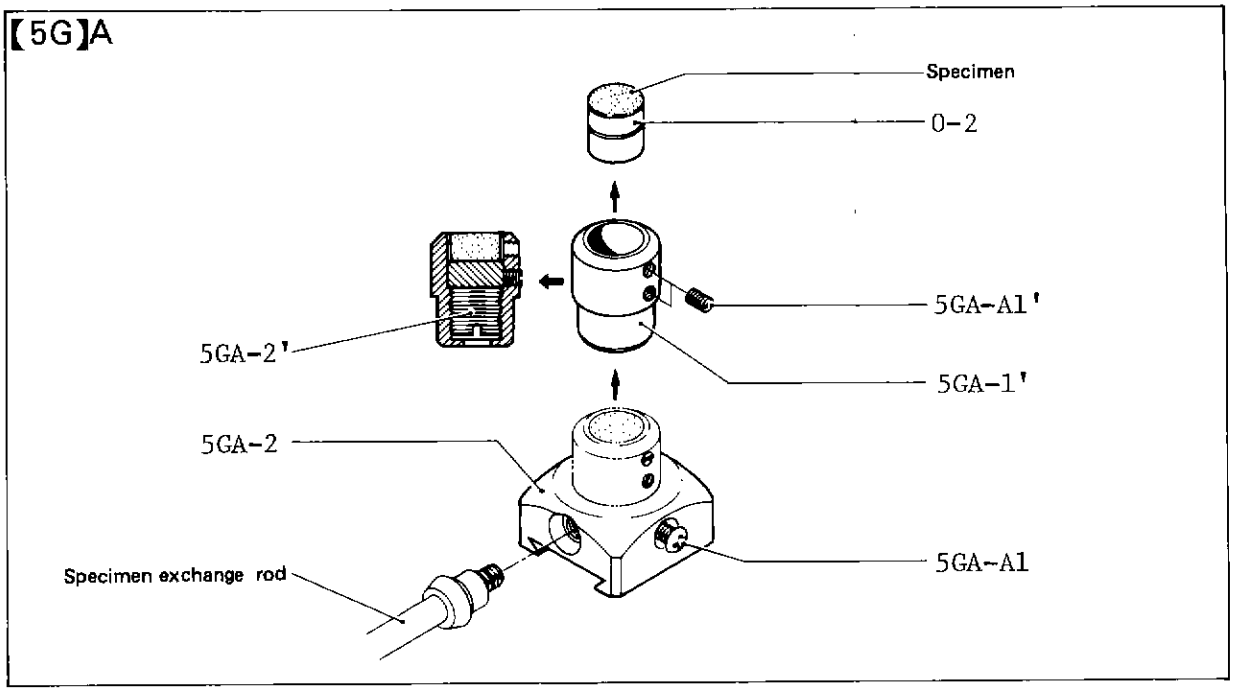
Replacing the specimen chamber illumination lamp

【5D】

MODEL	804000069	AG110133(03)	JSM-35C (M)		EP156085-
COMPO	804300178	AA237003(02)	LAMP HOLDER		800902

	SEQ	PART-NO.	DESCRIPTION		QTY
☞	1	800101707	NUT	AB370046-00 4	1
☞	2	800101715	HOLDER	AB370047-03 4	1
☞	3	800101723	SUPPORT	AB370048-01 4	1
☞	4	800101731	COVER	AB370049-01 4	1
☞A	1	409001902	+PAN HEAD SCREW	2*8 BSW2 CRP1	2
A	2	353002496	HERMTIC SEAL	C-133(C-520)	1
☞A	3	406000158	O-RING	JISB2401 P 12 4D	1
A	4	360004113	CABLE	JWD 15KT ﾐﾄﾞﾘ	
A	5	360004121	CABLE	AF04B050 OE	

【5G】A



WD15 specimen holder

【5G】A-1

MODEL	804000069	AG110133(03)	JSM-35C (M)	EP156085-
COMPO	804300194	UA334109(00)	SPEC.MOUNT	800902

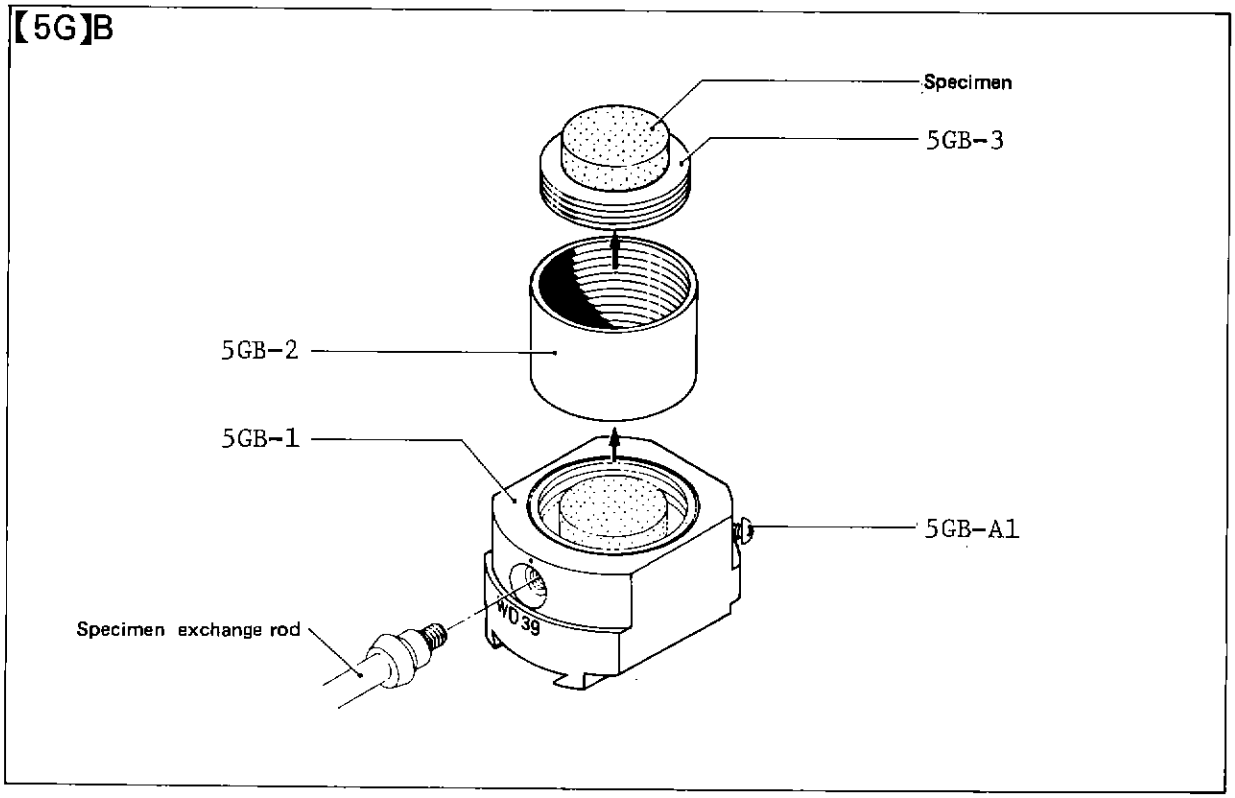
	SEQ	PART-NO.	DESCRIPTION		QTY
☞	1'	800103114	HOLDER	UB331375-00 4	1
☞	2'	800103122	SCREW	UB331376-00 4	1
☞A	1'	409008036	-SET SCREW	ㄷ5 3*4 BSW2	1

【5G】A-2

MODEL	804000069	AG110133(03)	JSM-35C (M)	EP156085-
COMPO	804900418	(00)	HOLDER	800902

	SEQ	PART-NO.	DESCRIPTION		QTY
☞	2	800105541	HOLDER	UB331372-00 4	1
	3	800103980	NPL,MODEL	AB230395-00 4	1
	4	800105559	DAMPER	UB331373-00 4	1
	6	800103955	CASE	AB230026-00 4	1
	7	800103963	CASE	AB230027-00 4	1
☞A	1	409007005	-PAN HEAD SCREW	3*5 BSW2	1
A	2	131100653	VINYL SHEET	0.5T*467W	1

【5G】B

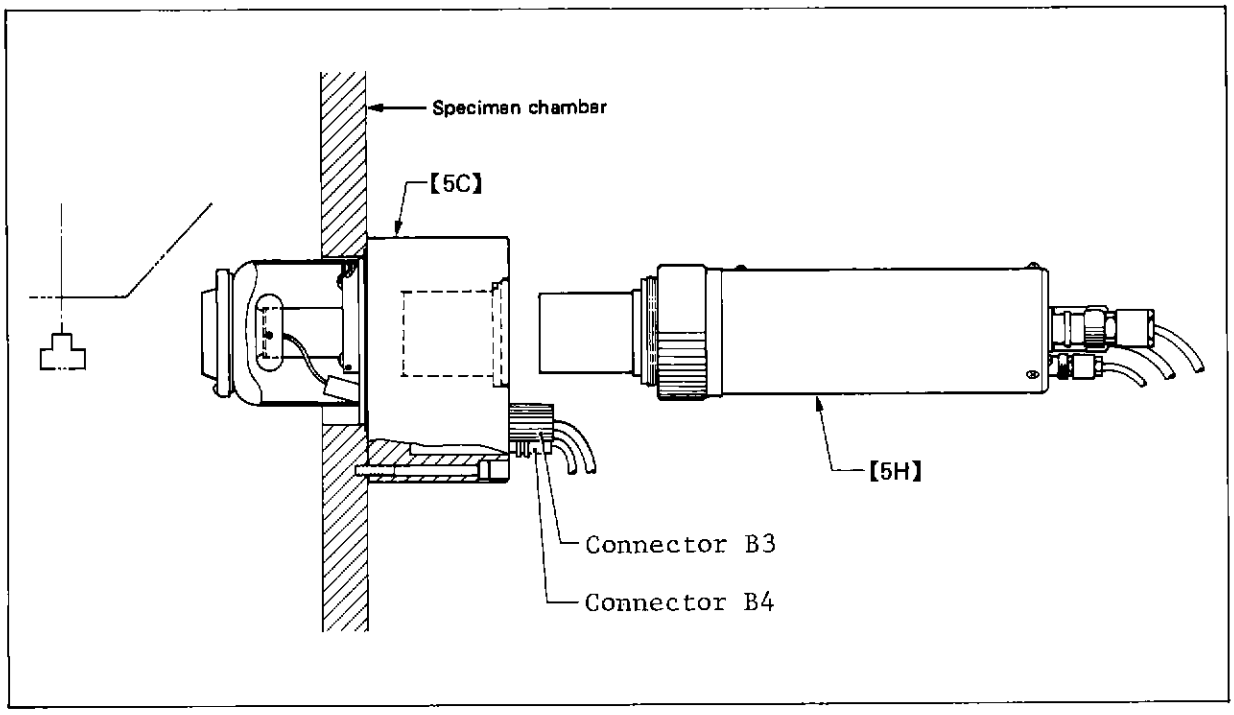


WD39 specimen holder

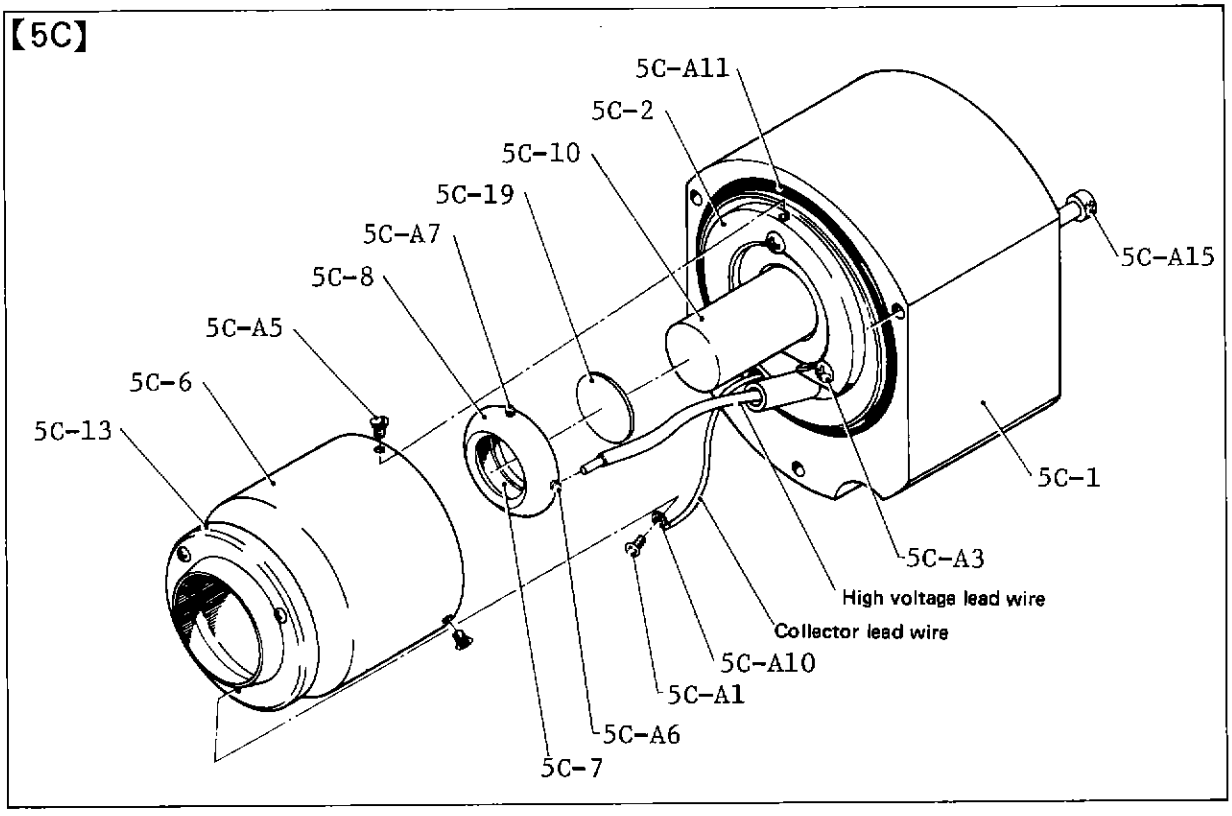
【5G】B

MODEL	804000069	AG110133(03)	JSM-35C (M)		EP156085-
COMPO	804500738	UA334110(00)	SPEC.HOLDER(B)		800902

	SEQ	PART-NO.	DESCRIPTION		QTY
☞	1	800105567	HOLDER	UB331377-00 4	1
☞	2	800105508	NUT	UB331378-04 4	1
☞	3	800103971	SCREW	AB230046-00 4	1
	4	800103980	NPL,MODEL	AB230395-00 4	1
	5	800105559	DAMPER	UB331373-00 4	1
	6	800103955	CASE	AB230026-00 4	1
	7	800103963	CASE	AB230027-00 4	1
☞A	1	409007005	-PAN HEAD SCREW	3*5 BSW2	1
A	2	131100653	VINYL SHEET	0.5T*467W	1



Remove the secondary electron detector



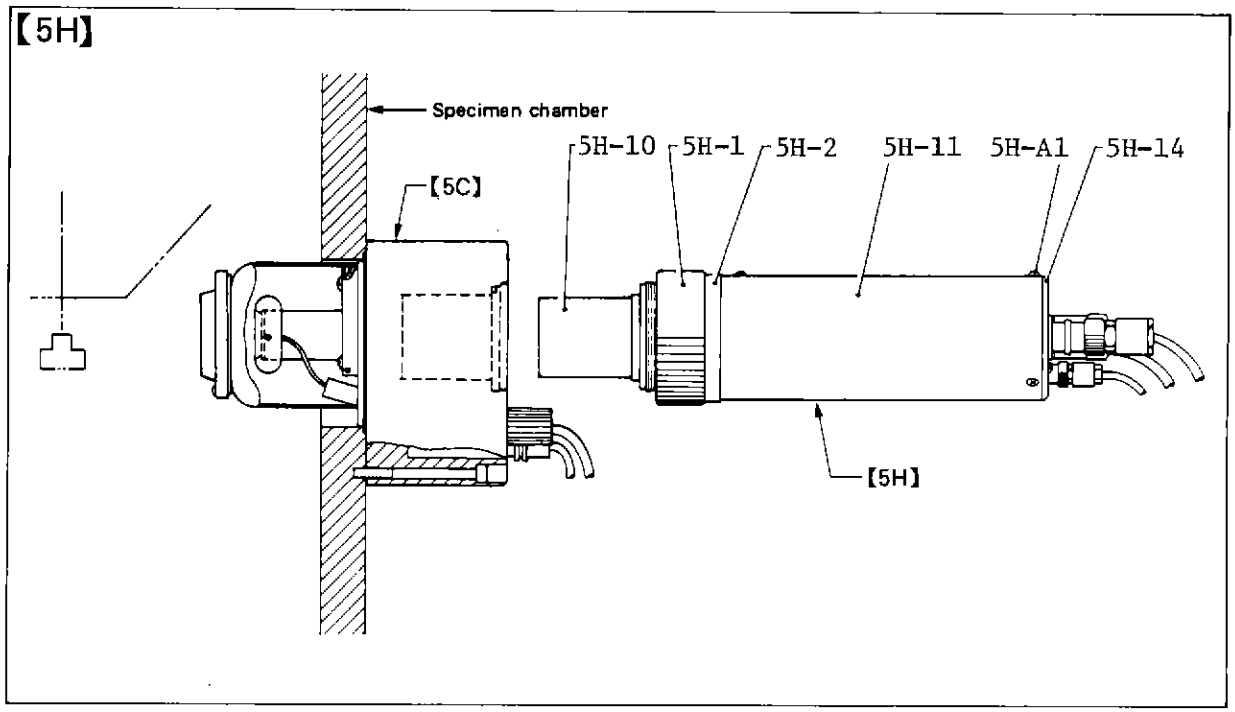
Exploded view of the secondary electron detector

【5C】

MODEL 804000069 AG110133(03) JSM-35C (M) EP156085-

COMPO 804700532 UA336110(06) DETECTOR 800902

	SEQ	PART-NO.	DESCRIPTION	QTY
☞	1	800500296	FLANGE UB332221-04 3	1
☞	2	800103416	FLANGE UB332222-01 4	1
	3	800102002	CAP UB331108-02 4	1
	4	800101642	INSULATOR AB260056-00 4	1
	5	800102576	RING UB331193-01 4	1
☞	6	800102011	COVER UB331109-02 4	1
☞	7	800101626	RING AB260048-01 4	1
☞	8	800101634	RING AB260049-02 4	1
☞	10	800101618	LIGHT GUIDE AB260046-02 4	1
	11	800101677	CONTACT AB260077-00 4	1
	12	800101600	RING AB260044-00 4	1
☞	13	800102428	ELECTRODE UB331167-00 4	1
	14	800102436	HOLDER UB331168-01 4	1
	15	600054080	TERMINAL UB332219-02 4	1
	16	600049426	HOLDER UB332223-01 4	1
☞	19	600009173	LIGHT GUIDE AB260108-00 4	1
☞A	1	409007153	+PAN HEAD SCREW 2*4 BSW2	5
A	2	409001449	+PAN HEAD SCREW 3*4 BSW2 NIP3	2
☞A	3	409006661	+PAN HEAD SCREW 3*16 BSW2 NIP3	3
A	4	409004383	FLAT HEAD SCREW 2*3 BSW2	3
☞A	5	409006866	+FLT HEAD SCREW 2*3 BSW2 NIP3	3
☞A	6	409006432	SET SCREW(SLOT) ﾋﾗ 2*2.5 S45C	1
☞A	7	409006572	SET SCREW(SLOT) ﾋﾗ 2*4 S45C	2
A	8	409008621	-SET SCREW ﾋﾗ 3*5 S45C	1
☞A	10	416000622	RUG TERMINAL 2	1
☞A	11	406001375	O-RING JISB2401 G 65 4D	1
A	12	406000221	O-RING JISB2401 P 20 4D	1
A	13	406000115	O-RING JISB2401 P 10 4D	1
A	14	353002330	HERMTIC SEAL A-306 (A-314)	1
☞A	15	411004174	HEXSOCKET BOLT 4*50 SCM3	3
A	16	406000069	O-RING JISB2401 P 5 4D	1
A	17	406000107	O-RING JISB2401 P 9 4D	1
A	20	405001291	TEFLON TUBE 1ﾏﾙ*2ﾏﾙ ｼﾛ	
A	21	405000677	TEFLON TUBE 2ﾏﾙ*3ﾏﾙ ｼﾛ	
A	22	360003966	POLYETHYLN WIRE 1.5KV-E-0.3SQ (2ﾏﾙ)	



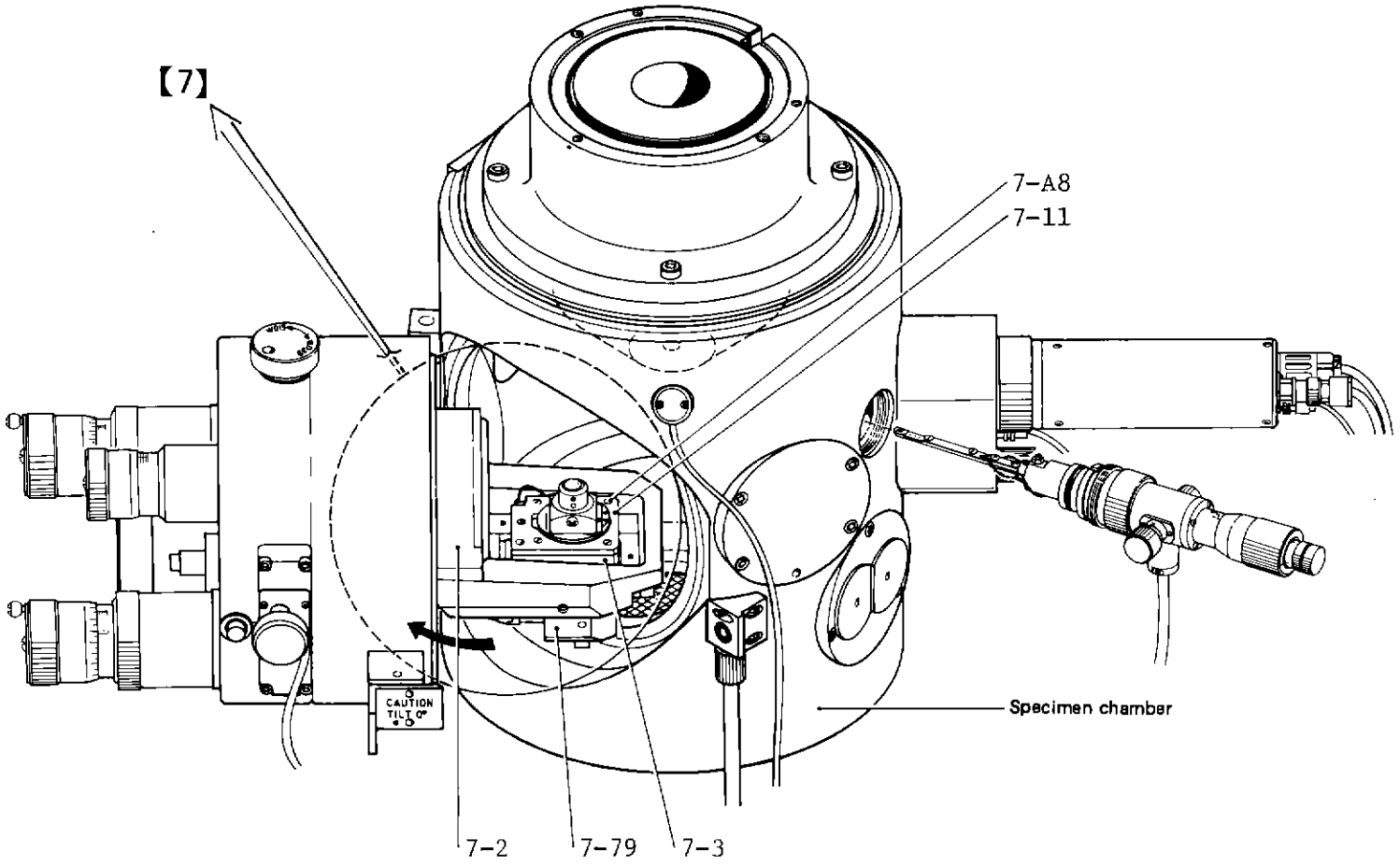
PMT holder

【5H】

MODEL 804000069 AG110133(03) JSM-35C (M) EP156085-

COMPO 804500746 UA336116(00) PMT HOLDER 800902

	SEQ	PART-NO.	DESCRIPTION		QTY
☞	1	800101529	SUPPORT	AB260012-02 4	1
☞	2	800101537	SPACER	AB260014-02 4	1
	3	800101545	DAMPER	AB260016-00 4	1
	4	800101553	COVER	AB260017-00 4	1
	5	800101561	NUT	AB260018-00 4	1
	6	800101570	BRACKET,TERM	AB260020-00 4	1
	7	800101588	HOLDER	AB260021-02 4	1
	8	800101596	SPRING,PRESSURE	AB260022-00 4	1
	9	800101651	HOLDER	AB260058-03 4	1
☞	10	800101669	COVER	AB260060-02 4	1
☞	11	800103807	CYLINDER	UB361176-00 4	1
	12	800103815	RING	UB361177-00 4	1
	13	800103823	POST	UB361178-00 4	1
☞	14	800103831	CAP	UB361179-00 4	1
☞A	1	409001881	+PAN HEAD SCREW	2*4 BSW2 CRP1	7
A	2	409001953	+PAN HEAD SCREW	2.6*8 BSW2 CRP1	4
A	3	409002003	+PAN HEAD SCREW	3*6 BSW2 CRP1	4
A	5	409008338	HEXSOCKET SCREW	ﾄｶﾞﾘ 3*4 SCM3	3
A	6	409007013	SET SCREW(SLOT)	ﾄｶﾞﾘ 2*4 S45C ZNP3C	4
A	7	412000199	HEXAGONAL NUT	M 2.6 BSBM NIP3	1
A	8	416000011	RUG TERMINAL	2.6	1



【7】

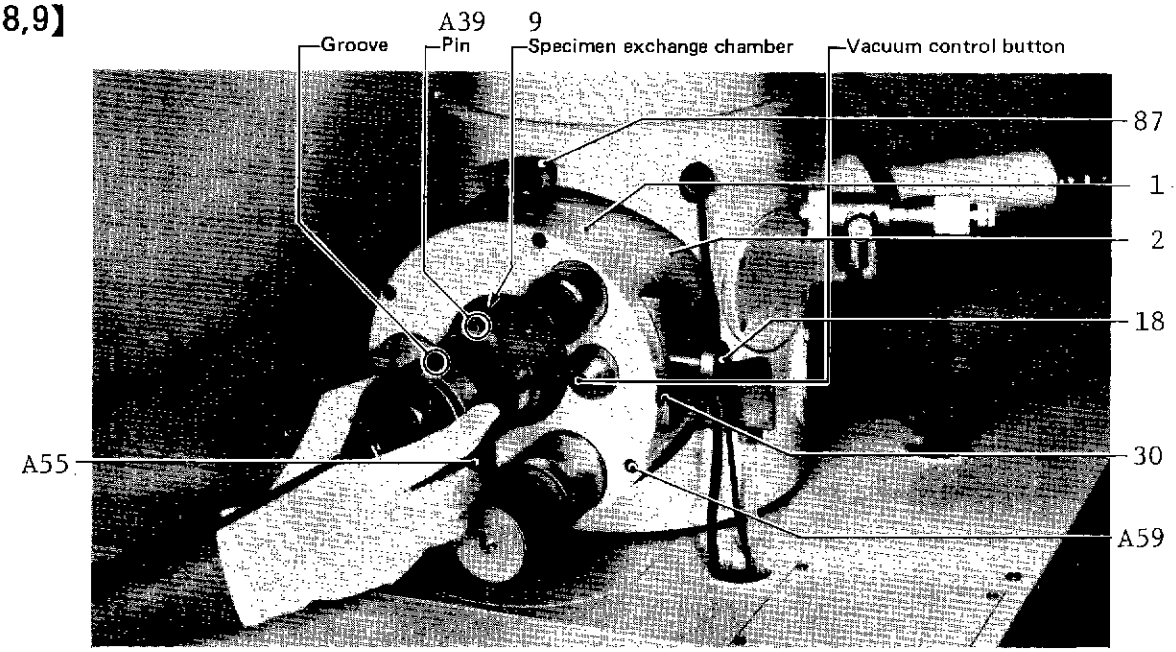
MODEL	804000069	AG110133(03)	JSM-35C (M)	EP156085-
COMPO	804800090	UA332102(12)	SPEC.STAGE/CONT	800902

	SEQ	PART-NO.	DESCRIPTION		QTY
☞	2	800700104	WORM WHEEL	UB331111-09 2	1
☞	3	800500211	BLOCK	UB331112-09 3	1
	4	800102029	RING	UB331113-01 4	1
	5	800102037	BRG,PLAIN	UB331114-03 4	1
	6	800102045	SLEEVE	UB331115-07 4	1
	7	800101952	BRG,PLAIN	UB331116-03 4	1
	8	800102053	CHUCK	UB331117-03 4	1
	9	800102061	NUT	UB331118-01 4	2
	10	800102070	FEED SCREW	UB331119-04 4	1
☞	11	800102088	PLATE	UB331120-06 4	1
	12	800102096	HOLDER	UB331121-02 4	1
	13	800102100	GUIDE	UB331122-03 4	1
	14	800102118	INSULATOR	UB331123-01 4	1
	15	800102126	HOLDER	UB331124-04 4	1
	16	800102134	GEAR,SPUR	UB331125-05 4	1

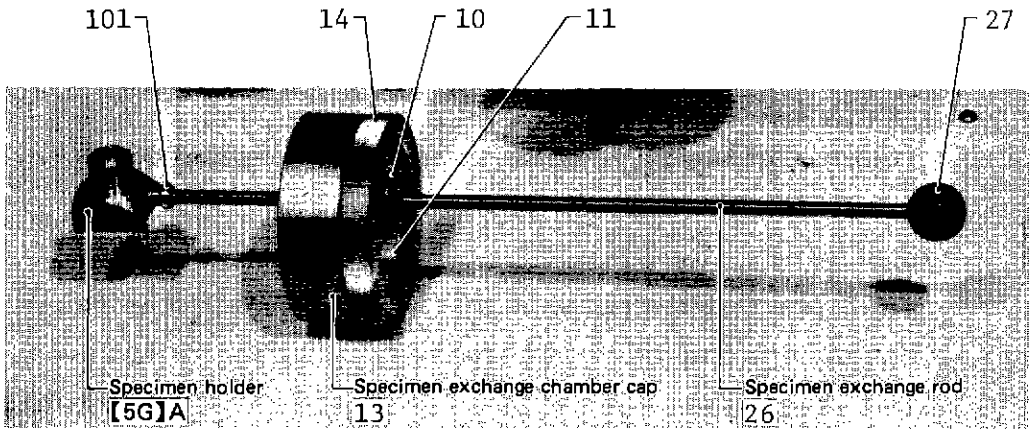
SEQ	PART-NO.	DESCRIPTION		QTY
17	800102142	SPRING,PRESSURE	UB331126-01 4	1
18	800102151	NUT	UB331127-01 4	1
19	800102169	RETAINER	UB331128-00 4	2
20	800102177	STOPPER	UB331129-00 4	4
21	800102185	GUIDE	UB331130-04 4	4
22	800102193	GEAR,RACK	UB331131-04 4	1
23	800102207	GEAR,SPUR	UB331132-01 4	1
25	800102215	SPRING,PRESSURE	UB331134-01 4	1
26	800109503	NUT	UB331135-01 4	1
27	800102223	PLATE	UB331136-03 4	1
29	800102231	SHAFT	UB331138-00 4	1
31	800102240	HOLDER	UB331140-01 4	1
32	800102258	BRG,PLAIN	UB331141-01 4	1
34	800102266	RETAINER	UB331143-01 4	2
35	800102274	PIN	UB331144-01 4	2
36	800102282	LEVER	UB331145-05 4	1
37	800102291	SHAFT	UB331146-01 4	1
38	800102304	BUSH	UB331147-00 4	1
39	800102312	FEED SCREW	UB331148-02 4	1
40	800102321	LEAD PLATE	UB331149-05 4	1
41	800102339	SUPPORT	UB331150-02 4	1
42	800102347	SCREW	UB331151-00 4	2
43	800102355	GUIDE	UB331152-04 4	4
44	800102363	INSULATOR	UB331153-02 4	1
45	800102371	SCREW	UB331154-00 4	6
47	800102380	SPACER	UB331156-01 4	1
48	800102398	SHAFT	UB331157-01 4	1
49	800102401	GEAR,SPUR	UB331158-00 4	1
50	800102410	GEAR,RACK	UB331159-04 4	1
52	800102444	CHUCK	UB331170-03 4	1
53	800102452	FEED SCREW	UB331171-03 4	1
54	800102461	SHAFT	UB331172-02 4	3
55	800102479	SHAFT	UB331173-01 4	1
56	800102487	SUPPORT	UB331174-03 4	1
57	800102495	SHAFT	UB331175-00 4	1
58	800102509	WORM	UB331176-01 4	1
61	800102517	SHAFT	UB331179-04 4	1
64	800102525	SHAFT	UB331182-00 4	1
65	800102533	SHAFT	UB331183-02 4	1
68	800102851	GEAR,BEVEL	UB331241-03 4	4
70	800103106	BAND	UB331371-02 4	1
71	800101685	CLAMP	AB320029-00 4	1
72	800103131	SPACER	UB331389-01 4	1
77	800103271	SPRING,TENSION	UB331867-00 4	2
78	800500288	FRAME,MECH	UB332079-01 3	1
☞ 79	800103327	BRG,PLAIN	UB332065-03 4	1
80	800103335	SHAFT	UB332066-00 4	1
81	800103343	BUSH	UB332080-00 4	1
82	800103173	SPRING,TENSION	UB331562-01 4	2
83	800103289	SPRING,TENSION	UB331996-00 4	2
84	800103297	SPACER	UB332062-00 4	3

	SEQ	PART-NO.	DESCRIPTION		QTY
	85	800101421	SUPPORTING PC	AB220444-02 4	6
	86	800101430	COUPLING	AB220445-02 4	12
	87	800103424	BRACKET,SW	UB332389-00 4	1
	89	800103432	SPACER	UB332391-00 4	1
	90	800101456	BRACKET,SW	AB221622-01 4	1
	91	800101464	BRG,PLAIN	AB221661-02 4	1
	92	800101472	BRG,PLAIN	AB221662-01 4	1
	93	800101693	SPACER	AB370015-00 4	2
	94	800700074	FLANGE	AB221663-02 2	1
	95	800700082	WORM WHEEL	AB222104-00 2	1
A	1	409007234	+PAN HEAD SCREW	3*6 BSW2	11
A	2	411000993	HEXSOCKET BOLT	3*8 SCM3	18
A	4	409007277	+PAN HEAD SCREW	3*20 BSW2	2
A	5	411004158	HEXSOCKET BOLT	3*22 SCM3	2
A	6	409008966	+PAN HEAD SCREW	3*25 BSW2	1
A	7	409007251	+PAN HEAD SCREW	3*12 BSW2	2
☞A	8	409007153	+PAN HEAD SCREW	2*4 BSW2	9
A	9	409006556	+PAN HEAD SCREW	2*4 ﾎﾟﾘｶﾎﾟ	1
A	10	409008648	+TRUSS HD SCREW	2*4 BSW2	1
A	11	409004391	FLAT HEAD SCREW	2*4 BSW2	4
A	12	401000800	STEEL BALL	3 M/M SUJ2	3
A	13	401001814	STEEL BALL	4 M/M SUJ2	8
A	14	401001415	BEARING	SSL-730-P5	2
A	16	415000246	PARALLEL PIN	H7B 2*6 S45C	1
A	17	415000254	PARALLEL PIN	H7B 2*8 S45C	3
A	18	415000882	TAPER PIN	2ｾﾝ 1.2*8 S50C	5
A	19	415000891	TAPER PIN	2ｾﾝ 1.2*10 S50C	14
A	20	414001630	CIRCLIP(E-TYPE)	4 SK5	2
A	21	416000029	RUG TERMINAL	3	1
A	23	409003981	+PAN HEAD SCREW	3*8 ﾎﾟﾘｶﾎﾟ	5
A	24	409007188	+PAN HEAD SCREW	2*10 BSW2	4
A	25	409007668	+FLT HEAD SCREW	2*4 BSW2	1
A	27	411001183	HEXSOCKET BOLT	6*18 SCM3	2
A	28	412003724	PLAIN WASHER(SM	M 3 BSP	5
A	29	412003295	HEXAGONAL NUT	M 3 BSW2	1
A	30	415000050	PARALLEL PIN	H7B 1*10 S45C	6
A	31	415000262	PARALLEL PIN	H7B 2*10 S45C	6
A	32	409007161	+PAN HEAD SCREW	2*6 BSW2	4
A	33	412003694	PLAIN WASHER(SM	M 2 BSP	8
A	34	412000466	SPRING WASHER	2ｺﾆﾜ 2 PBP NIP3	8

【8,9】



Mounting the specimen exchange chamber cap



Specimen holder secured to specimen exchange rod

【8,9】

MODEL	804000069	AG110133(04)	JSM-35C (M)	EP156091-
COMPO	804800111	UA333125(08)	STAGE FRONT CVR	800902

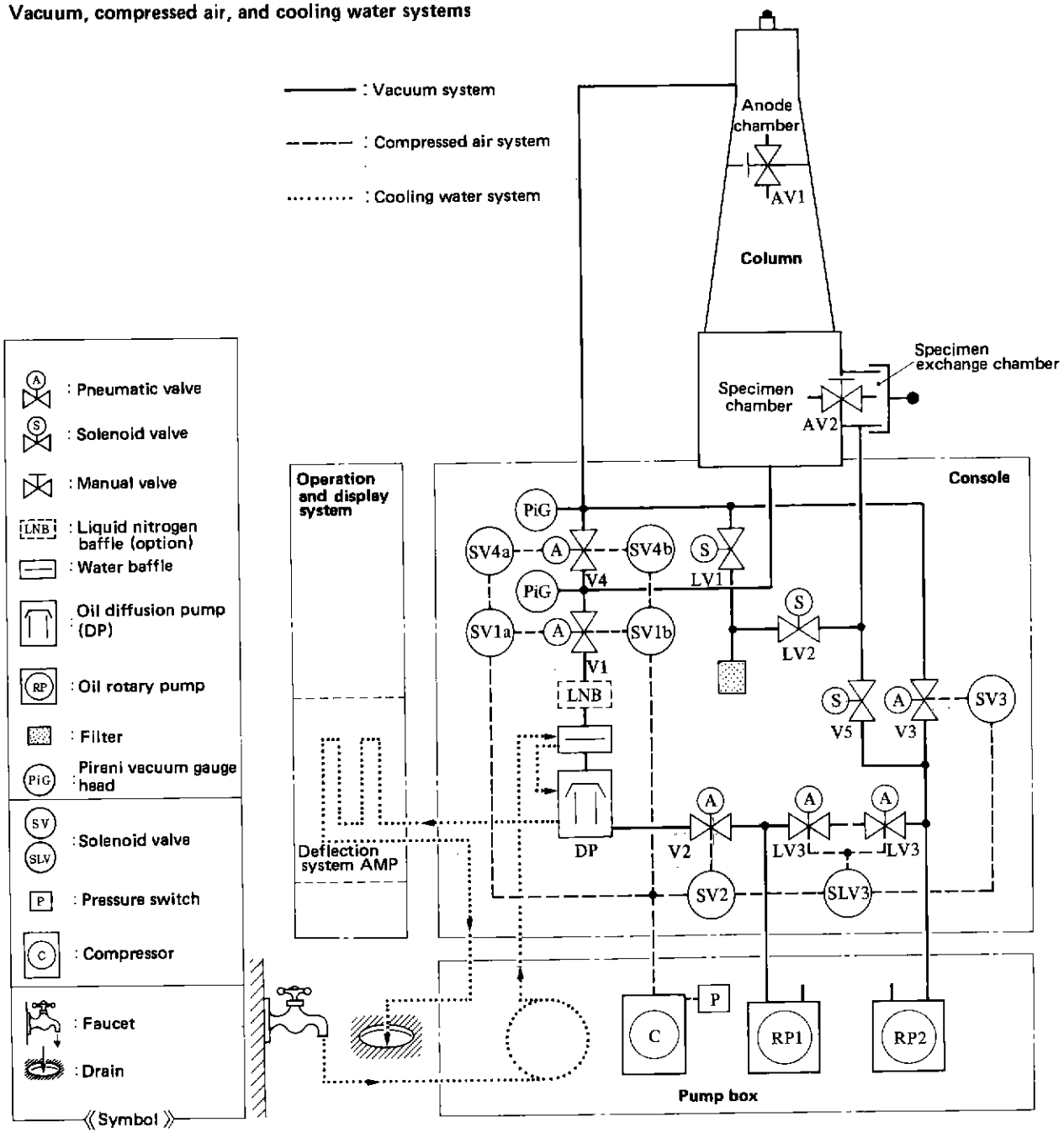
	SEQ	PART-NO.	DESCRIPTION		QTY
☞	1	800800028	COVER	UB332120-06 1	1
☞	2	800800036	CYLINDER	UB332121-03 1	1
	3	800500253	BRG,PLAIN	UB331200-03 3	1

	SEQ	PART-NO.	DESCRIPTION		QTY
	4	800102584	SPACER	UB331202-01 4	6
	5	800103220	HOLDER	UB331677-02 4	1
	6	800103211	SHAFT	UB331676-02 4	1
	7	800103203	GEAR,SPUR	UB331675-00 4	2
	8	800102592	SLEEVE	UB331205-03 4	2
☞	9	800103360	CHAMBER	UB332124-03 4	1
☞	10	800102606	BRG,PLAIN	UB331208-00 4	1
☞	11	800102614	GLASS	UB331209-01 4	1
	12	800102622	SHEET	UB331210-00 4	1
☞	13	800102631	HOLDER	UB331211-02 4	1
☞	14	800102649	NUT	UB331212-00 4	1
	15	800102657	RING	UB331213-05 4	1
	16	800103378	CAP	UB332125-00 4	1
	17	800102665	RING	UB331215-00 4	1
☞	18	800102673	KNOB	UB331216-00 4	1
	19	800102681	SHAFT	UB331217-04 4	1
	20	800102690	STOPPER	UB331218-03 4	1
	21	800102703	VALVE,BODY	UB331219-04 4	1
	22	800103386	FLANGE	UB332126-02 4	1
	23	800102711	PLATE	UB331221-02 4	1
	24	800102720	PLATE	UB331222-01 4	1
	25	800101294	ADDITIONAL WORK	AB210025-01 4	1
☞	26	800103157	SHAFT	UB331530-01 4	1
☞	27	800101308	KNOB	AB220366-00 4	1
	28	800101316	RING	AB220371-01 4	5
☞	30	800101367	CAP	AB220396-03 4	1
	31	800101375	NUT	AB220399-00 4	2
	32	800101383	HOLDER	AB220401-04 4	2
	33	800101391	COVER	AB220411-00 4	2
	36	800101448	GUIDE	AB220761-01 4	5
	37	800101286	ADDITIONAL WORK	AB210024-01 4	1
	38	800101405	CLAMP	AB220430-00 4	1
	39	800101413	CLAMP	AB220431-00 4	1
	44	800102738	GUIDE	UB331227-05 4	1
	45	800102746	HOLDER	UB331228-02 4	1
	46	800102754	BRACKET,SW	UB331229-00 4	1
	47	800102762	SHAFT	UB331230-02 4	1
	48	800102771	BRG,PLAIN	UB331232-01 4	1
	49	800102789	SHAFT	UB331233-01 4	3
	50	800102797	BRG,PLAIN	UB331234-02 4	1
	51	800102801	KNOB	UB331236-00 4	1
	52	800102819	FEED SCREW	UB331237-03 4	1
	53	800102827	BRG,PLAIN	UB331238-01 4	1
	54	800102835	INDICATOR	UB331239-03 4	1
	55	800102843	SHAFT	UB331240-02 4	1
	56	800102851	GEAR,BEVEL	UB331241-03 4	2
	57	800102860	GEAR,SPUR	UB331242-01 4	5
	58	800102878	SPACER	UB331243-02 4	2
	59	800102886	GEAR,SPUR	UB331244-00 4	2
	60	800103394	BRG,PLAIN	UB332127-01 4	1
	61	800109511	BRG,PLAIN	UB331246-02 4	1

	SEQ	PART-NO.	DESCRIPTION		QTY
	62	800102894	BUSH	UB331248-01 4	1
	63	800102908	LEVER	UB331249-01 4	1
	64	800102916	SHAFT	UB331250-00 4	1
	65	800102924	SPACER	UB331251-04 4	2
	67	800102932	SHAFT	UB331257-02 4	1
	69	800102941	SUPPORT	UB331259-02 4	1
	70	800102959	COVER	UB331260-01 4	1
	71	800102967	PIN SCREW	UB331261-01 4	1
	72	800102975	INDICATOR	UB331262-03 4	1
	73	800102983	FEED SCREW	UB331263-07 4	1
	74	800102991	KNOB	UB331264-01 4	1
	75	800103009	FLANGE	UB331268-04 4	1
	76	800103068	PIPE FITTING	UB331357-00 4	1
	80	800103181	FLANGE	UB331565-02 4	1
	81	800103190	SHAFT	UB331566-02 4	1
	82	800103165	GUIDE	UB331538-04 4	1
	83	800103238	SHAFT	UB331678-02 4	1
	84	800103246	HOLDER	UB331679-03 4	1
	85	800103254	FEED SCREW	UB331864-00 4	1
	86	800103408	BRG,PLAIN	UB332128-00 4	1
☞	87	800103262	KNOB	UB331866-00 4	1
	89	800103319	CYLINDER	UB332064-00 4	1
	90	800103297	SPACER	UB332062-00 4	8
	91	800103301	CYLINDER	UB332063-00 4	1
	92	800700112	WIRING LAYOUT	UB332133-01 2	1
	94	800101421	SUPPORTING PC	AB220444-02 4	4
	95	800101430	COUPLING	AB220445-02 4	4
	96	800101324	SLEEVE	AB220377-03 4	1
	97	800103149	SLEEVE	UB331514-02 4	3
	98	800101481	SPRING,LEAF	AB222374-01 4	1
	99	800101499	SPRING,LEAF	AB222375-00 4	1
	100	800101502	NUT	AB222376-00 4	1
☞	101	800101511	STOPPER	AB222377-01 4	1
	102	800173368	LEVER	AB223291-00 4	1
A	1	411004123	HEXSOCKET BOLT	6*22 SCM3	3
A	2	411001167	HEXSOCKET BOLT	6*12 SCM3	2
A	4	411004131	HEXSOCKET BOLT	4*35 SCM3	3
A	5	411003917	HEXSOCKET BOLT	4*25 SCM3	3
A	6	411004140	HEXSOCKET BOLT	4*22 SCM3	1
A	7	411001043	HEXSOCKET BOLT	4*8 SCM3	3
A	8	411004115	HEXSOCKET BOLT	3*25 SCM3	4
A	9	411004158	HEXSOCKET BOLT	3*22 SCM3	3
A	10	411000993	HEXSOCKET BOLT	3*8 SCM3	3
A	11	411000985	HEXSOCKET BOLT	3*6 SCM3	4
A	12	409006955	+PAN HEAD SCREW	3*14 BSW2 NIP3	11
A	13	409001465	+PAN HEAD SCREW	3*8 BSW2 NIP3	7
A	14	409001457	+PAN HEAD SCREW	3*6 BSW2 NIP3	14
A	15	409001368	+PAN HEAD SCREW	2*20 BSW2 NIP3	2
A	16	409001333	+PAN HEAD SCREW	2*10 BSW2 NIP3	2
A	17	409001309	+PAN HEAD SCREW	2*4 BSW2 NIP3	9
A	18	409003166	+TRUSS HD SCREW	4*6 BSW2 CRP1	2
A	19	409006963	+TRUSS HD SCREW	3*5 BSW2 NIP3	1

SEQ	PART-NO.	DESCRIPTION			QTY
A 20	409003298	HEXSOCKET SCREW	ﾌﾎﾞﾐ 3*4 SCM3		1
A 21	409005185	+FLT HEAD SCREW	2*5 BSW2 NIP3		4
A 22	406001618	O-RING	JISB2401 G 185	4D	1
A 23	406001391	O-RING	JISB2401 G 75	4D	1
A 24	406001375	O-RING	JISB2401 G 65	4D	1
A 25	406001367	O-RING	JISB2401 G 60	4D	1
A 26	406001359	O-RING	JISB2401 G 55	4D	2
A 27	406001341	O-RING	JISB2401 G 50	4D	1
A 28	406001278	O-RING	JISB2401 G 25	4D	2
A 29	406000221	O-RING	JISB2401 P 20	4D	3
A 30	406000191	O-RING	JISB2401 P 16	4D	1
A 31	406000158	O-RING	JISB2401 P 12	4D	1
A 32	406000123	O-RING	JISB2401 P 10A	4D	1
A 33	406000107	O-RING	JISB2401 P 9	4D	2
A 34	406000093	O-RING	JISB2401 P 8	4D	1
A 36	406000069	O-RING	JISB2401 P 5	4D	1
A 37	406000051	O-RING	JISB2401 P 4	4D	3
A 38	406000042	O-RING	JISB2401 P 3	4D	1
☞A 39	415001790	PARALLEL PIN	H7B 2*5 S45C		4
A 40	415000262	PARALLEL PIN	H7B 2*10 S45C		7
A 41	415000459	PARALLEL PIN	H7B 3*8 S45C		2
A 42	415002532	PARALLEL PIN	H7B 6*22 S45C		1
A 43	415002699	SPRING PIN	ﾅﾐｶﾞﾀA.W 2*16	SUS420J2	1
A 44	415001633	SPRING PIN	ﾅﾐｶﾞﾀA,W 2*12	SUS420J2	1
A 45	415001587	SPRING PIN	ﾅﾐｶﾞﾀA,W 1.6*12	SUS420J2	1
A 46	415002541	SPRING PIN	ﾅﾐｶﾞﾀA,W 1*6	SUS420J2	1
A 47	415000891	TAPER PIN	2ｷｻｶ 1.2*10 S50C		4
A 48	415000682	TAPER PIN	2ｷｻｶ 1.2*8 S50C		9
A 49	414001630	CIRCLIP(E-TYPE)	4 SK5		2
A 50	414001621	CIRCLIP(E-TYPE)	3 SK5		2
A 51	412003104	PLAIN WASHER(SM	M 6 BSP NIP3 (ｷｻｶJIS)		2
A 52	353002453	HERMTIC SEAL	C-504		1
A 53	401001814	STEEL BALL	4 M/M SUJ2		1
A 54	401001440	BEARING	SSL-1260ZZ		1
☞A 55	364000074	COUNTER	DM-15		1
A 58	406003122	O-RING	JISW1516 G 40	4D	1
☞A 59	411004166	HEXSOCKET BOLT	5*50 SCM3		4
A 60	415000548	PARALLEL PIN	H7B 4*8 S45C		1
A 61	415000050	PARALLEL PIN	H7B 1*10 S45C		4
A 62	360004130	WIRE	AF04B050 RD		
A 63	409003166	+TRUSS HD SCREW	4*6 BSW2 CRP1		1
A 64	401004171	BEARING	6804		2
A 65	401002055	BEARING	6900		2
A 66	360004067	CABLE	JWD 15KT BE		
A 67	360004075	WIRE	AF04B050 BK		
A 68	360004083	CABLE	AF04B050 BN		
A 69	360004121	CABLE	AF04B050 OE		
A 70	360004113	CABLE	JWD 15KT GN		
A 71	360004172	CABLE	AF04B050 YW		
A 72	360004148	CABLE	JWD 15KT VT		

Vacuum, compressed air, and cooling water systems



PUMPS, COMPRESSOR, ETC

CODE	PART-NO.	DESCRIPTION	QTY	REF
DP	804700028 [804700419 804300135 804900272]	DIFFUSION PUMP (DP-4E)	1	【12D】

CODE	PART-NO.	DESCRIPTION	QTY	REF
RP1 RP2	804700010 (338000763)	ROTARY PUMP (RP-100G)	2	【12C】
C	600028674	COMPRESSOR	1	【12A】
PIG	804300011 (359000193)	PIRANI GAUGE (SYS)	2	【12B】
B	804700036 804500568 804900281	WATER COOL BAFFLE (BF-4)	1	【12E】
F	804500045 600047369 600102513 600102505	AIR FILTER (SYS)	1	【12F】

LIST OF VALVES

CODE	PART-NO.	DESCRIPTION	QTY	REF
V1	804700044	4" BUTTERFLY VALVE	1	【10B】
V2 V3	804500011	1" PNEU L-TYPE VALVE	2	【11D】
V4	804700052	2" BUTTERFLY VALVE	1	【10B】
V5 LV1 LV2	349000093	SOLENOID VALVE	3	【11A】 【11F】 【11C】
LV3 LV3'	804500029	PNEU VENT VALVE	2	【11E】
SV1a SV1b SV2 SV3 SV4a SV4b SLV3	349003432	SOLENOID VALVE	7	【11B】
AV1 AV2	804500681 (800100689)	MANUAL AIRLOCK VALVE (ANODE CHAMBER)	1	【2C】
		MANUAL AIRLOCK VALVE (SPEC. EXCH. CHAMBER)	1	【8,9】

【12D】-1

MODEL	804000069	AG110133(03)	JSM-35C (M)	EP156085-
COMPO	804700419	MA013009(04)	DP-4E JET	800902

SEQ	PART-NO.	DESCRIPTION		QTY
1	800109767	SCREW	MB010172-01 4	1
2	800109856	JET	MB010223-01 4	1
3	800109775	JET	MB010174-02 4	1
4	800501454	CASE	MB010175-00 3	1
5	800109783	JET	MB010176-01 4	1
6	800501462	CASE	MB010177-00 3	1
7	800501471	CASE	MB010178-00 3	1
8	800109791	PIPE	MB010179-00 4	1
9	800109805	RING	MB010180-00 4	1
10	800109813	SUPPORT	MB010181-02 4	1
11	800109821	SCREW	MB010182-02 4	3
A 1	412000105	HEXAGONAL NUT	M 5 SUS304 1ｼｭ	1
A 3	415002770	SPRING PIN	ﾅﾐｶﾞﾀA,W 1.6*16 SUS420J2	1

【12D】-2

MODEL	804000069	AG110133(03)	JSM-35C (M)	EP156085-
COMPO	804300135	MA013010(01)	BP BAFFLE	800902

SEQ	PART-NO.	DESCRIPTION		QTY
1	800109198	ROD	MB010188-00 4	1
2	800109201	BAFFLE	MB010189-00 4	2
3	800109210	BAFFLE	MB010190-00 4	2
4	800109228	BAFFLE	MB010191-00 4	1
5	800109236	BAFFLE	MB010192-00 4	1

【12D】-3

MODEL	804000069	AG110133(03)	JSM-35C (M)	EP156085-
COMPO	804900272	804900272(00)	DP-4E PARTS	800902

	SEQ	PART-NO.	DESCRIPTION		QTY
	3	800501489	COVER	MB010183-02 3	1
	4	800109830	COVER	MB010184-00 4	1
	5	800501497	FLANGE	MB010185-01 3	1
	6	800109848	RING	MB010186-01 4	1
	7	800700317	CASING	MB010187-05 2	1
	8	800109678	NUT	MB010048-02 4	1
	9	800109686	NUT	MB010049-00 4	1
	10	800109694	SPRING,PRESSURE	MB010050-00 4	1
	11	800109708	CLAMP	MB010051-00 4	2
	12	800109716	SHEET	MB010052-00 4	1
	13	800109724	SUPPORT	MB010053-04 4	1
	15	322000025	HEATER	MB010055-01 4	1
	16	800109732	WIRE	MB010057-01 4	2
	17	800109741	PLATE	MB010059-00 4	2
	18	800109759	BRACKET	MB010060-00 4	1
	19	800111109	NAME PLATE	UB191014-01 4	1
	20	322000050	HEATER	MB430090-01 4	1
	21	800111117	NAME PLATE	UB191015-01 4	1
A	1	409001309	+PAN HEAD SCREW	2*4 BSW2 NIP3	4
A	2	409001457	+PAN HEAD SCREW	3*6 BSW2 NIP3	6
A	3	409001473	+PAN HEAD SCREW	3*10 BSW2 NIP3	6
A	4	409005061	+PAN HEAD SCREW	4*16 BSW2 NIP3	2
A	5	412000202	HEXAGONAL NUT	M 3 BSBM NIP3	8
A	6	412000211	HEXAGONAL NUT	M 4 BSBM NIP3	2
A	7	411003941	STUD BOLT	M3*18 BSBM NIP3	1
A	8	412001390	SPRING WASHER	2ｺﾞｳ 3 SUS	2
A	9	412000318	PLAIN WASHER	M 4 BSP NIP3	2
A	10	412000300	PLAIN WASHER	M 3 BSP NIP3	6
A	11	423007211	DP OIL	ﾗｲｵﾝA 100CCｲﾘ	1
A	12	327000694	INSULATR/FLANGE	NO.3	2
A	13	348000421	OVEN SOCKET	2P 1KW	1
A	14	423007220	DP OIL	ﾗｲｵﾝS 100CCｲﾘ	1
A	15	423007556	OIL	SANTOVAC-5 100CC	1

【12E】-1

MODEL 804000069 AG110133(03) JSM-35C (M) EP156085-

COMPO 804500568 MA012002(02) BAFFL.ASSMBLNG 800902

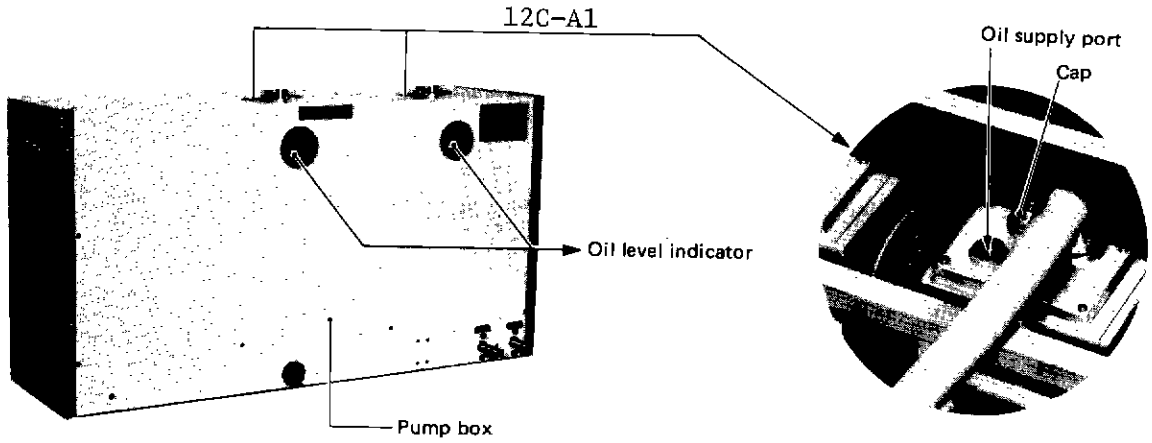
SEQ	PART-NO.	DESCRIPTION		QTY
1	800109074	PIPE	MB010006-01 4	1
2	800109082	PLATE	MB010007-01 4	1
3	800109091	PLATE	MB010008-01 4	2
4	800109104	PLATE	MB010009-01 4	2
5	800109112	PLATE	MB010010-01 4	2
6	800109121	PLATE	MB010011-01 4	2
7	800109139	PLATE	MB010012-01 4	2
8	800109147	PLATE	MB010013-01 4	2
9	800109155	PLATE	MB010014-01 4	2
10	800109163	PLATE	MB010015-01 4	3
11	800109171	PLATE	MB010016-02 4	1
13	800109252	PLATE	MB010255-01 4	1
14	800109279	PLATE	MB010257-00 4	1

【12E】-2

MODEL 804000069 AG110133(03) JSM-35C (M) EP156085-

COMPO 804900281 804900281(00) BF-4 PARTS 800902

SEQ	PART-NO.	DESCRIPTION		QTY
2	800501381	BASE,MECH	MB010003-05 3	1
3	800109066	CAP	MB010004-00 4	2
5	800109261	HOSE COUPLING	MB010256-00 4	2
6	800109287	CAP	MB010258-00 4	1
A 1	406001839	O-RING	JISB2401 V 100 4D	1
A 2	406001481	O-RING	JISB2401 G 120 4D	1

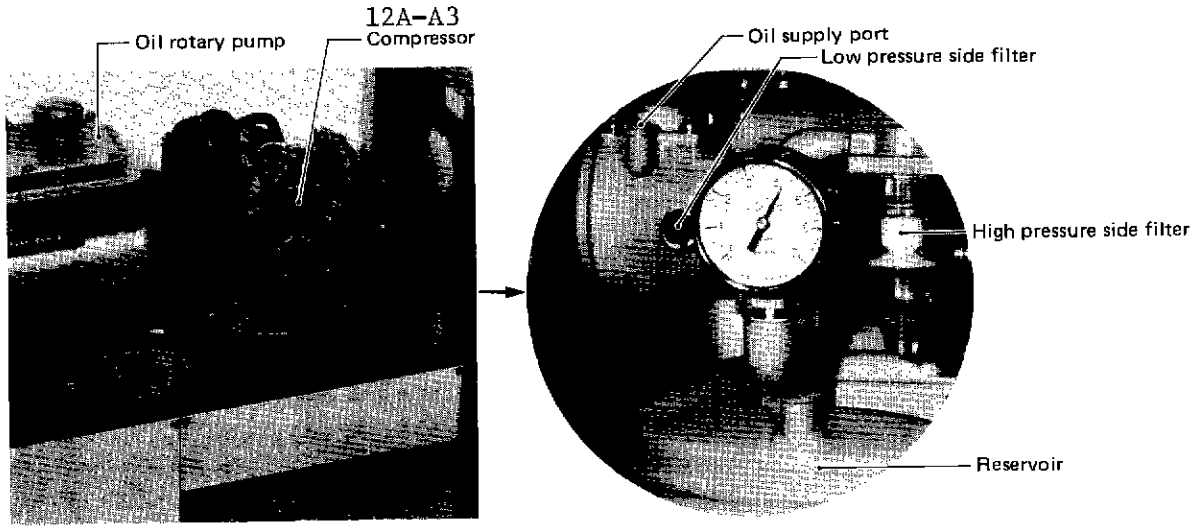


Rotary pump

【12C】

MODEL	804000069	AG110133(03)	JSM-35C (M)	EP156085-
COMPO	804700010	MA014001(04)	RP-100G	800902

SEQ	PART-NO.	DESCRIPTION		QTY
2	800111095	NAME PLATE	UB191013-04 4	1
3	800502132	NAME PLATE	MB010225-00 3	1
4	800128826	ADDITIONAL WORK	MB010268-00 4	1
☞A 1	338000763	ROTARY PUMP	RP-100ｶﾞﾀ ｹﾞｰﾃｶﾞﾀ 2ﾀﾝ	1
A 2	423002830	OIL	RPｵｲﾙ 1L(NEOVAC MR-200)	1
A 3	420018727	PULLEY	ｶﾞｲｹｲ180(ﾀﾞｲ)	1
A 4	420016724	V-BELT	REC-MF6310	1
A 5	420018735	PULLEY	ｶﾞｲｹｲ150(ｼﾖｳ)	1
A 6	332004023	MOTOR BASE	4.5T*220*210(MB010002-4)	1
A 7	411000730	HEXAGON HD BOLT	8*65 S20C ZNP3C	4
A 8	411005049	HEXAGON HD BOLT	8*25 SWRM12 ZNP3C	4
A 9	412001616	HEXAGONAL NUT	M 8 SWRM12 ZNP3C 1ｼｭ	20
A 10	412003627	PLAIN WASHER(SM	M 8 SS41 ZNP3C (ｷｴｳJIS)	24
A 11	412002264	SPRING WASHER	2ｺﾏｳ 8 SWRH ZNP3C	8
A 14	332000397	MOTOR	BKREC 91A4 300W	1



Air compressor

【12A】

MODEL	804000069	AG110133(03)	JSM-35C (M)	EP156085-
COMPO	804700486	UA370101(09)	EVAC.SYS.CONNEC	800902

	SEQ	PART-NO.	DESCRIPTION		QTY
	5	800700091	BLOCK	MB103115-00 2	1
	6	800101847	PIPE	MB103116-00 4	2
	8	800500202	WIRING LAYOUT	AB480020-00 3	1
A	1	405000693	POLYETHYLN PIPE	4マル*6マル	
A	2	405000413	VACUUM HOSE	18マル*42マル*600	2
☞A	3	600028674	100V COMPRESSOR	MA021001< >1	1
A	4	403000831	HI-PRESS.NOZZLE	1/4" 6マル オス BSBM	1
A	5	405000618	AIR HOSE	1/4"	
A	6	403000581	COUPLER(SP-TYPE	2S (1/4") ソケット	1
A	7	403000114	COUPLING	SHP-201 BSBM	1
A	8	403000092	COUPLING	SHP-200 BSBM	6
A	9	409007021	HEXSOCKET SCREW	6*10 S45C	4
A	10	405000421	VACUUM HOSE	18マル*42マル*700	2
A	12	403000173	COUPLING	SLP-300 BSBM	2
A	13	403007828	COUPLING	SHP-221 BSBM	1
A	14	405000707	POLYETHYLN PIPE	6マル*8マル	
A	15	430001037	A.BAND (ヘラバンド)	A-10 クロ (10MT)	1
A	16	430001045	SNAP BUTTON	A-10ヨウ ボタン2コウ クロ (500コ)	2
A	17	405000103	VACUUM PVC HOSE	4.5マル*10マル	
A	18	412003121	PLAIN WASHER	M 14 SS41P	1
A	19	412003139	SPRING WASHER	2コウ 14 SWRH ZNP3C	1
A	20	405000405	VACUUM HOSE	18マル*42マル*500	2
A	21	403000572	COUPLER(SP-TYPE	2P (1/4") プラグ	1
A	22	403000840	HI-PRESS.NOZZLE	1/4" 6マル メス BSBM	1

【12B】

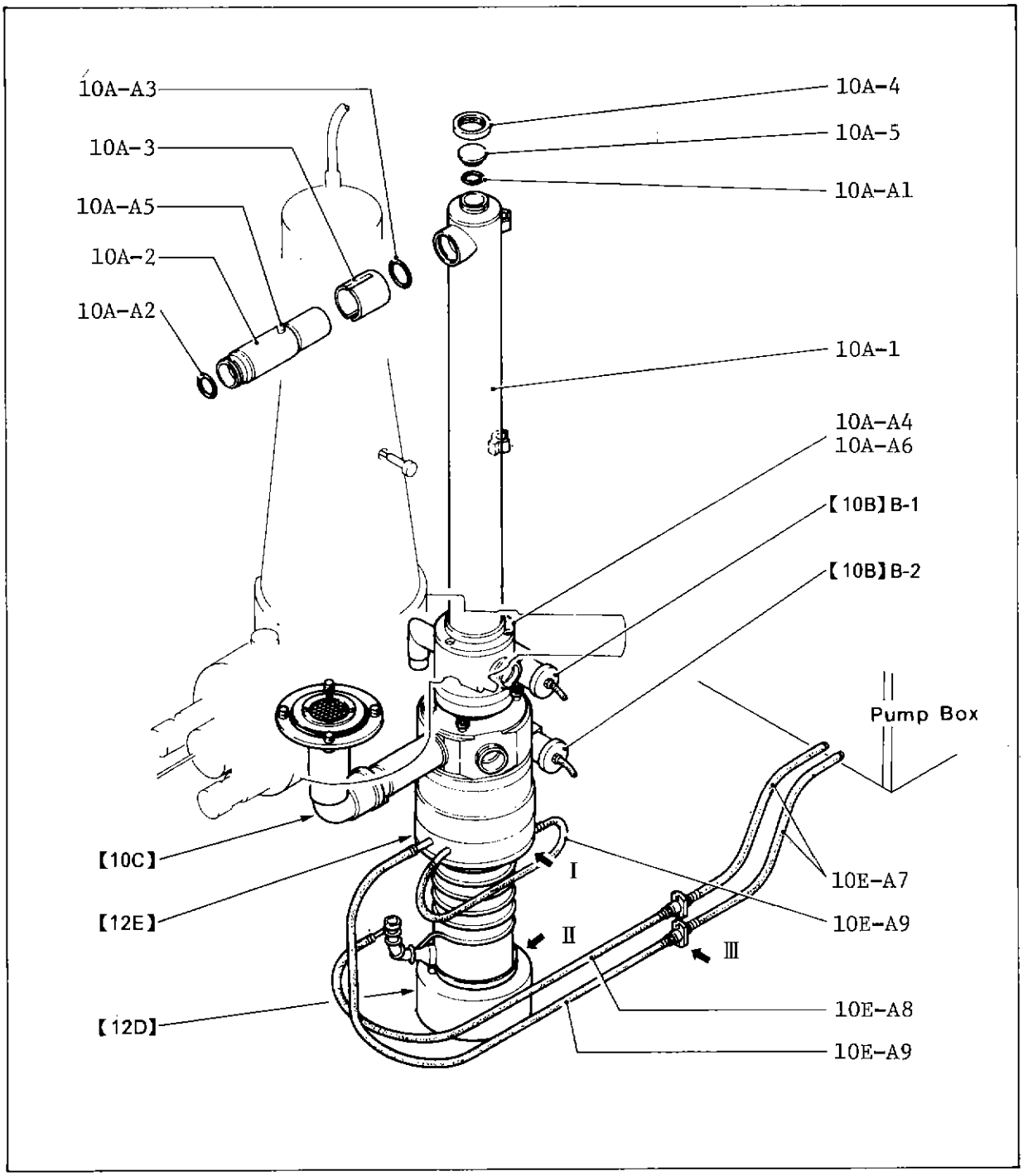
MODEL	804000069	AG110133(03)	JSM-35C (M)	EP156085-
COMPO	804300011	MA174004(02)	PIRANI TUBE MNT	800902

	SEQ	PART-NO.	DESCRIPTION		QTY
	1	600009963	FLANGE	MB102756-00 4	1
	2	600009971	NUT	MB102757-00 4	1
	3	600009980	BAND	MB102758-00 4	1
A	1	353002500	HERMTIC SEAL	D-901	1
A	2	359000193	PIRANI TUBE	PTA-3 (E-V-007)	1
A	3	406000379	O-RING	JISB2401 P 31.5 4D	1

【12F】

MODEL	804000069	AG110133(03)	JSM-35C (M)	EP156085-
COMPO	804500045	UA171119(00)	AIR FILTER	800902

	SEQ	PART-NO.	DESCRIPTION		QTY
	1	800101855	CASE	UB171097-00 4	1
	2	800101863	PIPE	UB171098-00 4	2
	3	600047369	FILTER	UB171099-00 4	1
	4	600102513	FILTER	UB171100-00 4	1
	5	600102505	FILTER	UB171101-00 4	1
A	1	423001213	SILICA GEL	18Lイリ ミツクス	
A	2	408001607	RUBBER CAP	5.5マル*25T	1



Evacuation manifold system

【10A】

MODEL	804000069	AG110133(03)	JSM-35C (M)	EP156085-
COMPO	804700460	UA371121(03)	ELEC.GUN EVAC.	800902

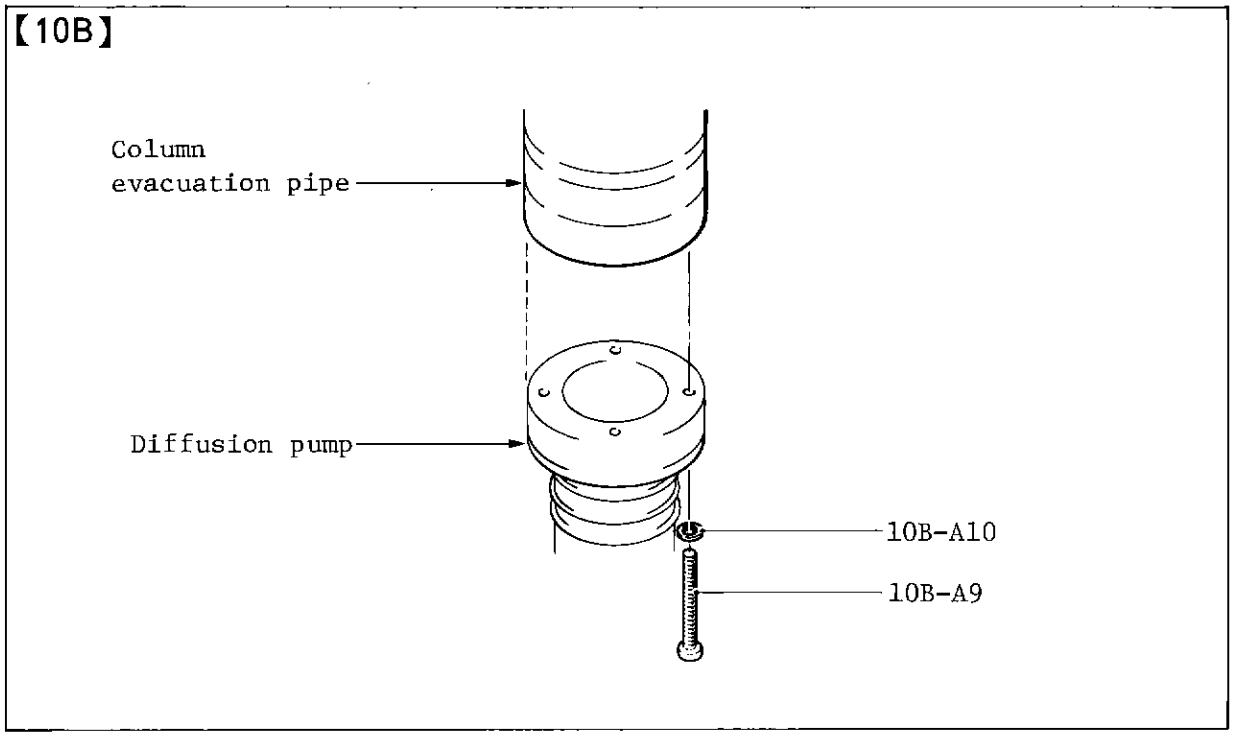
	SEQ	PART-NO.	DESCRIPTION		QTY
☞	1	800500342	PIPE W/FLANGE	UB371179-03 3	1
☞	2	800500351	PIPE	UB371180-00 3	1
☞	3	800103840	STOPPER	UB371181-00 4	1
☞	4	800101740	NUT	AB410029-00 4	1
☞	5	800101758	CAP	AB410030-00 4	1
☞A	1	406000387	O-RING	JISB2401 P 32 4D	1
☞A	2	406000433	O-RING	JISB2401 P 38 4D	1
☞A	3	406000514	O-RING	JISB2401 P 48 4D	1
☞A	4	406001383	O-RING	JISB2401 G 70 4D	1
☞A	5	415001838	PARALLEL PIN	H7B 6*56 S45C	1
☞A	6	411001175	HEXSOCKET BOLT	6*15 SCM3	3

【10C】

MODEL	804000069	AG110133(03)	JSM-35C (M)	EP156085-
COMPO	804500614	UA371109(02)	SPEC.CHMBR EVAC	800902

	SEQ	PART-NO.	DESCRIPTION		QTY
	1	800500181	PIPE W/FLANGE	UB371034-02 3	1
	2	800100247	PIPE	AB420066-00 4	1
	3	800100255	BAND	AB420069-00 4	1
	4	800100280	RING	AB420254-00 4	1
A	1	411001183	HEXSOCKET BOLT	6*18 SCM3	4
A	2	406000549	O-RING	JISB2401 P 50 4D	1
A	3	406001464	O-RING	JISB2401 G 110 4D	1
A	4	409001457	+PAN HEAD SCREW	3*6 BSW2 NIP3	4
A	5	490004326	WOVEN METAL NET	80マル10メッシュ 0.3マル BSW	1

【10B】



DETAIL I

【10B】

MODEL	804000069	AG110133(03)	JSM-35C (M)			EP156085-
COMPO	804700478	UA371105(06)	COLUMN EVAC.PIP			800902
SEQ	PART-NO.	DESCRIPTION				QTY
2	800500172	FLANGE	UB371015-03 3			1
3	800500091	PIPE	AB420072-01 3			1
4	800500105	PIPE	AB640003-02 3			1
5	800100417	CAP	AB640020-03 4			1
6	800100263	PIPE	AB420073-00 4			1
7	800100271	CAP	AB420075-00 4			1
8	800700058	HOLDER	UB371176-03 2			1
A 1	406000549	O-RING	JISB2401 P 50	4D		1
A 2	406001359	O-RING	JISB2401 G 55	4D		1
A 3	406001375	O-RING	JISB2401 G 65	4D		3
A 4	406001464	O-RING	JISB2401 G 110	4D		2
A 5	411001175	HEXSOCKET BOLT	6*15 SCM3			4
A 6	411002325	HEXSOCKET BOLT	6*35 SCM3			3
A 7	411002279	HEXSOCKET BOLT	10*20 SCM3			8
A 8	411002147	HEXSOCKET BOLT	10*40 SCM3			12
☞A 9	411001809	HEXSOCKET BOLT	10*110 SCM3			4
☞A 10	412000555	SPRING WASHER	ｽﾌﾟﾘﾝｸﾞ 10 PBP NIP3			4

【10B】B-1

MODEL	804000069	AG110133(03)	JSM-35C (M)	EP156085-
COMPO	804700052	MA011013(05)	2"BTTRFLY VALVE	800902

	SEQ	PART-NO.	DESCRIPTION		QTY
	1	800501438	CYLINDER	MB010041-05 3	1
	2	800501446	FLANGE	MB010042-01 3	1
	3	800109651	VALVE	MB010043-01 4	1
	4	800109660	SHAFT	MB010044-00 4	1
	5	800109571	SHAFT	MB010030-02 4	1
	6	800109864	CAP	MB010260-00 4	2
	7	800109589	PISTON	MB010032-01 4	2
	8	800109635	SPACER	MB010039-01 4	1
	9	800109643	SPACER	MB010040-03 4	2
	10	800109597	CAP	MB010035-02 4	1
	11	800109601	CAM	MB010036-00 4	1
	12	800109619	SCREW	MB010037-00 4	1
	13	800109627	ROLLER	MB010038-00 4	1
A	1	406005401	O-RING	JISW1516 P 42 4D	1
A	2	406000115	O-RING	JISB2401 P 10 4D	2
A	3	406003556	O-RING	JISB2401 P 30 1A	4
A	4	406003319	O-RING	JISB2401 P 8 1A	2
A	5	406001375	O-RING	JISB2401 G 65 4D	1
A	6	409001457	+PAN HEAD SCREW	3*6 BSW2 NIP3	3
A	7	412000725	DU BUSH	MB1010DU	1
A	9	409006505	+OVALCOUNTSCREW	6*8 BSW2 NIP3	2
A	10	411001060	HEXSOCKET BOLT	4*12 SCM3	3
A	11	411003071	HEXSOCKET BOLT	5*40 SCM3	2
A	12	412000105	HEXAGONAL NUT	M 5 SUS304 ﾐｿﾞ	1
A	13	412000695	DU BUSH	MB0610DU	1
A	14	412003619	PLAIN WASHER(SM	M 5 SS41 ZNP3C (ﾅﾛｳJIS)	1
A	15	412003015	SPRING WASHER	2ｺﾓﾝ 4 SWRH ZNP3C	3
A	16	412003007	PLAIN WASHER(SM	M 6 SS41 ZNP3C (ﾅﾛｳJIS)	2
A	17	415000467	PARALLEL PIN	H7B 3*10 S45C	2
A	18	415000467	PARALLEL PIN	H7B 3*10 S45C	1
A	19	415000637	PARALLEL PIN	H7B 5*10 S45C	1
A	20	415002290	SPRING PIN	ﾖｿﾞA,W 3*16 SK5	1
A	21	409008338	HEXSOCKET SCREW	ﾄｶﾞﾘ 3*4 SCM3	4

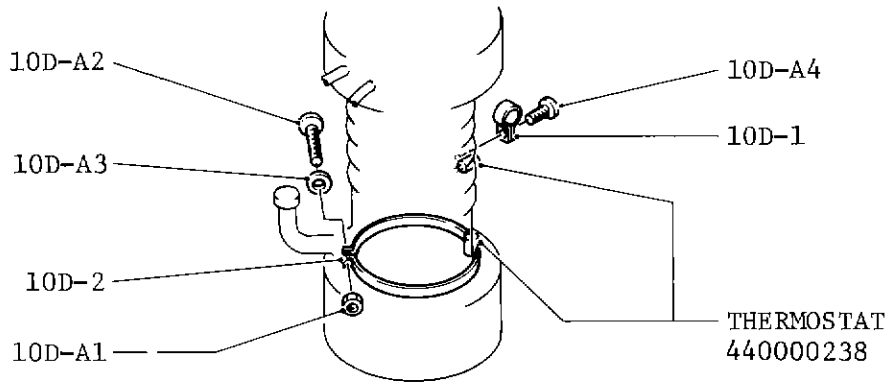
【10B】B-2

MODEL 804000069 AG110133(03) JSM-35C (M) EP156085-

COMPO 804700044 MA011012(05) 4"BTTRFLY VALVE 800902

	SEQ	PART-NO.	DESCRIPTION		QTY
	1	800501403	CYLINDER	MB010026-04 3	1
	2	800501411	FLANGE	MB010027-01 3	1
	3	800109562	VALVE	MB010028-03 4	1
	4	800501420	SHAFT	MB010029-01 3	1
	5	800109571	SHAFT	MB010030-02 4	1
	6	800109864	CAP	MB010260-00 4	2
	7	800109589	PISTON	MB010032-01 4	2
	8	800109635	SPACER	MB010039-01 4	1
	9	800109643	SPACER	MB010040-03 4	2
	10	800109597	CAP	MB010035-02 4	1
	11	800109601	CAM	MB010036-00 4	1
	12	800109619	SCREW	MB010037-00 4	1
	13	800109627	ROLLER	MB010038-00 4	1
A	1	406000701	O-RING	JISB2401 P 85 4D	1
A	2	406000115	O-RING	JISB2401 P 10 4D	2
A	3	406003556	O-RING	JISB2401 P 30 1A	4
A	4	406003319	O-RING	JISB2401 P 8 1A	2
A	5	406001464	O-RING	JISB2401 G 110 4D	1
A	6	409001457	+PAN HEAD SCREW	3*6 BSW2 NIP3	3
A	7	412000725	DU BUSH	MB1010DU	1
A	9	411001060	HEXSOCKET BOLT	4*12 SCM3	5
A	10	412000105	HEXAGONAL NUT	M 5 SUS304 1ﾐﾘ	2
A	11	412000695	DU BUSH	MB0610DU	1
A	12	411003071	HEXSOCKET BOLT	5*40 SCM3	2
A	13	412001683	SPRING WASHER	2ｺﾓﾉ 4 SUS	5
A	14	412003619	PLAIN WASHER(SM	M 5 SS41 ZNP3C (ｷｴｳJIS)	1
A	15	415000467	PARALLEL PIN	H7B 3*10 S45C	2
A	16	415000483	PARALLEL PIN	H7B 3*14 S45C	1
A	17	415002290	SPRING PIN	ﾐｿﾞA,W 3*16 SK5	1
A	18	412003007	PLAIN WASHER(SM	M 6 SS41 ZNP3C (ｷｴｳJIS)	2
A	19	415000637	PARALLEL PIN	H7B 5*10 S45C	1
A	20	409006505	+OVALCOUNTSCREW	6*8 BSW2 NIP3	2
A	21	409008338	HEXSOCKET SCREW	ﾄｶﾞﾘ 3*4 SCM3	4

【10D】

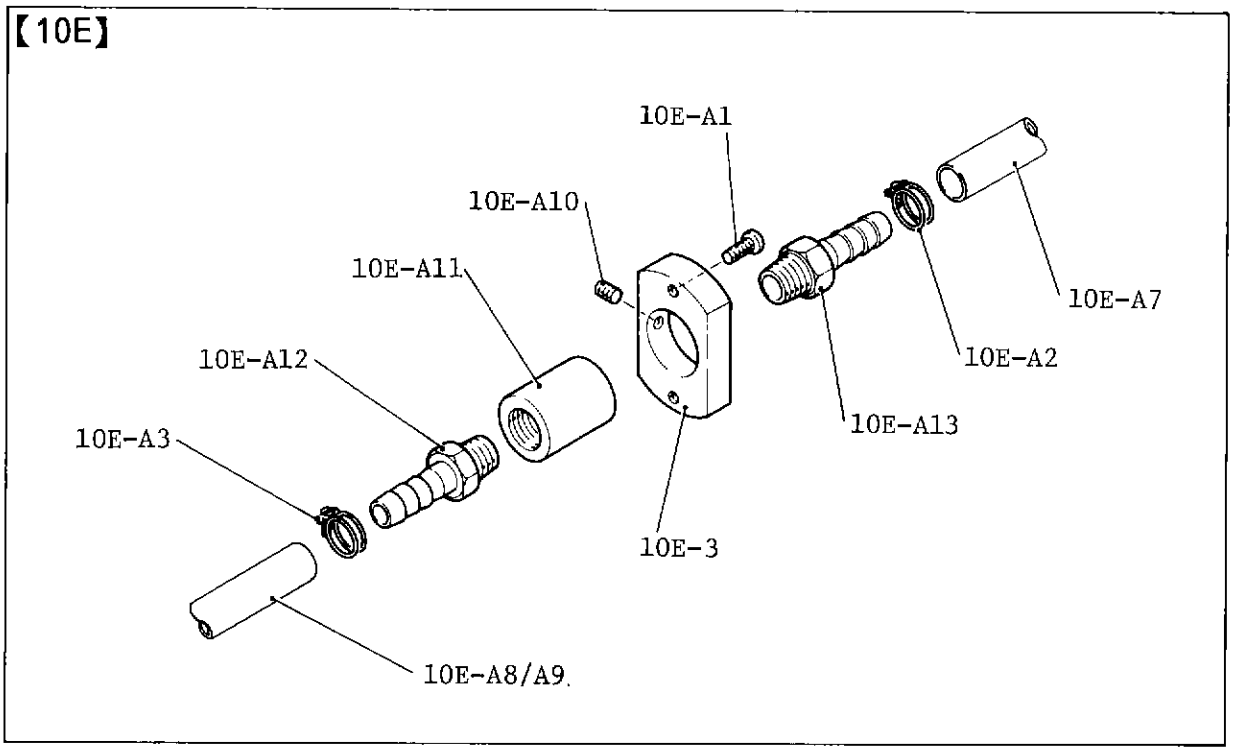


DETAIL Ⅱ

【10D】

MODEL	804000069	AG110133(03)	JSM-35C (M)	EP156085-
COMPO	804500622	UA372101(00)	THERMOSTAT MNT.	800902

	SEQ	PART-NO.	DESCRIPTION		QTY
☞	1	800100832	BAND	UB371016-00 4	1
☞	2	800100361	BAND	AB480015-00 4	1
☞A	1	412000202	HEXAGONAL NUT	M 3 BSBM NIP3	1
☞A	2	409001490	+PAN HEAD SCREW	3*20 BSW2 NIP3	1
☞A	3	412002566	PLAIN WASHER(SM	M 3 BSP NIP3 (ｻﾗJIS)	2
☞A	4	409005169	+PAN HEAD SCREW	3*5 BSW2 NIP3	1
☞		440000238	THERMOSTAT	ELECTRICAL PARTS	2

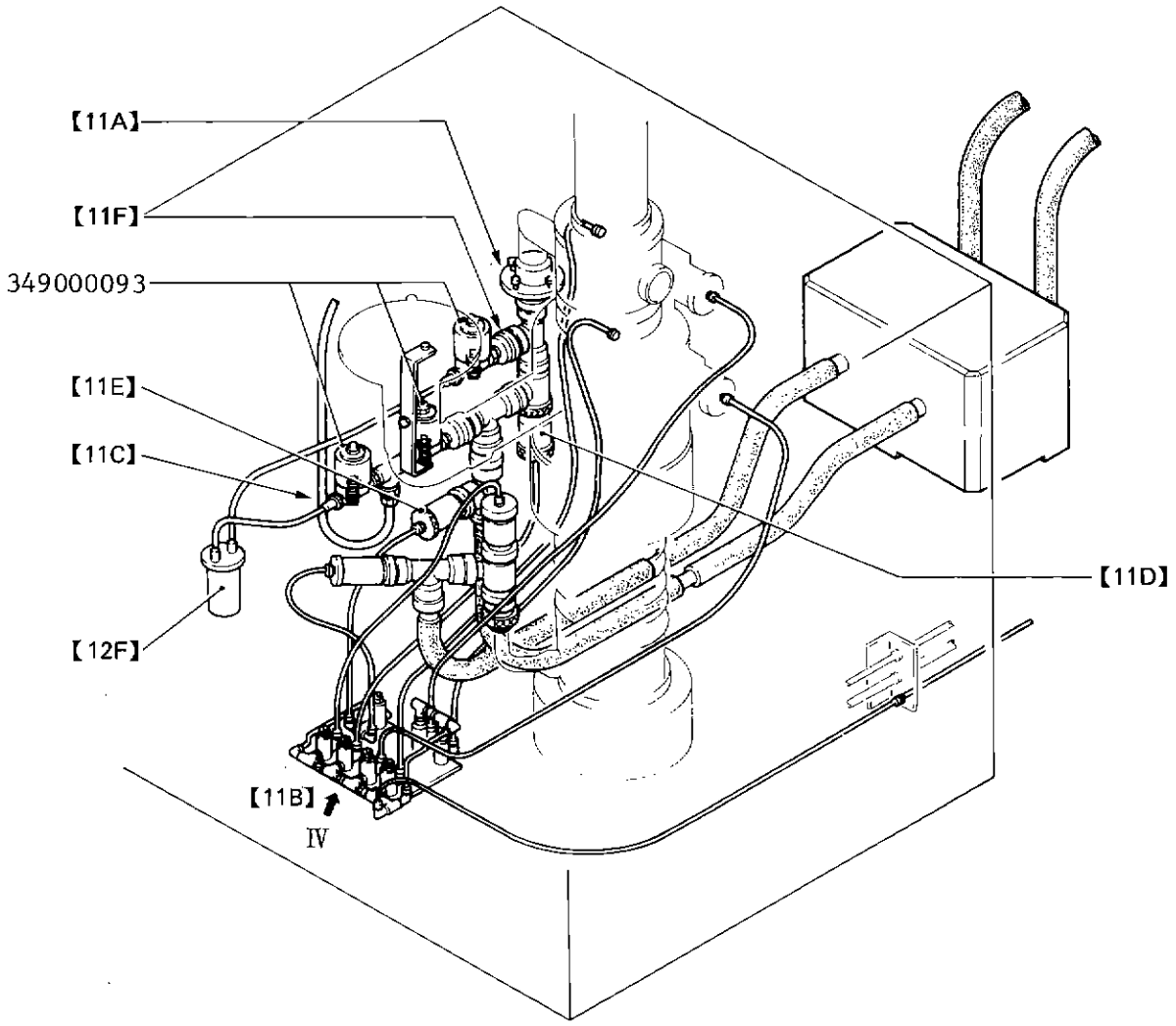


DETAIL Ⅲ

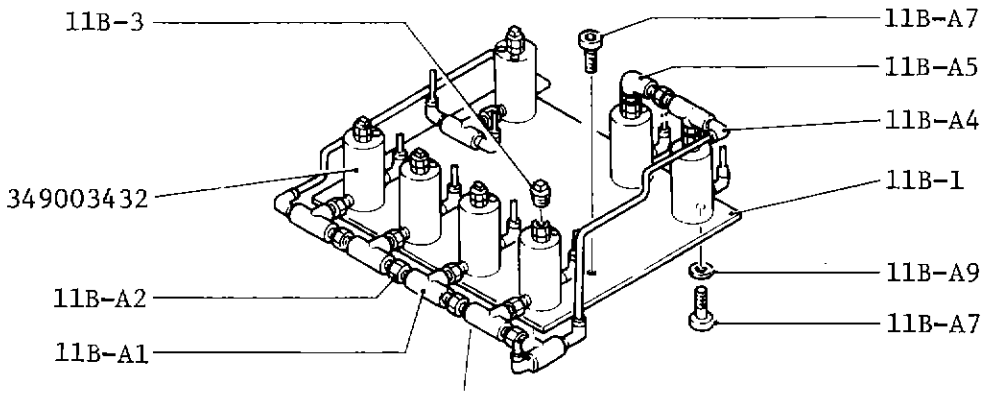
【10E】

MODEL	804000069	AG110133(03)	JSM-35C (M)	EP156085-
COMPO	804500631	AA247001(02)	COOL.WATER SYS.	800902

	SEQ	PART-NO.	DESCRIPTION		QTY
☞	3	800100352	FLANGE	AB470042-00 4	2
☞A	1	409001724	+PAN HEAD SCREW	5*12 BSW2 NIP3	4
☞A	2	403000459	WIRE HOSE-CLAMP	SYｶﾞﾀ 22ﾐﾘ (7/8")	4
☞A	3	403000491	WIRE HOSE-CLAMP	SMｶﾞﾀ 18ﾐﾘ	6
☞A	7	405000596	WTR.RUBBER HOSE	1/2" (12.7D*21.5D)ｸﾛ	
☞A	8	405000588	RUBBER HOSE	3/8"	
☞A	9	405000588	RUBBER HOSE	3/8"	
☞A	10	409005240	HEXSOCKET SCREW	ｸﾎﾞﾐ 4*10 SCM3	2
☞A	11	403001005	SOCKET	3/8" BSBM	2
☞A	12	403000858	HI-PRESS.NO2ZLE	3/8" 11ﾏﾙ ｵｽ BSBM	2
☞A	13	403000866	HI-PRESS.NO2ZLE	3/8"*14 ｵｽ BSBM	2



Valve system in main console



DETAIL Ⅳ

【11A】

MODEL	804000069	AG110133(03)	JSM-35C (M)	EP156085-
COMPO	804800103	AA142049(00)	PRE-EVAC PIPE	800902

	SEQ	PART-NO.	DESCRIPTION		QTY
	1	800100310	PIPE W/FLANGE	AB420307-01 4	1
	2	800100239	PIPE	AB410129-00 4	1
	3	800100221	PIPE	AB410128-00 4	2
	4	800100301	PIPE FITTING	AB420294-01 4	1
	5	800100484	RING	MB010070-00 4	1
	6	800100557	NUT	MB010099-00 4	1
	7	800100328	SUPPORT	AB420308-00 4	2
A	1	406000301	O-RING	JISB2401 P 26 4D	1
A	2	406000352	O-RING	JISB2401 P 30 4D	1
A	3	411001175	HEXSOCKET BOLT	6*15 SCM3	4
A	4	403008956	QUICK COUPLING	3/4" ﾀｲﾌﾟ135 BS	1
A	5	403008964	QUICK COUPLING	3/4" ﾀｲﾌﾟ125 BS	4
A	6	411001167	HEXSOCKET BOLT	6*12 SCM3	3
A	7	412000237	HEXAGONAL NUT	M 6 BSBM NIP3	1
A	8	412000334	PLAIN WASHER	M 6 BSP NIP3	4

【11B】

MODEL	804000069	AG110133(03)	JSM-35C (M)	EP156085-
COMPO	804500657	AA145043(01)	SOL.VALVE MOUNT	800902

	SEQ	PART-NO.	DESCRIPTION		QTY
☞	1	800104005	PLATE	AB450139-01 4	1
	2	800500407	WIRING LAYOUT	AB450140-01 3	1
☞	3	800103998	ADDITIONAL WORK	AB450046-09 4	6
	4	800104013	NAME PLATE	AB450158-00 4	1
☞A	1	403001072	CHASER	1/4" BC	7
☞A	2	403000921	SQUARE NIPPLE	1/4" BSBM	12
A	3	403000980	PLUG	1/4" BSBM	1
☞A	4	403000181	COUPLING	SLP-301 BSBM	13
☞A	5	403001064	ELBOW	1/4" BC	1
☞A	7	411001159	HEXSOCKET BOLT	6*10 SCM3	8
☞A	9	412003104	PLAIN WASHER(SM	M 6 BSP NIP3 (ﾃｲｺｳJIS)	6
☞		349003432	SOLENOID VALVE	ELECTRICAL PARTS	7

【11C】

MODEL	804000069	AG110133(03)	JSM-35C (M)	EP156085-
COMPO	804500649	AA142046(01)	EXCH.CHMBR EVAC	800902

	SEQ	PART-NO.	DESCRIPTION		QTY
	1	800100298	PIPE W/FLANGE	AB420289-00 4	1
	2	800100646	HOSE COUPLING	MB170177-00 4	1
	3	800100638	SUPPORT	MB170132-02 4	2
A	1	403000921	SQUARE NIPPLE	1/4" BSBM	3
A	2	353000701	TERMINAL(HARMON	ML-4662 U2P	2
A	3	411001159	HEXSOCKET BOLT	6*10 SCM3	2
A	4	409001473	+PAN HEAD SCREW	3*10 BSW2 NIP3	4
A	5	412000300	PLAIN WASHER	M 3 BSP NIP3	4
A	6	403001072	CHASER	1/4" BC	1
☞		349000093	SOLENOID VALVE	ELECTRICAL PARTS	2

【11D】

MODEL	804000069	AG110133(03)	JSM-35C (M)	EP156085-
COMPO	804500011	AA145035(02)	1"PNEU.L-VALVE	800902

	SEQ	PART-NO.	DESCRIPTION		QTY
	1	800100450	SHAFT	MB010063-03 4	1
	2	800100468	VALVE	MB010064-02 4	1
	3	800100476	SPACER	MB010068-00 4	1
	4	800100492	NUT	MB010072-01 4	1
	5	800100565	CYLINDER	MB010146-02 4	1
	6	800100573	NUT	MB010147-01 4	1
	7	800100581	PISTON	MB010148-01 4	1
	8	800100590	SPRING,PRESSURE	MB010149-01 4	1
	9	800100603	RING	MB010150-00 4	1
	10	800100336	VALVE,BODY	AB450131-02 4	1
A	1	406000093	O-RING	JISB2401 P 8 4D	1
A	2	406000123	O-RING	JISB2401 P 10A 4D	2
A	3	406000255	O-RING	JISB2401 P 22A 4D	1
A	4	406000352	O-RING	JISB2401 P 30 4D	1
A	5	406000387	O-RING	JISB2401 P 32 4D	1
A	8	411004182	HEXSOCKET BOLT	5*6 SCM3	1
A	9	412003619	PLAIN WASHER(SM	M 5 SS41 ZNP3C (ｷｲﾛJIS)	1
A	11	415002753	SPRING PIN	ﾅﾐｶﾞﾀA.W 3*18 SUS420J2	1

【11E】

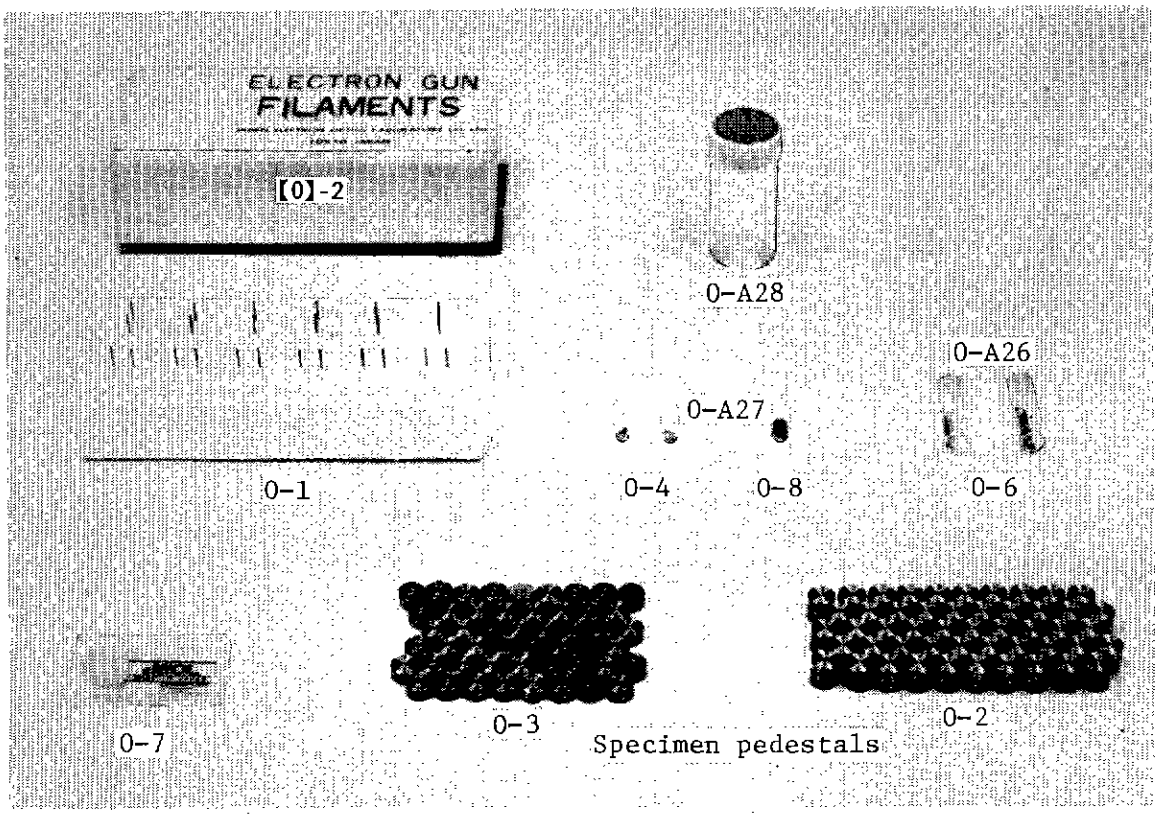
MODEL	804000069	AG110133(03)	JSM-35C (M)	EP156085-
COMPO	804500029	AA145036(02)	PNEU.VENT VALVE	800902

	SEQ	PART-NO.	DESCRIPTION			QTY
	1	800100344	PIPE FITTING	AB450132-00 4		1
	2	800100506	PIPE	MB010077-00 4		1
	3	800100514	PISTON	MB010078-00 4		1
	4	800100522	CAP	MB010079-00 4		1
	5	800100531	COVER	MB010080-00 4		1
	6	800100549	SPRING,PRESSURE	MB010081-01 4		1
A	1	406000069	O-RING	JISB2401 P 5	4D	1
A	2	406000158	O-RING	JISB2401 P 12	4D	2
A	3	424005573	FILTER PAPER	45*200		1
A	4	131102681	POLYURETHANE FOAM	5T*48*7		1

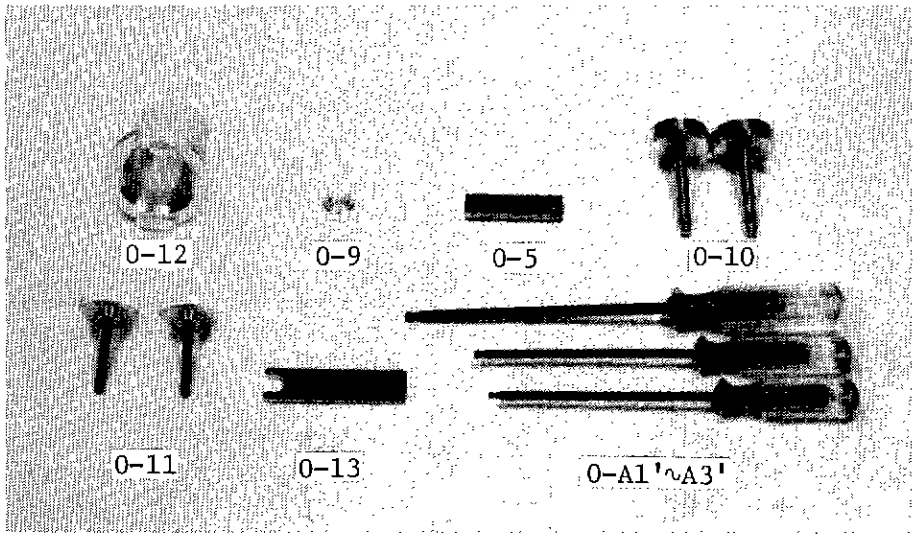
【11F】

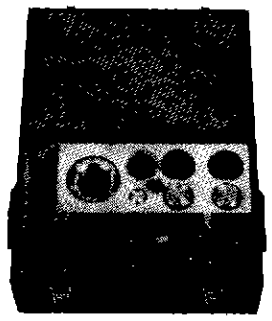
MODEL	804000069	AG110133(03)	JSM-35C (M)	EP156085-
COMPO	804500037	AA145037(00)	VENT VALVE	800902

	SEQ	PART-NO.	DESCRIPTION			QTY
	1	800100298	PIPE W/FLANGE	AB420289-00 4		1
	2	800100646	HOSE COUPLING	MB170177-00 4		1
	3	800100638	SUPPORT	MB170132-02 4		1
A	1	403000921	SQUARE NIPPLE	1/4" BSBM		1
A	2	353000701	TERMINAL(HARMON	ML-4662 U2P		1
A	3	411001159	HEXSOCKET BOLT	6*10 SCM3		1
A	4	409001473	+PAN HEAD SCREW	3*10 BSW2 NIP3		2
A	5	412002566	PLAIN WASHER(SM	M 3 BSP NIP3	(ヰ1ヵJIS)	2
☞		349000093	SOLENOID VALVE	ELECTRICAL PART		1



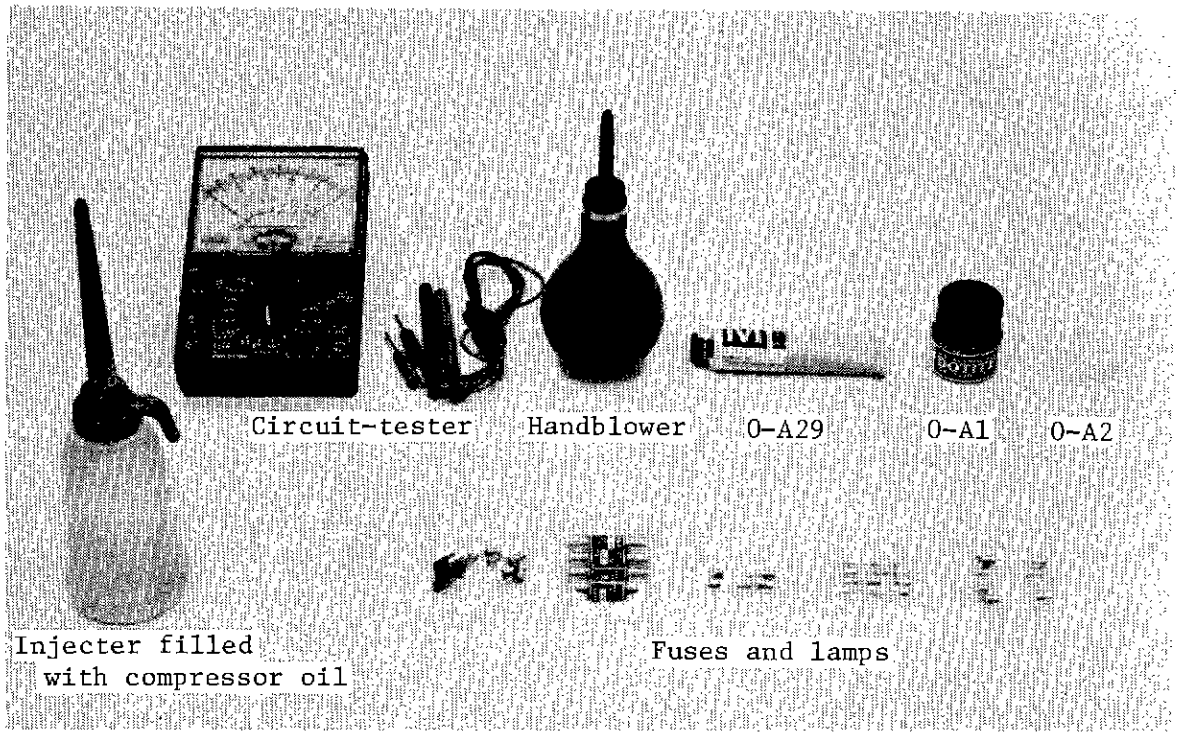
Accessories (1)



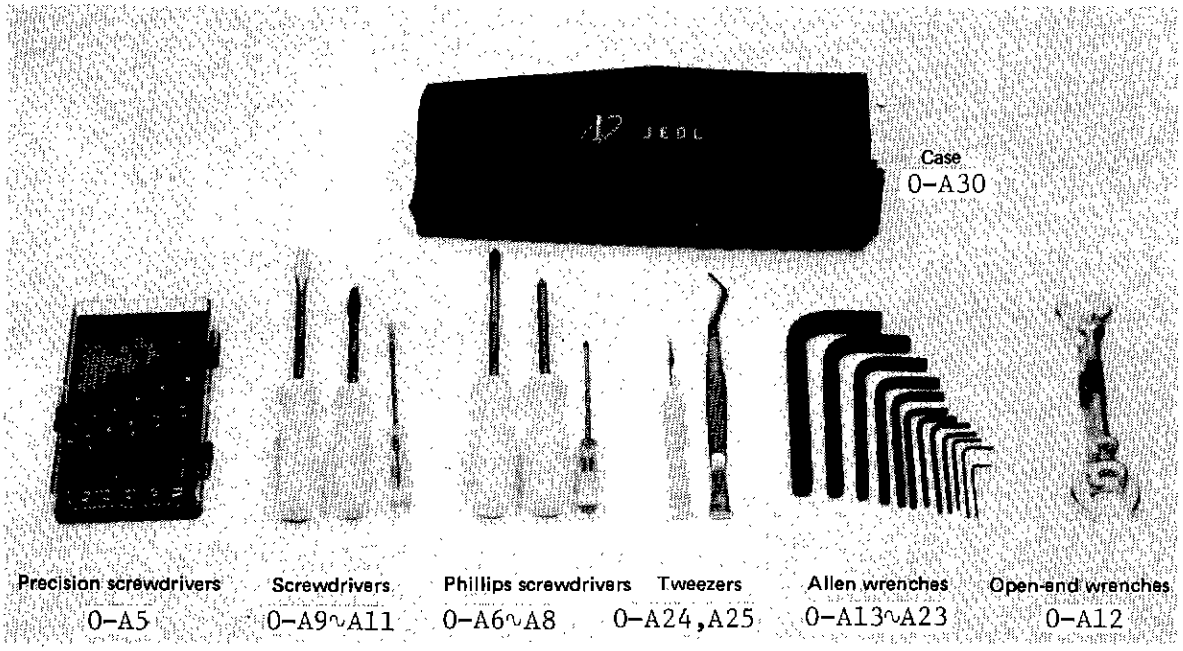


0-A4
Tool box

Accessories (2)



Accessories (3)



Accessories (4)

【0】-1

MODEL 804000069 AG110133(03) JSM-35C (M) EP156085-

COMPO 804900329 (00) ACCESSORIES 800902

SEQ	PART-NO.	DESCRIPTION		QTY
☞ 1	800500199	FILAMENT	AB120058-00 3	24
☞ 2	600006875	BLOCK	AB530004-00 4	50
☞ 3	600006735	BLOCK	AB530005-00 4	50
☞ 4	418000450	APERTURE	AB130151-03 4	2
☞ 5	800105605	JIG	UB391032-00 4	1
☞ 6	418001103	APERTURE	AB720027-02 4	2
☞ 7	600009173	LIGHT GUIDE	AB260108-00 4	2
☞ 8	800100611	APERTURE	MB102221-03 4	2
☞ 9	800105575	JIG	UB391029-01 4	1
☞ 10	800105583	TOOL	UB391030-00 4	2
☞ 11	800105591	TOOL	UB391031-01 4	2
☞ 12	800104021	TOOL	AB510012-02 4	1
☞ 13	800104030	TOOL	AB530006-00 4	1
☞A 1	423002988	CONDUCTIV.PAINT	D550 20Gｲﾘ	1
☞A 2	423003003	PIKAL	ｺﾀｲ (ｼｮｳ)	1
A 3	424005531	SYRINGE	10ML <ｻｲｹﾂｼｮｳｺﾝﾃﾅｾｯﾄ>	1
☞A 4	420018671	TOOL BOX	T360 <TOYO>	1
☞A 5	420006494	SCREW DRIVER	NO.75 (6 ﾎﾟﾝｸﾞﾐ)	1
☞A 6	420006079	TSCREW DRIVER	2M/M ﾌﾟﾗｽﾁｯｸ I (ｷｮｸｼｮｳ)	1
☞A 7	420006087	TSCREW DRIVER	3M/M ﾌﾟﾗｽﾁｯｸ I (NO.1)	1
☞A 8	420006109	TSCREW DRIVER	6M/M ﾌﾟﾗｽﾁｯｸ I (NO.2)	1
☞A 9	420006133	-SCREW DRIVER	2 M/M ﾌﾟﾗｽﾁｯｸ I (ｷｮｸｼｮｳ)	1
☞A 10	420006141	-SCREW DRIVER	3 M/M ﾌﾟﾗｽﾁｯｸ I	1
☞A 11	420006168	-SCREW DRIVER	6 M/M ﾌﾟﾗｽﾁｯｸ I (NO.2)	1
☞A 12	420003053	SPANNER(DBL-END	(6*8) (9*10) (14*17)	1
☞A 13	420003801	HEXSOCKETSPANNR	1.4 M/M (SD)	1
☞A 14	420003819	HEXSOCKETSPANNR	1.5 M/M	1
☞A 15	420003843	HEXSOCKETSPANNR	2.0 M/M	1
☞A 16	420003860	HEXSOCKETSPANNR	2.4 M/M	1
☞A 17	420003878	HEXSOCKETSPANNR	2.5 M/M	1
☞A 18	420003886	HEXSOCKETSPANNR	3 M/M	1
☞A 19	420003894	HEXSOCKETSPANNR	4 M/M	1
☞A 20	420003916	HEXSOCKETSPANNR	5 M/M	1
☞A 21	420003932	HEXSOCKETSPANNR	6 M/M	1
☞A 22	420003941	HEXSOCKETSPANNR	8 M/M	1
☞A 23	420003789	HEXSOCKETSPANNR	10 M/M	1
☞A 24	420009337	TWEEZERS	ｽﾃﾝﾚｽ ﾄｹｲﾖｳ GG 120	1
☞A 25	420009311	TWEEZERS	ｽﾃﾝﾚｽ ｼｶﾖｳ KK 160	1
☞A 26	424002922	STYROL BOTTLE	NO.101	2
☞A 27	424005158	GELLATIN CAPSUL	NO.00 100ｹｲﾘ	
☞A 28	424005077	PLASTIC CASE	120CC	1
☞A 29	423004620	GREASE(A)	ｱﾋﾟｴｿﾞﾝG L(25G)	
☞A 30	420011838	TOOL BAG		1

[0]-4

MODEL	804000069	AG110133(03)	JSM-35C (M)	EP156085-
COMPO	804900353	UA395102(00)	SPECIAL TOOLS	800902

SEQ	PART-NO.	DESCRIPTION		QTY
☞A 1'	420016422	BALL DRIVER	M 4	1
☞A 2'	420016431	BALL DRIVER	M 5	1
☞A 3'	420016449	BALL DRIVER	M 6	1

[0]-2

MODEL	804000069	AG110133(03)	JSM-35C (M)	EP156085-
COMPO	804300143	MA99-ANO-4(02)	FILAMENT BOX	800902

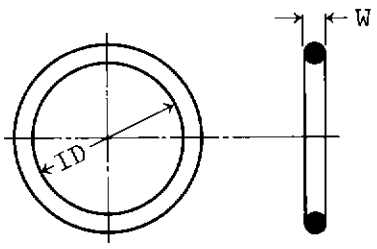
SEQ	PART-NO.	DESCRIPTION		QTY
1	800100433	CAP	MA99-022-4-00 4	1
2	800500113	COVER	MA99-023-3-01 3	1
3	800100441	CASE	MA99-091-4-02 4	1

[0]-3

MODEL	804000069	AG110133(03)	JSM-35C (M)	EP156085-
COMPO	804300151	UA393113(02)	STORE CASE	800902

SEQ	PART-NO.	DESCRIPTION		QTY
1	800100883	CASE	UB391117-00 4	1
2	800100891	CAP	UB391118-00 4	1
3	800100425	NAME PLATE	AD120806-00 4	1
4	800100034	DAMPER	AB100013-00 4	1

O-ring list



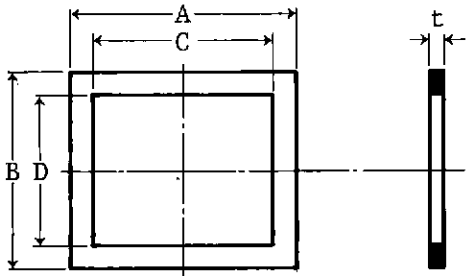
JIS B 2401 (Material: Viton)

NUMBER	PART-NO.	SIZE (mm)		QTY
		W	ID	
P 3	406000042	1.9±0.07	2.8±0.12	1
P 4	406000051	"	3.8 "	6
P 5	406000069	"	4.8 "	4
P 6	406000077	"	5.8 "	1
P 8	406000093	"	7.8 "	9
P 9	406000107	"	8.8 "	3
P 10	406000115	"	9.8 "	7
P 10A	406000123	2.4±0.07	9.8 "	8
P 12	406000158	"	11.8 "	6
P 14	406000174	"	13.8 "	2
P 16	406000191	"	15.8 "	1
P 18	406000204	"	17.8 "	2
P 20	406000221	"	19.8±0.15	4
P 22	406000242	"	21.8 "	1
P 22A	406000255	3.5±0.1	21.7 "	2
P 25	406000280	"	24.7 "	1
P 26	406000301	"	25.7 "	3
P 30	406000352	"	29.7 "	12
P 31.5	406000379	"	31.2 "	2
P 32	406000387	"	31.7 "	3
P 38	406000433	"	37.7 "	1
P 42	406000476	"	41.7±0.25	1
P 44	406000484	"	43.7 "	1
P 50	406000549	"	49.7 "	2
P 60	406000611	5.7±0.15	59.6 "	2
P 67	406000654	"	66.6 "	1
P 85	406000701	"	84.6±0.4	1
P125	406000808	"	124.6 "	1
P145	406000859	"	144.6±0.6	1
G 25	406001278	3.1±0.1	24.4±0.15	6
G 45	406001332	"	44.4±0.25	2
G 50	406001341	"	49.4 "	1
G 55	406001359	"	54.4 "	4
G 60	406001367	"	59.4 "	1
G 65	406001375	"	64.4 "	7
G 70	406001383	"	69.4 "	2
G 75	406001391	"	74.4±0.4	1
G100	406001448	"	99.4 "	1
G110	406001464	"	109.4 "	8

NUMBER	PART-NO.	SIZE (mm)		QTY
		W	ID	
G120	406001481	3.1±0.1	119.4±0.4	2
G185	406001618	5.6±0.15	184.3±0.8	1

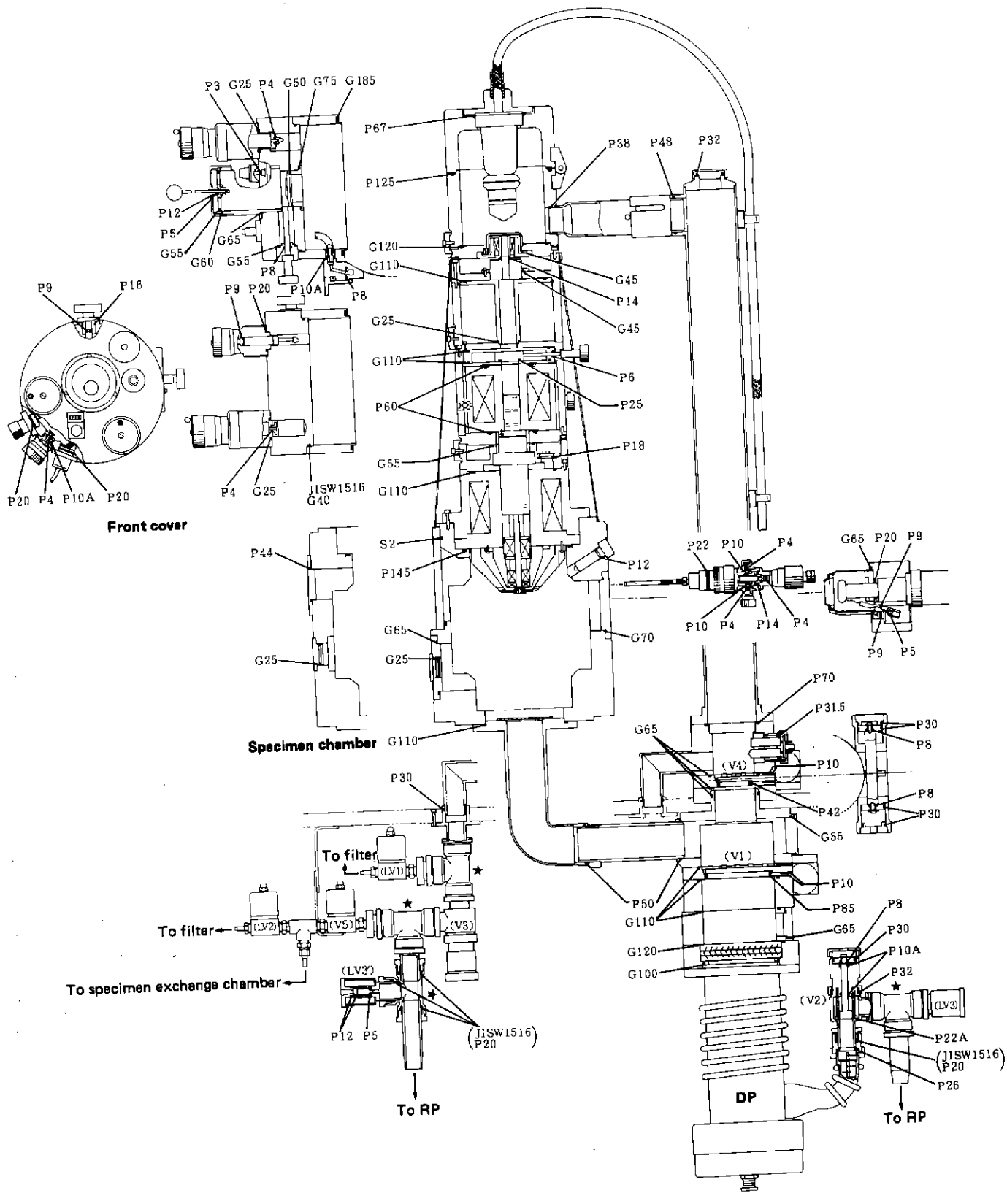
JIS W 1516 (Material: Viton)

NUMBER	PART-NO.	SIZE (mm)		QTY
		W	ID	
P 20	406002223	3.53±0.10	26.57±0.15	13
G 40	406003122	3.53±0.10	177.39±0.58	1



Square gasket

NUMBER	PART-NO.	SIZE (mm)					QTY
		A	B	C	D	t	
S2	600000095	125	93	115	83	$4.3^{0}_{-0.1}$	2


P3 G25 P4 G50 G75 G185
P12
P5
G55
G60
G65
G55
P8
P10A
P6
P9 P20
P4 G25
JISW1516
G40
P9 P16
P20 P4 P10A P20
Front cover
P67
P125
P38 P48 P32
G120
G110
G45
P14
G45
G25
G110
P6
P60
P25
G55
P18
G110
S2
P145
P12
P44
G25
G65
G25
G70
Specimen chamber
G110
P22 P10 P4
P10 P4 P14 P4
G65 P20 P9
P9 P5
P70
P31.5
P30
P8
G65
(V4)
P10
P8
P30
P42
G55
P30
To filter
(LV1)
(V1)
P10
P50
G110
P85
P8
G65
P30
P10A
P32
G120
G100
(V2)
(LV3)
P22A
(JISW1516)
P20
P26
To filter
(LV2)
(V5)
(V3)
To specimen exchange chamber
(LV3')
P12 P5
(JISW1516)
P20
To RP
DP
To RP

O-rings

2. SPECIFICATIONS

- Image mode: SEI (secondary electron image); AEI (absorbed electron image); BEI: TOPO and COMPO (backscattered electron image: topographic and composition images); CH1, CH2, CH3 (X-ray images); AUX (miscellaneous images).
- Video amplifier
  - Input impedance: 10 kΩ.
  - Gain: 1.
  - Bandwidth: DC to 70 kHz.
  - Output noise: Less than 10 mV.
- Pulse shaper
  - Input voltage: +5 V.
  - Output voltage: +5 V.
  - Output noise: Less than 10 mV.
- DC amplifier
  - Input voltage: 0 to 100 mV.
  - Input impedance: 10 kΩ.
  - Output voltage: 0 to 15 V.
  - Output noise: Less than 10 mV.
- Power requirements: DC +20 V, 4 mA; DC -20 V, 20 mA.
- Operating temperature: 0 to 50°C.
- Dimensions: 70 mm (W) × 300 mm (D) × 150 mm (H).

3. COMPOSITION

- Image selector unit 1
- Cables ..... 1 set

4. PANEL DESCRIPTION

- Buttons 1 and 2: Pushbutton switches for selecting the desired type of image. That is to say, 1 or 2 can select a secondary electron image (SEI), an absorbed electron image (AEI), a backscattered electron image (topographic image: TOPO or composition image: COMPO), an X-ray image (CH1, CH2 and CH3) or miscellaneous images such as transmitted electron, cathodoluminescence images, etc.
  1 or 2 also determines on which CRT the selected image is displayed.

- MIX switch: Switch for mixing two images optionally selected by buttons 1 and 2 respectively. In other words, by positioning the MIX switch at ON and depressing the SEI (1) and AEI (2) buttons for example, the respective video signals are mixed and the resultant SEI/AEI image is displayed on the CRT.

- PHA/RM.AUX switches 1 and 2: At PHA, an X-ray signal is fed into the CRT from the pulse height analyzer via the pulse shaper and DC amplifier, and the resultant output is displayed as an elemental distribution map.
  At RM.AUX, an X-ray signal is fed into the CRT from the ratemeter via the DC amplifier, and the resultant output is displayed as a line profile corresponding to the signal intensity.

- BRT knobs 1 and 2: Knobs for adjusting the brightness of the X-ray image and the level of the line profile.

5. INSTALLATION

1. Turn off the supplementary power supply (35-SPS1: attachment) switch and push up the UNATTENDED OPERATION switch.
2. Install the image selector unit in the supplementary cabinet (35-SCB·S: attachment).
   Note: Necessary power for the image selector unit is supplied by the supplementary power supply housed in the cabinet.
3. Connect up the microscope, the image selector unit and the extra CRT (if used) with the cables as provided by referring to the JSM-35C and 35-IMS circuit diagrams.
4. Turn on the 35-SPS1 switch and push down the UNATTENDED OPERATION switch.

6. OPERATION

6.1 Obtaining a secondary electron, absorbed electron, backscattered electron or miscellaneous image

1. Depress the SEI, AEI, TOPO, COMPO or CH3/AUX button as desired.
2. Adjust the image contrast, brightness, etc. by manipulating the contrast, brightness, etc. controls on the attachment corresponding to the image selected.

6.2 Obtaining an X-ray image

X-ray images show the elemental distribution in the analyzed area.

1. Obtain a secondary electron image (or absorbed electron image or backscattered electron image).
2. Bring the particular portion of the image to be examined to the screen center with the specimen stage X and Y controls.
3. Carry out qualitative analysis by operating the spectrometer/spectrometers (SDS, DDS, TDS), and the X-ray counting system/systems (SDX, DDX, TDX), and set the spectrometer on the peak of the desired element.
4. Position the PHA/RM·AUX (1 or 2) switch at PHA, then depress the CH1 or CH2 (1 or 2) button depending on the spectrometer in use.
5. Adjust the image brightness with the BRT1 (2) knob.
6. Set the vertical scanning (frame) speed with the SCAN GENERATOR unit scanning speed selection thumbwheel VERT switch and then photograph the X-ray image.
   Note: The image brightness (i.e., the picture element brightness) is adjusted with the BRT1 (2) knob. However, since the number of X-ray pulses necessary to activate one picture element is 1, the time taken to activate all the picture elements differs according to the X-ray counting rate. Accordingly, the actual exposure time is determined as follows. For example, if one picture element measures 0.2 mm × 0.2 mm (0.04 m^2), the total number of picture elements in the case of a 90 mm × 120 mm CRT screen would be 270,000.
   Now, if we assume the X-ray counting rate to be 1,000 cps, the

time (t) necessary to expose all the picture elements can be expressed as follows.

$$t = \frac{270,000}{1,000} = 270 \text{ sec.}$$

Accordingly, if the vertical scanning speed is 250 sec/frame, a single frame exposure will suffice; if the vertical scanning speed is say 50 sec/frame, however, a five frame multi-exposure will be necessary.

6.3 Obtaining a X-ray line profile

X-ray line profiles show the distribution of selected element along a line within the image.

1. Carry out Steps 1 to 3 in Sect. 6.2.
2. Position the PHA/RM·AUX (1 or 2) switch at RM·AUX and then depress the CH1 or CH2 (1 or 2) button depending on the spectrometer in use.
3. Set the SCAN GENERATOR unit scanning mode selection switch at - (line scanning).

   Notes: 1. The line scanning speed (msec/line) accords with the frame scanning horizontal scanning speed.

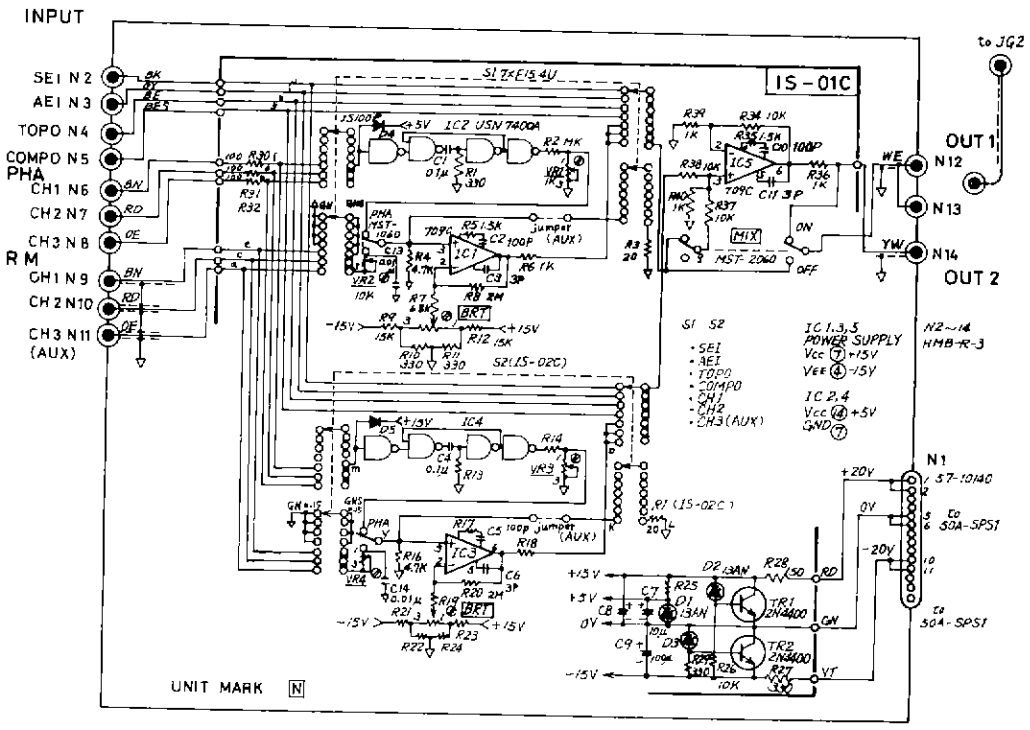
   2. The probe scanning position on the specimen corresponds to the center line of the displayed image. To obtain a partial X-ray line profile within the image, first position the SCAN GENERATOR unit SELECTED AREA switch downwards and then position the modulation mode selection switch downwards (brightness modulation setting). By so doing, a brightness modulated scanning line (analysis line) is displayed on the CRT. Now by changing over the scanning mode selection switch, the position of the scanning line can be ascertained by utilizing the CRT afterglow. The scanning line (i.e., the position of the analysis line) can be moved up or down to the desired position on the image by manipulating the POSITION Y knob. Also, by leaving the SELECTED AREA switch positioned downwards and by positioning the modulation mode selection switch upwards (amplitude modulation setting), a line profile along the analysis line can be obtained. Further, the line profile width and the horizontal position of the line profile can be selected with the WIDTH X and POSITION X knobs, respectively.

4. Adjust the X-ray line profile (waveform) amplitude and level with the ratemeter COUNTS/SEC knob and the image selector unit BRT 1 (2) knob, respectively.

   Note: By depressing the SCAN GENERATOR unit PHOTO button, the line profile can be photographed at an exposure corresponding to the setting of the scanning speed selection (for photography) VERT (vertical) thumbwheel switch.

6.4 Obtaining a mixed image

1. Select two buttons (one from each row of buttons on the image selector unit panel) according to the two types of image it is desired to mix and depress them.
2. Position the MIX switch at ON.


INPUT
SEI N2
AEI N3
TOPO N4
COMPO N5
PHA
CH1 N6
CH2 N7
CH3 N8
R M
CH1 N9
CH2 N10
CH3 N11
(AUX)
IS-01C
to JG2
OUT 1
N12
N13
N14
OUT 2
WE
YW
MIX
ON
OFF
MSF 2060
S1 S2
· SEI
· AEI
· TOPO
· COMPO
· CH1
· CH2
· CH3(AUX)
IC 1,3,5
POWER SUPPLY
Vcc ⑦ +15V
VEE ④ -15V
IC 2,4
Vcc ⑭ +5V
GND ⑦
N2~14
HMB-R-3
N1
+20V
0V
-20V
to 50A-SPS1
to 50A-SPS1
UNIT MARK N

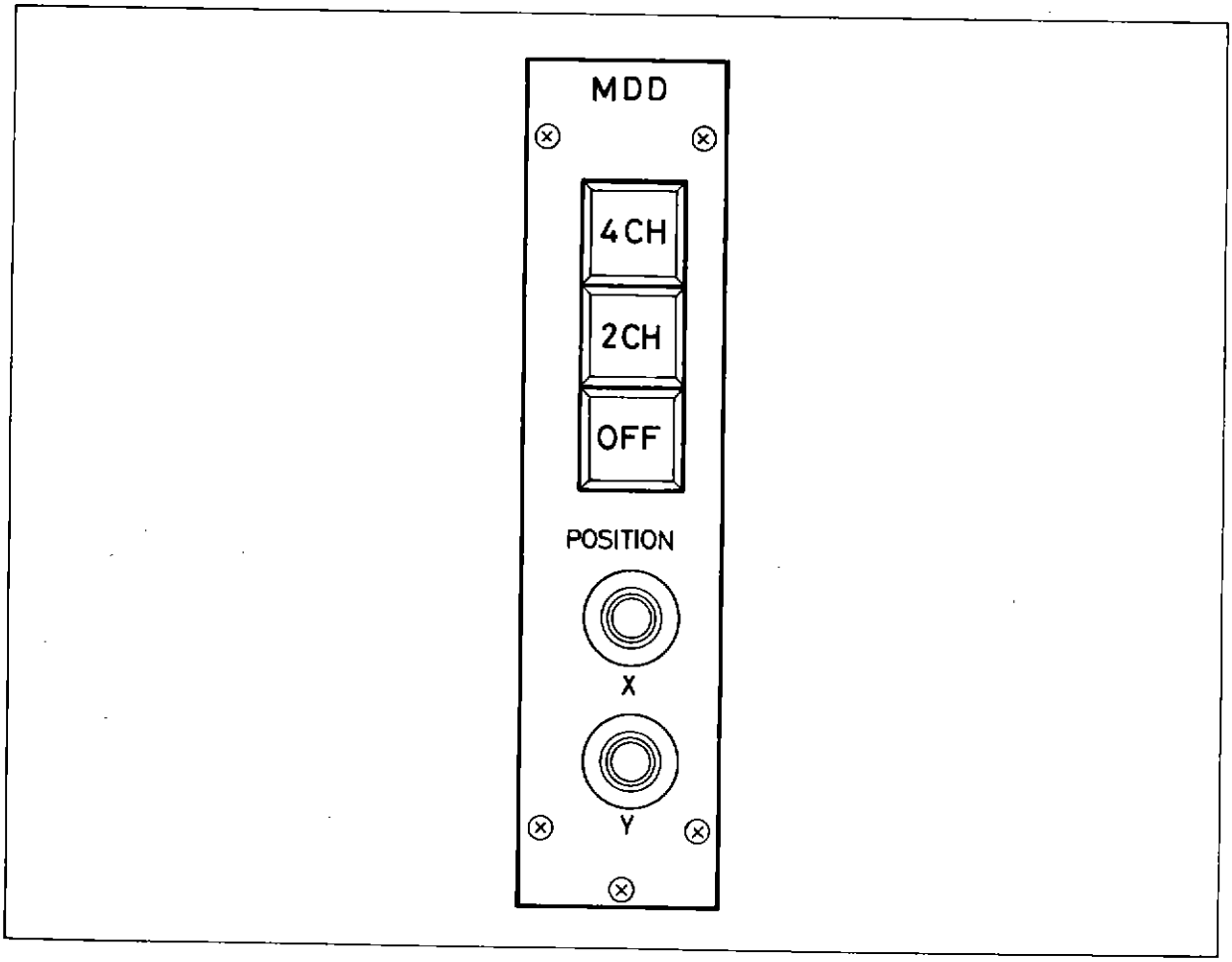
INSTRUCTIONS

35-MDD

MULTI DISPLAY DEVICE

No. IEP35C-MDD

(EP532037)



1. GENERAL

By using this device in conjunction with the JSM-35CF Scanning Microscope, two or four different images can be simultaneously displayed on one CRT, thus making it possible to make a convenient comparative study of the specimen under examination.

2. SPECIFICATIONS

- Display modes
  - 4CH: 4 types of image are simultaneously displayed
  - 2CH: 2 types of image are simultaneously displayed
  - OFF: 1 image is displayed
- Inter-image spacing: Variable in both X and Y directions
- Video input channels: 4, ±10 Vmax (input impedance: 10 kΩ).
- Video output channels: 1, ±10 Vmax (output impedance: 1 Ω or less).
- Bandwidth: 0 to 100 kHz.
- Power requirements: +5 V, 40 mA; ±12 V, 50 mA.
- Operating temperature: 0 to 50°C.
- Dimensions: 35 mm (W) × 300 mm (D) × 150 mm (H).

3. COMPOSITION

- MDD unit 1
- Cables 4

4. PANEL CONTROLS

- 4CH, 2CH, OFF button switch
  Used for selecting the display mode. By depressing the 4CH button, four different images are displayed on the CRT screen. In this case, the space between the left and right images is varied with the POSITION X knob and the space between the upper and lower images is varied with the POSITION Y knob. By depressing the 2CH button, two different images are displayed on the CRT screen. In this case, the space between the two images (left and right) is varied by the POSITION X knob. By depressing the OFF button, a full frame image is displayed on the CRT screen; in which case, the POSITION X and Y knobs are inoperative.
- POSITION X and Y knobs
  Used for varying the space between the displayed images. The X knob is used for varying the space between the left and right side images and the Y knob is used for varying the space between the upper and lower images.

5. INSTALLATION

1. Disengage the supplementary power supply (35-SPS1: attachment) power switch.
2. Install the MDD unit in the supplementary cabinet (35-SCB·S: attachment).
   Note: The power for the MDD unit is provided by the supplementary power supply installed in the cabinet.
3. Connect up between the MDD unit and the JSM-35CFScanning Microscope with the cables as provided by referring to the respective wiring diagrams.
   Note: Under normal circumstances, one or two image selectors (35-IMS: attachments) are necessary when using the 2CH or 4CH mode respectively. However, if this attachment is unavailable, feed in the video outputs directly by connecting connectors MD3 and MD4 or MD3, MD4, MD5 and MD6 (depending on the number of image modes to be displayed) to the MDD unit.
4. Engage the supplementary power supply power switch.

6. OPERATION

When the MDD is used, it is only possible to display the data in the SLOW 1, SLOW 2 and PHOTO speed modes. When displaying the data, the two pictures must be the same size and must cover the entire screen without overlapping. If the pictures overlap or if there is a clearance between the pictures, the data will be partially illegible. Furthermore, in the case of 4 channel display, vertical overscanning will cause the data to be shifted below the CRT screen. If data display is not needed, set the CHARACT switch on the indicator panel to OFF.

1. Carry out steps a and b below after first depressing the MDD unit OFF button.
   a. Position the SCAN GENERATOR unit SELECTED AREA switch for selected area scanning (i.e., down).
   b. Set the POSITION X and Y knobs (SCAN GENERATOR unit) at their midway positions and reduce the picture frame to 1/4 (1/2 the height and width of the full screen size) with the WIDTH X and Y knobs in the 4CH mode or 1/2 (1/2 the width) in the 2CH mode.
2. To obtain the 2CH display mode, depress the 2CH button and carry out steps a and b below.
   Note: Two pictures should now appear on the left and right sides of the screen.
   a. Select two buttons (one from each row of buttons 1 and 2 on the IMAGE SELECTOR (1) unit panel) according to the two types of image it is desired to display and depress them.
      Note: The two displayed images correspond to the video inputs fed through connectors MD3 and MD4 as shown in the attached circuit diagram.
   b. Position the images, if necessary, with the MDD unit POSITION X knob.
      Note: The number of scanning lines of each picture is half or less the number in the case when the OFF button (full frame picture) is depressed.
3. To obtain the 4CH display mode, carry out steps a and b below after first depressing the 4CH button.

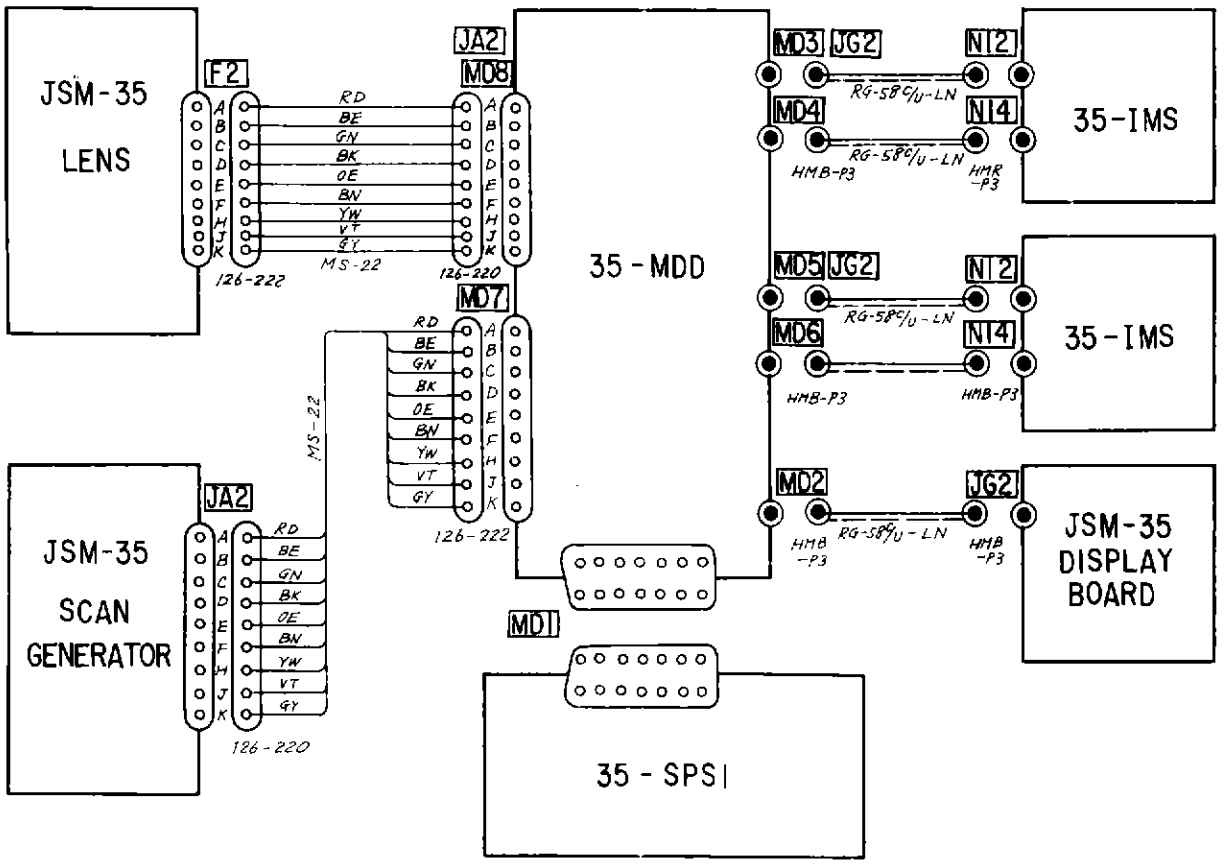
Note: Four 1/4 size pictures should now appear in the four quarters of the CRT screen.

a. Select four buttons (one from each row of buttons 1 and 2 on IMAGE SELECTORS (1 and 2) unit panels respectively) according to the four types of image it is desired to display and depress them.

   Note: Two of the four displayed images correspond to the video inputs fed through connectors MD3 and MD4 (IMAGE SELECTOR (1)) and the other two images correspond to the video inputs fed through connectors MD5 and MD6 (IMAGE SELECTOR (2)).

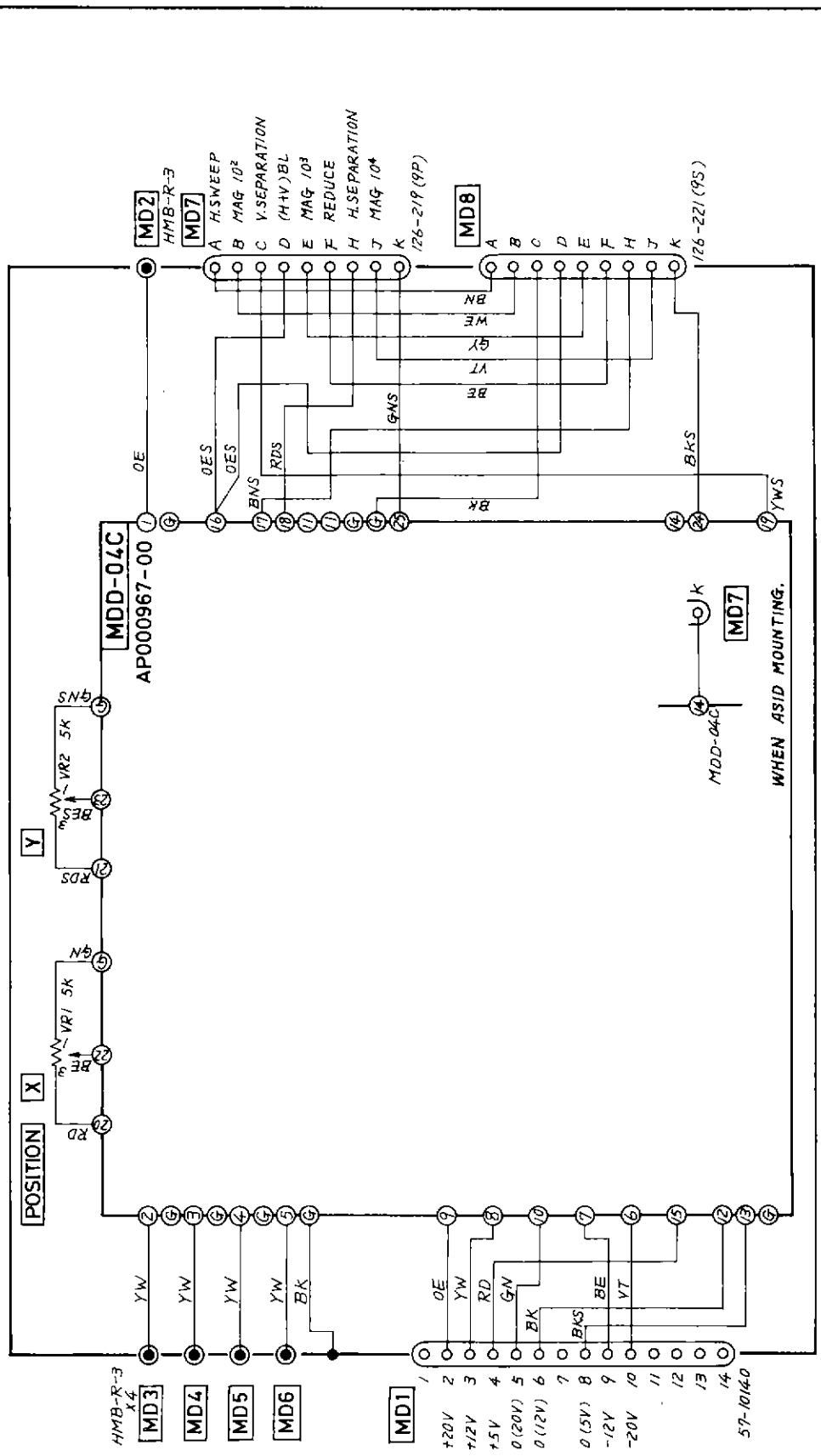
b. Position the upper and lower images, if necessary, with the MDD unit POSITION Y knob.

   Note: The number of scanning lines of each picture is a quarter or less the number in the case when the OFF button (full frame picture) is depressed.



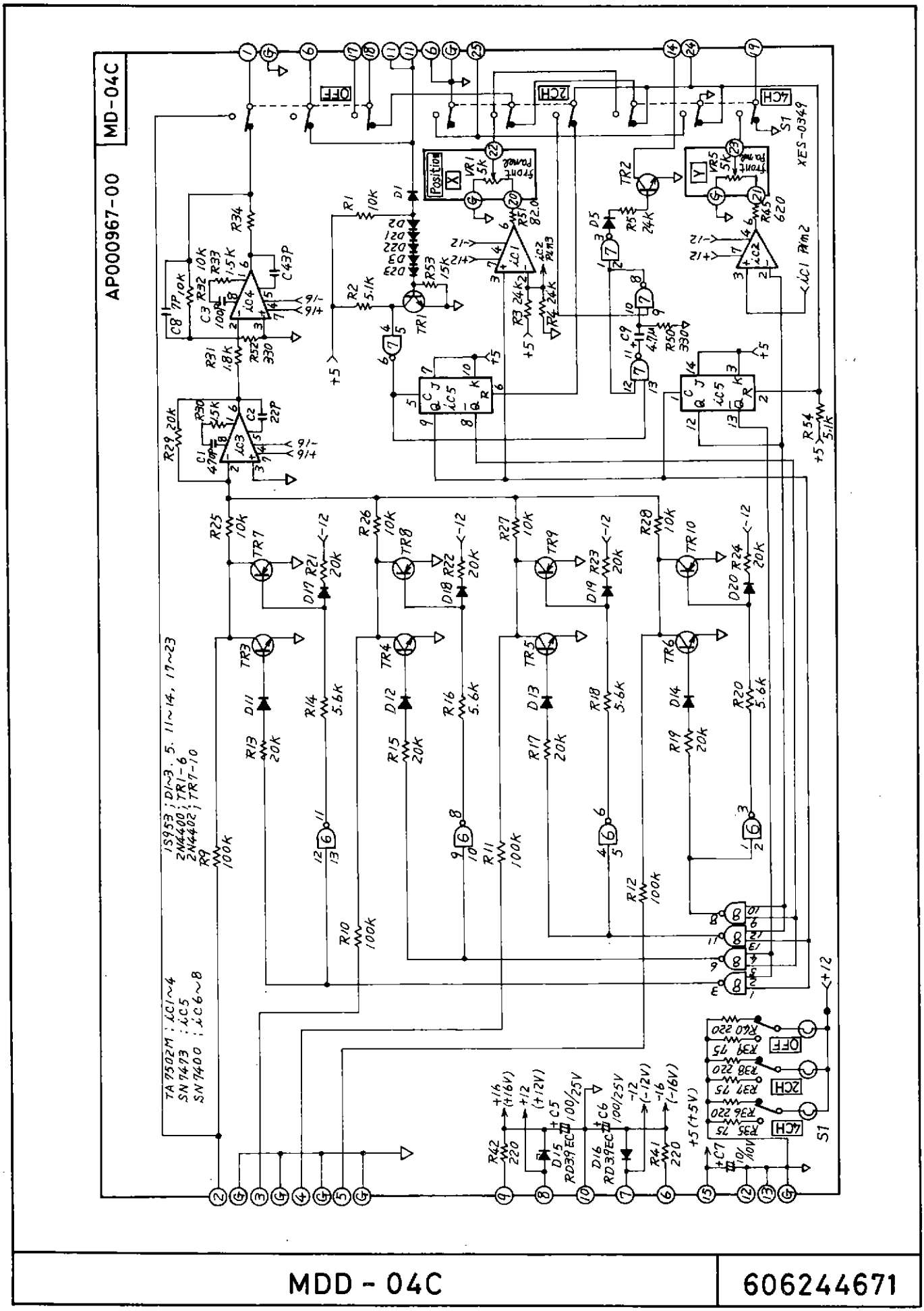
INTERCONNECTION DIAGRAM

606004076



25/35 - MDD CIRCUIT

606244662


MD-04C
AP000967-00
OFF
2CH
4CH
S1
XES-0349
Position
X
Y
VR1 5K
VR5 5K
TR1
TR2
IC1
IC2
IC3
IC4
IC5
IC6
TA7502M ; IC1~4
SN7473 ; IC5
SN7400 ; IC6~8
1S953 ; D1~3, 5, 11~14, 17~23
2N4400 ; TR1-6
2N4402 ; TR7-10
MDD - 04C
606244671

INSTRUCTIONS

50A-MRH

MAMIYA 6 x 7 ROLL FILM HOLDER

No. IEP 35C-MRH
(EP528101)

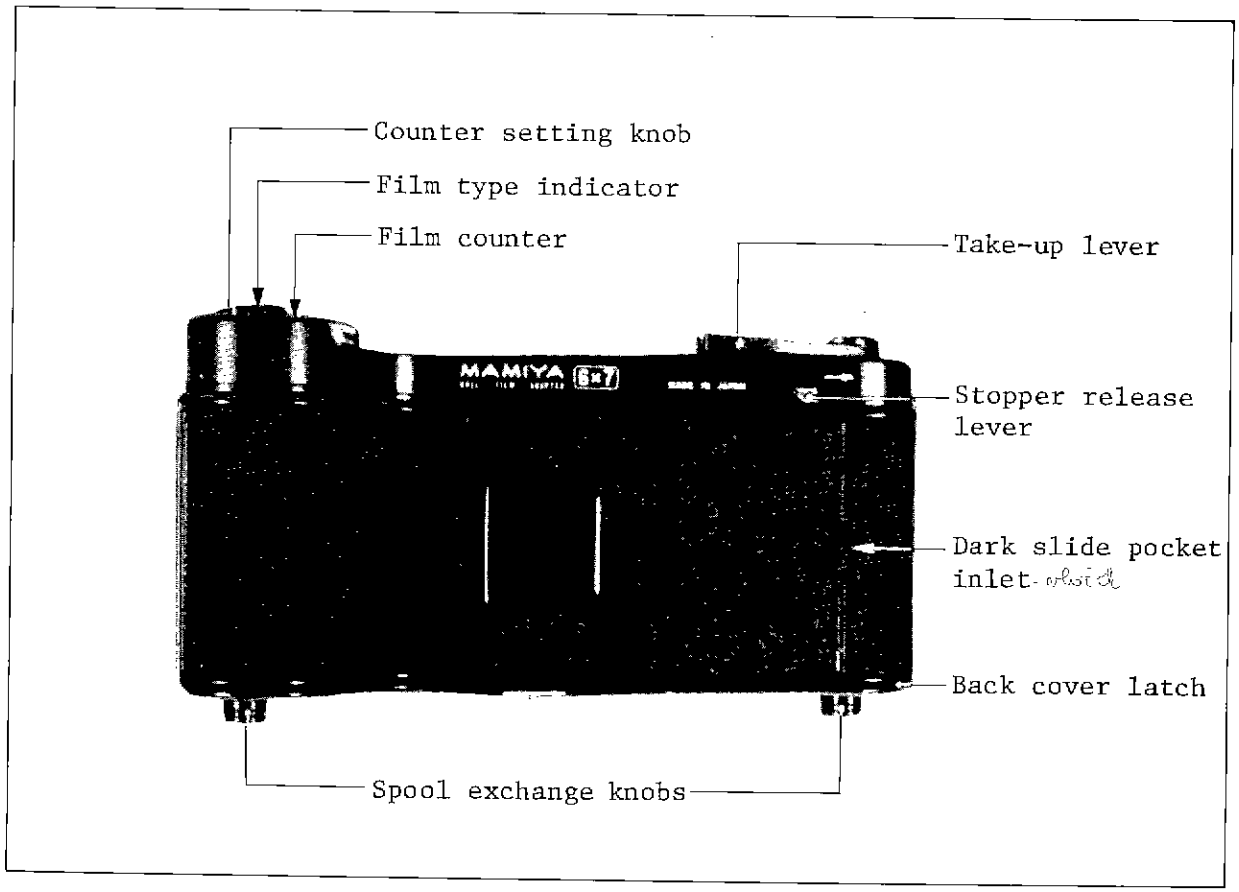


Fig. 1 Roll film holder

1. GENERAL

The MAMIYA 6 × 7 roll film holder is used for photographing the scanning image displayed on the JSM-35C Scanning Microscope recording system CRT.

2. SPECIFICATIONS

- Number of exposures: 10 (for 120 roll film).
  20 (for 220 roll film).
- Photographing ratio: 1 to 0.58.

3. COMPOSITION

- Roll film holder proper ..... 1 set.
- Focus screen .....1.

4. INSTALLATION

1. Attach the adapter to the camera.
2. Attach the focus screen to the adapter, and set the lens opening to f/5.6 with the f-number adjust knob.
3. Obtain a spot image at the center of the 5" CRT screen and focus the image with the focusing knob.
4. Detach the focus screen and attach the film holder.

5. FILM LOADING

1. Set the film type indicator to 120 or 200 (depending on the type of film used) with the counter setting knob (automatic stop mechanism should be set).
2. Insert the dark slide, and open the back cover by pulling out the latch (see Fig. 2).

   Notes: 1. If exposed film is left in the film holder, roll up the film and leader paper with the take-up lever until lever-turning becomes loose.

   2. When not photographing or when the film holder being loaded with film is to be detached from the camera, be sure to insert the dark slide into the film holder.
3. Lock the spool exchange knobs by pulling them out and turning them slightly.
4. Mount a loaded spool on the right side, the take-up spool on the left side, and secure the two spools with the spool exchange knobs.
5. Draw out the leader paper and insert it in the take-up spool.

   Caution: Be careful not to draw out the leader paper more than necessary.
6. Roll up the leader paper until the arrow on the leader paper aligns with the start mark on the film holder (see Fig. 3).
7. Confirm that the film pressure plate on the back cover is set properly for the type of film used (120 or 220).

   Note: If the film pressure plate is not properly set, detach it by pushing it a little to the left, turn it over and replace it.
8. Close the back cover and secure it with the back cover latch (the film counter now indicates S).
9. Set the film counter to 1 by turning the take-up lever until it stops, and draw out the dark slide (store the dark slide in the dark slide pocket)

   Note: The first frame of the film is now ready for exposure. Each time an exposure is completed, push the stopper release lever slightly to the right and advance the film with the take-up lever. After exposing the full number of frames (10 or 20 depending on the type of film used), turn the take-up lever until it feels loose (i.e., until the film and leader paper are completely rolled up), open the back cover and remove the film.

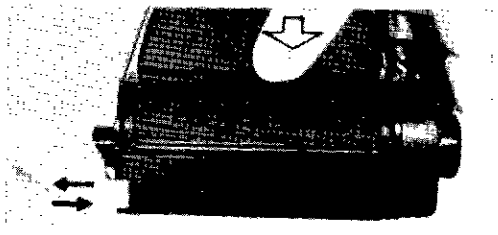


Fig. 2 Opening/closing back cover

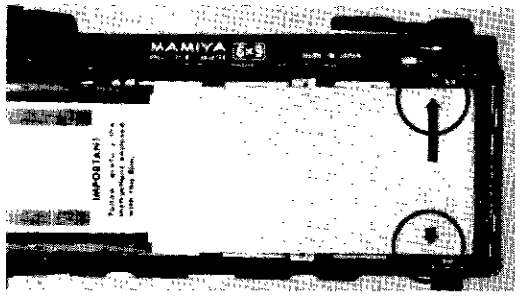


Fig. 3 Leader paper setting

INSTRUCTIONS

50A-PRH

POLAROID #545 FILM HOLDER

No. IEPSM-PRH
(EP599001)

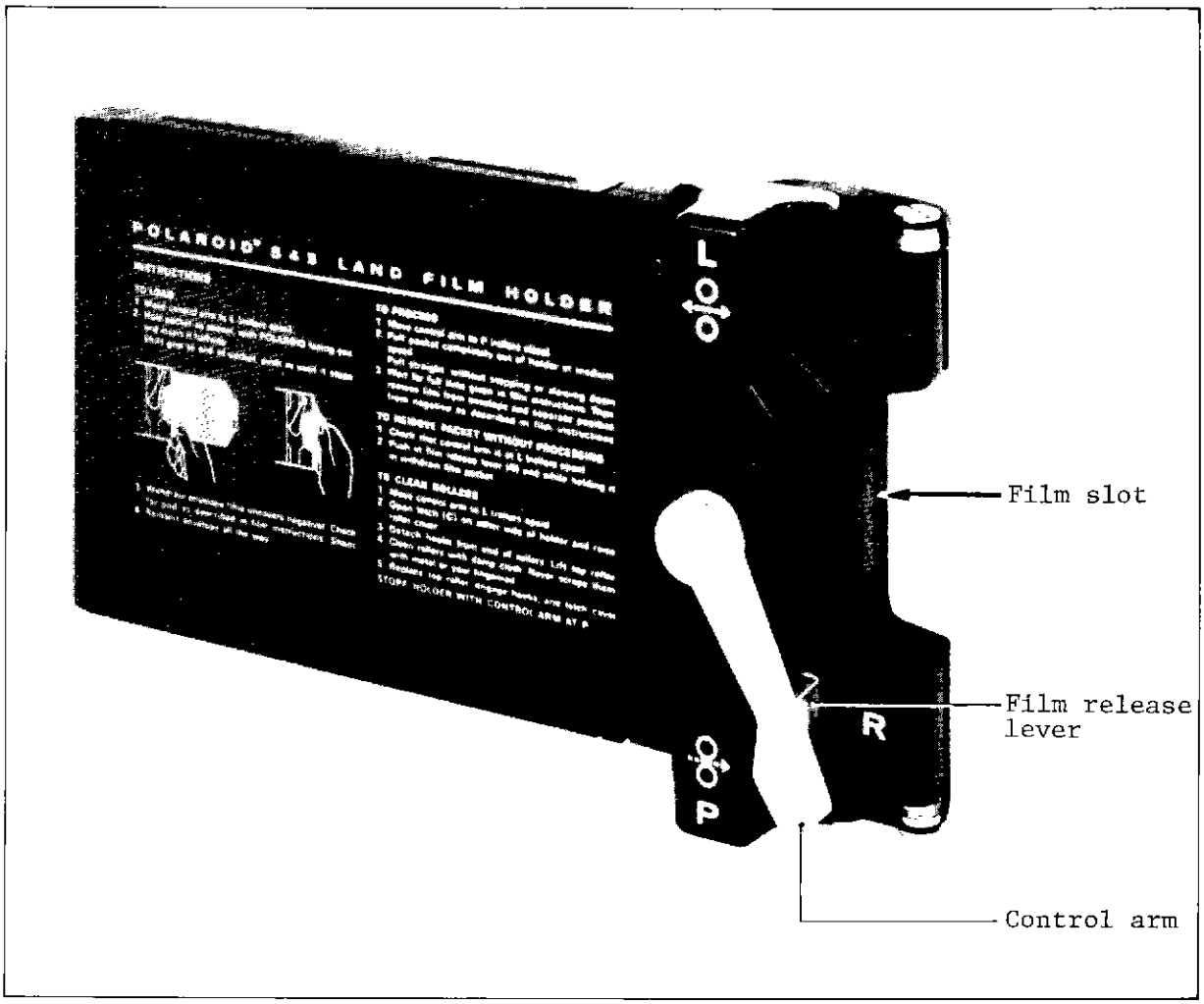


Fig. 1 Film holder

1. GENERAL

The Polaroid #545 Film Holder is used for photographing the scanning image displayed on the short persistence CRT of the JSM type Scanning Microscope photographic recording system.

2. SPECIFICATIONS

- Film: Polaroid 4 × 5 Land film.
- Magnification: 1 to 1 ratio.

3. COMPOSITION

- Film holder ..... 1 set.

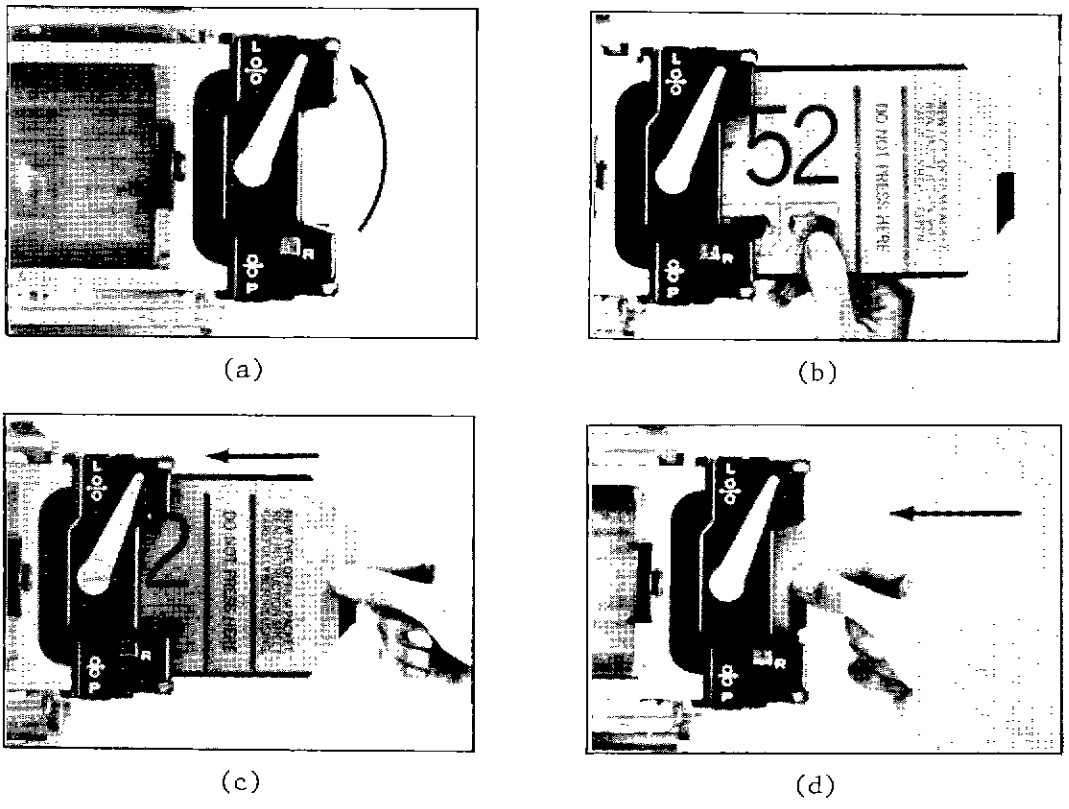
4. INSTALLATION

1. Attach the focus screen to the photographic recording system camera and set the lens opening to f/5.6 with the f-number adjust knob.
2. Obtain a spot image at the center of the CRT screen and focus the image with the focusing knob.
3. Detach the focus screen and attach the film holder.

5. FILM LOADING

1. Set the control arm to L (see Fig. 2a).
   Note: When the holder is not used, the control arm should be set at P.
2. Hold the film packet as shown in Fig. 2b and partially insert it (about halfway) into the film slot. Then hold the film packet as shown in Fig. 2c and push it into the slot as far as it will go (Fig. 2d).

Notes: 1. Be sure to insert the packet with the THIS SIDE TOWARD LENS side facing the camera.
2. Never press the DO NOT PRESS HERE portion on the packet.
3. Never bend the packet nor apply excessive force to it.



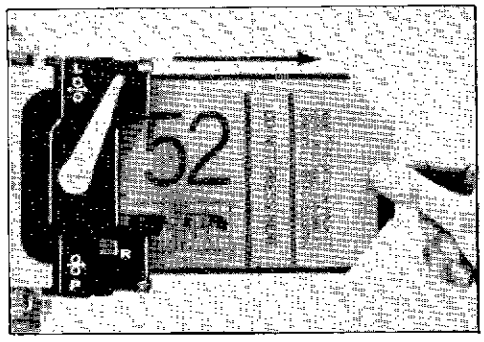
(a) (b)

(c) (d)

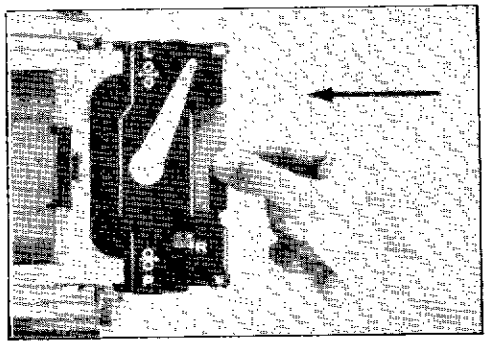
Fig. 2 Film loading

6. PHOTOGRAPHY AND DEVELOPMENT

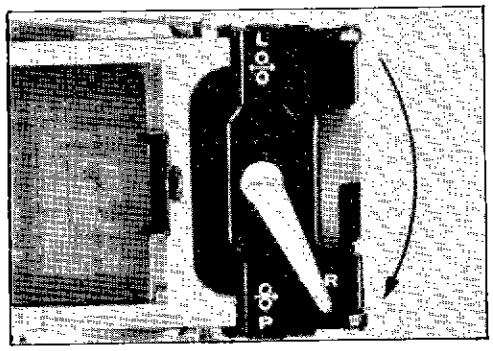
1. Hold the film packet as shown in Fig. 3a and draw it out as far as possible.
   Note: By this procedure, the lightproof cover and positive sheet are drawn out; the negative film, however, is left in the holder and is now ready for exposure.
2. After photographing the scanning image, reinsert the packet as far as possible (see Fig. 3b).
3. Set the control arm to P (see Fig. 3c), and draw out the packet smoothly (see Fig. 3d).
   Notes: 1. By this procedure, jelly developer spreads uniformly between the negative film and positive sheet, and development commences. For details on developing time and how to open the film packet, refer to the instructions for the Land film in question.
   2. If the lightproof cover is not inserted and withdrawn correctly and/or the packet is not drawn out smoothly, the film may remain unexposed, a part of the frame may be missed, or vertical streaks may appear on the micrograph. If spots are observed on the micrograph, open the roller cover, unlock the roller hooks and clean the processing rollers and rubber light seal roller (see Fig. 4).
   3. If the film packet is to be removed before development, draw out the packet with the control arm set at L and with the film stopper release lever (R) depressed (see Fig. 1). To develop the film, reinsert the packet and after setting the control arm to P, draw out the packet.



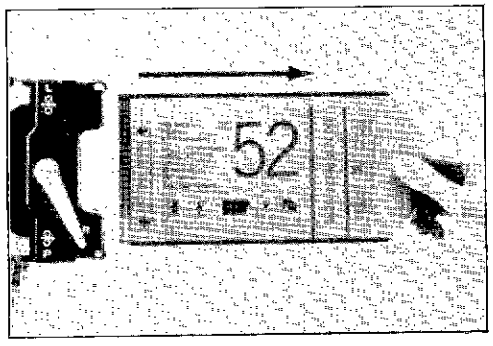
(a)



(b)



(c)



(d)

Fig. 3 Photography and development

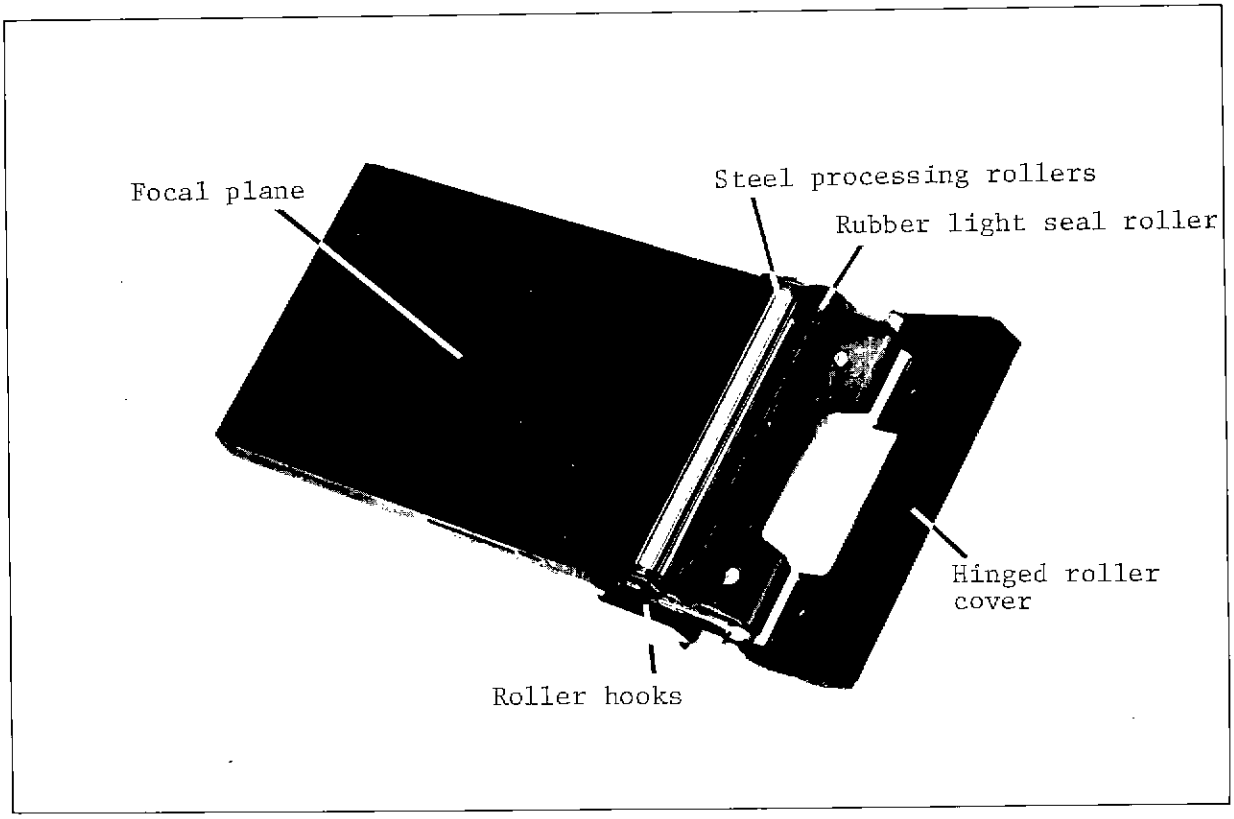


Fig. 4 Opening the roller cover

INSTRUCTIONS

SM-PRH2

POLAROID #405 FILM HOLDER

No. SM-PRH2
(EP600001)

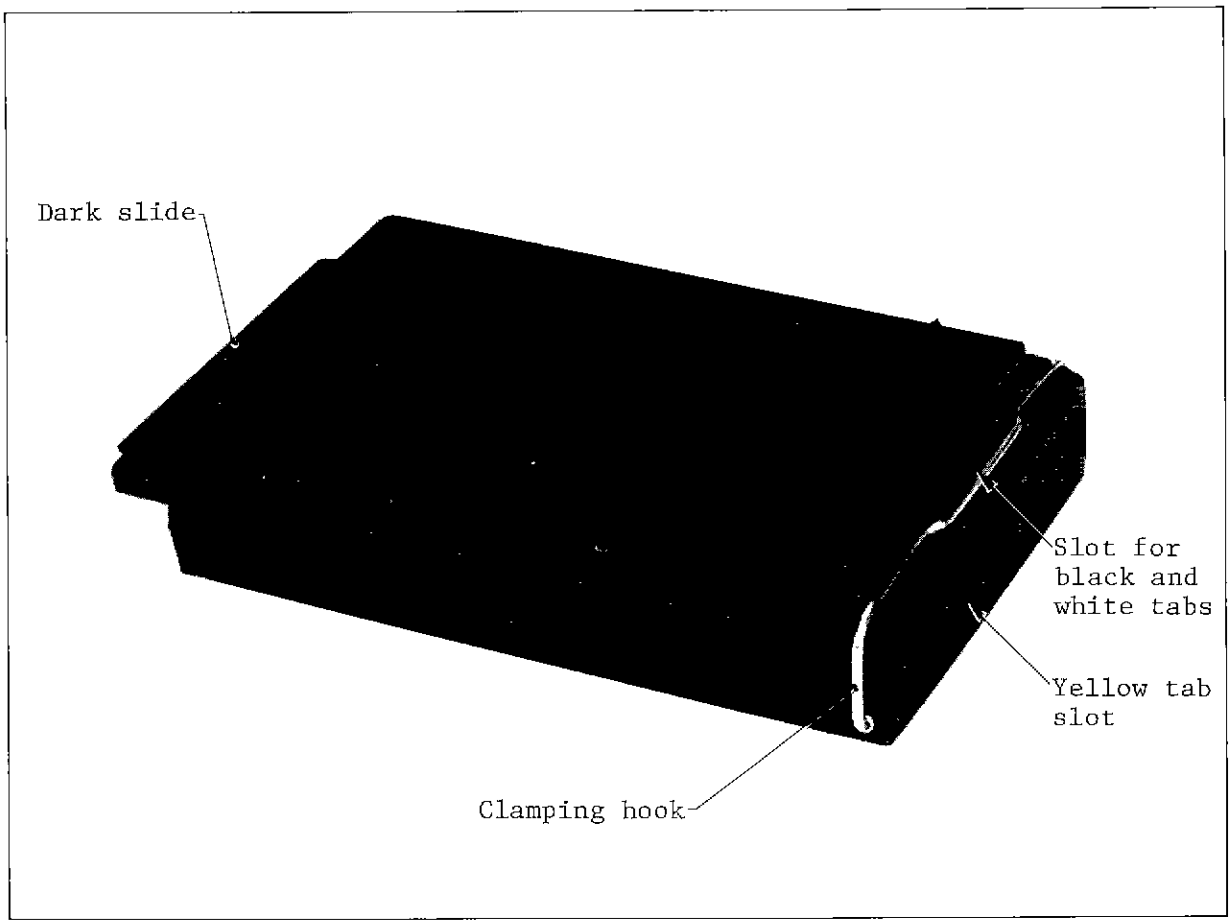


Fig. 1 Film holder

1. GENERAL

The Polaroid #405 Film Holder is used for recording the scanning image displayed on the CRT of the JSM type scanning electron microscope photographic recording system.

2. SPECIFICATIONS

- Film: Polaroid Land film, type 105 or 107.
- Photographing ratio: 1 to 0.83.

3. COMPOSITION

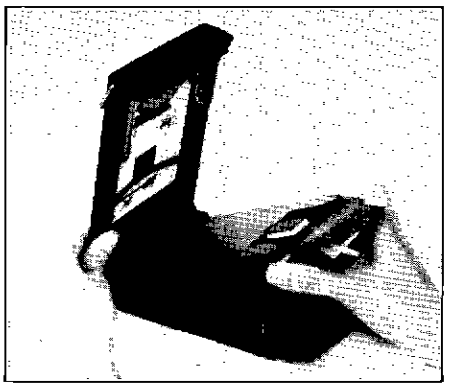
- Film holder ..... 1 set.

4. INSTALLATION

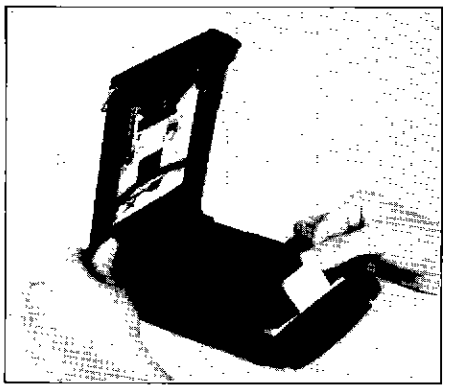
1. Attach the adapter and focus screen to the recording system camera, and set the lens opening to f/5.6 with the f-number adjust knob.
2. Focus the image with the focusing knob (refer to the microscope instruction manual).
3. Detach the focus screen and attach the film holder.

5. FILM LOADING

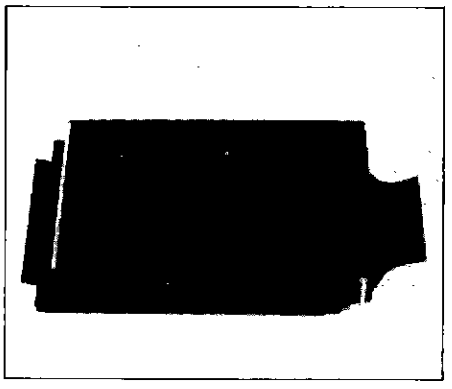
1. Unlock the clamping hook, open the holder back, push a pack into holder and down so it snaps into place (Fig. 2a).
   Cautions: 1. Be sure to insert the dark slide into the holder before loading the pack.
   2. Be sure to insert the pack with the DO NOT PRESS HERE side facing the camera.
   3. Never press the DO NOT PRESS HERE portion on the pack.
   4. Never bend the pack nor apply excessive force to it.
2. Close the holder back (Figs. 2b, c) and lock the back. The black tab sticks out of the tab slot.
   Caution: Be sure the white tabs are not caught between the film pack and the film holder.



(a)



(b)

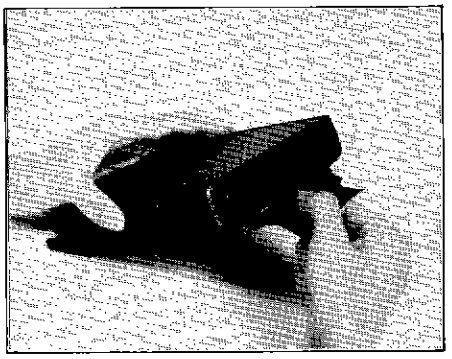


(c)

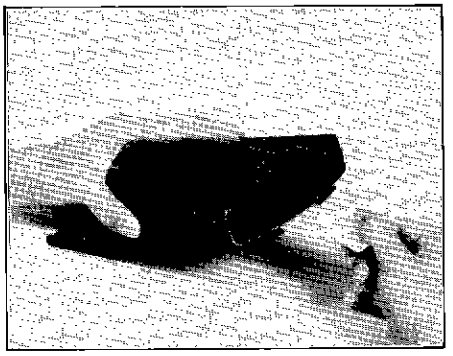
Fig. 2 Film loading

6. PHOTOGRAPHY AND DEVELOPMENT

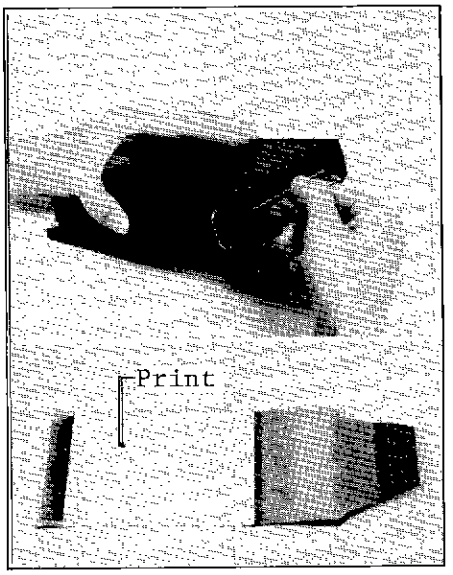
1. Pull the black tab (safety cover) all the way out of the holder (Fig. 3a). The film is now ready for exposure. A white tab will pop out.
2. After photographing the scanning image with the dark slide pulled out, pull the white tab all the way out of the holder (Fig. 3b).
   Note: A yellow tab will pop out. DO NOT pull another white tab.
3. Grip the center of the yellow tab and pull it straight, without stopping, all the way out of the holder (Fig. 3c). This starts development.
   Notes: 1. For details of development time and separating the negative from the print, refer to the instructions of the Polaroid film pack.
   2. Spotty stains on micrographs indicate the dirty processing roller. In this case, clear the processing roller by referring to the enclosed instructions for the holder (Polaroid Corporation).
   Caution: Be sure to return the dark slide to the holder after each exposure.
4. Coat the print, and if necessary clear the negative, according to the film instructions.



(a)



(b)



(c)

Fig. 3 Photography and development

INSTRUCTIONS

35-SCB·S

SUPPLEMENTARY CABINET

No. IEP35C-SCB·S
(EP705001)

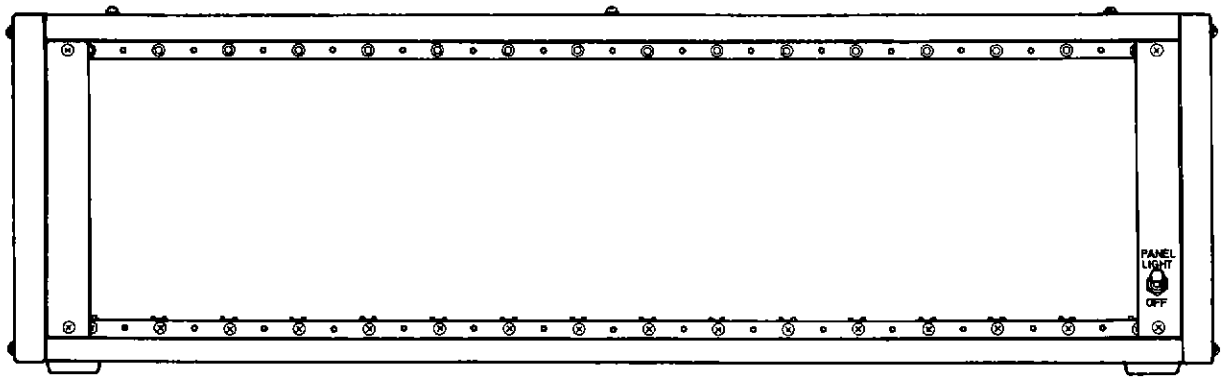


Fig. 1 Supplementary cabinet

1. GENERAL

This cabinet is intended for attachments of the JSM-35C Scanning Microscope. A supplementary power supply (35-SPS1 or -SPS3) is necessary to supply power to the attachments. The cabinet can accommodate fifteen or eight basic attachment modules depending on the type of the supplementary power supply (35-SPS1 or 35-SPS3).

2. SPECIFICATIONS

- Dimensions: 600 mm (W) × 562 mm (D) × 180 mm (H).
- Weight: 20 kg.

3. COMPOSITION

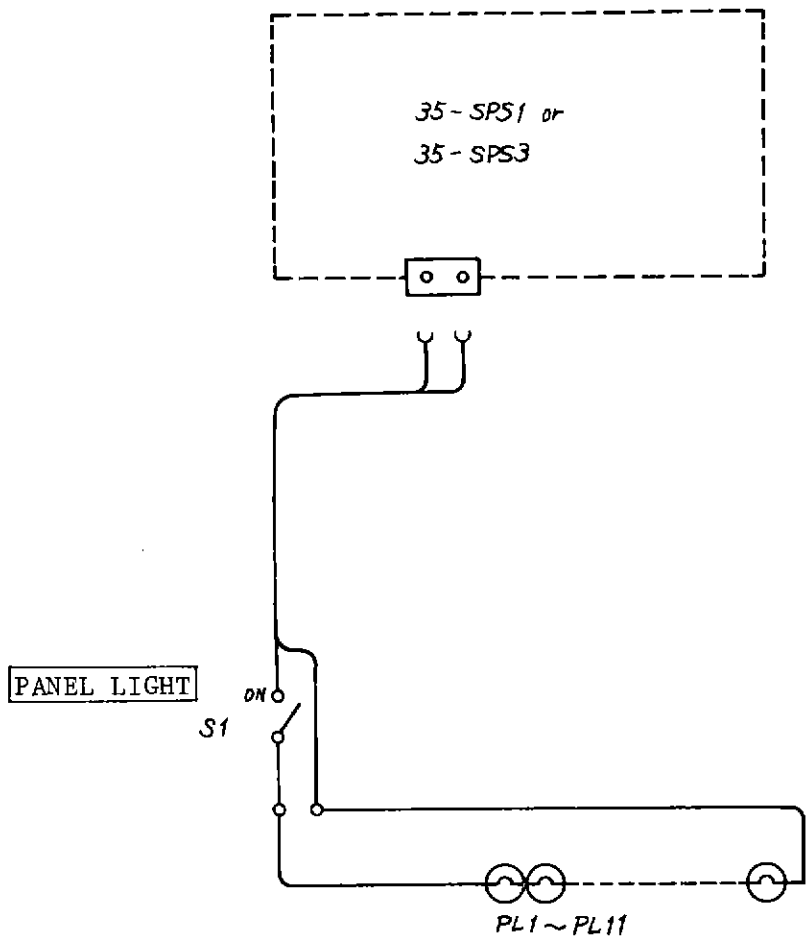
- Cabinet 1

4. INSTALLATION

1. Place the cabinet incorporated with the supplementary power supply on the operation and display system of the scanning microscope.
2. Insert the cable plug protruding from the cabinet into the AC 100 V socket of the power supply unit (accessible by removing the right side panel of the operation and display system).
3. Insert the attachment modules intended for use into the cabinet.
4. Turn on the supplementary power supply switch (accessible from the rear of the cabinet).

5. OPERATION

Power application to the operation and display system turns the cabinet on. Push the PANEL LIGHT switch up to illuminate the panel whenever necessary.



35 - SCB·S	XEA-3696

INSTRUCTIONS

50A-SDT

STEP-DOWN TRANSFORMER

No. IEPSM-SDT
(EP693001)

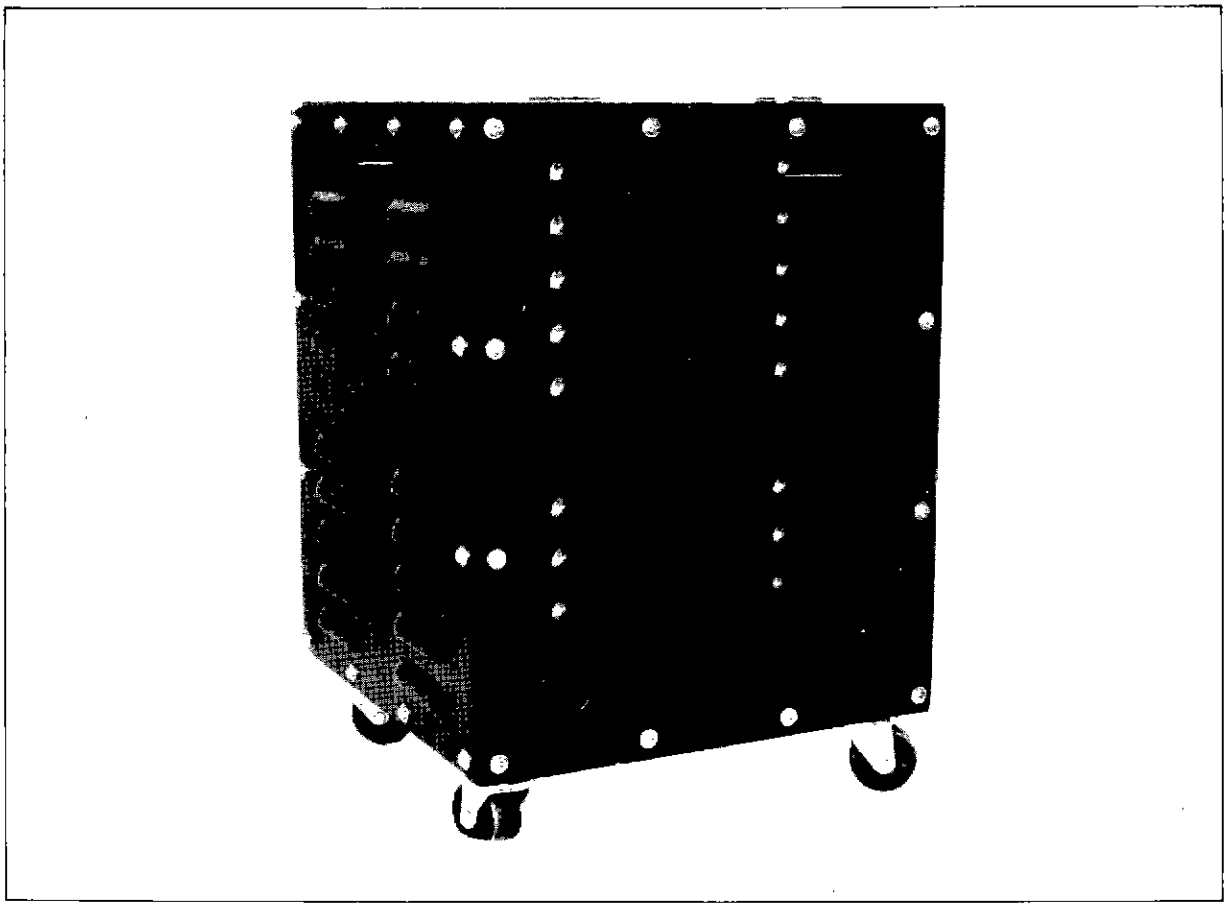


Fig. 1 Transformer

1. GENERAL

This transformer supplies the JSM type scanning microscope with AC 100 V (single phase) power when it is not available from the power line.

2. SPECIFICATIONS

- Input voltage: 120, 200 and 240 V.
- Output voltage: 90, 95, 100, 105, 110 V.
- Operating temperature: 0 ∿ 50°C.
- Dimensions: 280 mm (W) × 280 mm (D) × 330 mm (H).

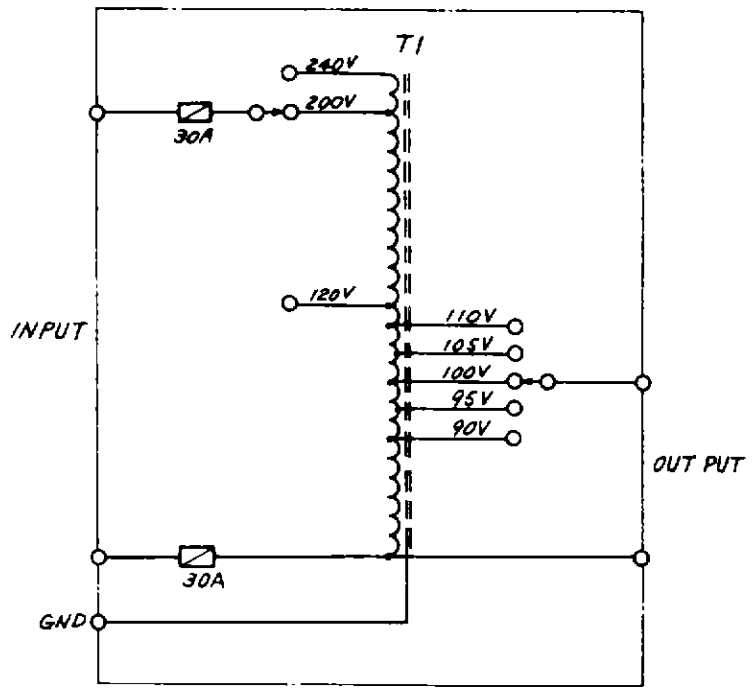
3. COMPOSITION

- Transformer ..... 1.
- Cable ..... 1.

4. CABLING

1. Connect the scanning microscope power cable to the AC 100 V output terminal and ground terminal of the transformer.
2. After confirming that the switch on the power board is off, connect one end of the provided cable to an appropriate input terminal and also the ground terminal of the transformer, and the other end to the power board.

INPUT	120 – 200 – 240 V 1φ 50/60 Hz
OUTPUT	90 – 95 – 100 – 105 – 110 V 30A



XES - 0191

STEP - DOWN TRANSFORMER	XEA - 3302

INSTRUCTIONS

35-SPS1, 3

SUPPLEMENTARY POWER SUPPLY

No. IEP35C-SPS1, 3
(EP704010, EP711001)

1. GENERAL

The 35-SPS1 or 35-SPS3 supplies regulated power to the various attachments housed in the supplementary cabinet (35-SCB.S).

2. SPECIFICATIONS

◦ Input:	AC 100 V, 50/60 Hz.
◦ Output:	SPS1: DC ±12 V, 2 A; DC ±20 V, 1 A; DC ±40 V, 1 A; DC +5 V, 3 A.
	SPS3: DC ±20 V, 1 A; DC ±12 V, 1 A.
◦ Operating temperature:	0 to 50°C.
◦ Dimensions:	SPS1: 545 mm (W) × 165 mm (D) × 90 mm (H).
	SPS3: 235 mm (W) × 157 mm (D) × 90 mm (H).
◦ Weight:	SPS1: 10 kg.
	SPS3: 7 kg.

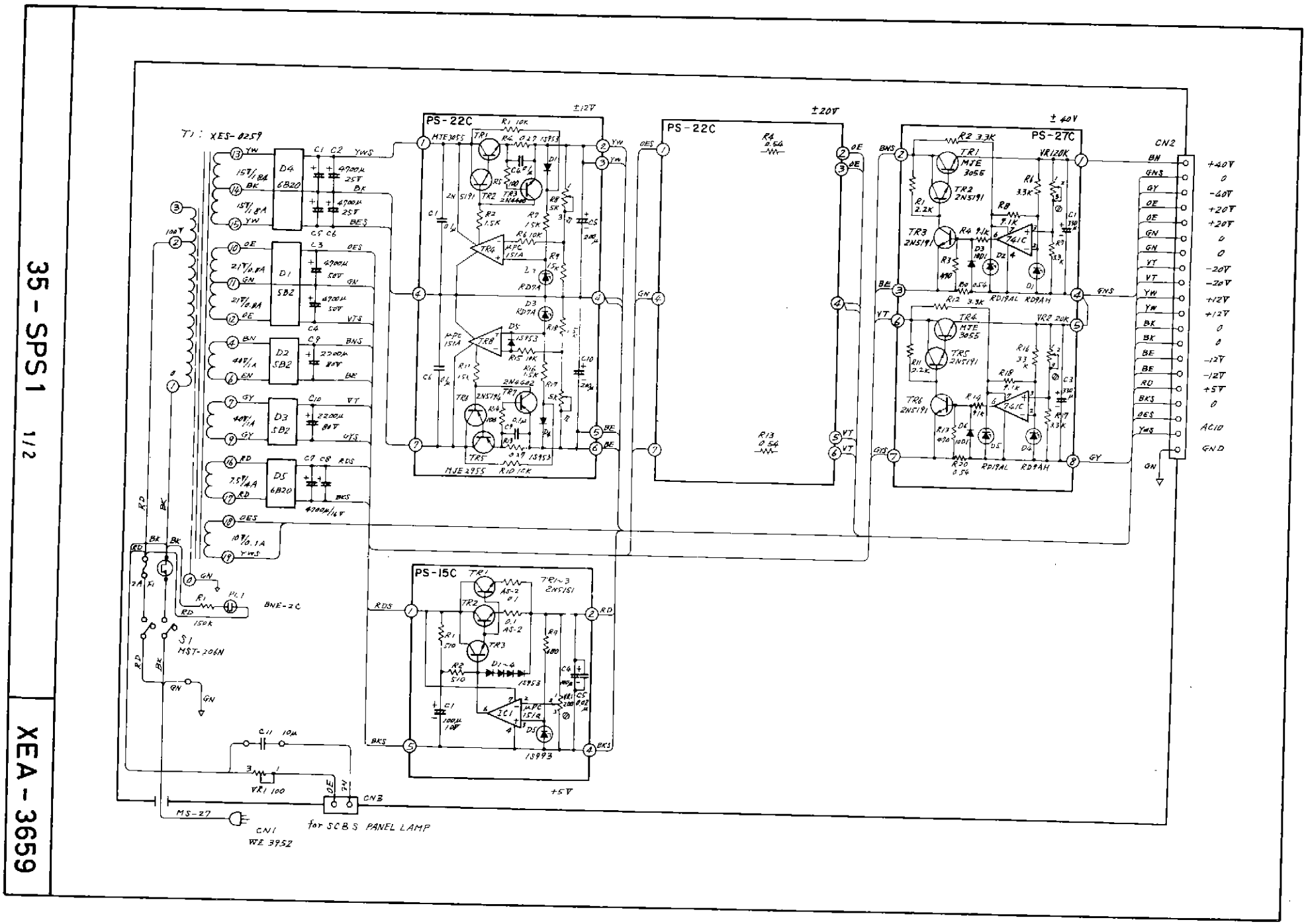
3. COMPOSITION

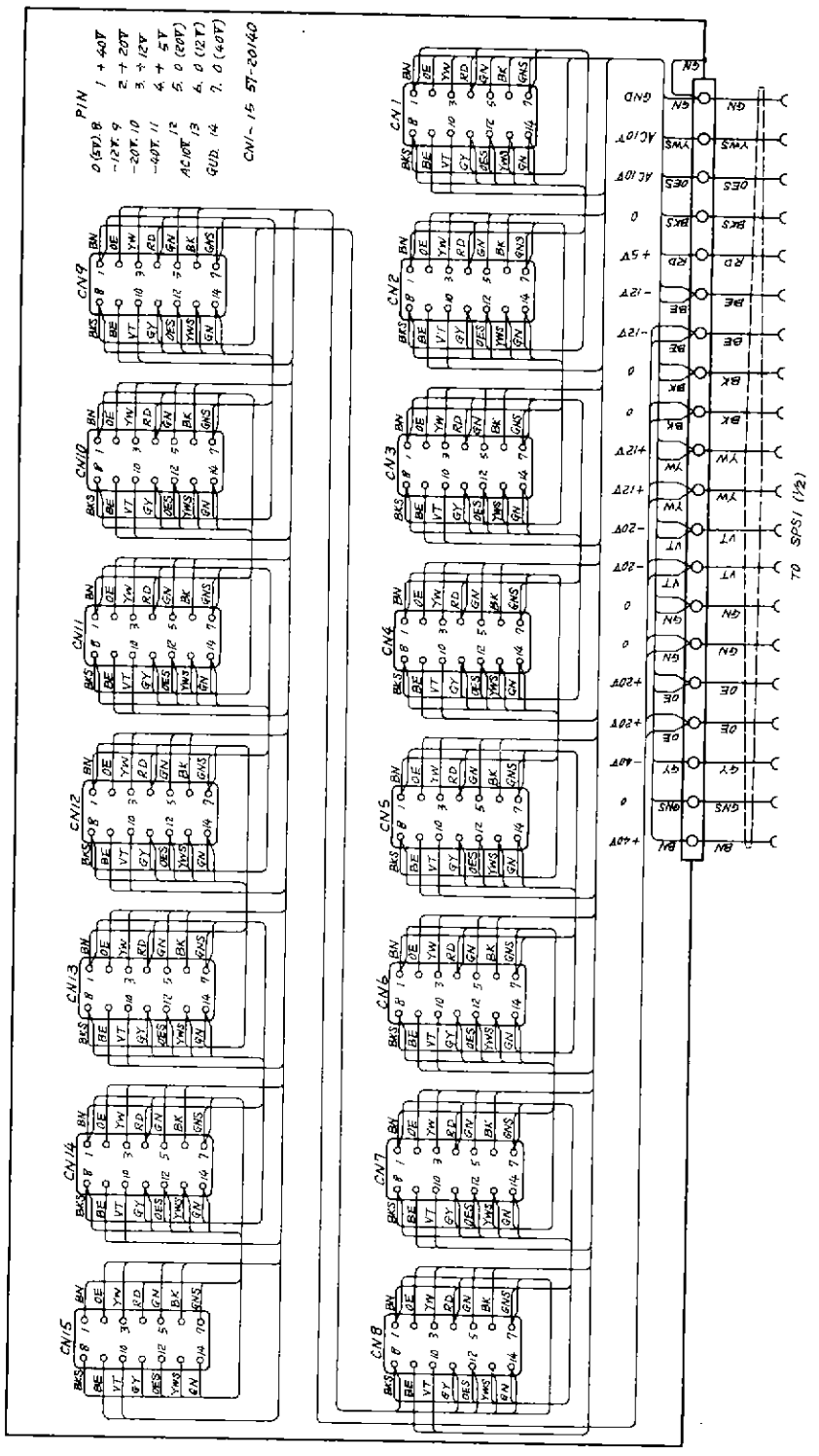
◦ Power supply unit ..... 1 set

4. INSTALLATION

1. Install the power supply unit in the supplementary cabinet and connect terminals of the cable leading from the power supply unit to the cabinet terminals.
2. Connect the PANEL LIGHT cable terminals to the supplementary cabinet terminals.
3. Place the supplementary cabinet on the operation and display system of the microscope.

4. Plug the power supply cable connector leading from the supplementary cabinet into the AC 100 V socket on the power supply unit (accessible by removing the right side panel of the display and operation system).
5. Install the attachment electronics units in the cabinet.
   Note: The 35-DMA, -DU7, -IZD, and -MDD cannot be used in the case of the SPS3.
6. Turn on the supplementary power supply unit power supply switch (accessible from the rear side of the cabinet).


35 - SPS1 1/2
XEA - 3659
T1 : XES-0259
PS-22C
±12V
PS-22C
±20V
PS-27C
±40V
PS-15C
+5V
CN2
for SCBS PANEL LAMP
CN1
WE 3952
MS-27
S1
MST-206N
BNE-2C
VR1 100
+40V
0
-40V
+20V
+20V
0
0
-20V
-20V
+12V
+12V
0
0
-12V
-12V
+5V
0
AC10
GND


CN1 ~ 15 57-20140
PIN
0 (5V). 8
-12V. 9
-20V. 10
-40V. 11
AC/DT. 12
GND. 13
GND. 14
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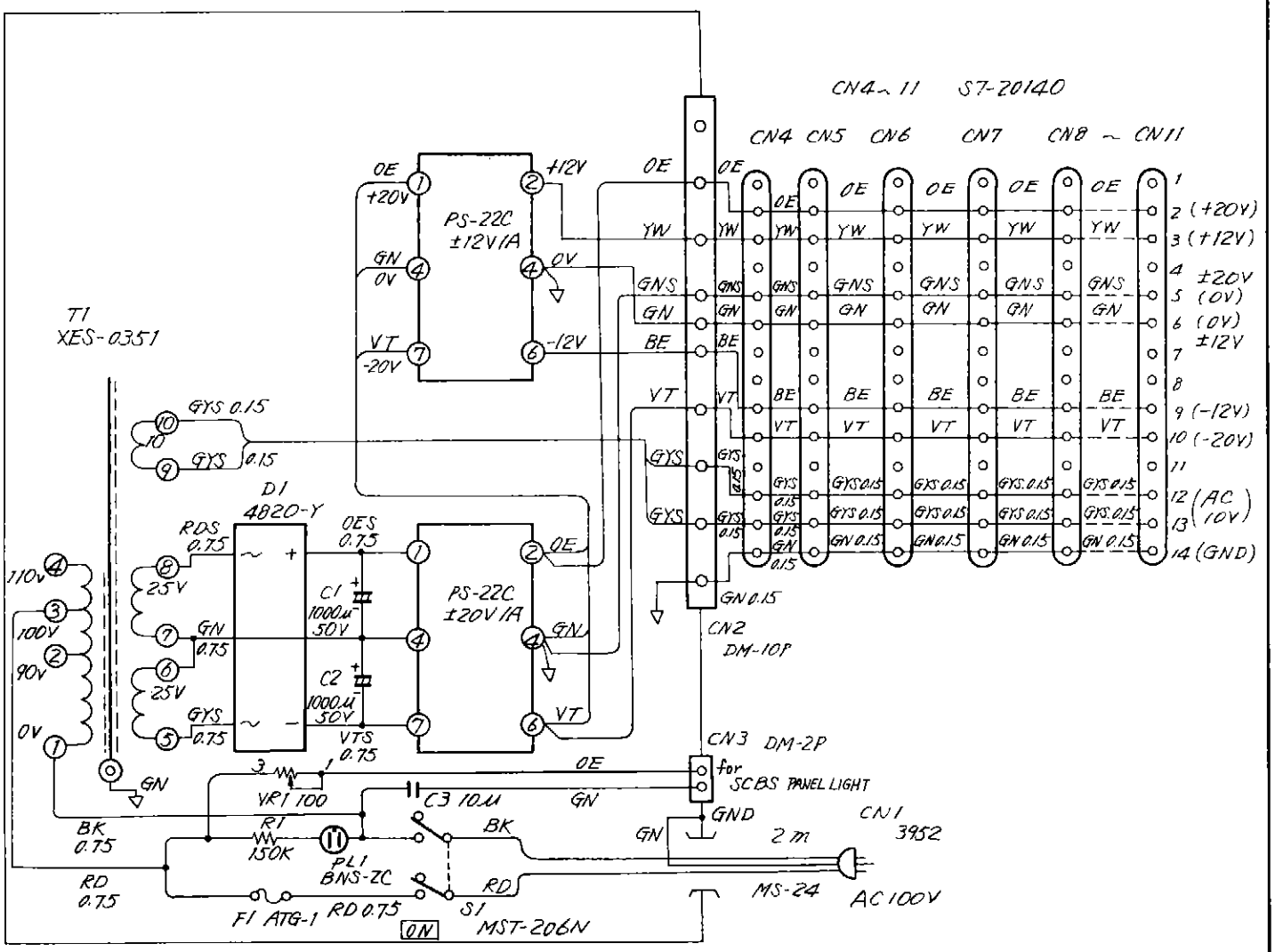
2. + 20T
3. + 12V
4. + 5V
5. 0 (20T)
6. 0 (12T)
7. 0 (40T)
CN1
CN2
CN3
CN4
CN5
CN6
CN7
CN8
CN9
CN10
CN11
CN12
CN13
CN14
CN15
GND
AC10T
AC10T
0
+5V
-12V
-12V
0
0
+12V
+12V
-20T
-20T
0
0
+20T
+20T
-40T
0
+40T
TO SPS1 (1/2)

35-SPS3

XEA-3948



INSTRUCTIONS

35-TED

TRANSMITTED ELECTRON DETECTOR

No. IEP35C-TED-2
(EP729119)

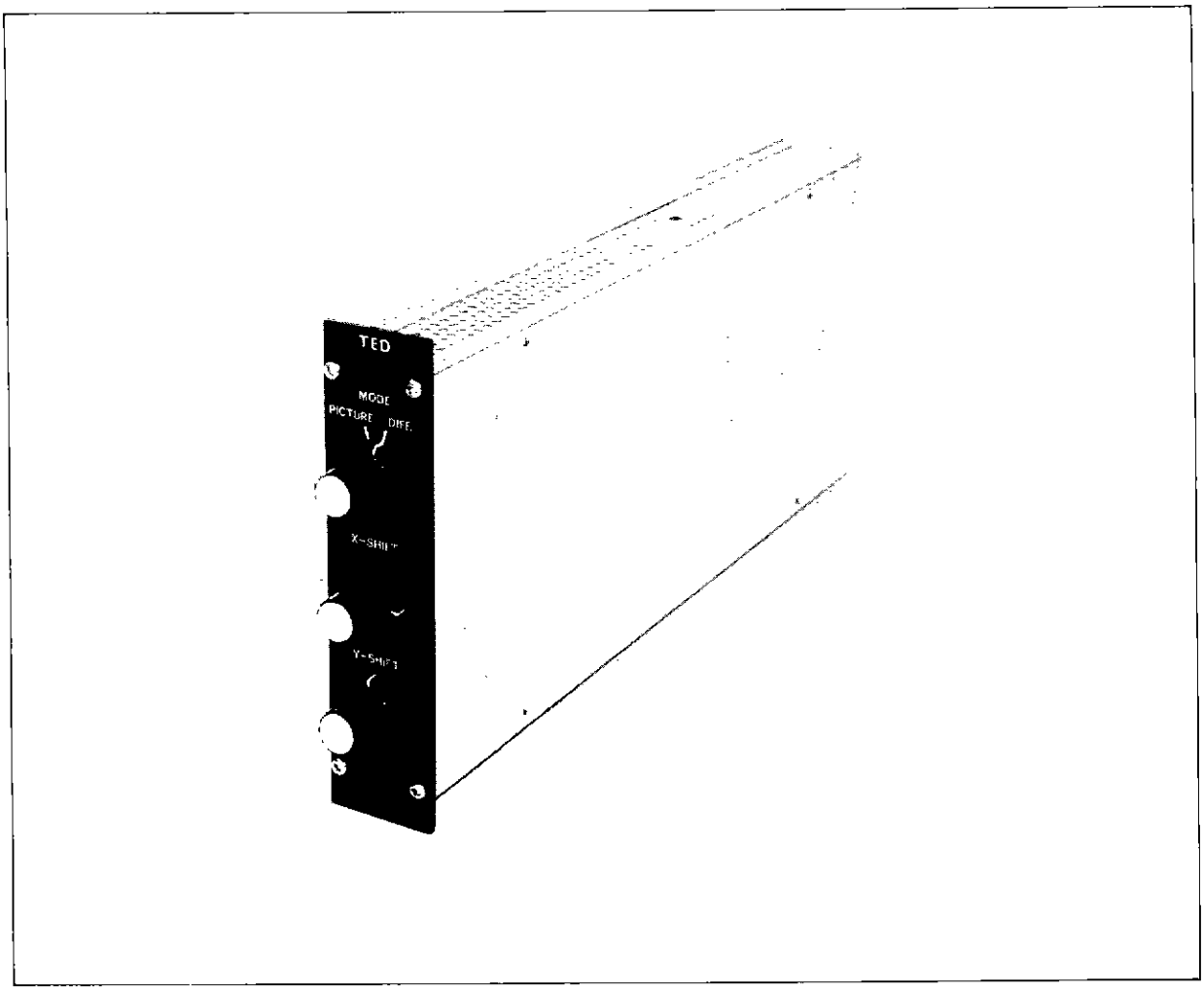


Fig. 1 TED electronics unit

1. GENERAL

Designed for use with the JSM-35C Scanning Microscope, this detector allows the instrument to operate in the STEM (scanning transmission electron

microscope) mode. In addition to conventional STEM images, the 35-TED permits dark field images in two modes (using scattered electrons and Bragg reflection), and scanning electron diffraction patterns to be displayed. The STEM image provides almost the same information as a conventional transmission electron microscope image. However, the advantages of the STEM technique are that chromatic aberration due to inelastic scattering in thick specimens can be disregarded, specimen damage due to electron bombardment is minimal, and improved image contrast is assured. An added advantage is that the signal carrying information on the specimen can be optionally processed. Furthermore, the use of a SM-SDU Supplementary Detector, 35-CLD Cathodo-luminescence Detector, etc. makes it possible to display images from said detectors simultaneously.

Operation modes

- Bright field (Fig. 2a)

  In this mode, the image is formed by electrons transmitted through the specimen when the electron probe scans the specimen.

- Dark field image I (Fig. 2b)

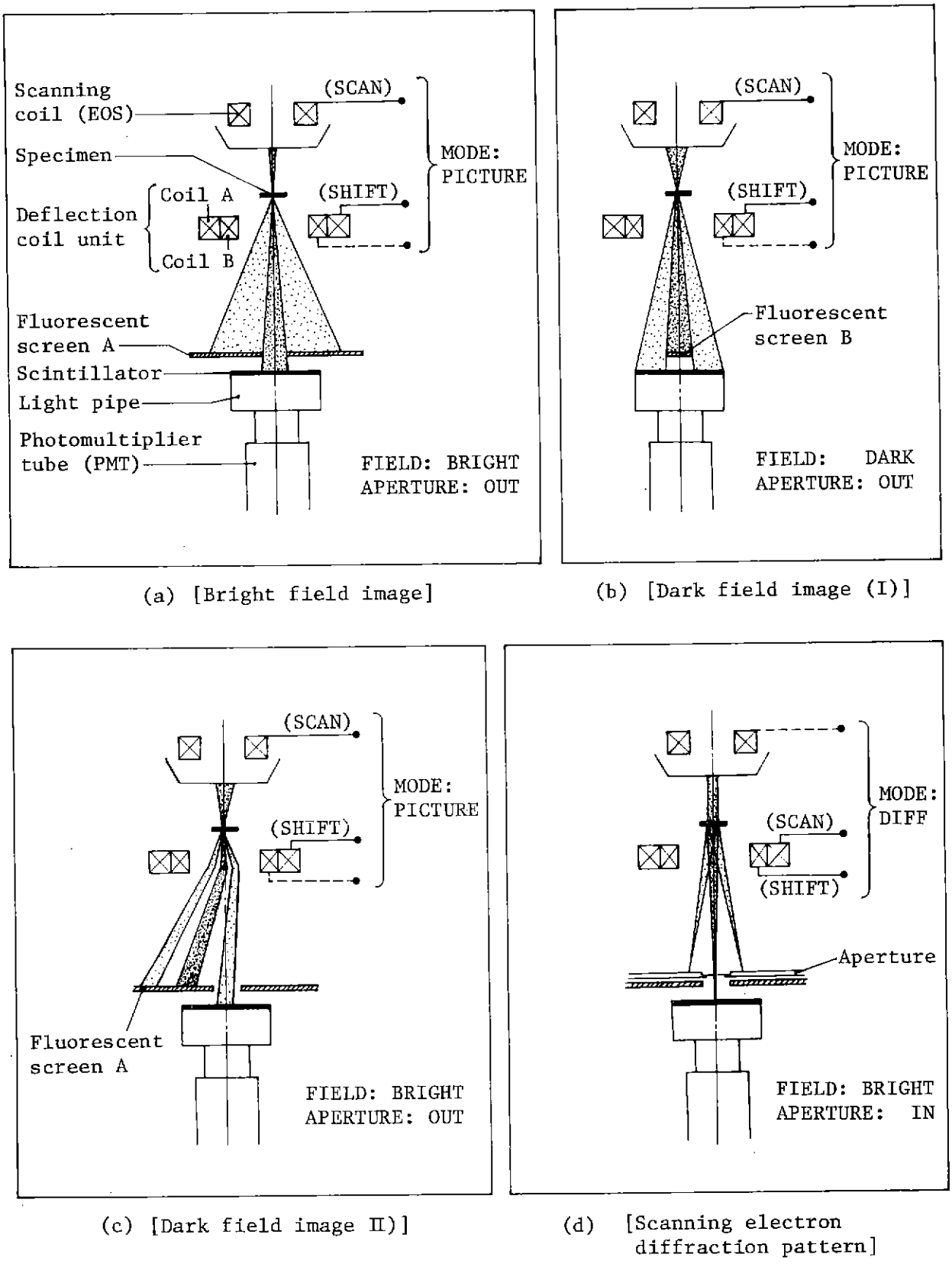
  In this mode, the image is formed by electrons scattered forward when the electron probe scans the specimen.

- Dark field image II (Fig. 2c)

  In this mode, the image is formed by electrons scattered in a specified direction when the electron probe scans the specimen.

- Scanning electron diffraction pattern (line profile) (Fig. 2d)

  In this mode, the pattern (line profile) is formed by frame-scanning (or line-scanning) a diffraction pattern.



(a) [Bright field image]

(b) [Dark field image (I)]

(c) [Dark field image II)]

(d) [Scanning electron diffraction pattern]

Fig. 2 Ray diagrams

2. SPECIFICATIONS

- Detecting distance (specimen-detector): 402 mm (working distance: 15 mm)
  378 mm (working distance: 39 mm).
- Bright field aperture: 7 mm in diameter.
- Dark field contrast stop: 8 mm in diameter.
- Scanning electron diffraction aperture: 200 μm in diameter.
- Specimen carrier: 3 mm diameter transmission electron microscope specimen grid.
- Specimens loadable at one time: 4 specimens.
- Beam deflection: Electromagnetic X-Y deflector (auxiliary coil for scanning electron diffraction attached).
- Power requirements: DC ±12 V, 500 mA.
- Ripple: Less than 0.1%.
- Electronics unit dimensions: 35 mm (W) × 150 mm (H) × 300 mm (D).

3. COMPOSITION

- TED electronics unit 1
- Detector (incl. scintillator, light pipe, aperture platform and light proof cover A) 1
- Fluorescent screens (A and B) ..... 1 of each
- Diffraction apertures 3
- Control unit 1
- Name plate 1
- O-ring gasket 1
- Ladder chains 3
- Specimen holder (encased) 1
- Specimen exchange rod adapter 1
- Light proof cover (B) 1
- Interconnecting braided wire (complete with connector) 1
- Cables 2
- Specimen chamber evacuation pipe 1
- Specimen exchange chamber adapter (for WD 39 mm) 1

4. INSTALLATION

4.1 Preparation

1. Turn the ACCELERATING VOLTAGE unit GUN FILAMENT knob fully counter-clockwise and position the ON/OFF switch at OFF.
2. Set the SEI unit SEI/BEI switch at the midway position to turn off the detector power supply.
3. Set the UNATTENDED OPERATION switch to its upper position to switch off the power supply except the vacuum system power supply.
4. Confirm that the anode chamber airlock valve is open and then depress the VACUUM SYSTEM unit VENT button to expose the column to the atmosphere.
5. Remove the specimen exchange chamber cap; then set the tilt control at 0°, the WD control at 39 mm and open the front cover by pulling the lock lever towards you.

4.2 Parts removal (see Fig. 3)

1. Remove the front console panel by loosening off the four screws A.
2. Loosen off the four screws B and remove the rectangular plate.

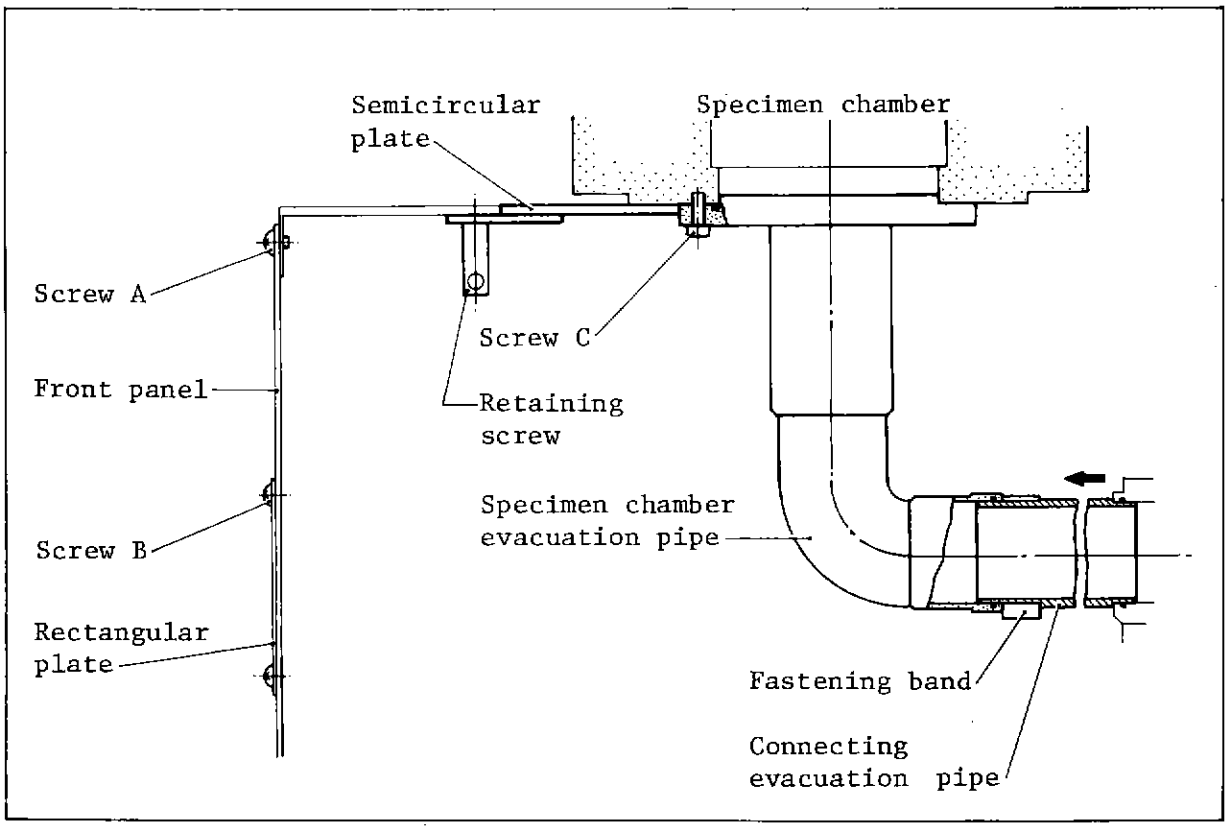


Fig. 3 Standard parts removal

3. Remove the semicircular plate by loosening off the two retaining screws.
   Note: To loosen off the retaining screws, insert a screwdriver or the like through the holes in the side cover and turn the screwdriver counterclockwise.
4. Unloosen the fastening band and push the connecting evacuation pipe in the direction of the arrow.
5. Loosen off the four screws C and remove the specimen chamber evacuation pipe.

4.3 Installing the TED (see Figs. 4 to 8)

1. Remove the connecting evacuation pipe from the specimen chamber evacuation pipe removed in Step 5, Sect. 4.2 and insert it into the cylinder evacuation port (see Fig. 4).

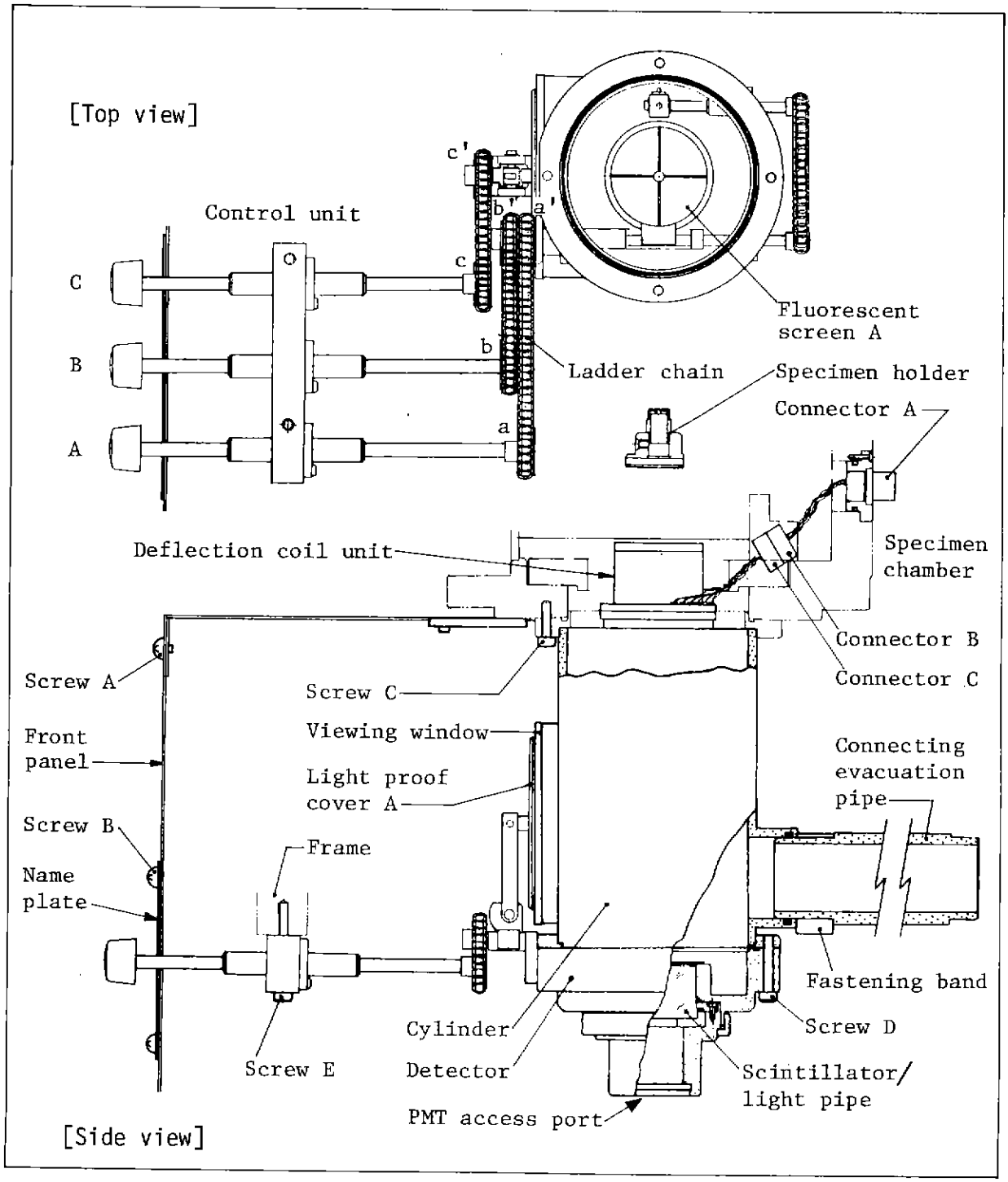


Fig. 4 TED parts installation

2. Attach the cylinder to the base underside of the specimen chamber so that the viewing window faces towards the front and secure the cylinder with the screws C.
3. Connect the connecting evacuation pipe to the evacuation system and secure it with the fastening band.
4. Unloosen the two screws, remove the aperture fixing disk from the aperture platform and mount the electron diffraction aperture (see Fig. 5a).

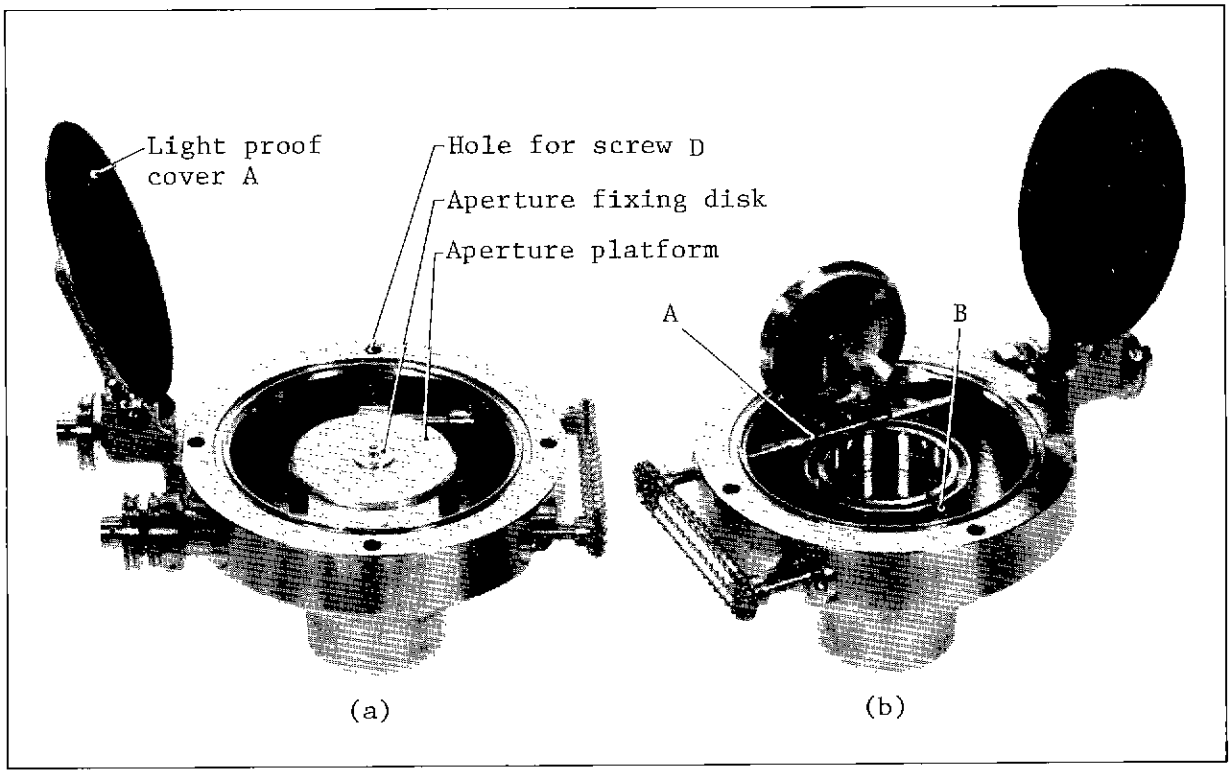


Fig. 5 Detector

5. Mount fluorescent screens A and B on rods A and B (Fig. 5b) respectively (see Fig. 6).
6. Place the O-ring gasket in the groove (upper part of detector) and then attach the detector to the cylinder and secure it with the four screws D (see Fig. 4).
7. Disconnect the two PMT connectors, loosen the ring nut, remove the PMT from the secondary electron detector and replace it with light proof cover B.
8. Attach the PMT to the base of the detector and reconnect the two connectors disconnected in Step 7.
   Note: When the SDU Supplementary Detector Unit is used in conjunction with the TED, omit Steps 7 and 8, install the SDU-PMT and connect up the SDU as described in the SDU manual.
9. Attach the control unit to the frame at the front of the console and secure it with the two screws E (see Figs. 4 and 7).

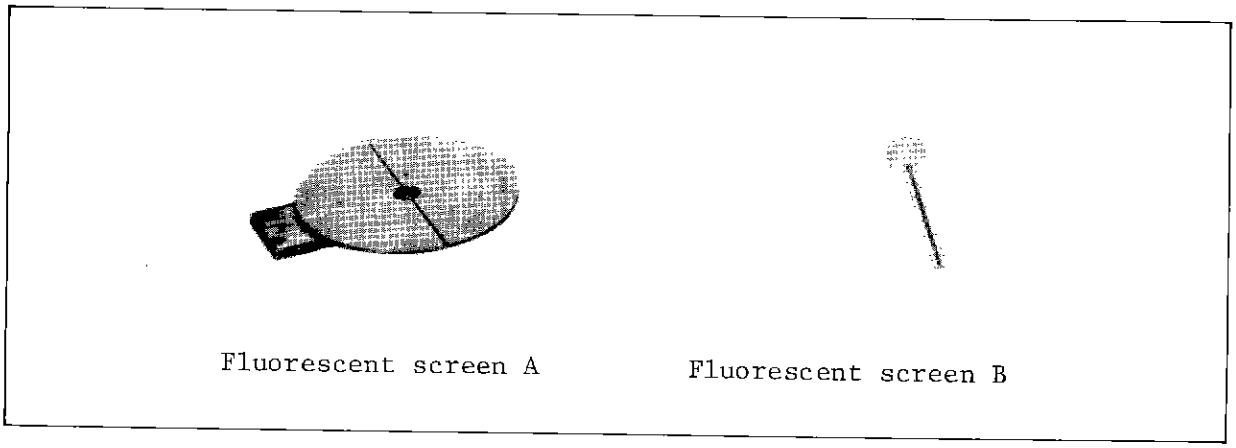


Fig. 6 Fluorescent screens

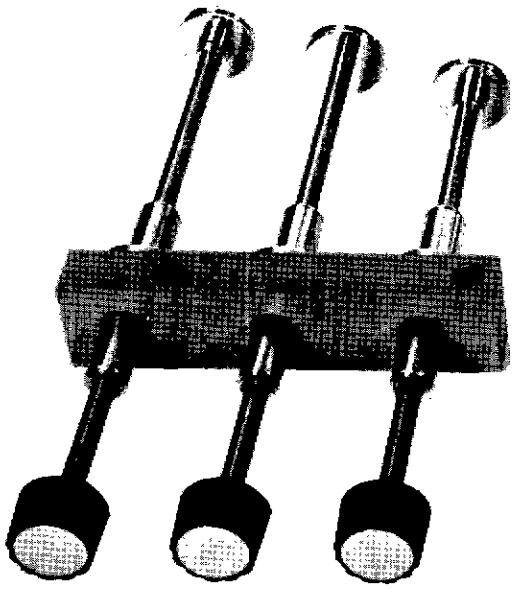


Fig. 7 Control unit

10. Attach the three chains between the control unit pulleys a, b, and c and the detector pulleys a', b', and c', respectively, as shown in Fig. 4.
11. Turn control knobs A, B, and C to check that the control unit is working properly and, if all is in good order, replace the front console panel removed in Sect. 4.2, Step 1.
12. Attach the name plate over the opening exposed by removing the rectangular plate in Step 2, Sect. 4.2 and secure it with screws B (see Fig. 4).

13. Remove either one of the two semicircular plate located at the lower part of the specimen chamber objective lens aperture assembly and plug up the exposed opening with interconnecting cord connector A (see Fig. 4).
14. Insert the deflection coil unit into the specimen chamber and install it by aligning the guide pin located inside the chamber (near the center) with the deflection coil unit guide hole (Fig. 8).

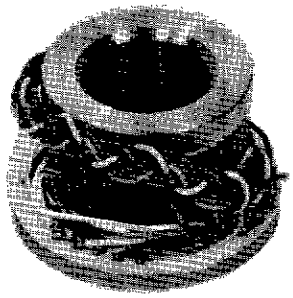


Fig. 8 Deflection coil unit

15. Connect up interconnecting cord connector B and deflection coil unit connector C.
    Note: Be sure to connect up the connectors so that the colors of the respective lead wires match.
16. Close the front cover.
17. Turn off the 35-SPS1 Supplementary Power Supply switch and install the TED unit in the 35-SCB·S Supplementary Cabinet.
18. Referring to the JSM-35C Scanning Microscope and the 35-TED circuit diagrams, connect up the various cables.
19. Re-evacuate the column by depressing the VACUUM SYSTEM unit PUMP DOWN button.
20. Set the UNATTENDED OPERATION switch to its lower position and then turn on the 35-SPS1 switch.

4.4 Installing the specimen exchange rod adapter

Attach the adapter to the tip of the specimen exchange rod and secure it with the fixing screw (see Fig. 9).

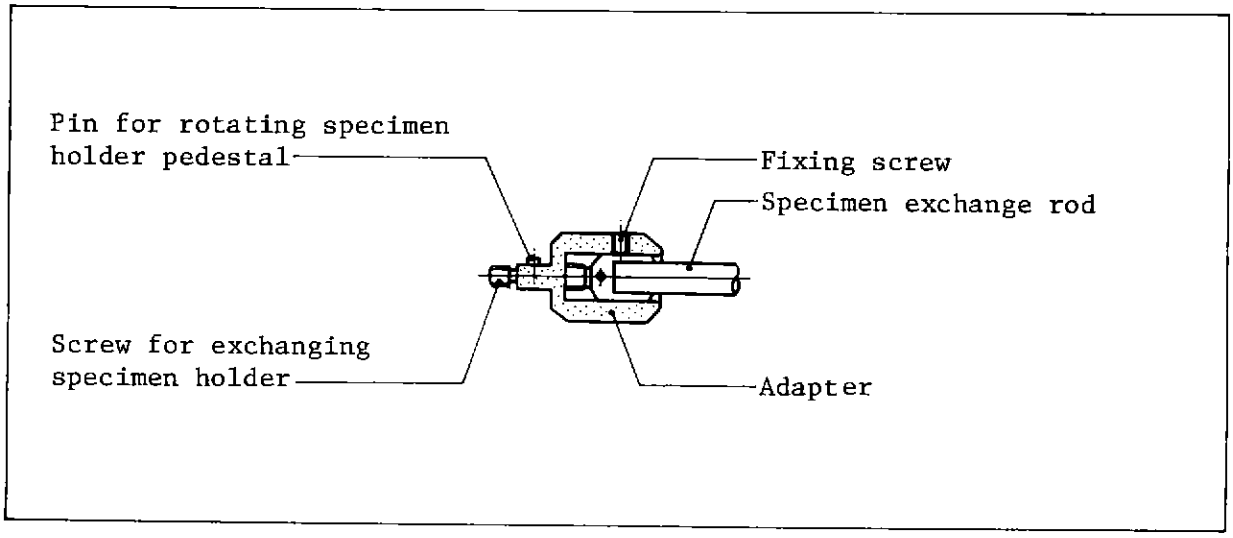


Fig. 9 Specimen exchange rod adapter installation

5. SPECIMEN EXCHANGE (see Fig. 10)

5.1 Specimen exchange

1. Remove the specimen holder cap.
2. Remove the spring and washer, and the used specimen. Then mount a new grid (3 mm dia), complete with the desired specimen, on the specimen holder pedestal with the aid of tweezers.
   Note: Up to 4 specimens can be mounted at one time.
3. Place the washer and spring on the specimen and mount the specimen holder cap making sure that pin A passes through the cap hole.

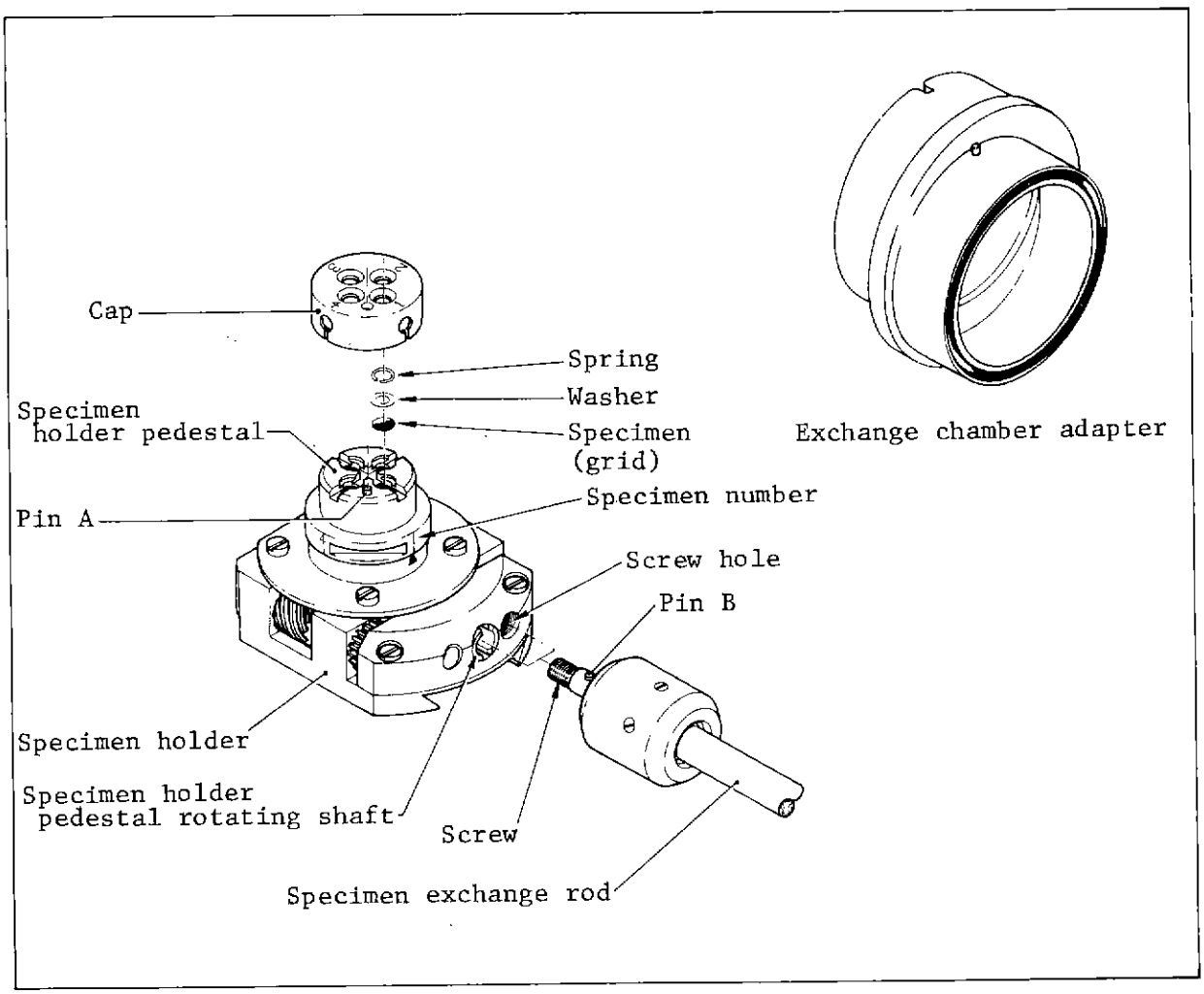


Fig. 10 Specimen holder

1. GENERAL

Dynamic observation of specimens is routine when the 35-TVS TV Scanning Device, which is composed of a conventional TV monitor and a TV scanning unit, is used in conjunction with the JSM-35C Scanning Microscope. Accordingly, rapid changes on the specimen can be readily observed on the TV monitor, and the use of a commercially available video tape recorder makes it possible to record and play back the TV scanning image. These facilities are extremely useful when observing specimen changes which occur due to heating or tensile stress. Furthermore, the 35-TVS permits image focusing and field of view selection to be easily carried out. In addition, the 35-TVS provides zoom observation because the magnification can be continuously changed.

2. SPECIFICATIONS

- Scanning mode: Standard TV scanning.
- Image display: 130 mm (H) × 170 mm (W) (9" CRT).
- Magnification: ×100 to ×10,000, continuously variable (at accelerating voltage 25 kV).
- Bandwidth: 4 MHz.
- Power requirements:
  TV monitor: 100 V AC, 0.2 A.
  Control unit: +20 V, 0.3 A.
  -12 V, 0.2 A.
- Operating temperature: 0 to 50°C.
- Dimensions:
  TV monitor:
  220 mm (W) × 235 mm (D) × 215 mm (H).
  TV scanning unit:
  70 mm (W) × 300 mm (D) × 150 mm (H).

3. COMPOSITION

TV monitor 1
TV scanning unit 1
Cables ..... 1 set

4. PANEL DESCRIPTION

4.1 TV scanning unit

TV-SLOW switch:	Selects the scanning mode. When the switch is set at TV, the 35-TVS scanning circuit, magnification control circuit and video amplifier are brought into operation and a TV image is displayed on the 35-TVS monitor. When set at SLOW, the above mentioned circuits and amplifier are drived with the standard system and the image is displayed on the standard CRT.
MAGNIFICATION knobs:	The COARSE knob selects the magnification in four steps. To select the magnification between the four coarse steps, use the FINE knob. The FINE knob is also used as a zoom magnification control.

4.2 TV monitor

POWER button:	Power switch for TV monitor.
CON knob:	Controls TV image contrast.
BRT knob:	Controls TV image brightness.
HOR knob:	Establishes horizontal synchronization.
VER knob:	Establishes vertical synchronization.

5. PRINCIPLE OF OPERATION

When the TV-SLOW switch is positioned at TV, a sawtooth wave generated by the scanning circuit for horizontally and vertically deflecting the electron probe (horizontal scanning frequency 15.75 kHz, vertical scanning frequency 50/60 Hz) is supplied to the scanning coils via the magnification control circuit. As a result, the electron probe scans the specimen surface. The probe scanning area is controlled by varying the amplitude of the sawtooth wave which is controlled by the magnification control circuit and secondary electrons emitted from the scanned specimen area are detected as a video signal, which is amplified by the video amplifier. Horizontal and vertical synchronizing pulses from the scanning circuit are mixed with the video signals and the resultant signals are fed to the TV monitor. Accordingly, the probe scan and the TV monitor raster scan are synchronized. Also, since the brightness of the CRT raster is modulated by the video signal, information pertaining to the specimen surface is reproduced on the CRT; that is, a TV image is obtained. With the TV-SLOW switch at the SLOW position, the scanning coil and detector are disconnected from the TV scanning circuit and connected to the standard scanning circuit, etc. A conventional scanning image is displayed on the standard CRT.

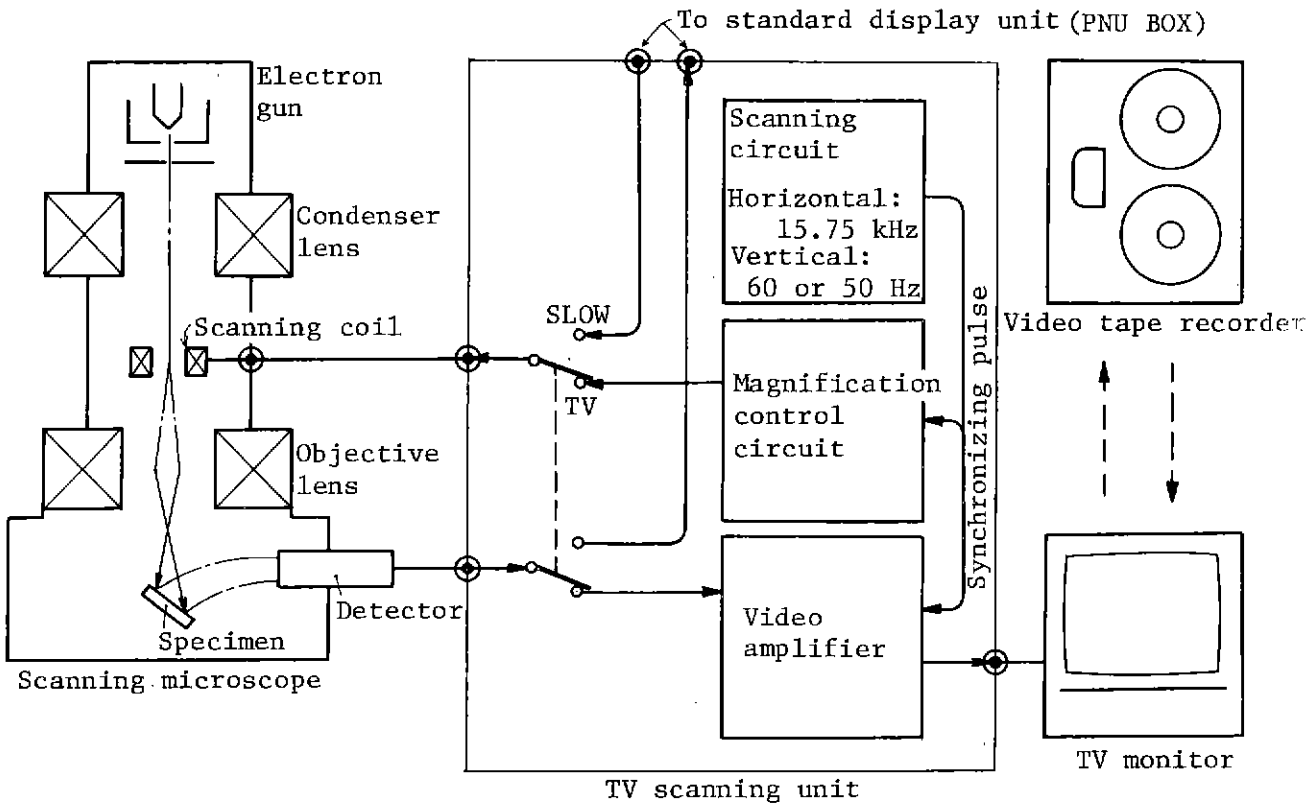


Fig. 2 Block diagram of scanning microscope, TV scanning unit, and video tape recorder

6. INSTALLATION

1. Turn off the supplementary power supply (35-SPS1).
2. Mount the TV scanning unit on the supplementary cabinet (35-SCB·S).
   Note: The necessary power for the control unit is supplied from the supplementary power supply that is built into the cabinet.
3. Place the TV monitor on top of the 35-SCB·S supplementary cabinet (or in the 35-SCB supplementary cabinet rack).
4. Referring to the circuit diagrams of the scanning microscope and the 35-TVS diagrams, connect the cables.
   Note: By connecting the cables, video signals and sawtooth waves for electron scanning take the following course:
   - *With the TV-SLOW switch positioned at TV, signals from the detector pass the TV scanning unit and are supplied to the TV monitor; the scanning coil receives the output from the TV scanning unit and operates.*
   - *At the SLOW position, the signal from the detector proceeds via the TV scanning unit, passes the display unit, and is supplied to the standard CRT; the scanning coil receives the output (of signal via the TV scanning unit) from the display unit and operates.*

   Further, AC input (100 V) for the TV monitor is supplied from a socket located inside the operation and display system.
5. Turn on the supplementary power supply.

7. OPERATION

1. Push on the TV monitor POWER button.
2. Set the input impedance switch at the back of the TV monitor at 75 Ω.
3. Set the TV-SLOW switch at TV. With this operation power is supplied to the TV scanning device. A TV image will appear on the TV monitor after a 30-second warm-up period.
4. If necessary, synchronize the TV image with the VER and HOR knobs.
5. Adjust the TV image contrast and brightness with the respective CON and BRT knobs.
   Note: A specimen illumination current of 3×10^{-9} A or over is required.
6. Adjust the MAGNIFICATION knobs to obtain the desired magnification and observe the TV image. To observe a slow scanning image, set the TV-SLOW switch at SLOW for a display on the standard CRT. To halt all TV scanning device functions, set the switch at SLOW and push off the TV monitor POWER button.
   Note: TV scanning image is focused with the OBJECTIVE LENS knobs.

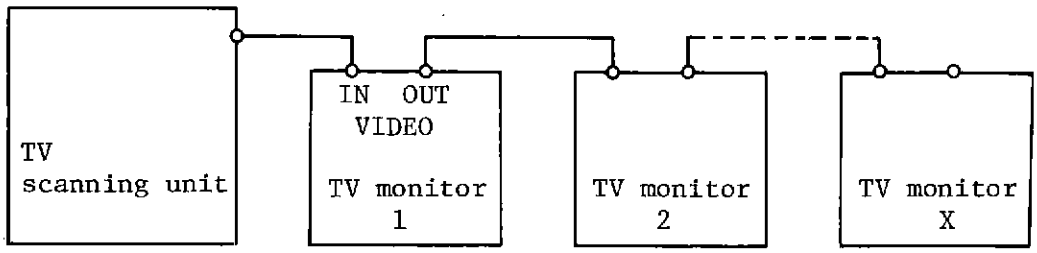
Magnification selection

The magnification is selected by the COARSE knob setting as shown below:

COARSE knob	Magnification
3×10^2	100 - 300
1×10^3	300 - 1000
3×10^3	1000 - 3000
1×10^4	3000 - 10000

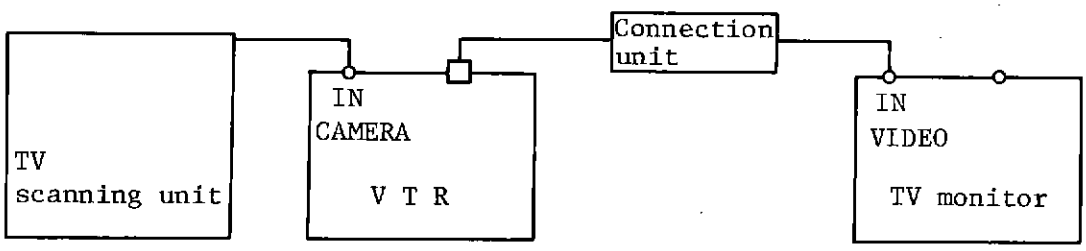
For the COARSE knob settings of 3×10^2 and 3×10^3, read the inner scale of the FINE knob and for the COARSE knob settings of 1×10^3 and 1×10^4, read the outer scale of the FINE knob.

8. PLURAL MONITOR CONNECTIONS

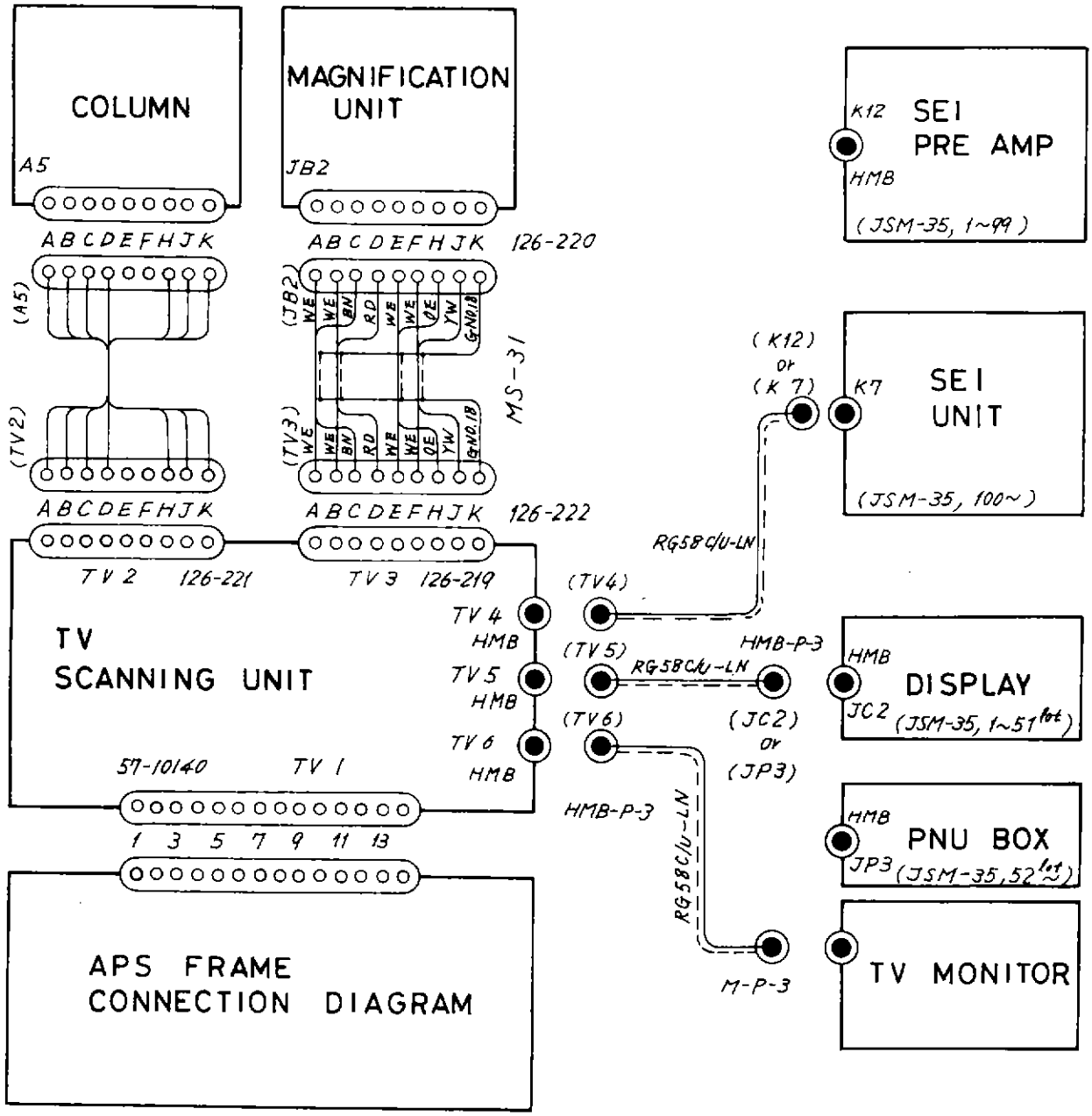


To match the impedance of the line, set the input impedance switch of the last TV monitor (X) to 75 Ω and turn the other monitor input impedance switches off.

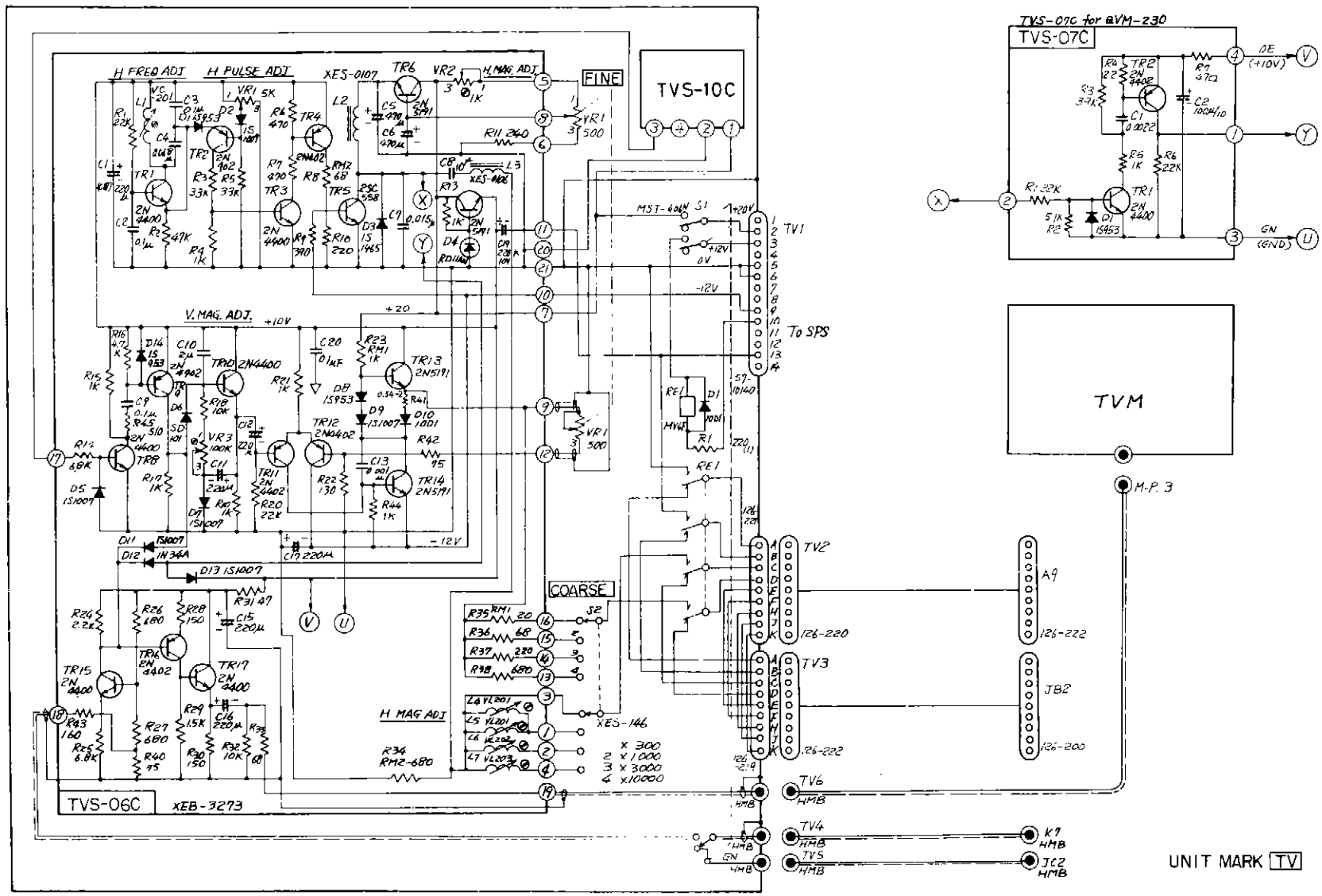
9. VIDEO TAPE RECORDER CONNECTIONS

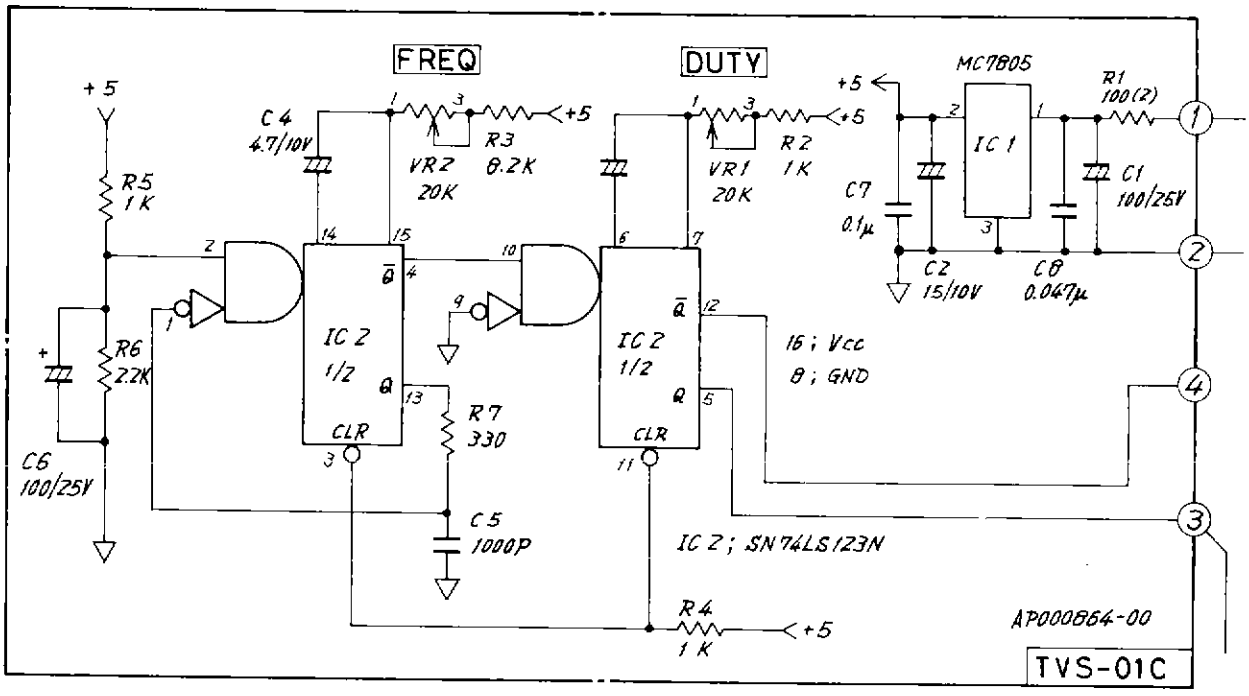


Connect a video tape recorder as per the instructions accompanying with the the recorder.

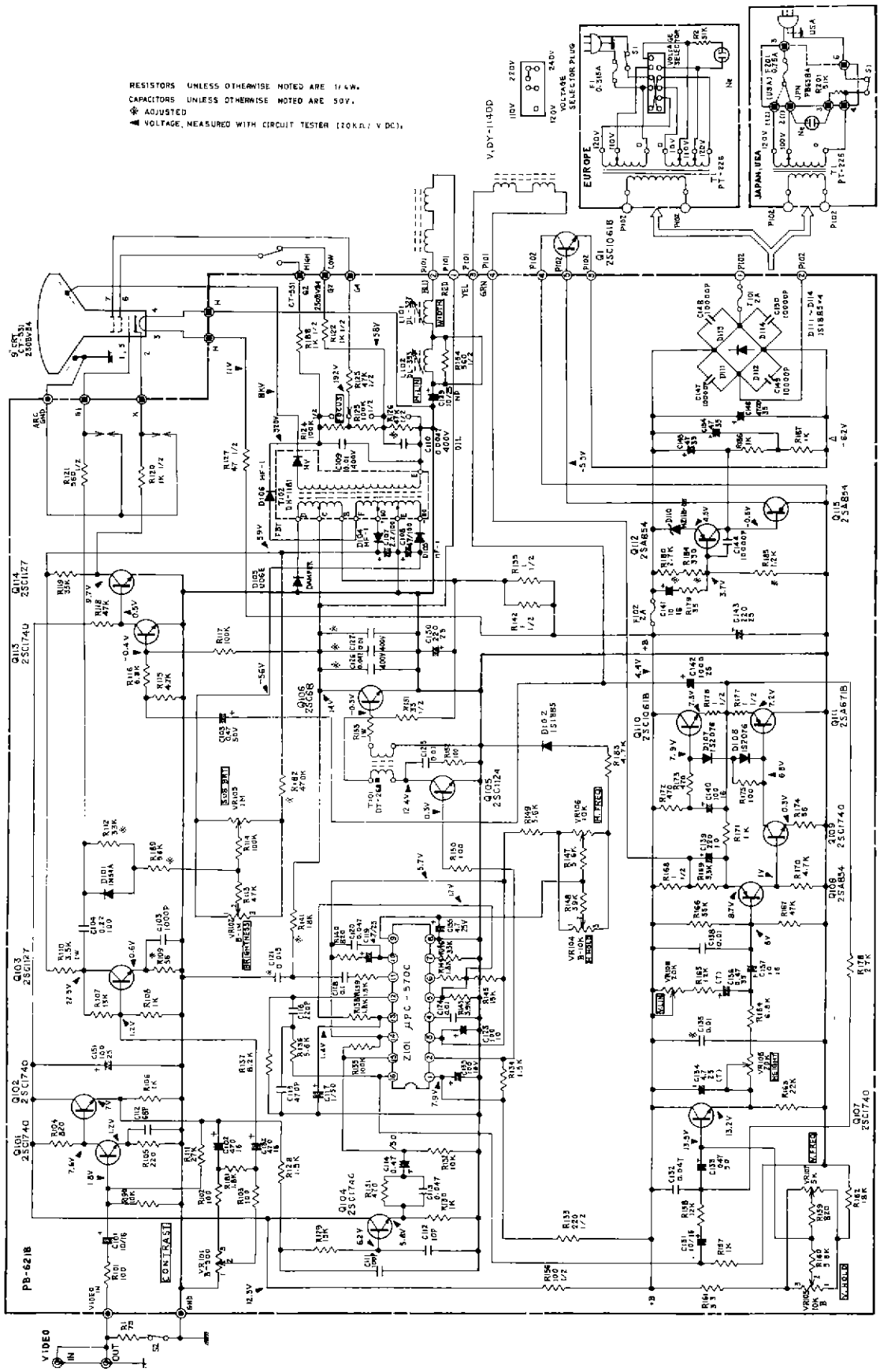


INTERCONNECTION DIAGRAM	606005072


TVS-10C
FINE
COARSE
TVM
TVS-07C for aVM-230
TVS-07C
To SPS
TV1
TV2
TV3
TV4
TV5
TV6
A9
JB2
K7
JC2
M-P. 3
TVS-06C
XEB-3273
XES-0107
XES-146
H FREQ ADJ
H PULSE ADJ
H MAG ADJ
V MAG. ADJ.
UNIT MARK TV



TVS-10C	606212531



TVM CIRCUIT

606270418

INSTRUCTIONS

35-AEM

MICRO-MICRO AMMETER

No. IEP35C-AEM

(EP301022)

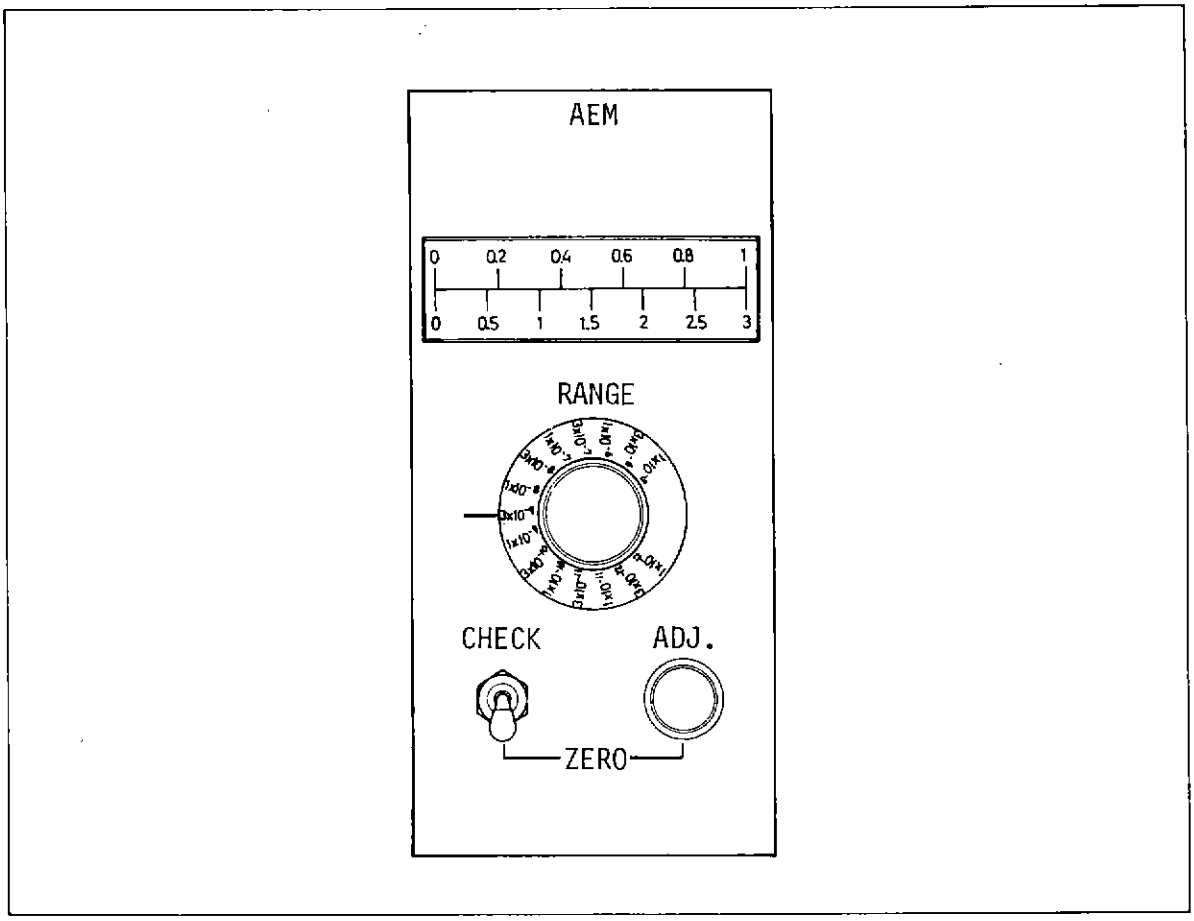


Fig. 1 AEM unit

1. GENERAL

The AEM unit monitors the specimen (absorbed) current which is used to align the axis of the illumination system and set the emission of the electron gun filament.

2. SPECIFICATIONS

- Measurement range: 1×10^{-5} to 1×10^{-12} A.
- Measurement accuracy: ±5%.
- Zero drift: 1%/hr (after 30 minute warmup).
- Output voltage: DC 1 V (max.).
- Output noise: Less than 20 mVp-p.
- Recorder output: 100 mV (max.).
- Power: DC +20 V, 50 mA; DC -12 V, 100 mA.
- Operating temperature: 0 to 50°C.
- Dimensions: 70 mm (W) × 300 mm (D) × 150 mm (H).

3. COMPOSITION

- 35-AEM unit 1
- Cables 2

4. PANEL DESCRIPTION

- AEM meter :
  Micro-micro ammeter for measuring the specimen absorbed current. When the RANGE knob is positioned at $1 \times 10^{-\times}$, read the upper scale; at $3 \times 10^{-\times}$, read the lower scale.
- RANGE knob:
  Changes over the measurement range in 15 steps (10^{-5} to 10^{-12} A).
- ZERO CHECK switch:
  Push up when measuring the absorbed current; push down to check the meter zero setting.
- ZERO ADJ. knob:
  Adjusts zero setting.

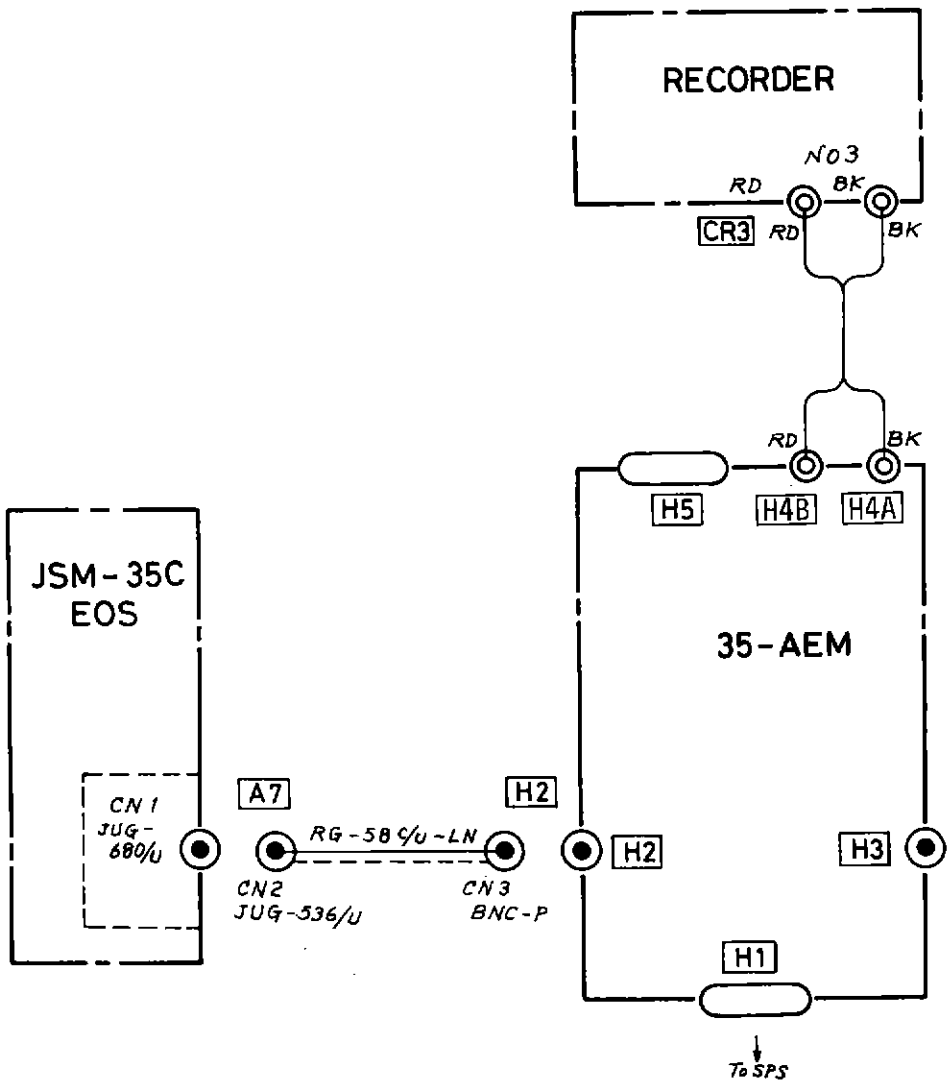
5. INSTALLATION

The AEM unit can be installed in either the operation and display system cabinet or the supplementary cabinet (35-SCB·S-optional). In the case of the former cabinet, however, the AEM unit must be installed in the compartment normally reserved for the VACUUM SYSTEM unit. In this case, remove the VACUUM SYSTEM unit from the cabinet and install it in the supplementary cabinet.

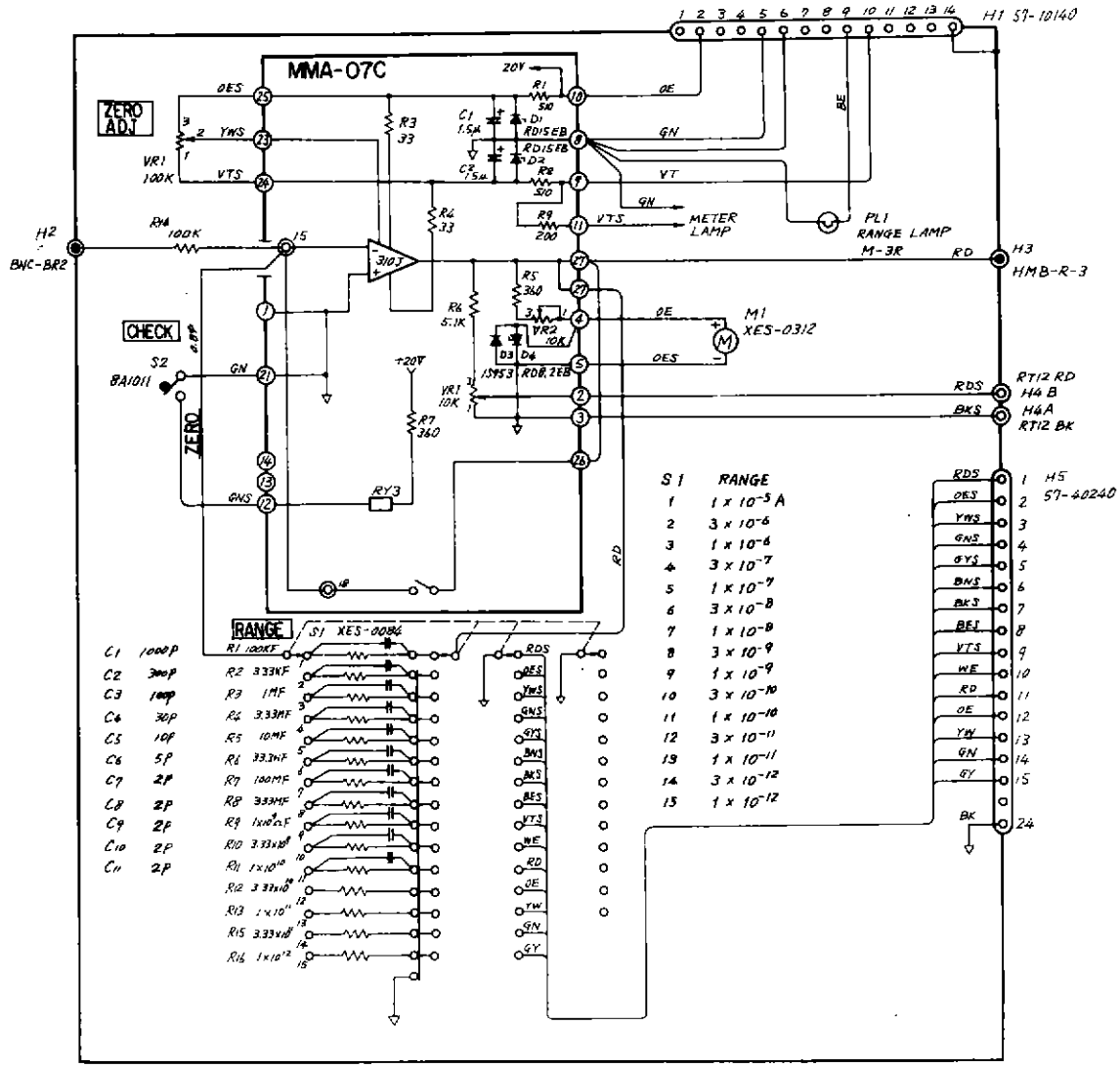
1. Turn off the power to the cabinets and then insert the AEM unit into the cabinet of your choice.
2. Connect up the cables as per the scanning microscope and AEM unit circuit diagrams.
3. Turn on the cabinet power switches.

6. OPERATION

1. Push down the ZERO CHECK switch, check the meter zero setting, and adjust as necessary with ZERO ADJ knob.
2. After setting the RANGE knob to the desired value, push the ZERO CHECK switch up and measure the specimen absorbed current.
   Note: The ZERO CHECK switch should always be set at its lower position when the AEM unit is not in use.



INTERCONNECTION DIAGRAM | XEA-3711a


MMA-07C
ZERO ADJ
VR1 100K
CHECK
S2 BA1011
ZERO
RANGE
S1 XES-0086
M1 XES-0312
PL1 RANGE LAMP
METER LAMP
H1 57-10140
H2 BNC-BR2
H3 HMB-R-3
H4 B RT12 RD
H4A RT12 BK
H5 57-40240
S1 RANGE
1 1 x 10⁻⁵ A
2 3 x 10⁻⁶
3 1 x 10⁻⁶
4 3 x 10⁻⁷
5 1 x 10⁻⁷
6 3 x 10⁻⁸
7 1 x 10⁻⁸
8 3 x 10⁻⁹
9 1 x 10⁻⁹
10 3 x 10⁻¹⁰
11 1 x 10⁻¹⁰
12 3 x 10⁻¹¹
13 1 x 10⁻¹¹
14 3 x 10⁻¹²
15 1 x 10⁻¹²

INSTRUCTIONS

35-BEI·S

BACKSCATTERED ELECTRON DETECTOR

No. IEP35C-BEI·S

(EP304001)

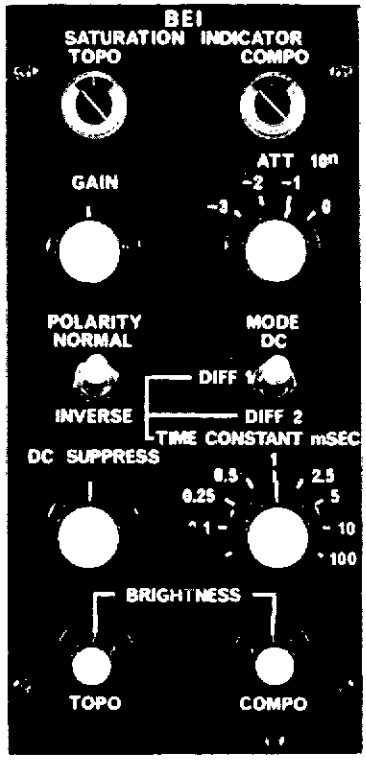


Fig. 1 Operational amplifier unit (BEI unit)

1. GENERAL

This detector is designed for use in conjunction with the JSM-35C Scanning Microscope in order to observe a backscattered electron scanning image of the specimen under examination.

The detector consists essentially of two detecting elements each comprising two semiconductors, a preamplifier, an operational amplifier complete with differentiation circuit, associated cables and connectors, etc.

The backscattered electron scanning image is displayed on the JSM-35C CRTs either as a composition image or topographic image by adding or subtracting the video signals generated by the two detecting elements after being amplified by the pre- and operational amplifiers.

2. SPECIFICATIONS

- Backscattered electron detecting element: Si p-n junction.
- Amplification gain: ×200 to ×100,000
  Preamplifier ..... ×50.
  Operational amplifier ..... ×2,000.
- Video output signals: Topographic and composition image signals.
- Output noise: Less than 0.5 V.
- Bandwidth: DC to 30 kHz.
- Image modes: DC image, differential images 1 and 2.
- Differential time constant: 0.05 to 100 msec (9 steps).
- Image polarity: Positive and negative.
- Level indicator: Built-in (for topographic and composition image signals).
- Power requirements: DC ±20V, 50 mA.
- Operating temperature: 0 to 50°C.
- Dimensions: Preamplifier unit:
  90 mm (W) × 38 mm (D) × 38 mm (H).
  Operational amplifier unit:
  70 mm (W) × 300 mm (D) × 150 mm (H).

3. COMPOSITION

- Detecting elements mounted in detector complete with cord and connector ..... 1 set.
- Preamplifier unit complete with plug-in cable ..... 1.
- Operational amplifier unit (BEI unit) ..... 1.
- Interunit connecting cables ..... 1 set.
- Hook ..... 1.

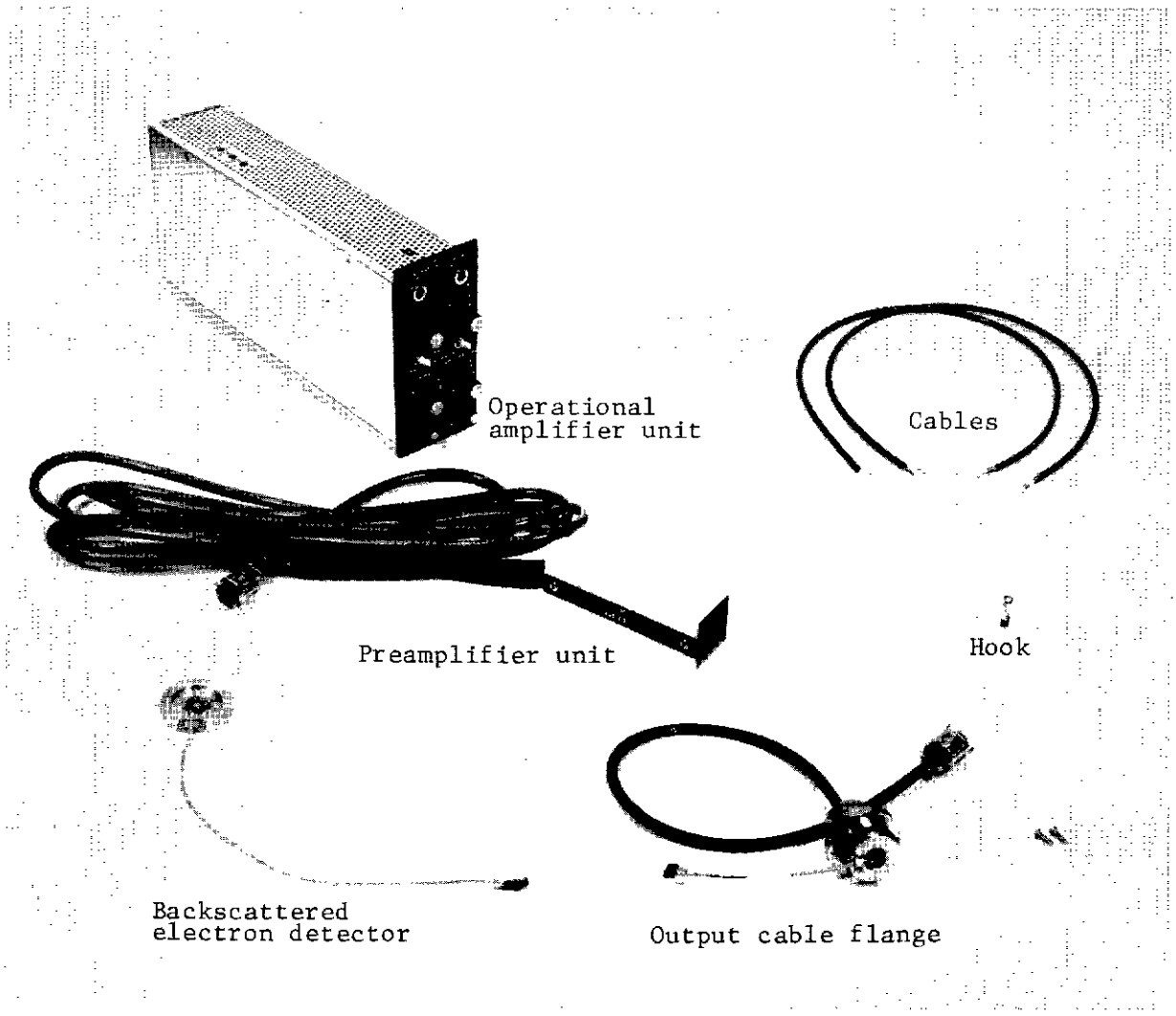


Fig. 2 Component parts

4. PANEL DESCRIPTION

Operational amplifier unit (BEI unit)

- SATURATION INDICATOR (TOPO & COMPO)
  Indicate the DC level of the TOPO (topographic) image and COMPO (composition) image input signals.
- GAIN knob
  Controls the image contrast by varying the amplifier gain.
- POLARITY switch
  Selects the polarity of the video output signal. At NORMAL, a normal or positive image is displayed on the CRT, and at INVERSE, an inversed contrast or negative image is displayed on the CRT. The INVERSE setting is useful for making photographic slides.
- DC SUPPRESS knob
  Adjusts the DC level of output signal from the preamplifier to protect on the TOPO and COMPO saturation indicators.
- ATT 10^n knob
  Attenuates the signal from the preamplifier, varying over 4 steps (×1, ×1/10, ×1/100, ×1/1000).
- MODE switch
  Selects the video signal in 3 modes, DC (direct current), and DIFF (differentiation) 1 & 2. Fig. 3 shows the relationship between the input and output signals for the respective modes.
  When the MODE switch is set to DIFF 1, the grain boundaries of the composition image can be observed clearly. When set to DIFF 2, the image presents 3D-appearance and the grain structure disappears.

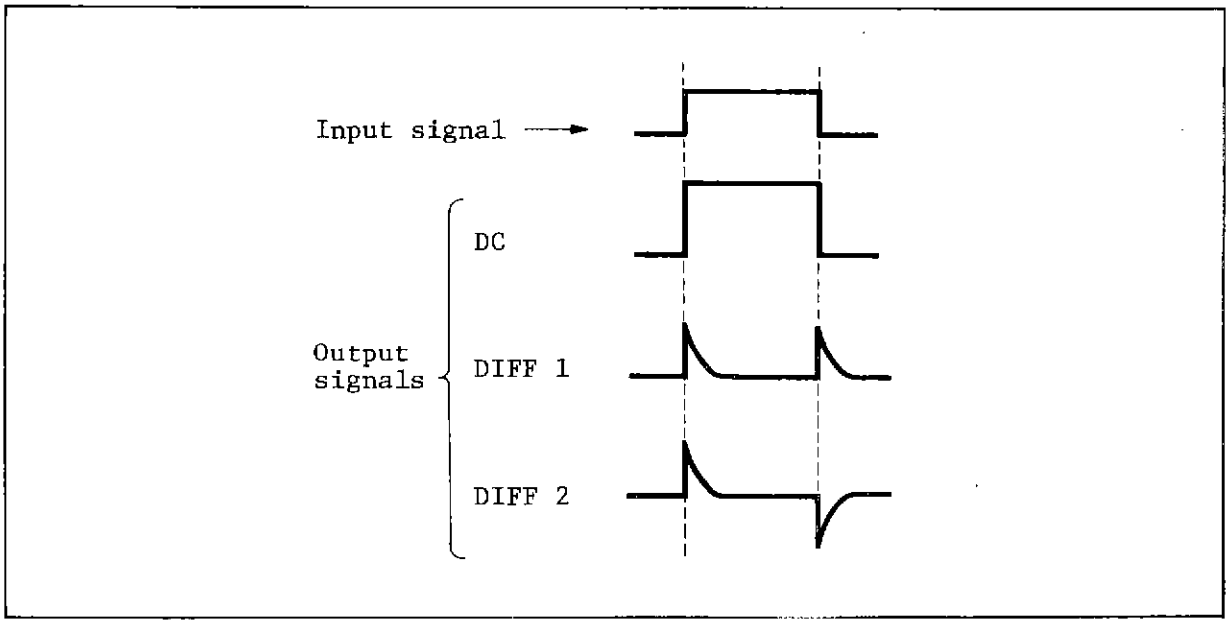


Fig. 3 Video signal modes

- TIME CONSTANT switch

  Selects the time constant for the differential images. Selectable between 0.05 and 100 msec in 9 steps (0.05, 0.1, 0.25, 0.5, 1, 2.5, 5, 10, 100 msec). The faster the scan speed is, the smaller the time constant should be selected.

- BRIGHTNESS (TOPO & COMPO) knobs

  Control the brightness of the topographic and composition images respectively by varying the output signal level of the operational amplifier.

5. PRINCIPLE OF OPERATION

Fig. 4 is block schematic showing the processing of the input signals in order to form composition and topographic images.

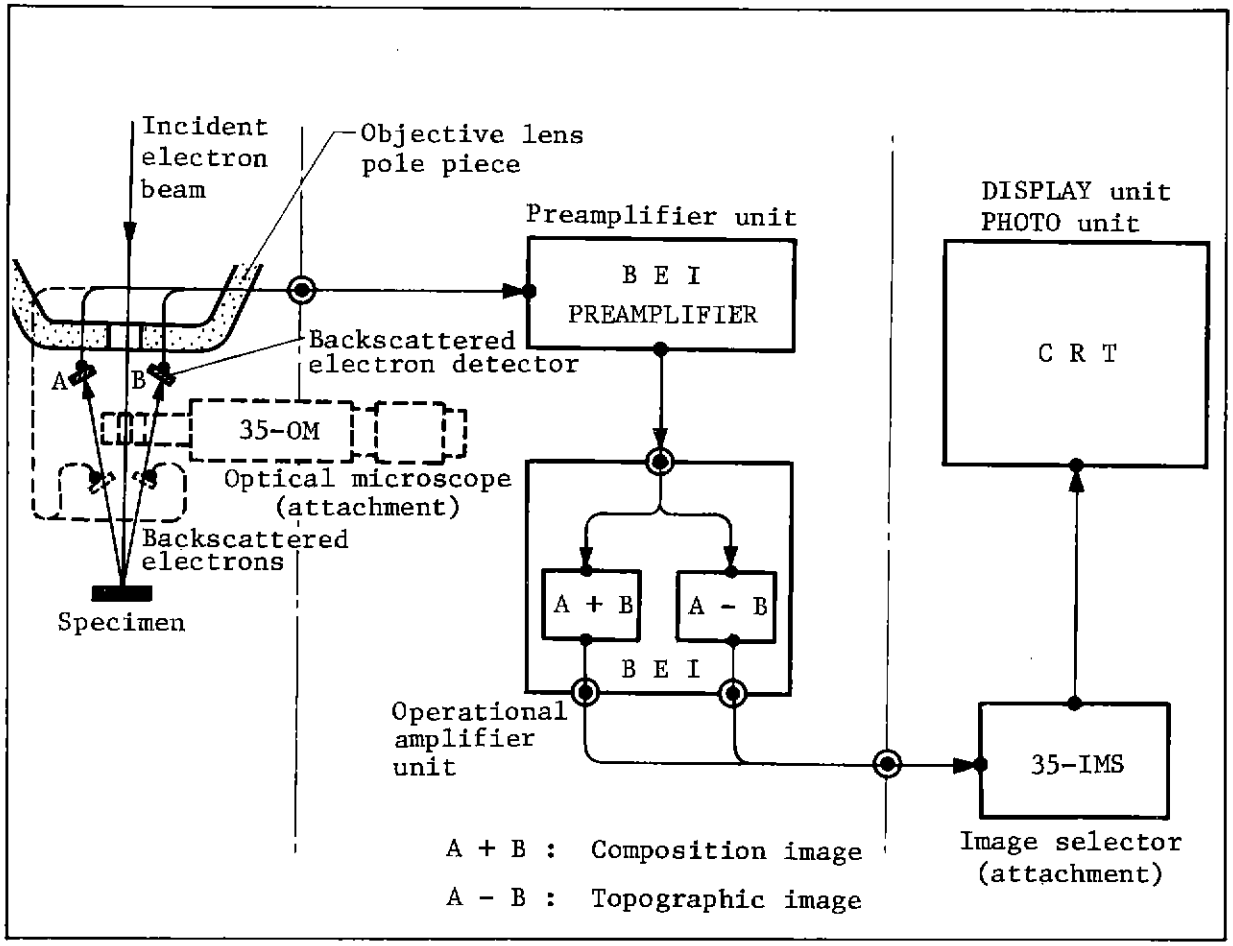


Fig. 4 Block schematic

Referring to the figure, the specimen surface is scanned by an incident electron beam. As a result, backscattered electrons are emitted which contain information pertaining to elemental discrimination and the surface topography of the specimen. These emitted electrons containing said information are detected by detecting elements A and B arranged symmetrically with respects to the optical axis of the scanning microscope and the quantitative variation of each bundle of detected electrons is converted into an electrical signal. Incidentally, if the scanning microscope is equipped with a 35-OM optical microscope, the detecting elements attached to the OM are used instead of the above detecting elements A and B. The two signals are then amplified by the preamplifier and then fed into the operational amplifier where, in addition to further amplification, the signals are processed. That is to say, the signals entering the A + B circuit are added to form a composition image signal and the signals entering the A - B

circuit are subtracted to form a topographic image signal as shown in Fig. 5. The composition and topographic image signals are then applied to an image selector (IMS) where the desired signal is selected and applied to the display unit in order to modulate the brightness of the CRT which is syncronized with the scanning of the electron beam.

By adjusting the GAIN (amplifier gain), the DC SUPPRESS (direct current level), the BRIGHTNESS (amplifier signal level) and the ATT 10^n controls appropriately, an image corresponding to the information contained in the backscattered electrons emitted from the specimen can be obtained under optimum contrast and brightness conditions. Further, by setting the MODE switch to DIFF 1 or DIFF 2 and selecting the time constant with the TIME CONSTANT switch, a differential image can be obtained.

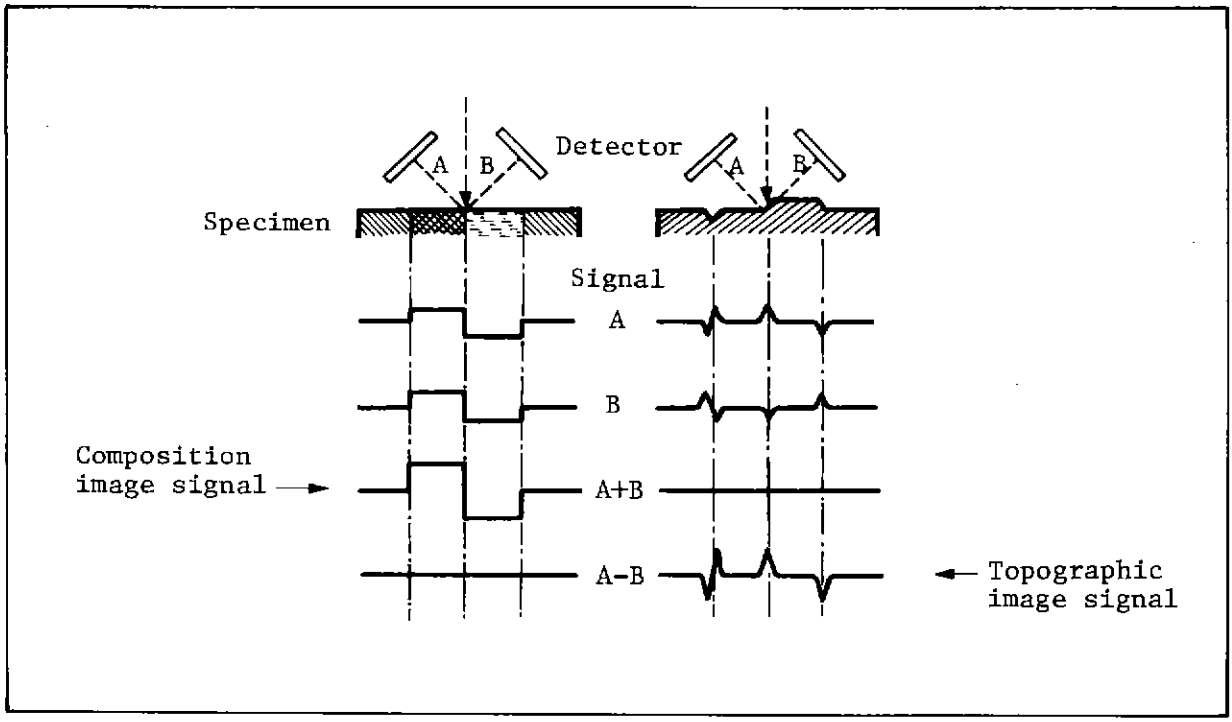


Fig. 5 Signal processing

6. INSTALLATION

Note: If the JSM-35C Scanning Microscope is equipped with a 35-OM Optical Microscope, it will not be necessary to remove the protection cylinder as the OM detecting elements are used in place of the 35-BEI detecting elements (skip Steps 4 and 5).

1. Set the following specimen stage (goniometer stage) controls as indicated.
   - TILT control ..... 0°
   - WD control ..... 39 mm

   Note: If it is necessary to open the front cover, be sure to complete Step 1 before doing so. If the front cover is opened without carrying out Step 1, the stage will come into contact with the objective lens pole piece.
2. Expose the microscope column to the atmosphere as per the normal procedure.
3. Pull the lock lever and open the front cover attached to the stage.
4. Remove the standard protection cylinder from the objective lens pole piece.
5. Attach the backscattered electron detector to the objective lens by screwing the detector into the objective lens, orient it as shown in Fig. 6 and secure with two screws.

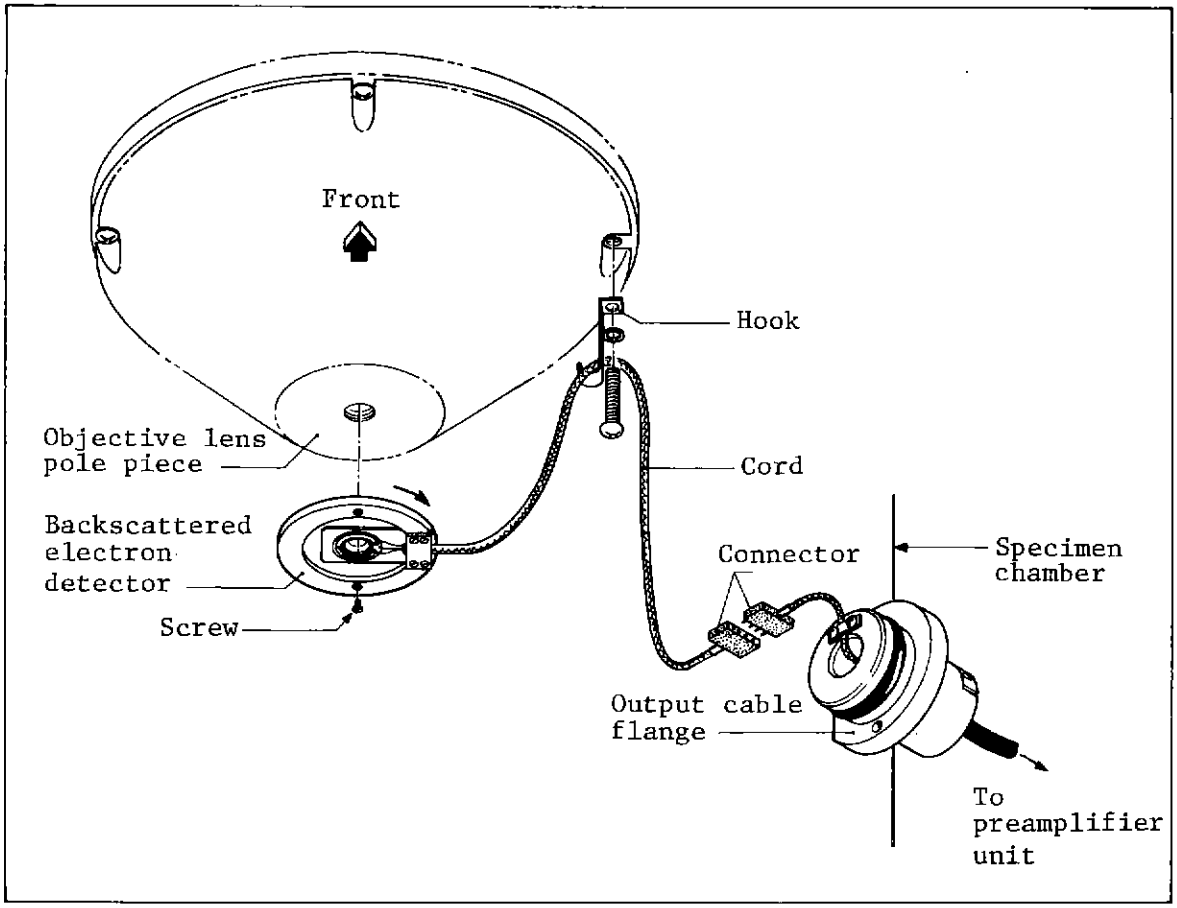


Fig. 6 Installing the detector

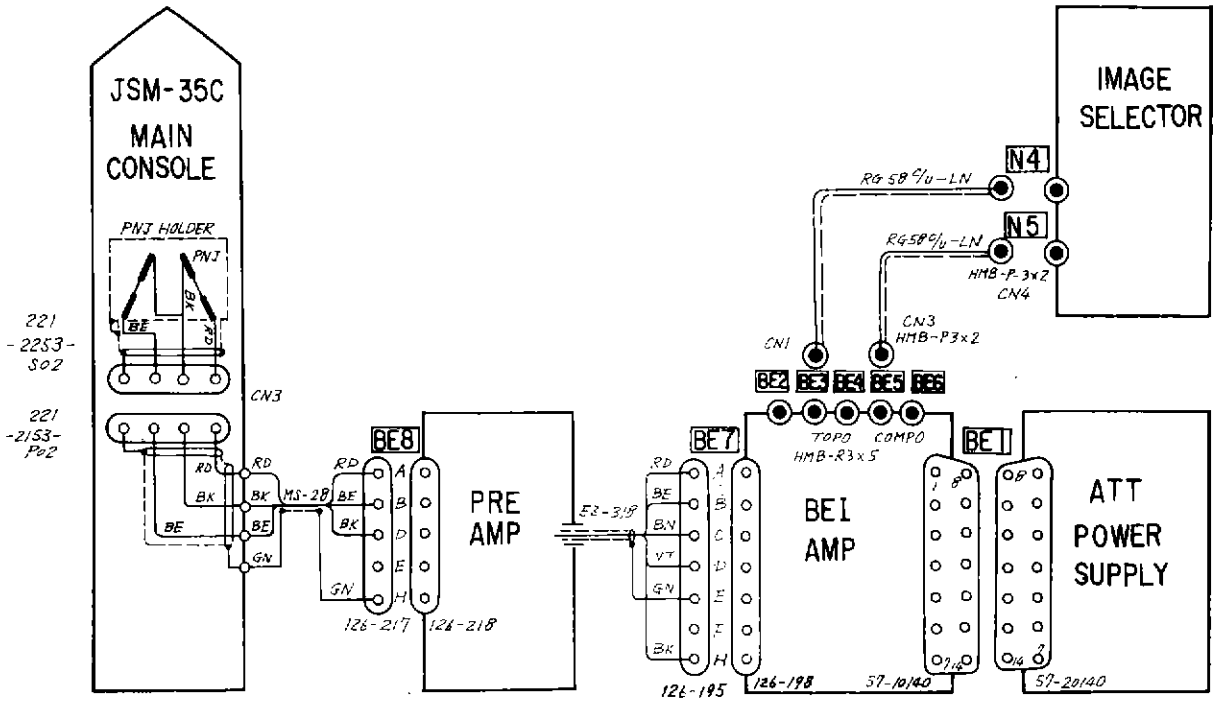
6. Attach the hook with the right pole piece securing screw (see Fig. 6).
7. Remove the semi-circular blank cover at the right rear side of the specimen chamber and replace it with the output cable flange (Fig. 6).
8. Suspend the detector cord on the hook and then plug in the connector.
   Note: Plug in the connector so that the coluors of the respective detector cord and output cable lead wires accord.
9. Close the front cover and re-evacuate the column as per the normal procedure.
10. Disengage the supplementary power supply (35-SPS1: attachment) switch.
11. Install the operational amplifier unit (BEI unit) in the supplementary cabinet (35-SCB.S: attachment).

7. OPERATION

1. Obtain a secondary electron image.
   The purpose of this step is to position the control panel knobs and switches so as to make the following procedure easier.
   Notes: 1. Use the 240 μm diameter objective lens aperture (aperture selector No. 2).
   2. Normally, to obtain an optimum contrast image, the absorbed specimen current should be more than 10^{-10} A in the case of composition images and more than 10^{-9} A in the case of topographic images. The absorbed current is adjusted with the CONDENSER knob; to measure the absorbed current, however, a 35-AEM Micro-Micro Ammeter is required.
2. Position the following controls on the operational amplifier panel as indicated.
   - GAIN knob ..... fully counterclockwise
   - POLARITY switch ..... NORMAL
   - BRIGHTNESS knobs ..... fully counterclockwise
   - MODE switch ..... DC
   - DC SUPPRESS knob ..... fully counterclockwise
   - ATT 10^n knob 0
3. Push the IMS image selector TOPO or COMPO button according to the image to be displayed.
4. Level the specimen (tilt control dial reading: 0°) and set the working distance to 15 or 39 mm.
   Note: If the JSM-35C is equipped with a 35-OM Optical Microscope, since the OM detecting elements are used in place of the 35-BEI detecting elements, it will be necessary to set the optical microscope in the beam path after first setting the working distance to 39 mm.
5. Adjust the DC SUPPRESS knob so that the SATURATION INDICATOR (TOPO, COMPO) indicators are at the midway position on their respective scales.
   Note: If the needle goes beyond the scale when the DC SUPPRESS knob is turned fully clockwise, lower the input signal level of the BEI unit by setting the ATT knob at -1, -2, and -3 in sequence until the indicator can be read (the level of the input signal will be reduced by a factor of 10, 100 and 1000, respectively.)
6. Turn the BRIGHTNESS (TOPO, COMPO) knob clockwise to obtain the optimum raster intensity.
7. Turn the GAIN knob to obtain the optimum contrast image.
8. Obtain the required magnification with the MAGNIFICATION (COARSE and FINE) knobs and the desired field of view with the specimen shift controls (X- and Y-controls).
9. Focus the image with the OBJECTIVE LENS (MEDIUM and FINE) knobs.
   Note: If necessary, position the MODE selecting knob at DIFF 1 or 2 to obtain a differential image and select the time constant according to the scanning speed with the TIME CONSTANT knob. At DIFF 1, the boundaries of the various elemental components constituting the composition image can be clearly observed and at DIFF 2,

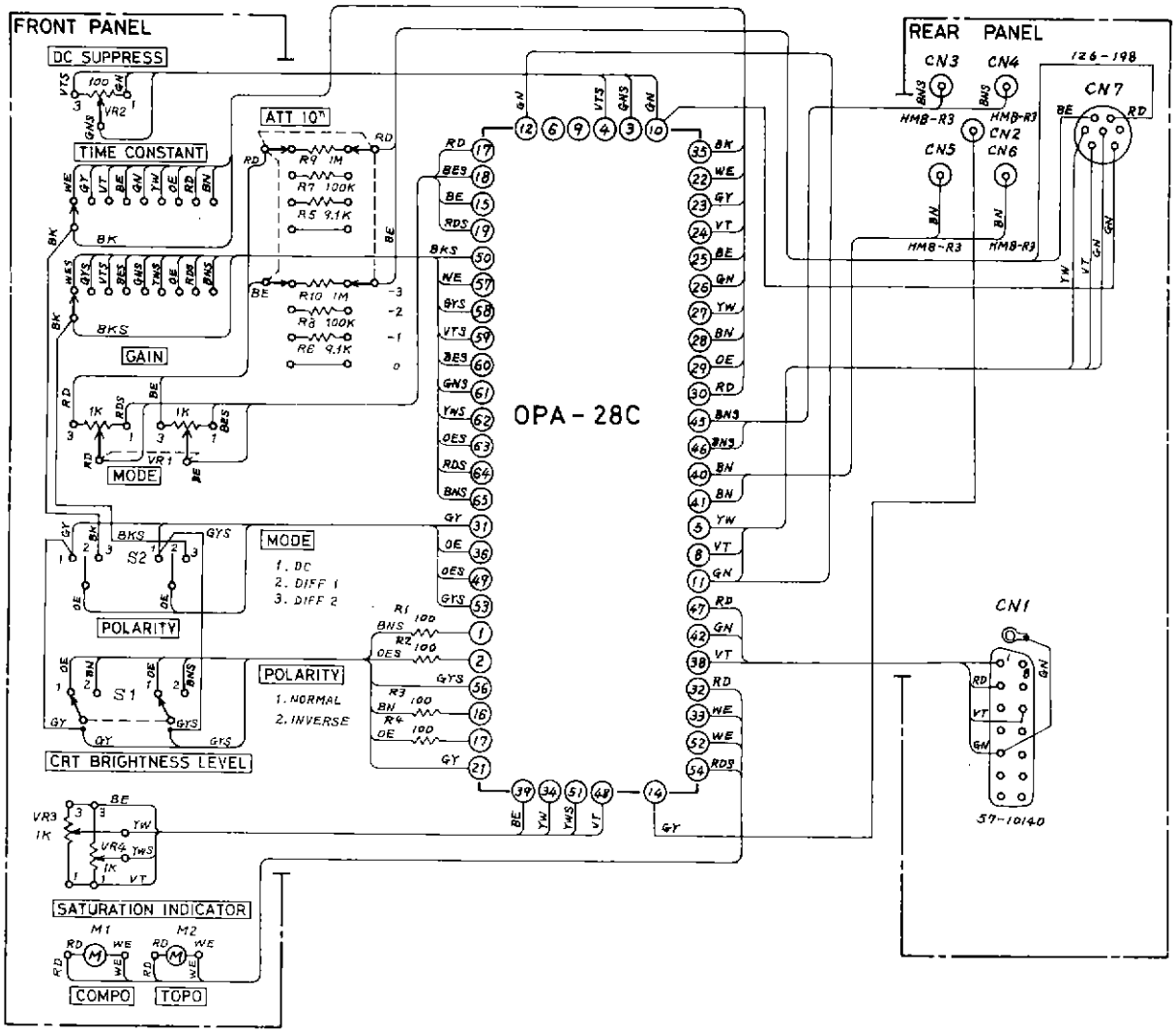
the image can be viewed stereoscopically. Further, as the horizontal scanning speed (msec/line) increases, decrease the time constant (msec).

10. Adjust the DC SUPPRESS and GAIN knobs to set the video signal for proper photography while observing the waveform monitor, then take micrographs (see JSM-35C manual).



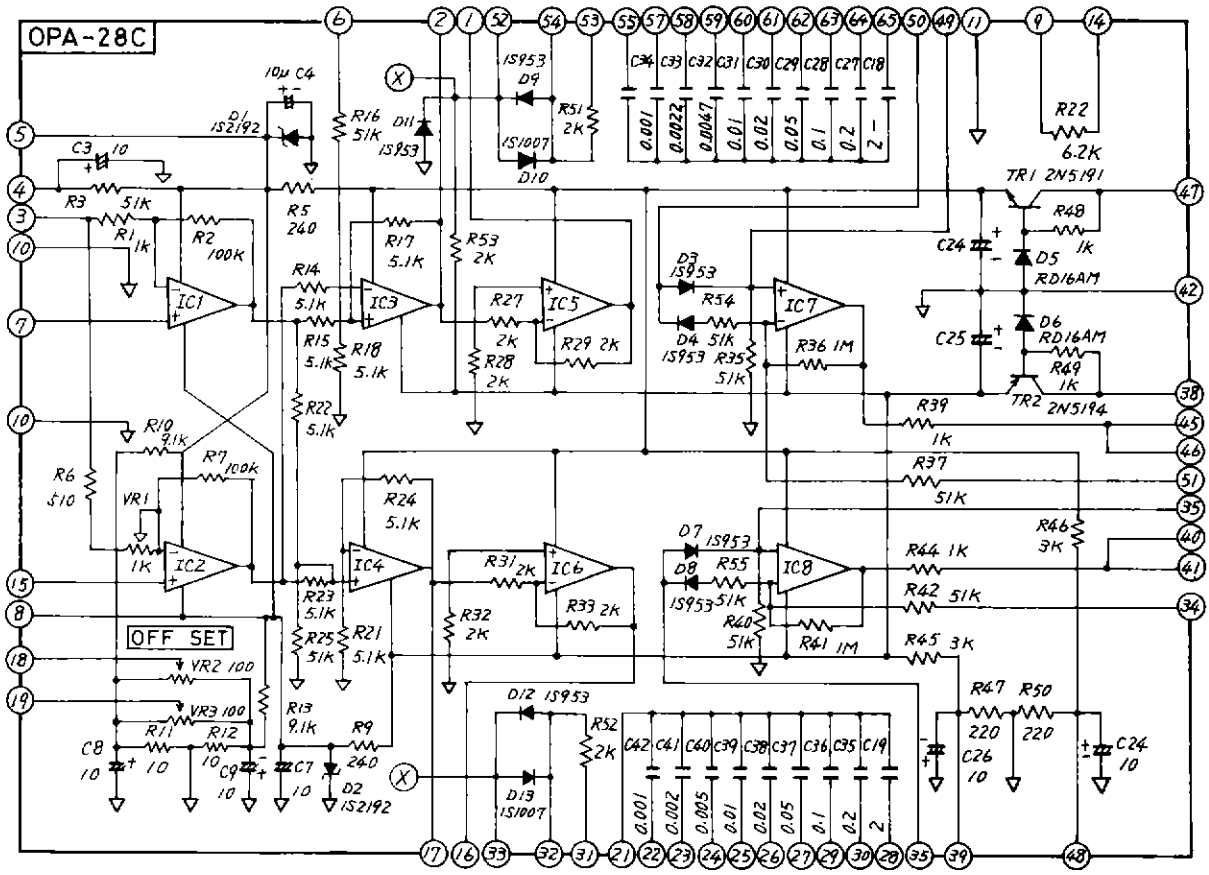
INTERCONNECTION DIAGRAM

606212339



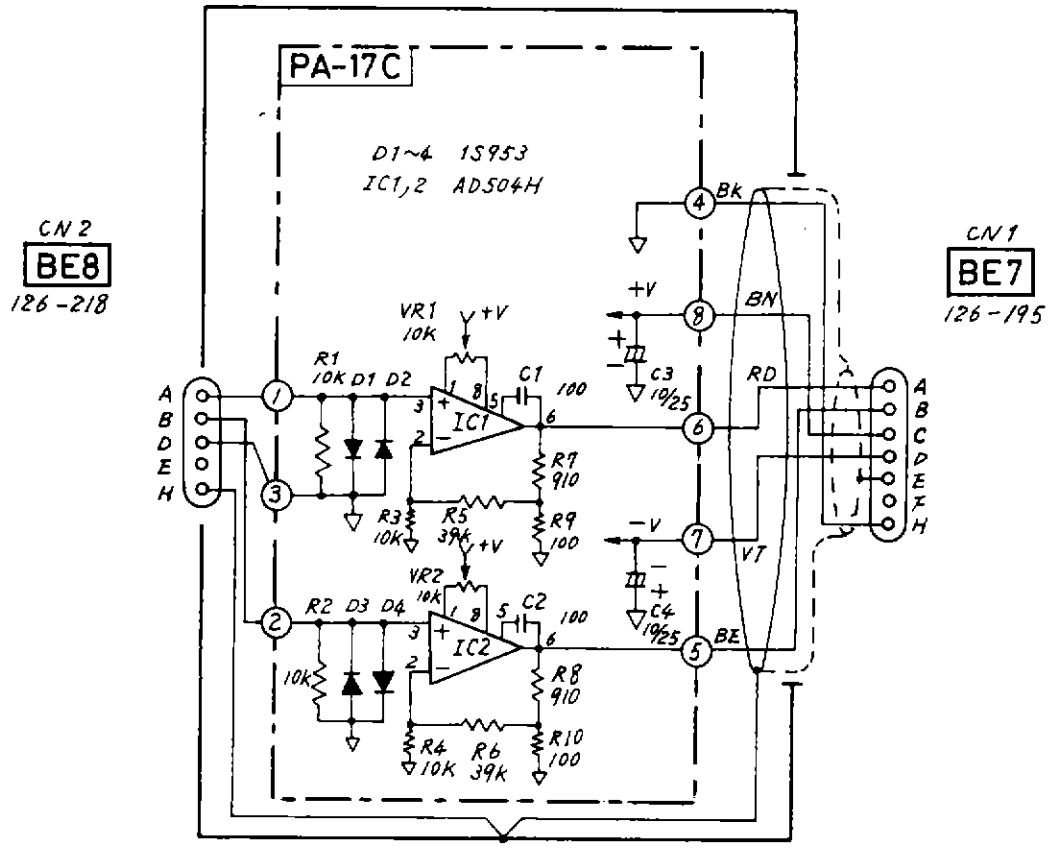
BEI AMPLIFIER

606212311



IC 1 ~ 8 : LF356H

OPA-28C	606212329



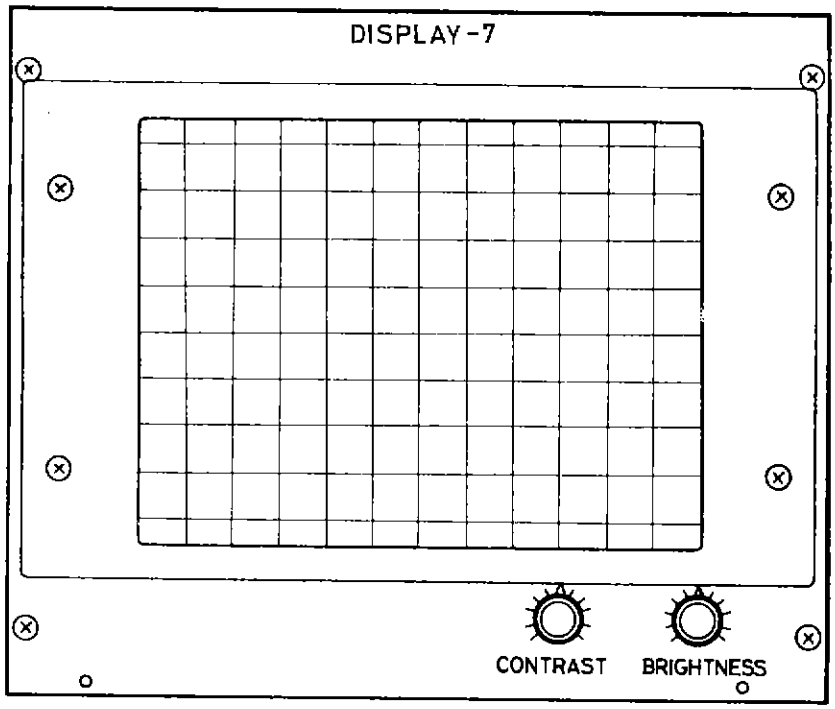
PA-17C	606212302
PRE AMP	606212299

INSTRUCTIONS

35-DU7

7" DISPLAY UNIT

No. IEP35C-DU7
(EP337012)



7" display unit

1. GENERAL

This unit is designed for combined use with the standard CRT so as to directly observe two different kinds of images at the same time; e.g., a secondary electron image and an X-ray image.

The 35-DU7 is driven by the standard SCAN GENERATOR unit and the image to be displayed is selected by the image selector (35-IMS, attachment).

2. SPECIFICATIONS

Scan mode:	Frame, line, spot
CRT (Image size):	170AB7 (120 mm × 90 mm)
Linearity:	Better than 3%
Input impedance:	10 kΩ
Power requirements:	DC ±20 V, 0.5 A; DC ±40 V, 0.6 A; DC ±12 V, 100 mA; +14 kV, 10 μA, +500 V; 2 mA
Dimensions:	175 mm (W) × 150 mm (H) × 300 mm (D)
Operating temperature:	0 to 50°C

3. COMPOSITION

7 inch CRT complete with associated circuits ..... 1 set

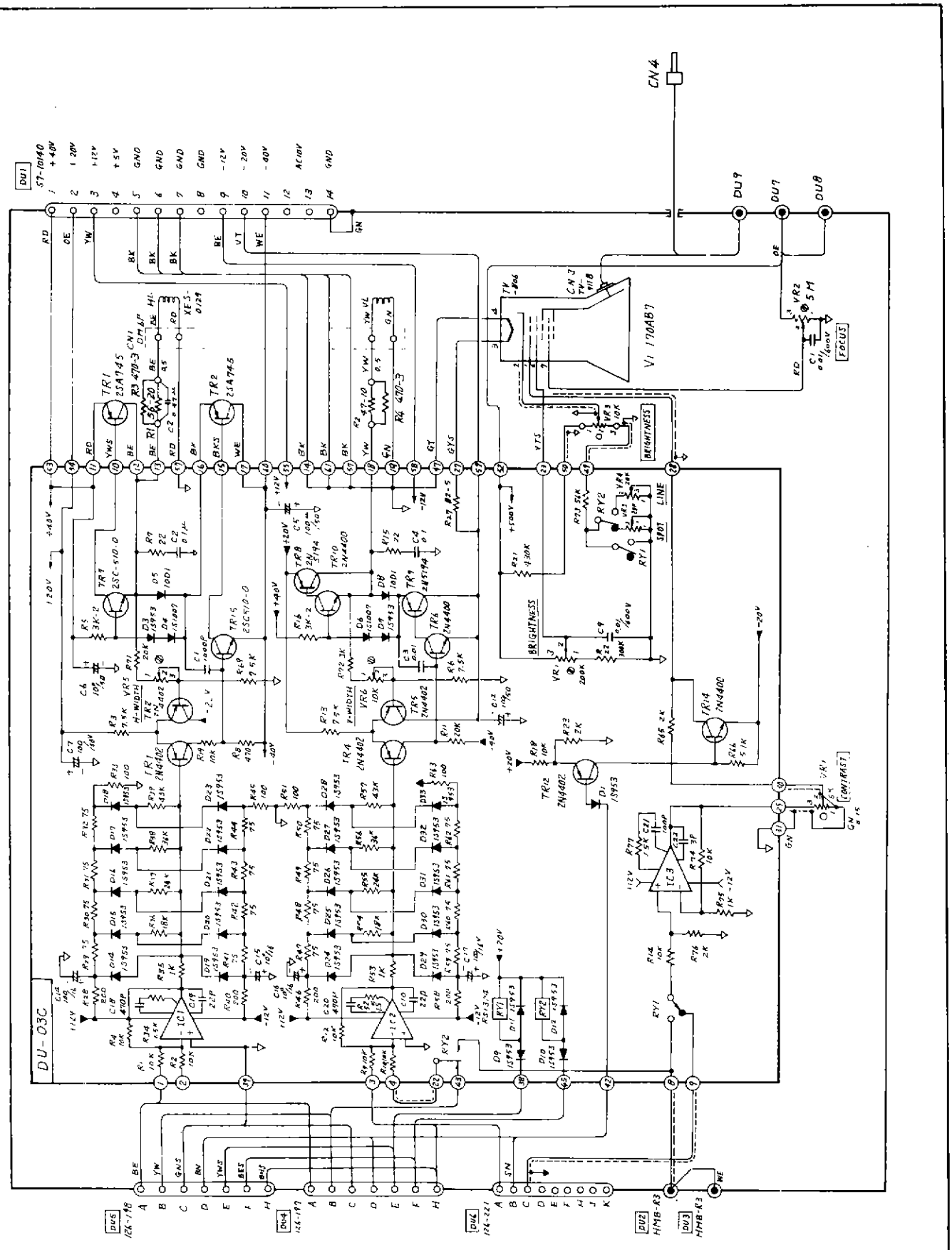
4. INSTALLATION

1. Turn off the 35-SPS1 Supplementary Power Supply switch and then mount the 35-DU7 7" Display Unit on the rack.
2. Connect the cables by referring to the 35-DU7 circuit diagram.
3. Turn on the supplementary power supply switch.

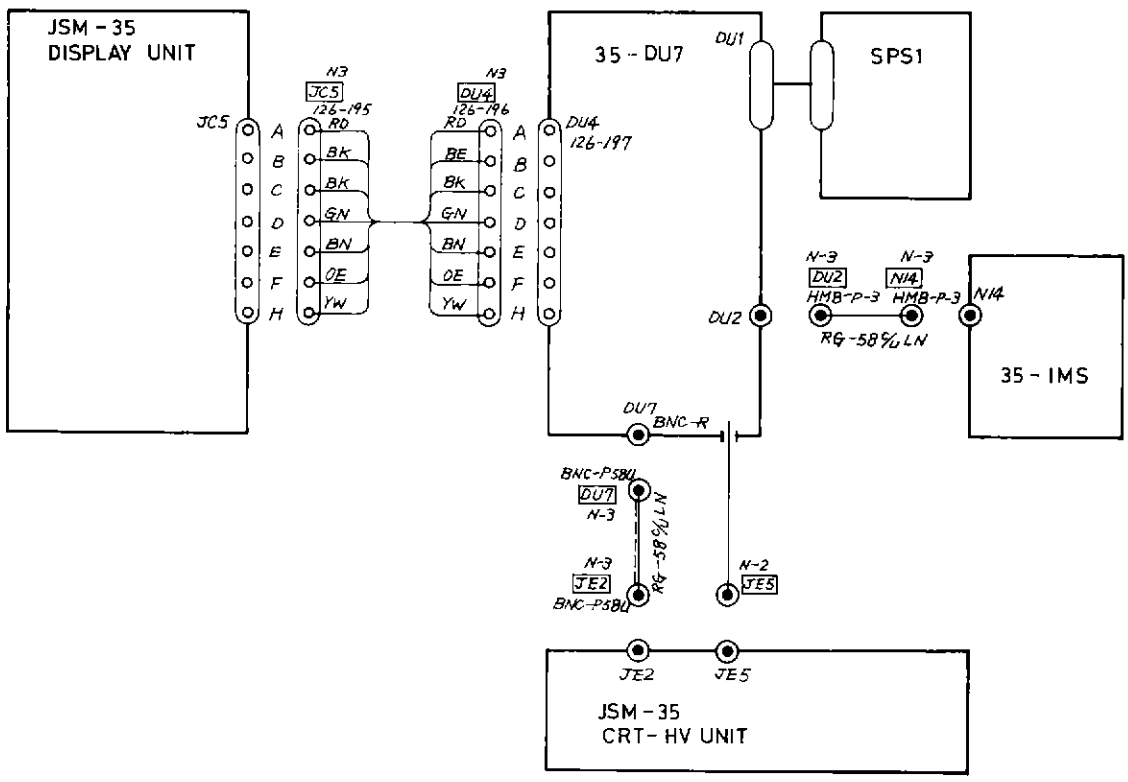
Notes:

1. With RAPID1 and 2, the DU7 is inoperative.

2. The DU7 is not interlocked with the astigmatism monitor.



35-DU7 7" DISPLAY UNIT | XEC-3648



INTERCONNECTION DIAGRAM

XEC-3650

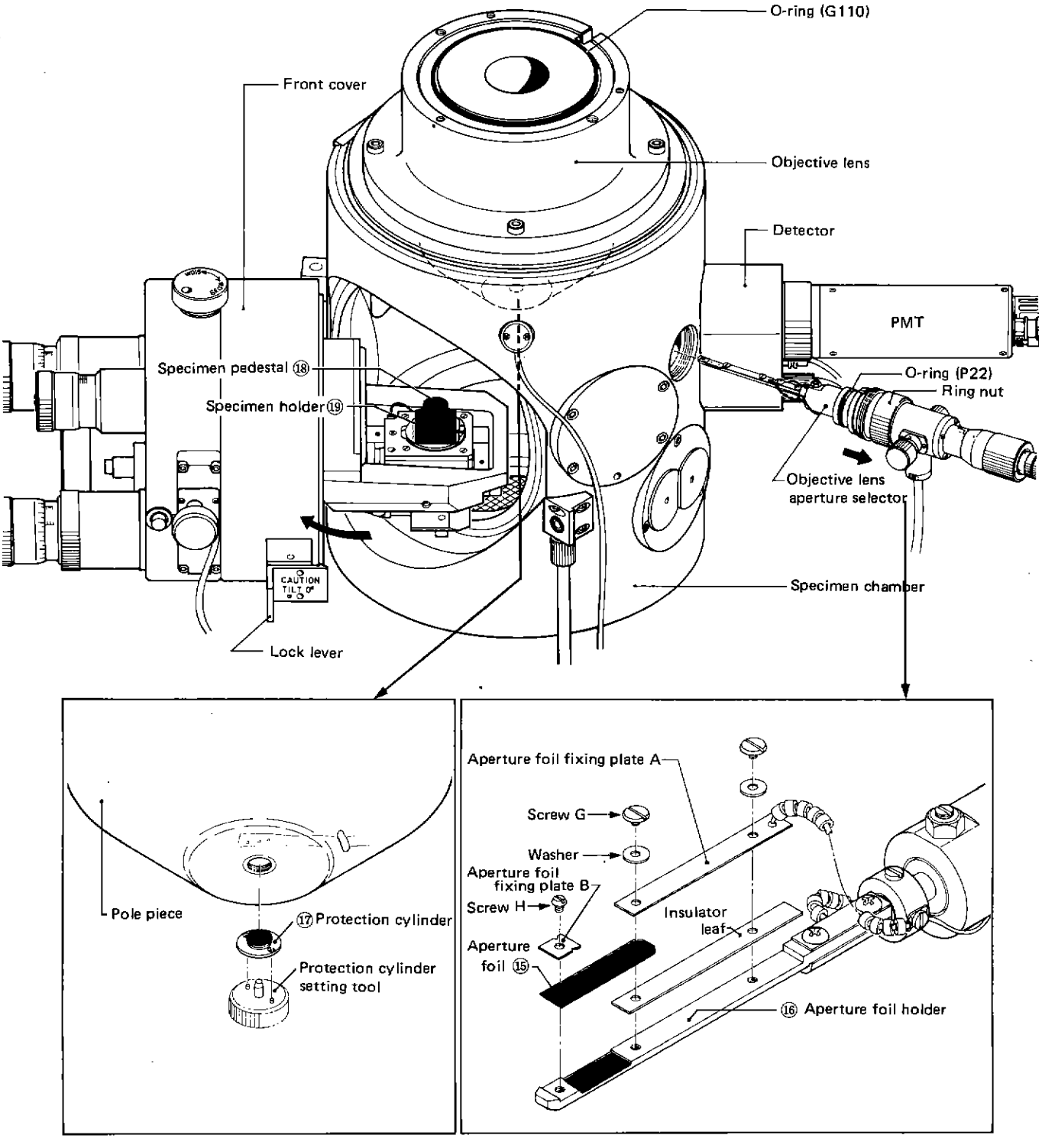


Fig. 6.18 Disassembling the objective lens and specimen chamber

See overleaf, Fig. 6.19

6. Screw the anode in the anode chamber flange.
7. Seat the O-rings on the anode chamber flange and the lower anode chamber after checking the O-rings and their contact surfaces.
8. Unite the upper and lower anode chambers, place the electron gun and anode chambers on the anode chamber flange concentrically while holding the lower anode chamber, and secure the anode chamber with the clamps and screws A.

   Caution: During this step, take care so as not to tip over the upper anode chambers.
9. Connect the connecting pipe to the lower anode chamber after checking the O-ring, and slightly turn the securing ring to secure the pipe.
10. Secure the high voltage cable in place with the clamps.
11. Open the upper anode chamber, replace the Wehnelt assembly, and close the upper anode chamber.
12. Set the UNATTENDED OPERATION switch on the master power supply panel to its lower position.
13. Evacuate the column according to Section 6.1.2.

6.6.4 Location of O-rings

The column and vacuum system O-rings are located as shown in Fig. 6.20. To prevent confusion, the O-rings in their entirety are not shown. That is, O-rings having the same specification and used on similar parts have been omitted.

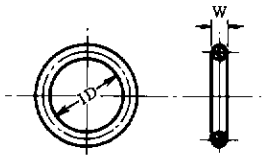
The vacuum valves in parentheses correspond with those in Fig. 3.8, where LV3 and V2 are the same as LV3′ and V3, respectively, and valves with an asterisk are identical.

Table 6.2 lists the O-ring part numbers, the size in millimeters and quantity. The O-ring size, thickness, etc. corresponding to each part number is dimensioned in accordance with JIS (Japanese Industrial Standards).

Table 6.2 O-ring list

JIS B 2401 (Material: Viton)

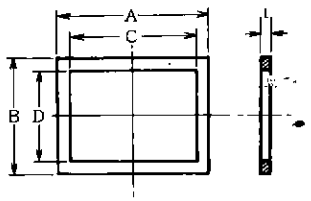
Number	Size (mm)		Qty.
	W	ID	
P 3	1.9 ± 0.07	2.8 ± 0.12	1
P 4	〃	3.8 〃	6
P 5	〃	4.8 〃	4
P 6	〃	5.8 〃	1
P 8	〃	7.8 〃	9
P 9	〃	8.8 〃	3
P 10	〃	9.8 〃	7
P 10A	2.4 ± 0.07	9.8 〃	8
P 12	〃	11.8 〃	6
P 14	〃	13.8 〃	2
P 16	〃	15.8 〃	1
P 18	〃	17.8 〃	2
P 20	〃	19.8 ± 0.15	4
P 22	〃	21.8 〃	1
P 22A	3.5 ± 0.1	21.7 〃	2
P 25	〃	24.7 〃	1
P 26	〃	25.7 〃	3
P 30	〃	29.7 〃	12
P 31.5	〃	31.2 〃	2
P 32	〃	31.7 〃	3
P 38	〃	37.7 〃	1
P 42	〃	41.7 ± 0.25	1
P 44	〃	43.7 〃	1
P 50	〃	49.7 〃	2
P 60	5.7 ± 0.15	59.6 〃	2
P 67	〃	66.6 〃	1
P 85	〃	84.6 ± 0.4	1
P125	〃	124.6 〃	1
P145	〃	144.6 ± 0.6	1



Number	Size (mm)		Qty.
	W	ID	
G 25	3.1 ± 0.1	24.4 ± 0.15	6
G 45	〃	44.4 ± 0.25	2
G 50	〃	49.4 〃	1
G 55	〃	54.4 〃	4
G 60	〃	59.4 〃	1
G 65	〃	64.4 〃	7
G 70	〃	69.4 〃	2
G 75	〃	74.4 ± 0.4	1
G100	〃	99.4 〃	1
G110	〃	109.4 〃	8
G120	〃	119.4 〃	2
G185	5.6 ± 0.15	184.3 ± 0.8	1

JIS W 1516 (Material: Viton)

Number	Size (mm)		Qty.
	W	ID	
P 20	3.53 ± 0.10	26.57 ± 0.15	13
G40	3.53 ± 0.10	177.39 ± 0.58	1



Square gasket

Number	A	B	C	D	E	t	Qty.
S1	—	—	—	—	22	5	1
S2	125	93	115	83	—	$4.3_{-0.1}^{0}$	2

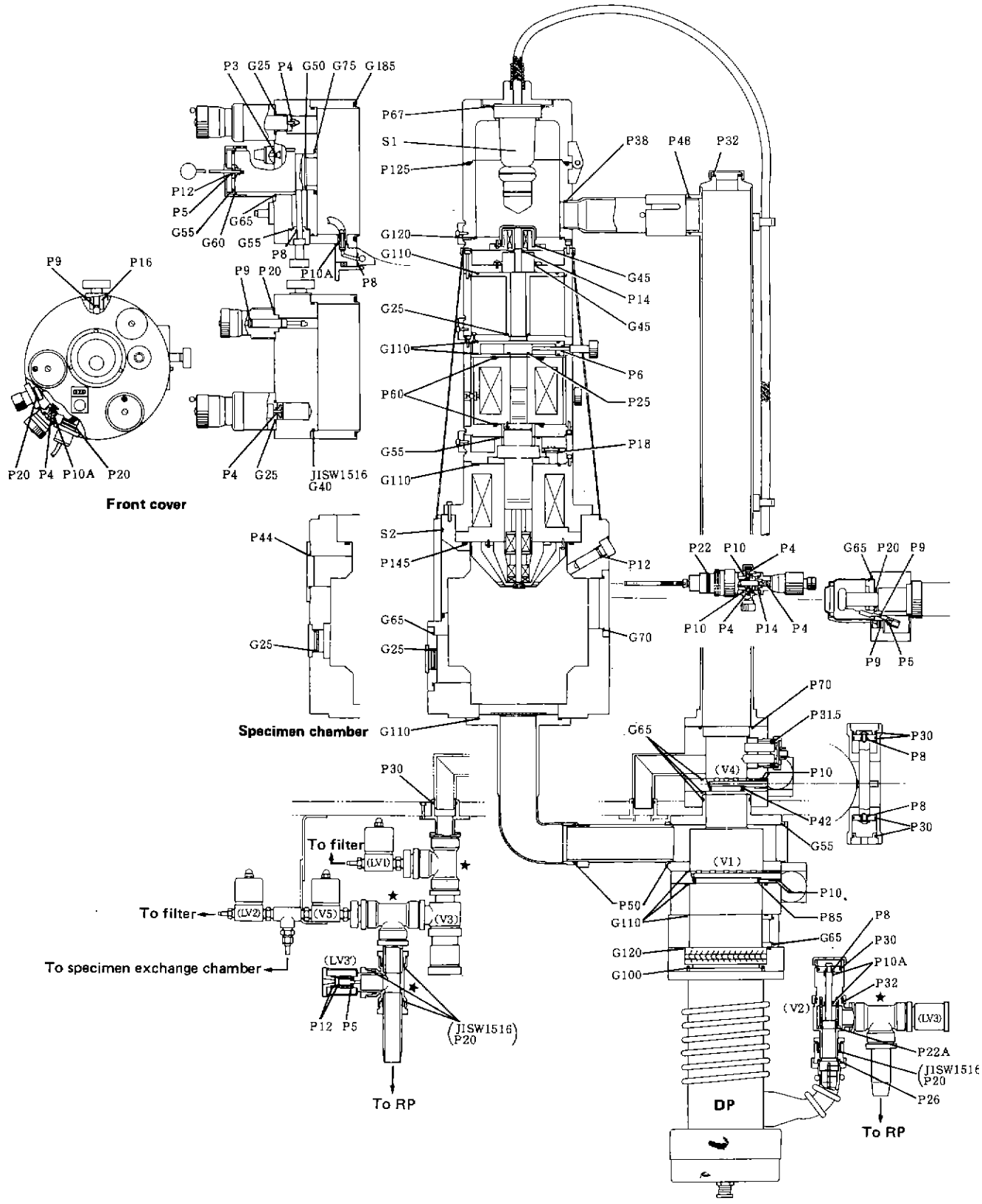


Fig. 6.20 O-rings

6.7 Service Outlets

When the PANEL LIGHT/ROOM LIGHT switch on the master power supply panel is set to ROOM LIGHT, AC 100 V is supplied to the service outlets. And since the maximum current capacity from these two outlets is 2 A, these outlets can be used to light the installation room, etc. Fig. 6.21 shows the spotlight and table light in use. The lamps on the panel light up when the switch is turned to PANEL LIGHT. At OFF, both are off.

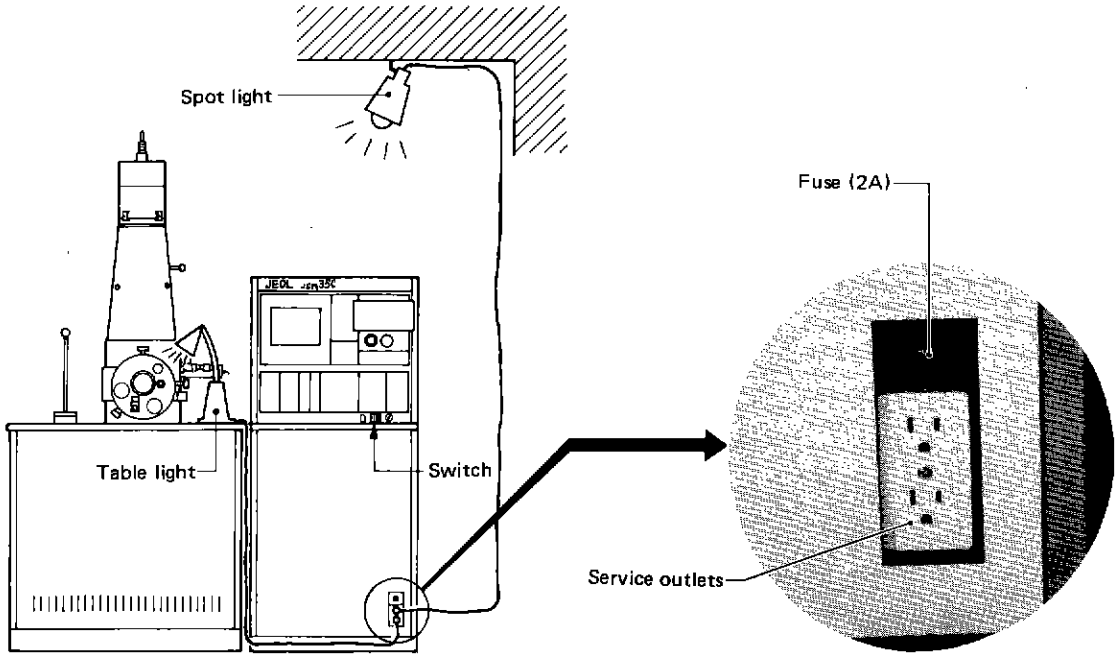


Fig. 6.21 Service outlets

6.8 Focusing the CRT

To achieve the best possible micrographs of scanning images, it is not only necessary to focus the recording system camera but also to periodically focus the CRT, even when the recording system has not been used for an extended period.

The room in which CRT focusing is to be done should be as dark as possible. And since focusing requires a high degree of accuracy, a focus screen made of transparent glass plate (or acrylic resin plate) should be readied beforehand in place of the fogged glass screen used with the film holder. Also ready a magnifier of 30X for purposes of focusing. Paste two 5 mm thick spacers on the glass-plate focus screen facing the CRT screen so that the distance between the CRT and the focus screen is the same as that between the CRT and film side of the film holder (see Fig. 6.22).

Focus the magnifier on the surface of the focus screen facing the CRT.

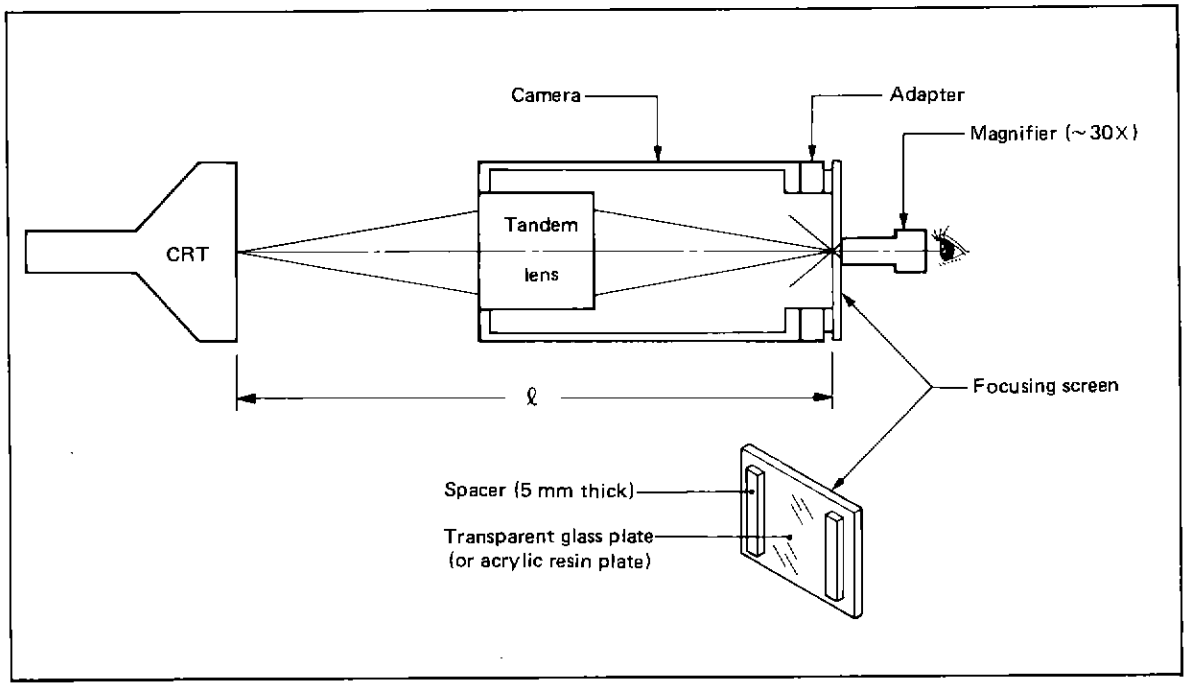


Fig. 6.22 CRT focusing

1. Set the UNATTENDED OPERATION switch on the master power supply panel to its upper position, unscrew two screws on the DISPLAY unit and draw out the DISPLAY unit on the microsope table.

   Note: Excercise care not to damage the panel under the DISPLAY unit when drawing out the unit. If else, consult your nearest JEOL service engineer.

2. Connect up the DISPLAY unit JC1 connector and its power supply connector with the extension cable, and then set the UNATTENDED OPERATION switch to its lower position.
3. Attach the Polaroid #545 film holder (PRH) adapter to the recording system camera (see Fig. 5.37a).

4. Attach the Polaroid focus screen to the adapter (see Fig. 5.38a).
5. Set the lens opening to f/5.6 with the f-number adjust knob.
6. Set the recording system BRIGHTNESS knob to 0.0.
7. Set the scanning mode selection switch on the SCAN GENERATOR panel to ● (spot).
8. Push the MF pushbutton to open the camera shutter and gradually turn the BRIGHTNESS knob clockwise to obtain a spot.

   Caution: Avoid excessive spot brightness to prevent the screen from burning.
9. Focus the spot on the screen with the focus adjust knob, using the previously adjusted magnifier.
10. Remove the focus screen for the film holder and replace it with the transparent glass plate (acrylic resin plate) focus screen using adhesive tape or the like.
11. Focus the spot on the screen with the focus adjust knob, using the magnifier for this purpose.
12. Make the spot as small as possible by adjusting the DISPLAY unit CSI-FOCUS variable resistor (Fig. 6.23), using the magnifier.

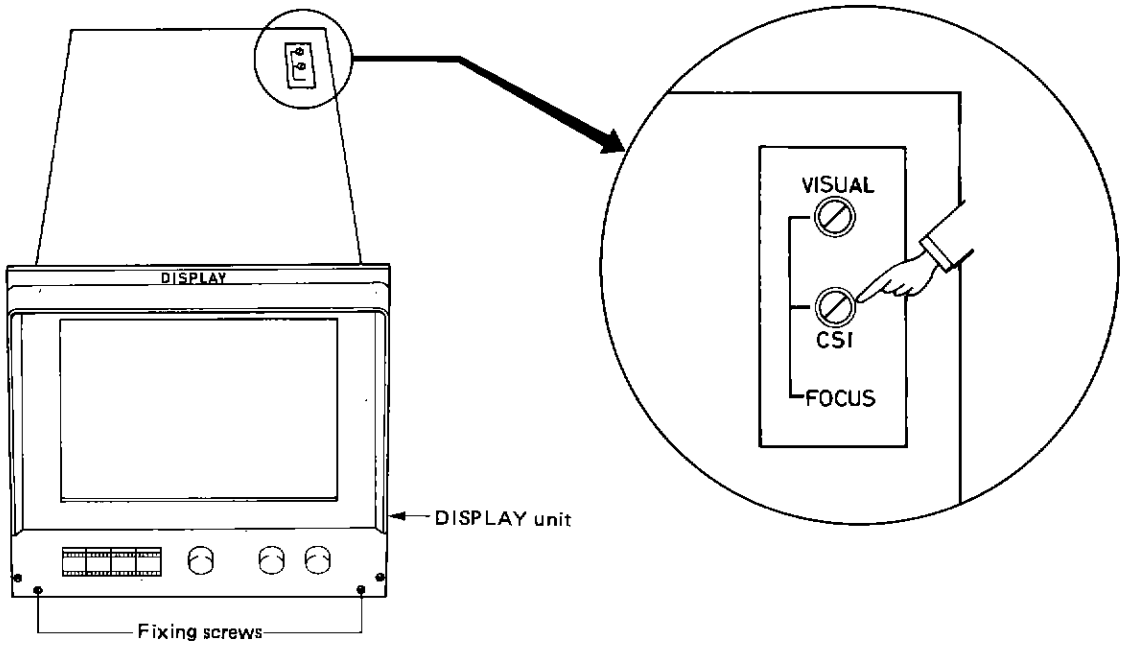


Fig. 6.23 CSI-FOCUS resistor

13. Set the UNATTENDED OPERATION switch to its upper position and then remove the extension cable.
14. Replace the DISPLAY unit and secure it with the two screws, then set the UNATTENDED OPERATION switch to its lower position .
15. Remove the focus screen and install the desired film holder according to Section 5.2.11 (if necessary. change the adapter and re-adjust the focus adjust knob).

6.9 Manual Control of Vacuum System

Normally, the vacuum system is automatically controlled and no thought need be given to the opening and closing of the various valves. However, if it becomes necessary to adjust the control circuits or if there is a malfunction, the vacuum valve can be opened/closed as the need arises by using the switches located on the MANUAL VACUUM CONTROL panel on the left of the console. (The opned/closed state of the valves can be known by observing the flashing of the vacuum valve indicator lamps on the VACUUM SYSTEM unit panel.) But when the vacuum system is to be controlled automatically, all switches on the panel are to be set to their lower positions (see Fig. 6.24).

6.9.1 Startup (Corresponds to Section 5.2.2)

1. Perform initial setting according to Section 5.3.1.
2. Confirm that all switches on the MANUAL VACUUM CONTROL panel are set at their respective lower positions (automatic control).
3. Supply water to the instrument.
4. Insert the key into the master power key switch and turn the switch to MAIN POWER.
5. Set the MANUAL VACUUM CONTROL panel VALVE LOCK/AUTO switch to VALVE LOCK and the POWER switch to ON.

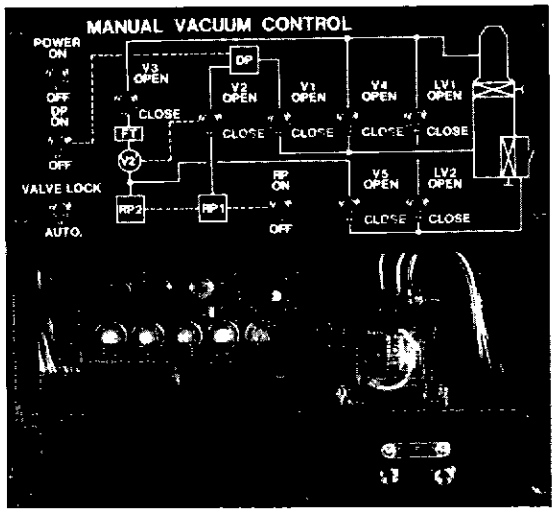


Fig. 6.24 MANUAL VACUUM CONTROL panel

6. Confirm that the reading of the air compressor pressure gauge is 3.5 kg/cm^2 or over (see Fig. 6.10).
7. Turn on the RP switch (indicator lamp on) and wait until the pumping noise of the oil rotary pumps cease. With this operation, both oil rotary pumps RP1 and RP2 start up and vacuum valves LV3 and LV3′ close.

8. Set the V2 switch to OPEN and evacuate the diffusion pump (DP). With this operation, valve V2 open and the V2 lamp lights up.
9. Turn on the DP switch.

   Note: After the DP lamp of the indicator lights up (takes 10 min), the DP is ready to be operated.
10. Set the V3 and V4 switches to OPEN to rough-pump the column. Valves V3 and V4 open and the respective lamps light up.
11. Verify that the DP lamp is lit and that the vacuum pressure of the column is of the 10^{-1} Torr order.

    Note: The vacuum pressure can be known by inserting the circuit-tester plugs into the METER outlets on the lower portion of the MANUAL VACUUM CONTROL panel. Set the tester range to 1 mA, because an order of 10^{-1} Torr is reached at approx. 170 μA. As the vacuum level improves, the current will decrease.
12. Set the V3 switch to CLOSE and the V1 switch to OPEN to fine-pump the column. Now, rough pumping stops and fine pumping of the column starts by means of the DP (V1 lamp lights up.) When the column reaches the specified vacuum pressure, the ACCELERATING VOLTAGE unit LOAD CURRENT meter lamp lights up and the instrument is ready for operation.

6.9.2 Shutdown (Corresponds to Section 5.2.12)

1. Turn the ACCELERATING VOLTAGE panel GUN FILAMENT knob fully counterclockwise and turn off the ON/OFF switch.
2. Set the SEI panel SEI/BEI switch to the center position.
3. Set the MANUAL VACUUM CONTROL panel V1 switch to CLOSE, turn off the DP switch and leave the instrument stand for approx. 10 min to permit the DP to cool.

   Note: When the column is in a high vacuum state, the V3 valve is closed, that is, the V3 switch is set at CLOSE. To shut down the instrument during rough pumping, carry out the above Step 3 after a high vacuum state has been reached.
4. Confirm that the V3 and V5 switches are set at CLOSE. Then set the V4 and V2 switches to CLOSE and turn off the RP switch. With this operation, both oil rotary pumps stop and valves LV3 and LV3′ open.
5. Turn off the master power key switch and remove the key.
6. Turn off the distribution board switch.
7. Close the water faucet.
8. Set all of the switches on the MANUAL VACUUM CONTROL panel to their lower positions.

6.9.3 Venting and re-evacuating the column

6.9.3a Venting

1. Turn the ACCELERATING VOLTAGE panel GUN FILAMENT knob fully counterclockwise and turn off the ON/OFF switch.
2. Set the SEI panel SEI/BEI switch to the center position.
3. If the need arises to expose the anode chamber to the atmosphere, close the airlock valve AV1 by pushing in the airlock knob and turning it fully clockwise (about 180°), and set the V4 switch to CLOSE, then the LV1 switch to OPEN. The V4 lamp will go out, the LV1 lamp will light up, and the anode chamber will be exposed to the atmosphere. To vent the entire column, skip this step.
4. Set the V1 switch to CLOSE and then the LV1 switch to OPEN. The V1 lamp will go out, the LV1 lamp will light up, and the entire column will be exposed to the atmosphere.

6.9.3b Re-evacuating

1. Set the LV1 switch to CLOSE and the V3 switch to OPEN.
2. When the vacuum pressure reaches 10^{-1} Torr order, set the V3 switch to CLOSE and the V1 switch to OPEN. When re-evacuating the anode chamber only, set the V3 switch to CLOSE, the V4 switch to OPEN and open the anode chamber airlock valve.

   Note: When the column is evacuated to the specified pressure, the ACCELERATING VOLTAGE panel LOAD CURRENT meter lamp lights up to indicate the microscope is ready for operation.

6.9.4 Inserting (or removing) the specimen holder into (or from) the specimen chamber

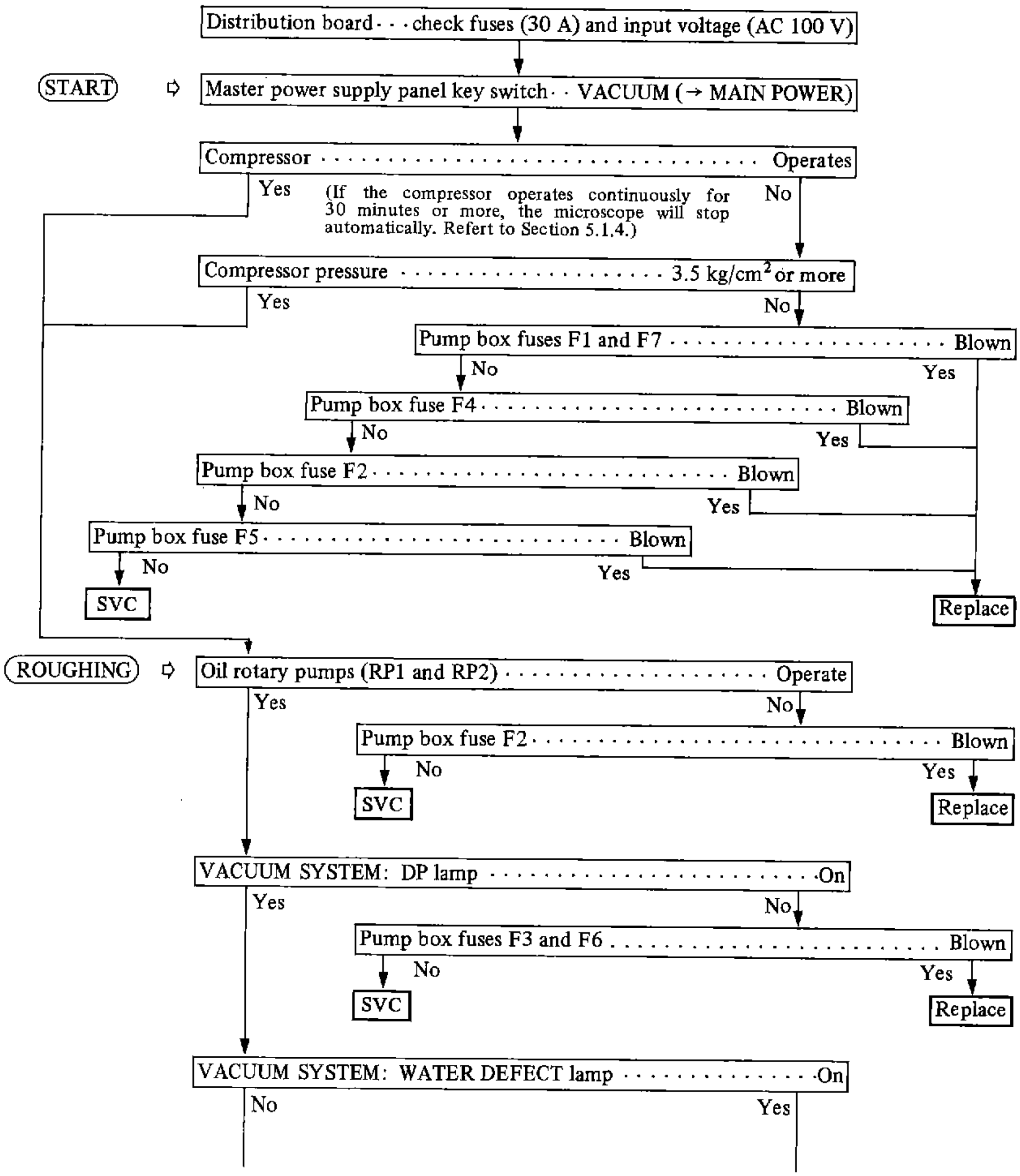
(Corresponds to Section 5.2.3b)

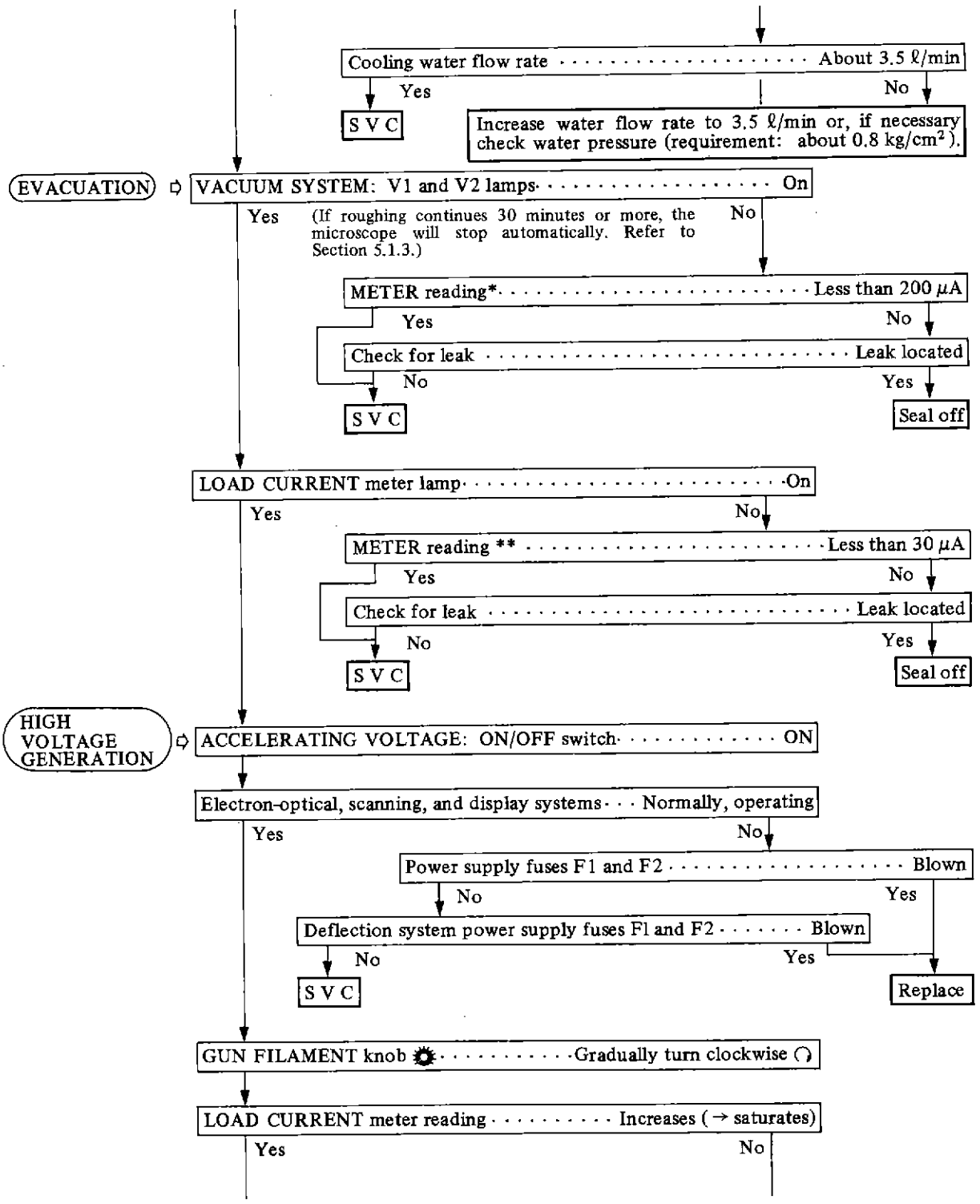
1. Carry out Steps 1 to 5 of Section 5.2.3b.
2. Attach the specimen exchange chamber cap to the specimen chamber (with the cap slot aligned with the pin).
3. Set the LV2 switch to CLOSE and the V5 switch to OPEN to evacuate the specimen exchange chamber (takes about 30 sec.).
4. Set the V5 switch to CLOSE and carry out Steps 7 and 8 of Section 5.2.3.
5. Close airlock valve AV2 by pushing in the specimen exchange chamber airlock knob.
6. Set the LV2 switch to OPEN so as to expose the specimen exchange chamber to the atmosphere. Remove the cap from the said chamber.
7. Remove the specimen holder from the specimen exchange rod when the specimen holder is removed from the specimen chamber.

6.10 Troubleshooting and Fuse Replacement

The following flowchart is intended as an aid to pinpointing and/or solving simple problems. If a problem cannot be cleared by fuse replacement or other simple remedial measures, it will be necessary to enlist help by calling your local JEOL service engineer (SVC in the flowcharts).

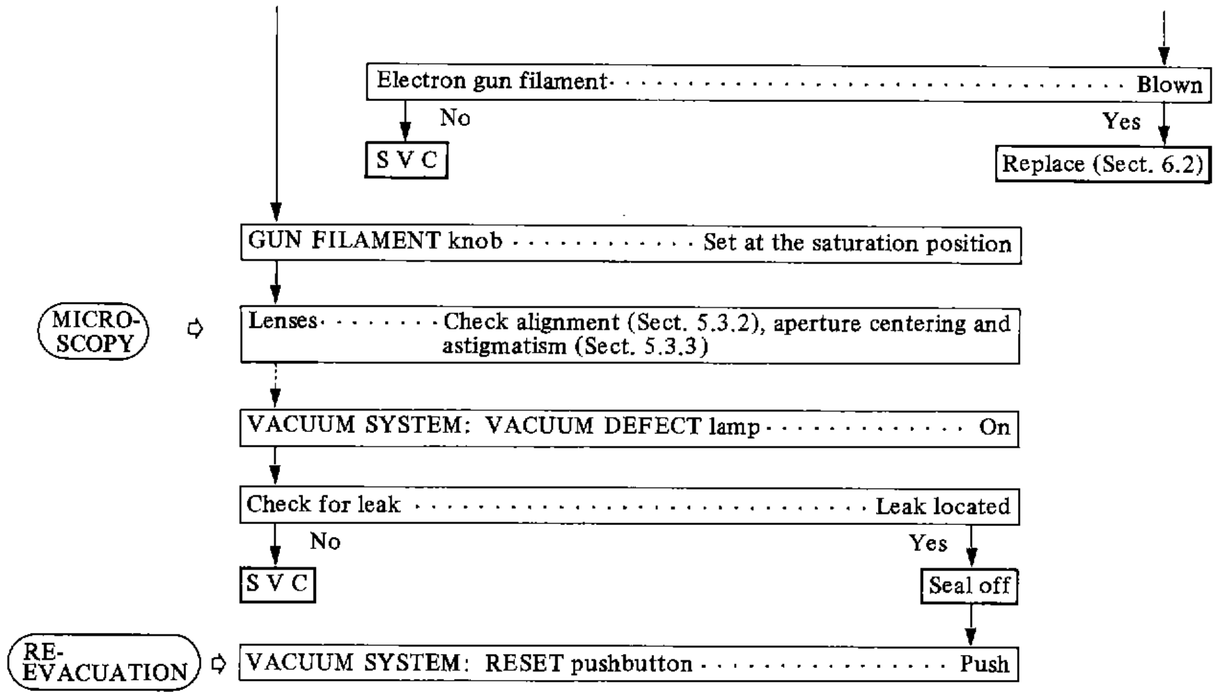
6.10.1 Simple troubleshooting





* *This reading will be achieved 10 minutes after starting the microscope.*

** *Measure after sufficient evacuation.*



6.10.2 Fuse replacement

Replace blown fuses as follows (refer to Table 6.3 and Figs. 6.26 to 6.29).

- Shut down the microscope and turn off the main power supply and replace the blown fuse or fuses.

Caution: Besure to replace the blown fuse with one of the same type and having the same rating. Not to do so may subject the circuit in question to overload conditions with damage to vital electrical parts resulting (see Table 6.3 and Fig. 6.25).

- If a newly replaced fuse also blows (despite correct rating), contact your local JEOL service engineer immediately.

Note: Do not continue to replace the fuses or attempt to use higher ratings.

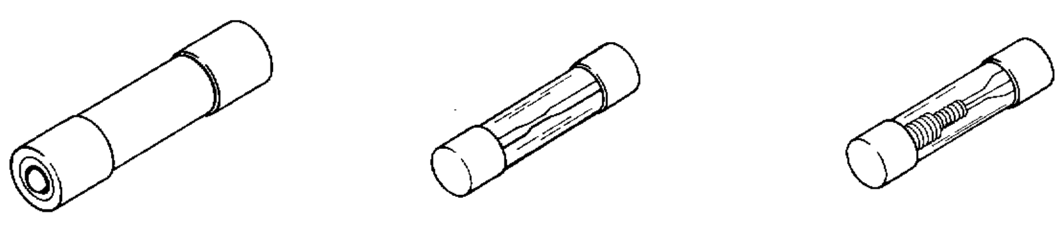


Fig. 6.25 Types of fuses used

Table 6.3 Fuse ratings

Symbol	Type	Rating	Related circuit
■ Pump box (Fig. 6.26)			
F1, F7	Indicating type	30 A	Master power supply
F2	Indicating type	20 A	Oil rotary pump
F3, F6	Glass tube	10 A	Oil diffusion pump
F4	Glass tube	2 A	Vacuum system power supply
F5	Slow-blowing	7 A	Compressor
■ Power supply (Fig. 6.27)			
F1	Slow-blowing	2 A	Electron-optical, scanning and display system power supply
F2	Slow-blowing	3A	
F3	Glass tube	10 A	Spare outlet
■ Deflection system power supply (Fig. 6.28)			
F1, F2	Slow-blowing	5 A	Deflection system amplifiers
■ Service outlets (Fig. 6.29)			
F1	Glass tube	2 A	Room light

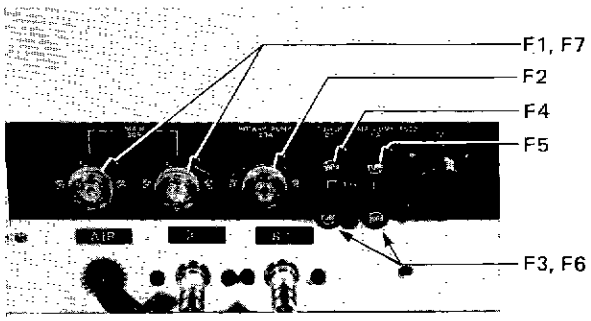


Fig. 6.26 Pump box fuses

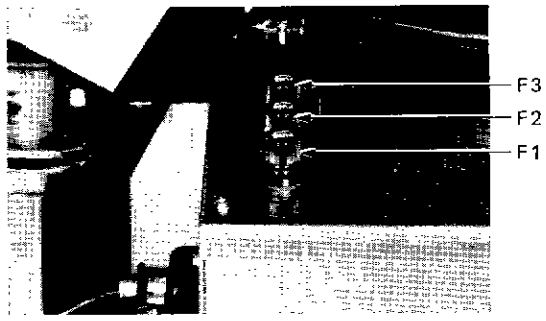


Fig. 6.27 Power supply circuit fuses

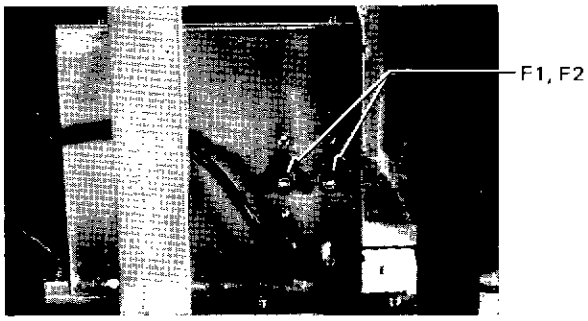


Fig. 6.28 Deflection system power supply circuit fuses

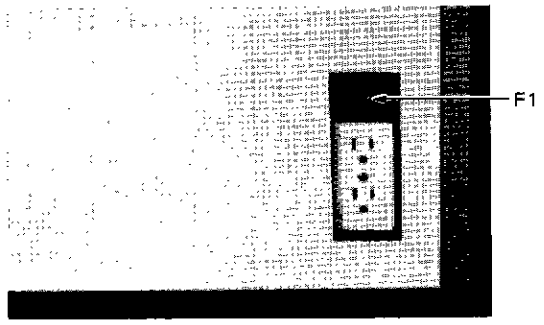
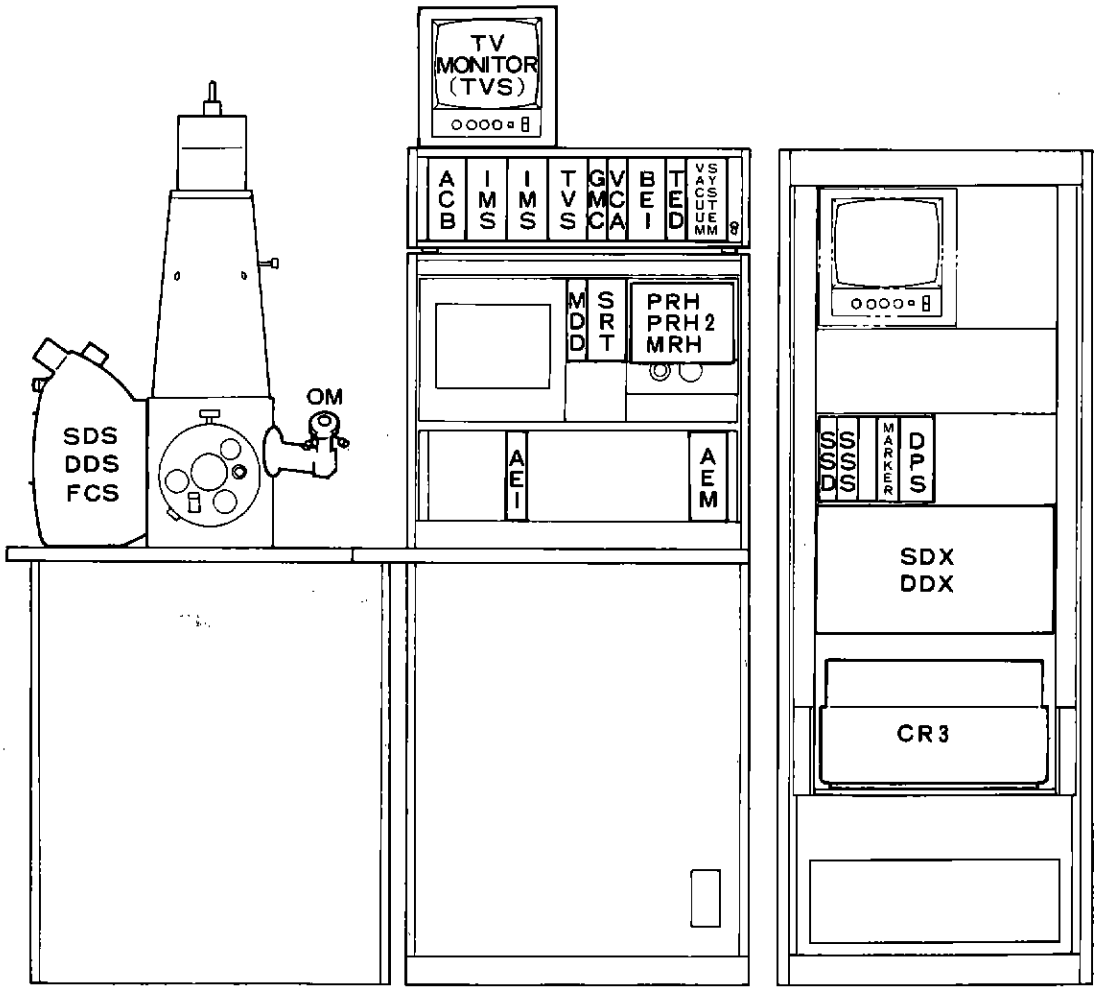


Fig. 6.29 Service outlet fuses

[ATTACHMENTS]

ATTACHMENT CONFIGURATION (Example)



ACB
BEI
GMC
IMS
TED
TVS
VCA
} For these attachments, the SCB·S and SPS1 or 3 are required.

MDD
SRT
} These attachments are installed any vacant space in the display panel.

AEM ..... This unit is installed in place of the VACUUM SYSTEM unit and the VACUUM SYSTEM unit is transferred to the SCB·S or SCB.

AEI ..... This unit is installed in any vacant space in the operation panel.

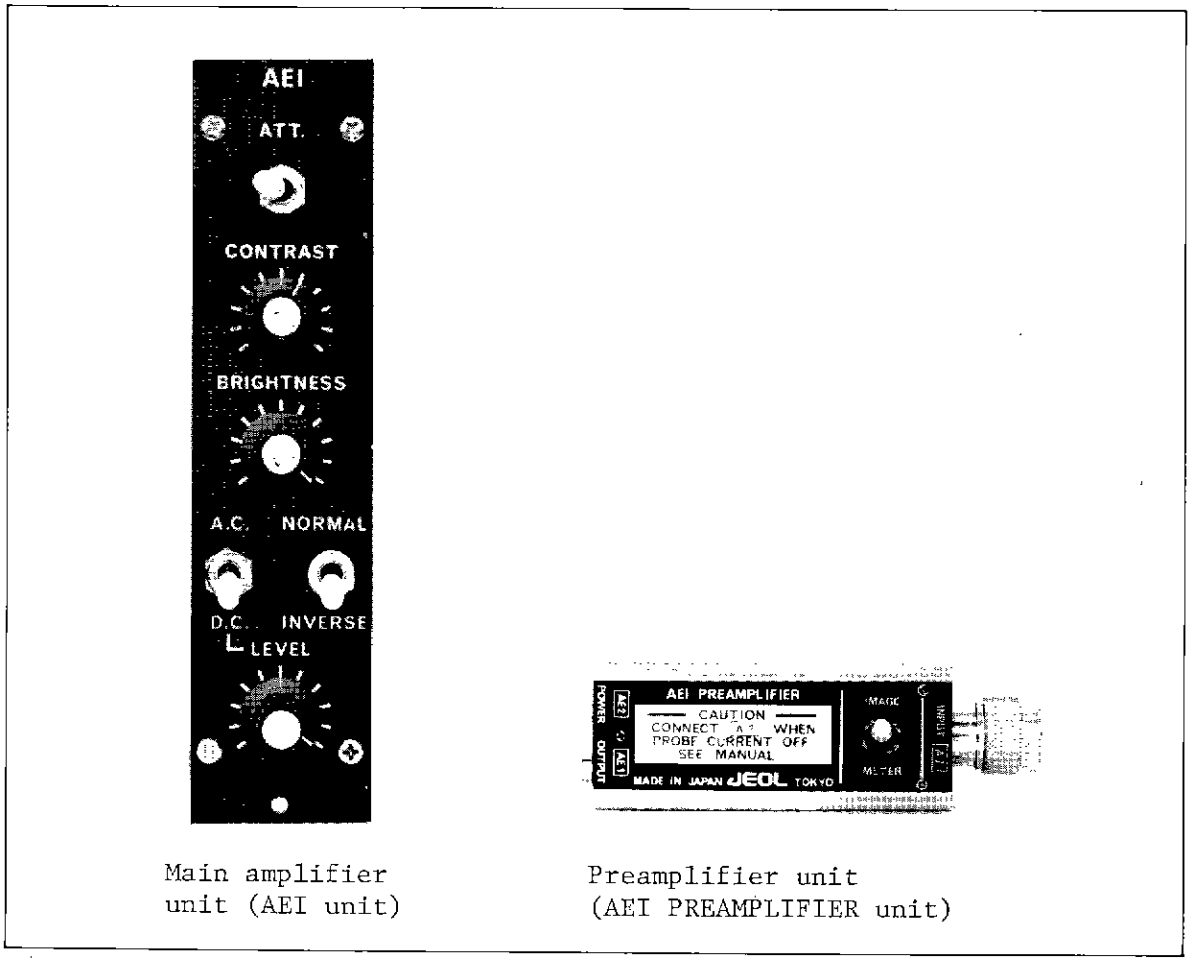
SSD
SSS
MARKER
DPS
SDX (DDX)
CR3
} For these attachments, the SCB and SPS1 or 2 are required.

INSTRUCTIONS

35-AEI

ABSORBED CURRENT AMPLIFIER

No. IEP 35C-AEI
(EP300001)



Main amplifier unit (AEI unit)

Preamplifier unit (AEI PREAMPLIFIER unit)

Fig. 1 Absorbed current amplifier

1. GENERAL

This amplifier is used to amplify the specimen absorbed current, which varies with specimen topography and the elements constituting the specimen, so as to display absorbed electron images on the CRT. Composed of a

preamplifier and a main amplifier, this device can obtain almost noiseless absorbed electron images with a probe current as small as 10^{-10} A.

2. SPECIFICATIONS

2.1 Preamplifier

- Input: 10^{-7} A (max.).
- Output: 1 V (max.).
- Output noise: Less than 5×10^{-11} A.
- Bandwidth: DC to 1.5 kHz.
- Power: DC ±15 V, 10 mA.
- Operating temperature: 0 to 50°C.
- Dimensions: 90 mm (W) × 38 mm (D) × 38 mm (H).

2.2 Main amplifier

- Input: Att.: 1.0; 10 mV, 1 kΩ.
  Att.: 0.1; 100 mV, 10 kΩ.
- Output: ±10 V, 1 kΩ.
- Gain: Att.: 1.0; ×1000.
  Att.: 0.1; ×100.
- Attenuation: ×0.1, ×1.0.
- Output noise: Less than 10 mV.
- Bandwidth: DC to 7 kHz.
- Power requirements: DC ±20 V, 30 mA.
- Operating temperature: 0 to 50°C.
- Dimensions: 35 mm (W) × 300 mm (D) × 150 mm (H).

3. COMPOSITION

- Preamplifier unit (AEI PREAMPLIFIER unit) 1
- Main amplifier unit (AEI unit) 1
- Cables 2

4. PANEL DESCRIPTION

4.1 Preamplifier unit

- IMAGE/METER switch
  Input switch for the preamplifier. At the IMAGE position, absorbed current is supplied to the preamplifier; at the METER position, absorbed current is supplied directly to the 35-AEM micro-micro ammeter (optional attachment).

4.2 Main amplifier unit

- ATT switch:
  Selects the desired attenuation. Used for attenuating the intensity of the input signal in order to obtain images of desired contrast.
- CONTRAST knob:
  Varies the amplifier gain, thereby controlling image contrast.
- BRIGHTNESS knob:
  Varies the signal level so as to adjust image brightness.
- AC/DC switch:
  Changes over the level control mode of the amplifier. At the AC position, the DC level is automatically controlled even if the image contrast is changed, and the desired brightness is obtained. Thus, the AC position is most suitable when locating the desired field of view. Switch to the DC position for photography.
- NORMAL/INVERSE switch:
  Changes the polarity of the video output signal. At NORMAL, an ordinary image (positive picture) is displayed on the CRT; at INVERSE, an inverted contrast image (negative picture) is displayed on the CRT. The INVERSE setting is also used when making slides.
- LEVEL knob:
  With the AC/DC switch at the DC position, the DC level is controlled with this knob, after the amplifier gain has been changed with the CONTRAST knob. In other words, the LEVEL knob adjusts image brightness.

5. INSTALLATION

1. Turn off the supplementary power supply (35-SPS1) switch.
2. Insert the main amplifier unit (AEI unit) into the supplementary cabinet (35-SCB-S: optional attachment).
3. Set the preamplifier (AEI PREAMPLIFIER unit) on the table just to the left of the scanning microscope column.
4. Connect up the cables (2) as per the scanning microscope and 35-AEI amplifier circuit diagrams.
5. Turn on the Supplementary Power Supply.
   Note: A 35-AEM Micro-micro Ammeter (optional attachment) is necessary in

order to measure the absorbed current. Further, a 35-IMS Image Selector (optional attachment) is required to distinguish absorbed electron images from other types of images on the standard CRT. Refer to the respective manuals for information related to the installation and handling of the AEM and IMS.

6. OPERATION

1. Obtain a secondary electron image (SEI).
   Note: If a 35-AEM Micro-micro Ammeter is available, set the IMAGE/METER switch to METER and read out the absorbed current. Check that the electron probe scans the specimen normally..
2. Set or confirm the following settings.

• ATT switch:	0.1.
• CONTRAST knob:	Turned fully counterclockwise.
• BRIGHTNESS knob:	Turned fully counterclockwise.
• AC/DC switch:	DC.
• LEVEL knob:	Turned fully clockwise.
• NORMAL/INVERSE switch:	NORMAL.
• IMAGE/METER switch:	IMAGE.

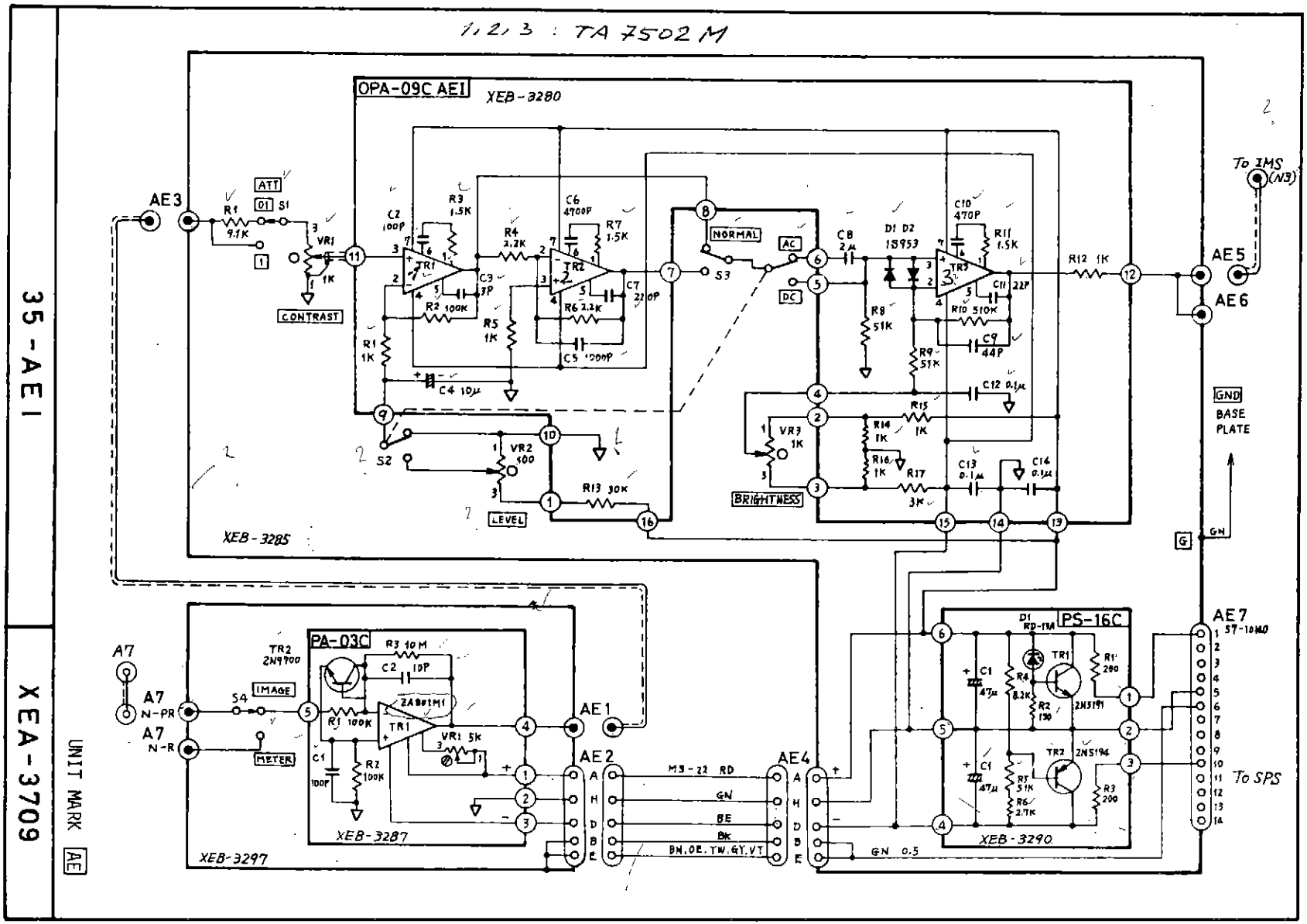
3. Depress the AEI button on the 35-IMS Image Selector.
4. Turn the BRIGHTNESS knob clockwise until the scanning line (raster) on the DISPLAY unit 10" CRT is faintly discernible.
5. Turn the CONTRAST knob clockwise until the desired image contrast is achieved.
   Note: If no image appears on the CRT, increase the signal intensity by setting the ATT switch to the 1.0 position. If the image still fails to appear, reduce the GUN BIAS thumbwheel (ACCELERATING VOLTAGE panel) reading, or turn the CONDENSER LENS knob (LENS panel) counterclockwise to increase the specimen illuminating current (probe current), that is, the absorbed current.
6. Reduce the image brightness as necessary (the image brightness increases when the image contrast is optimized) with the LEVEL knob.

35-AE1

XEA-3709

UNIT MARK AE

1, 2, 3 : TA 7502 M



INSTRUCTIONS

35-CLD

CATHODELUMINESCENCE DETECTOR

No. IEP35C-CLD
(EP321101)

1. GENERAL

Designed for use in conjunction with the JSM-35C scanning electron microscope, the 35-CLD detector permits cathodoluminescence images in the visible region to be observed. The 35-CLD is especially useful for research work of minerals and semiconductors.

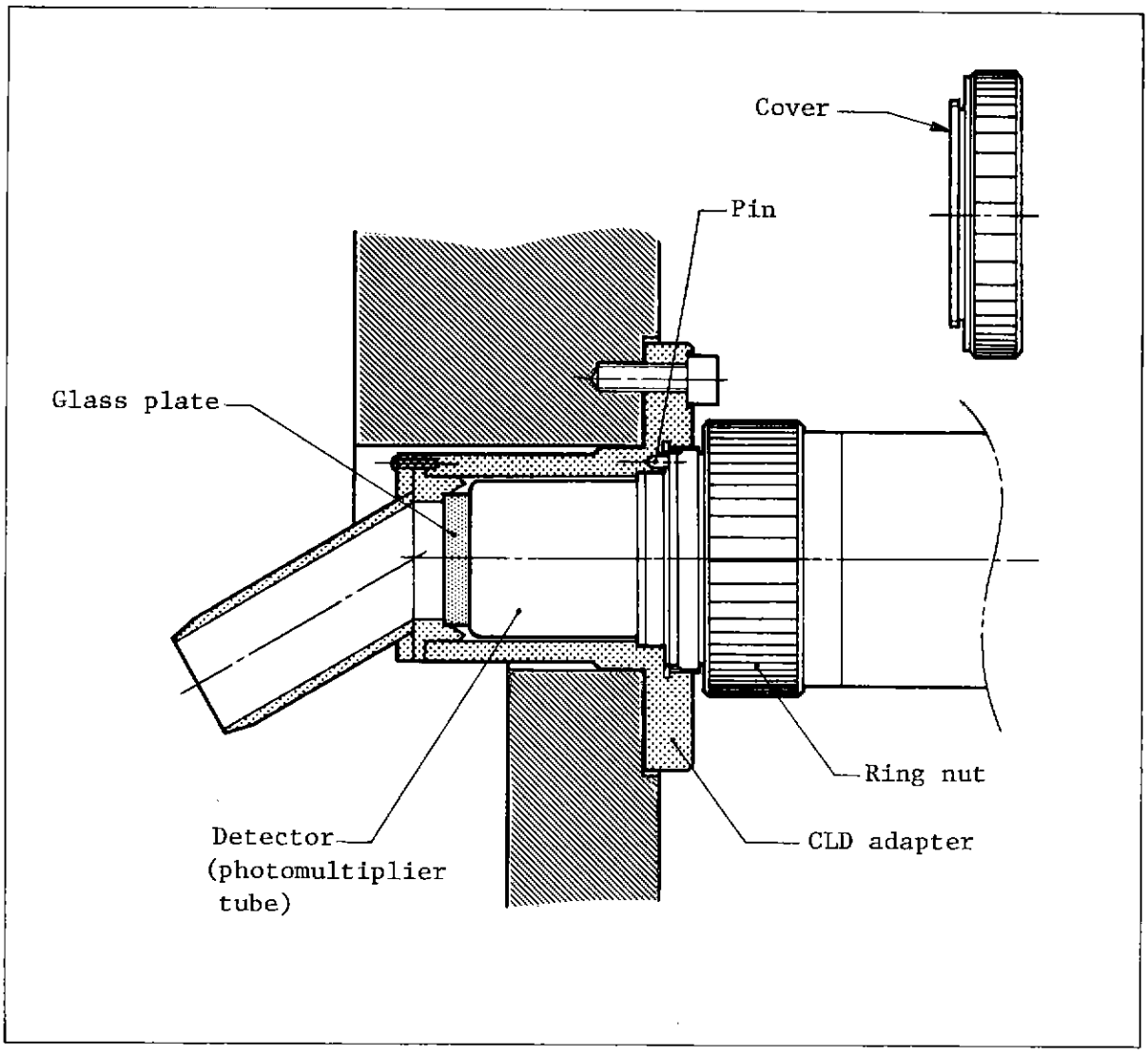
2. SPECIFICATIONS

Detector:	JSM-35 secondary electron detector photomultiplier tube (S-11).
Wavelength range:	3,000 to 6,500 Å (max. sensitivity wavelength: 4,400 Å).

3. COMPOSITION

- CLD adapter 1
- Cover 1

4. INSTALLATION (see the figure below)



1. Expose the column to the atmosphere.
2. Remove the ⬚ shaped blank cover attached to the back side of the specimen chamber and mount the CLD adapter in lieu thereof.
3. Remove the photomultiplier tube (PMT) from the secondary electron detector by loosening off the ring nut and attach the PMT to the CLD adapter.
4. Evacuate the column.
5. If the standard photomultiplier tube is used as the CLD detector, attach the cover as provided to the opening exposed by removing the photomultiplier tube.

5. OPERATION

1. Confirm that column evacuation is complete.
2. Confirm that the SEI unit SEI/BEI switch is set at its midway (off) position in order to protect the secondary electron detector against damage.
3. Obtain a cathodoluminescence image.
   Note: The procedure for obtaining a cathodoluminescence image is more or less the same as that for obtaining a secondary electron image.
4. After removing the photomultiplier tube upon completion of cathodoluminescence image observation, attach the cover, as provided, to the CLD adapter.
   Caution: If the cover is not placed over the adapter, light will enter the specimen chamber and adversely affect the secondary electron detector.

Operational notes

1. It is possible to use the TED (transmitted electron detector) PMT instead of the secondary electron detector PMT.
2. A secondary electron image and cathodoluminescence image can be simultaneously observed by incorporating the SDU auxiliary detector and IMS image selector and depressing the appropriate pushbutton on the IMS.

INSTRUCTIONS

35-GMC

GAMMA CONTROL CIRCUIT

No. IEP35C-GMC
(EP412001)

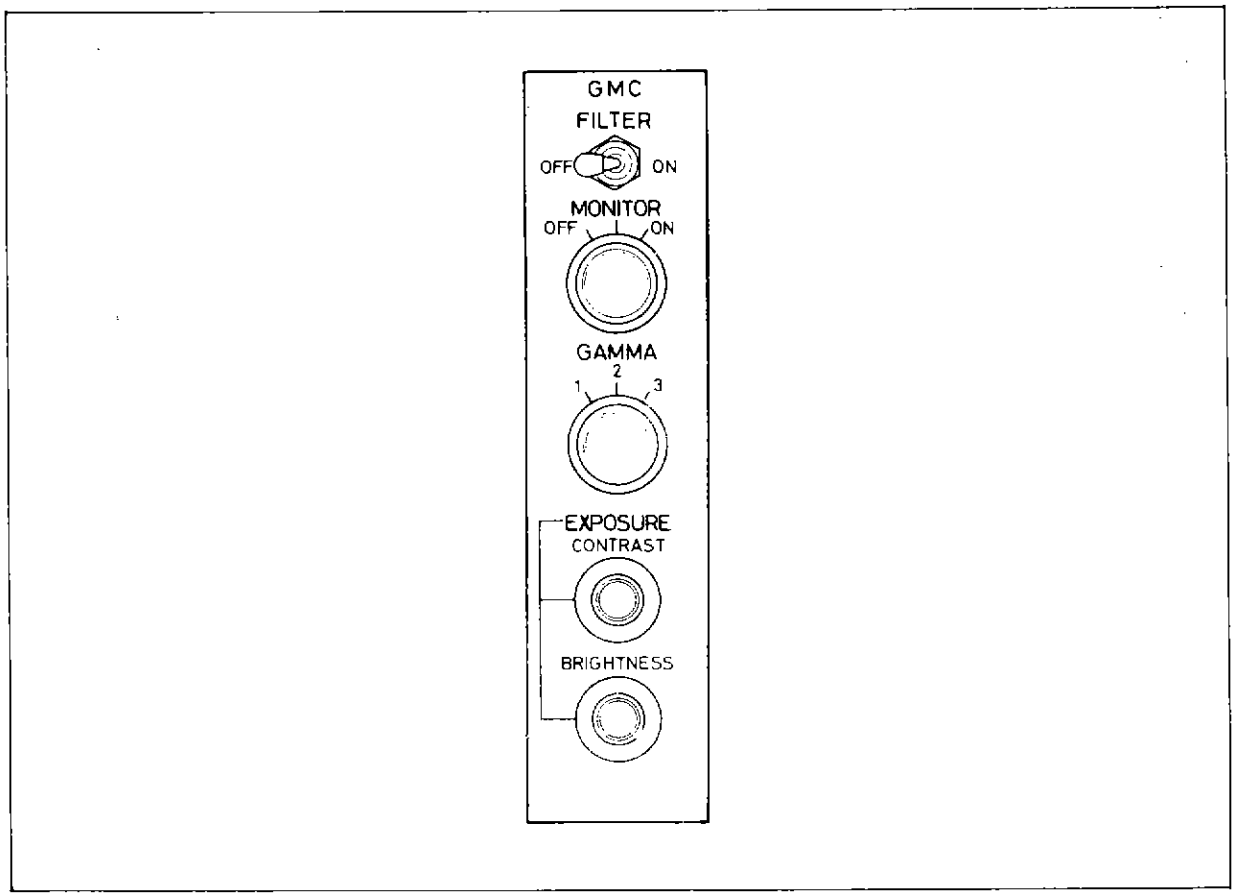


Fig. 1 Gamma control unit

1. GENERAL

This unit provides three gamma control functions for the video signal in order to enhance the image contrast in low signal intensity regions and reduce the contrast in high-light regions. Furthermore, the control level of the video signal can be optionally selected. Accordingly, specimens exhibiting excessive high and low contrast in the normal imaging mode can be observed under optimum contrast conditions.

2. SPECIFICATIONS

- Control modes: Three ($X^{2/3}$, $X^{1/2}$, $X^{1/3}$).
- Level control monitor: Built-in.
- Input: 0 to 6 V, 10 kΩ.
- Output: ±6 V, 1 kΩ.
- Output noise: Less than 10 mV.
- Bandwidth: DC to 30 kHz.
- Power requirements: DC ±12 V, 40 mA.
- Operating temperature: 0 to 50°C.
- Dimensions: 35 mm (W) × 330 mm (D) × 150 mm (H).

3. COMPOSITION

- Gamma control unit 1
- Cable 1

4. PANEL DESCRIPTION

- FILTER switch

  When this switch is at the OFF position, both the low and high frequency components of the video signal are processed according to the gamma curve. At the ON position, only the low frequency component is subjected to the gamma control process. That is, at ON, the contrast of rough structures is suppressed; that of fine structures, however, is unaffected.

- OFF/MONITOR/ON knob

  Gamma control circuit and monitor switch. When the knob is positioned at ON, the video signal is fed into the CRT via the gamma control circuit. At OFF, the video signal is supplied directly to the CRT, and at MONITOR, the level of input signal is locked.

- GAMMA knob

  When set at 1, 2 or 3, the video signal is processed according to a gamma curve of $X^{2/3}$, $X^{1/2}$ or $X^{1/3}$, respectively.

- EXPOSURE CONTRAST-BRIGHTNESS knobs

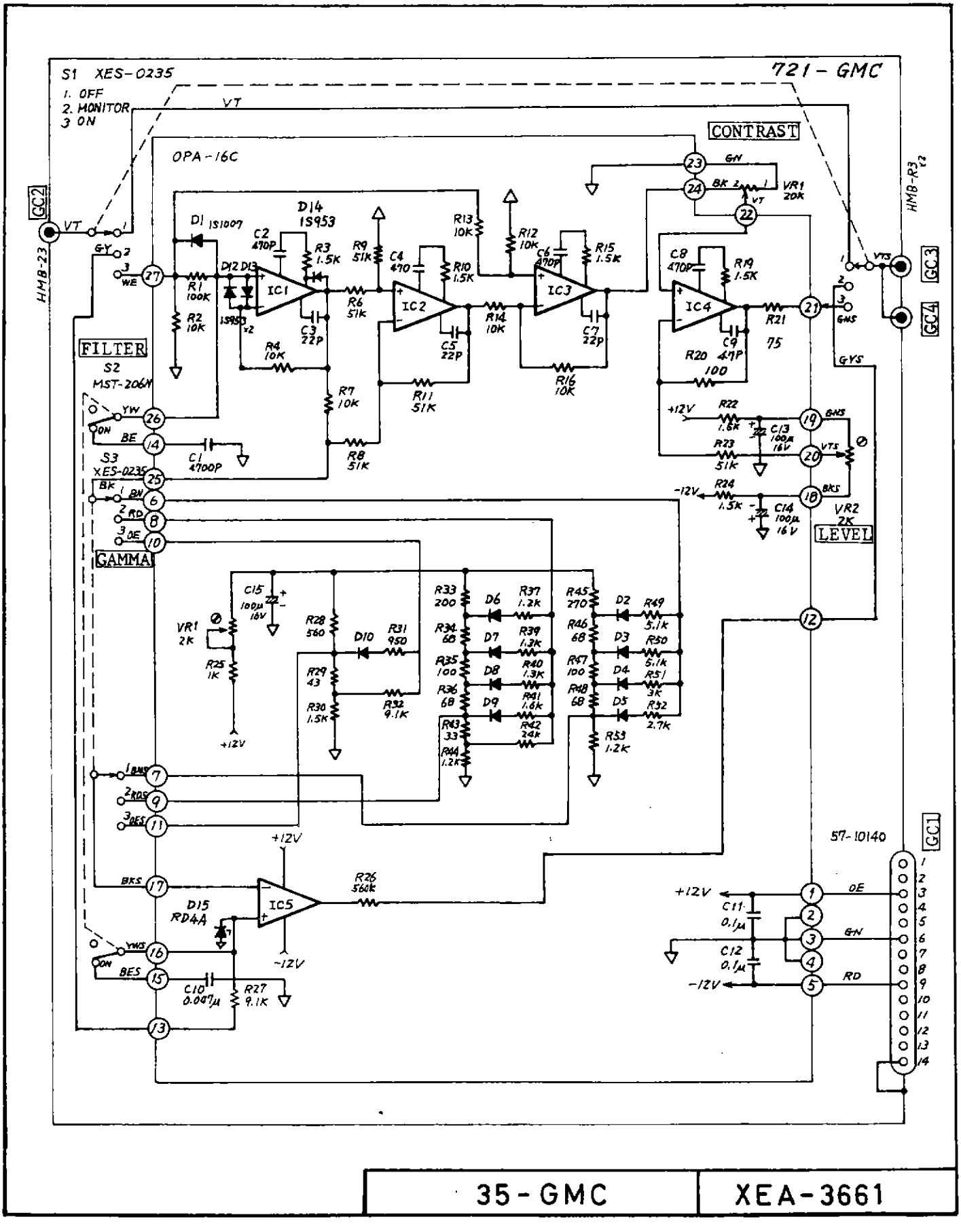
  These knobs are used to adjust the image contrast and brightness for recording. If the exposure meter is set with the CONTRAST and BRIGHTNESS knobs on the SEI unit, the input conditions for the GMC circuit change. Since this is undesirable, the exposure meter must be set with the EXPOSURE CONTRAST and BRIGHTNESS knobs.

5. INSTALLATION

1. Turn off the power switch of the supplementary power supply (35-SPS1, attachment).
2. Insert the gamma control unit into the supplementary cabinet (35-SCB·S, attachment).
   Note: The required power for the unit is supplied from the supplementary power supply built into the cabinet.
3. Connect the cables by referring to the circuit diagrams of the scanning microscope proper and the gamma control unit.
4. Turn on the supplementary power supply switch.

6. OPERATION

1. With the OFF/MONITOR/ON knob at the OFF position, optimize image contrast and brightness (refer to the JSM-35C instruction manual).
2. Set the OFF/MONITOR/ON knob at MONITOR and adjust the BRIGHTNESS knob of the SEI unit so that the portion of the image to be processed by gamma control becomes white, while the remaining portion becomes dark.
   Note: With the knob set at MONITOR, the portion of the image above the selected video signal level becomes white (white level) and the portion beneath it becomes dark (dark level). (There is no intermediate level.) By setting the desired procession level of the video signal so that it is slightly above this border, correct gamma control is achieved.
3. Set the OFF/MONITOR/ON knob at ON and change over the GAMMA knob so that the structure of the dark portion of the image can be clearly observed.
   Note: White areas in an unprocessed image mode where an image is adjusted to the average brightness and contrast reveals their structures on the CRT according to the circuit characteristics (gamma curve) selected. Further, the structures hidden in the dark area are also accentuated. Image processing is adjustable with the GAMMA knob.
4. Adjust the image contrast and brightness on the 10" CRT with the CONTRAST and BRIGHTNESS knobs of the DISPLAY unit, respectively.
5. Adjust the EXPOSURE-CONTRAST and -BRIGHTNESS knobs so that the EXPOSURE (CONTRAST and BRIGHTNESS) meters indicate the specified readings, respectively.
   Note: Since the meter indicators shift when carrying out gamma control, they must be reset. However, do not touch the other controls.
6. Push the FILTER switch to the ON position if the situation demands.



35 - GMC	XEA-3661

INSTRUCTIONS

35-VCA

VIDEO CONTROL AMPLIFIER

No. IEP35C-VCA
(EP739001)

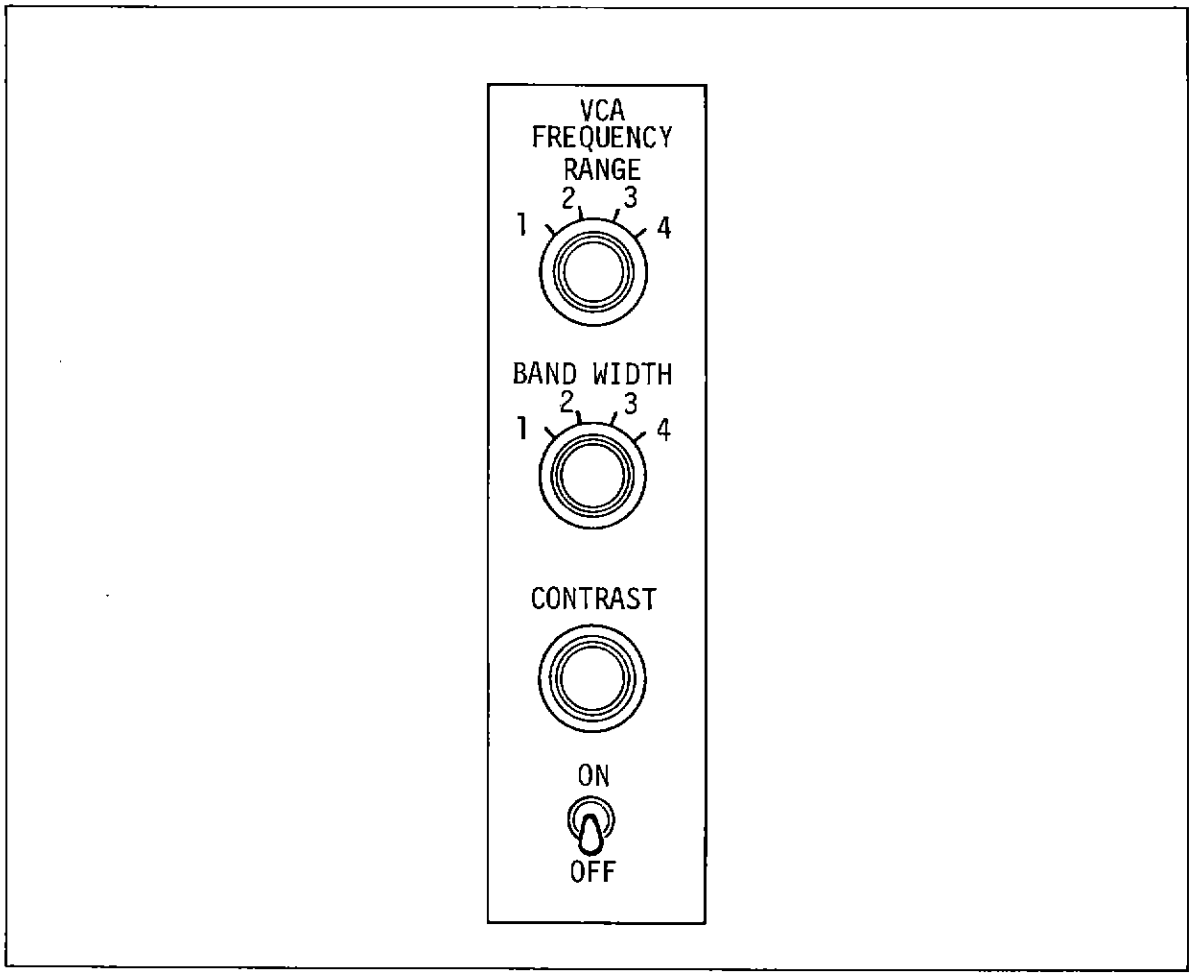


Fig. 1 VCA unit

1. GENERAL

This amplifier, which comprises an attenuator, a bandpass amplifier, and a mixing amplifier (see Fig. 2), has been designed for the purpose of enhancing the structural detail of image patterns by selectively increasing the amplification gain of signals having certain frequencies.

Video signals from the specimen entering this amplifier unit are attenuated. After which, the attenuated output enters a bandpass amplifier, where signals having frequencies within a selected frequency range are amplified, and the output of the bandpass amplifier is fed to the mixing amplifier. Simultaneously, the attenuated signals enters the mixing amplifier directly from the attenuator. In the mixing amplifier, the signals are mixed and amplified, and the resultant signals are sent to the display unit to display an image.

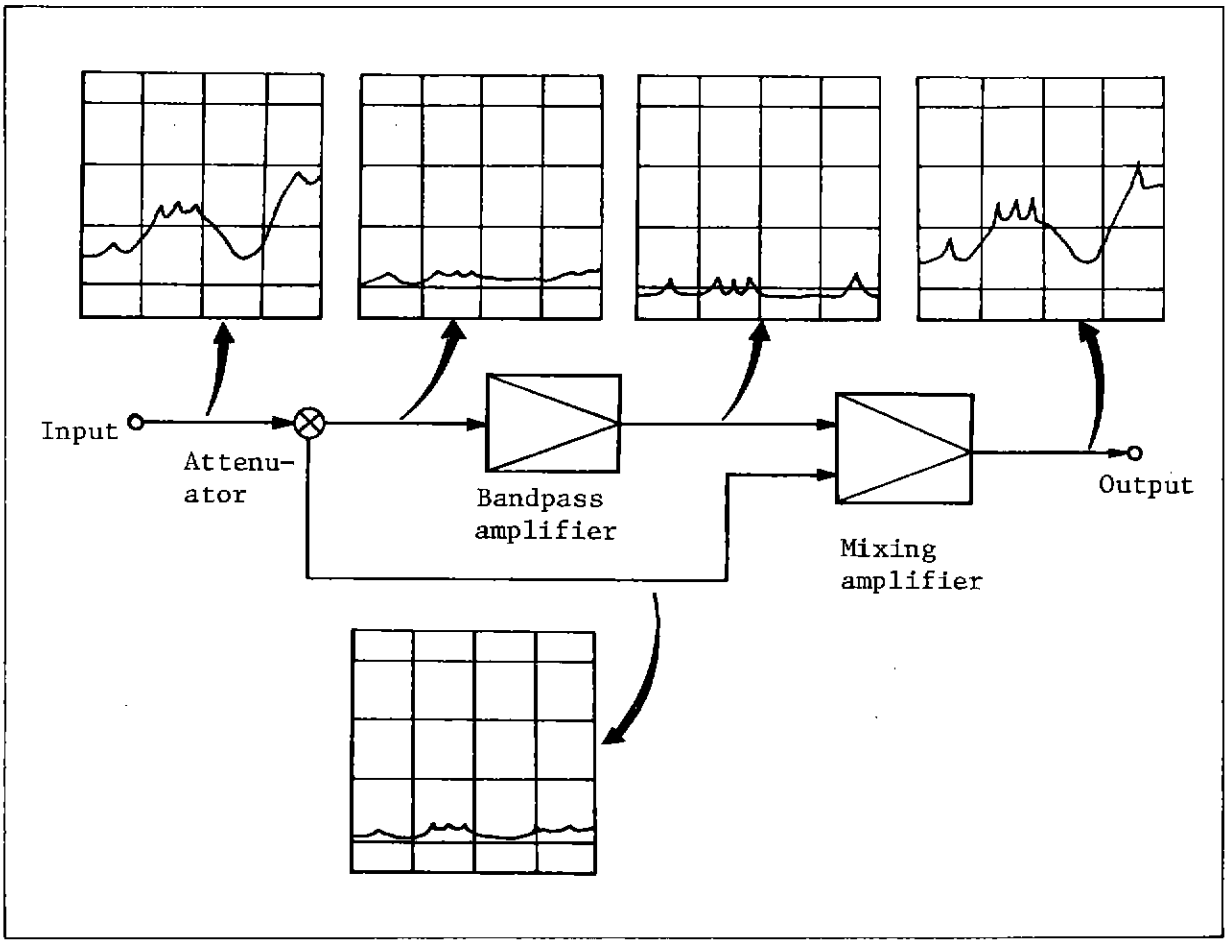


Fig. 2 VCA principle of operation

2. SPECIFICATIONS

• Frequency range:	Variable in 4 steps.
• Bandwidth:	Variable in 4 steps.
• Attenuation:	1/10.
• Amplifier gain:	Bandpass amplifier: 0 to ×10.
	Mixing amplifier: ×10.
	Overall gain
	Differential output: 0 to ×10.
	Direct output: ×1.
• Input:	0 to 6 V, 10 kΩ.
• Power requirements:	DC ±20 V, 25 mA.
• Operating temperature:	0 to 50°C.
• Dimensions:	35 mm (W) × 300 mm (D) × 150 mm (H).

3. COMPOSITION

- VCA unit 1
- Cables 2

4. PANEL CONTROLS

- FREQUENCY RANGE knob:

Switches over the frequency range in 4 steps.
The frequency range can be switched over while keeping the ratio of the high cut-off frequency f2 (3dB) to the low cut-off frequency f1 (3dB) constant, as shown in Fig. 3.

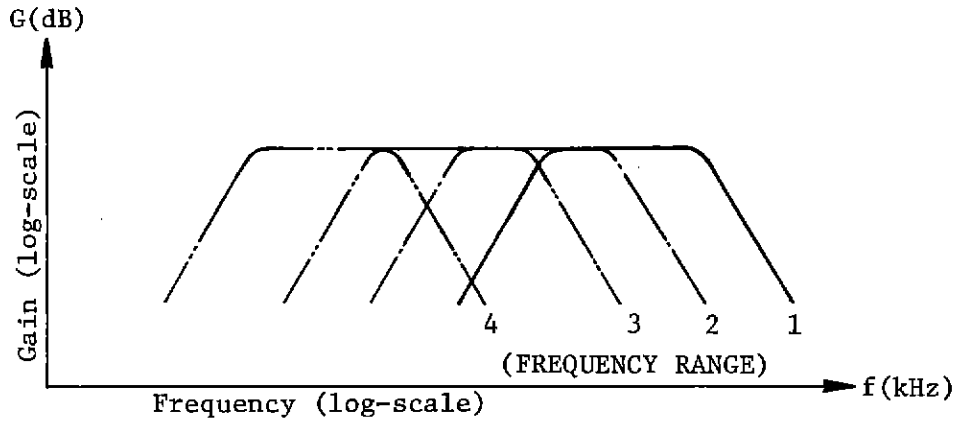


Fig. 3 Frequency range switchover

The frequency range is selected in accordance with the scanning speed and the purpose of observation.

- BAND WIDTH knob:

Switches over the bandwidth in 4 steps. The bandwidth can be switched over while keeping the high cut-off frequency f2 constant, as shown in Fig. 4 (the low cut-off frequency f1 changes).

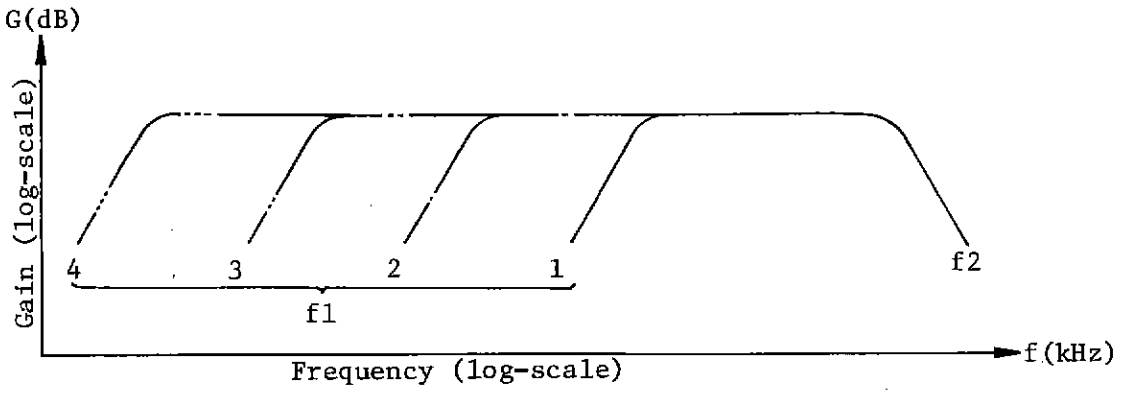


Fig. 4 Bandwidth switchover

When emphasizing the contrast of fine structure, select a narrow (→ 1) bandwidth. On the other hand, when emphasizing the contrast of coarse structure, select a wide (→ 4) bandwidth. When changing over the

FREQUENCY RANGE and BAND WIDTH knobs, the low cut-off frequency f1 and the high cut-off frequency f2 are as follows.

BAND WIDTH knob / FREQUENCY RANGE knob	1	2	3	4
	Frequency range f1-f2 (kHz)			
1	20 - 66	6.6 - 66	2 - 66	0.66 - 66
2	10 - 33	3.3 - 33	1 - 33	0.33 - 33
3	5 - 17	1.7 - 17	0.5 - 17	0.17 - 17
4	2 - 6.7	0.67 - 6.7	0.2 - 6.7	0.067 - 6.7

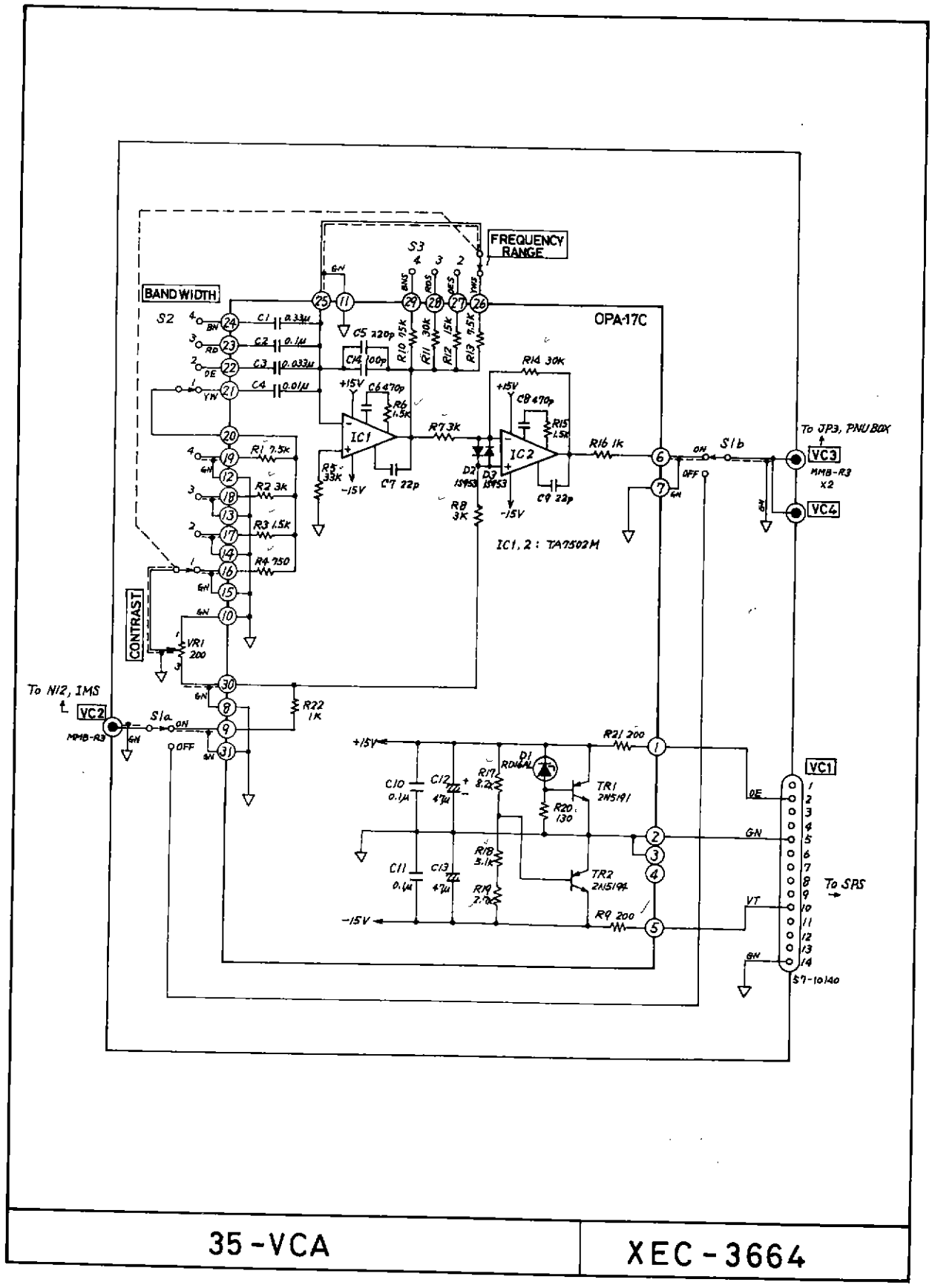
- CONTRAST knob:
  Changes the image contrast by varying the gain (amplification factor) of the bandpass amplifier.
- ON/OFF switch:
  VCA unit power switch. At ON, the video signal is fed into the CRT after being processed by the VCA unit. At OFF, the video signal is fed directly into the CRT without passing through the VCA unit.

5. INSTALLATION

1. Turn off the supplementary power supply (35-SPS1: attachment) switch.
2. Install the VCA unit in the supplementary cabinet (35-SCB·S: attachment).
   Note: The power required for the VCA unit is supplied by the supplementary cabinet supply unit.
3. Connect up the cables as per the scanning microscope and 35-VCA circuit diagrams.
4. Turn on the supplementary power supply switch.

6. OPERATION

1. Adjust the brightness and contrast of the scanning image with the ON/OFF switch set at OFF.
2. Turn the ON/OFF switch to ON and set the FREQUENCY RANGE and BAND WIDTH knobs so that the desired portion of the scanning image becomes sharp.
   Note: In general, set each knob to a small number (→ 1) in order to emphasize fine structure and to a larger number (→ 4) to emphasize coarse structure. If the frequency range and bandwidth are not properly set, the scanning image may exhibit directional blurring. Moreover, black shadows may appear at the contour.
3. Adjust the contrast of the scanning image with the CONTRAST knob.



35 - VCA | XEC - 3664

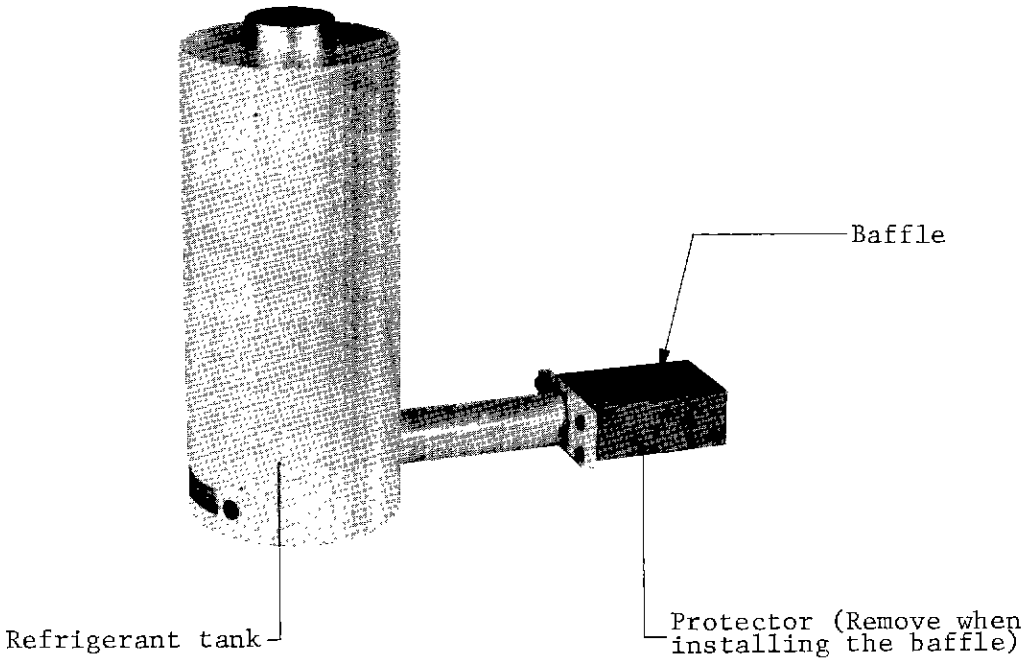
INSTRUCTIONS

50A-LNB

LIQUID NITROGEN BAFFLE

No. IEP35-LNB

(EP506001)



1. GENERAL

The 50A-LNB Liquid Nitrogen Baffle, to a large extent, prevents the backstreaming of diffusion pump oil vapor, thereby greatly reducing column and specimen contamination. Comprised of a cooling baffle and a refrigerant reservoir (Dewar vessel), the 50A-LNB remains operative for about 10 hours on a full reservoir of liquid nitrogen.

2. SPECIFICATIONS

- Refrigerant: Liquid nitrogen (N_2).
- Reservoir capacity: 4 liters.
- Operating time: About 10 hours per full reservoir of refrigerant.

3. USAGE

1. Confirm that the V1 lamp (VACUUM SYSTEM unit) is on and then fill the reservoir with refrigerant using a funnel or the like.
2. Replenish the reservoir every 5 to 8 hours.

INSTRUCTIONS

35-LNT

LIQUID NITROGEN TRAP

No. IEP35C-LNT-3
(EP510050)

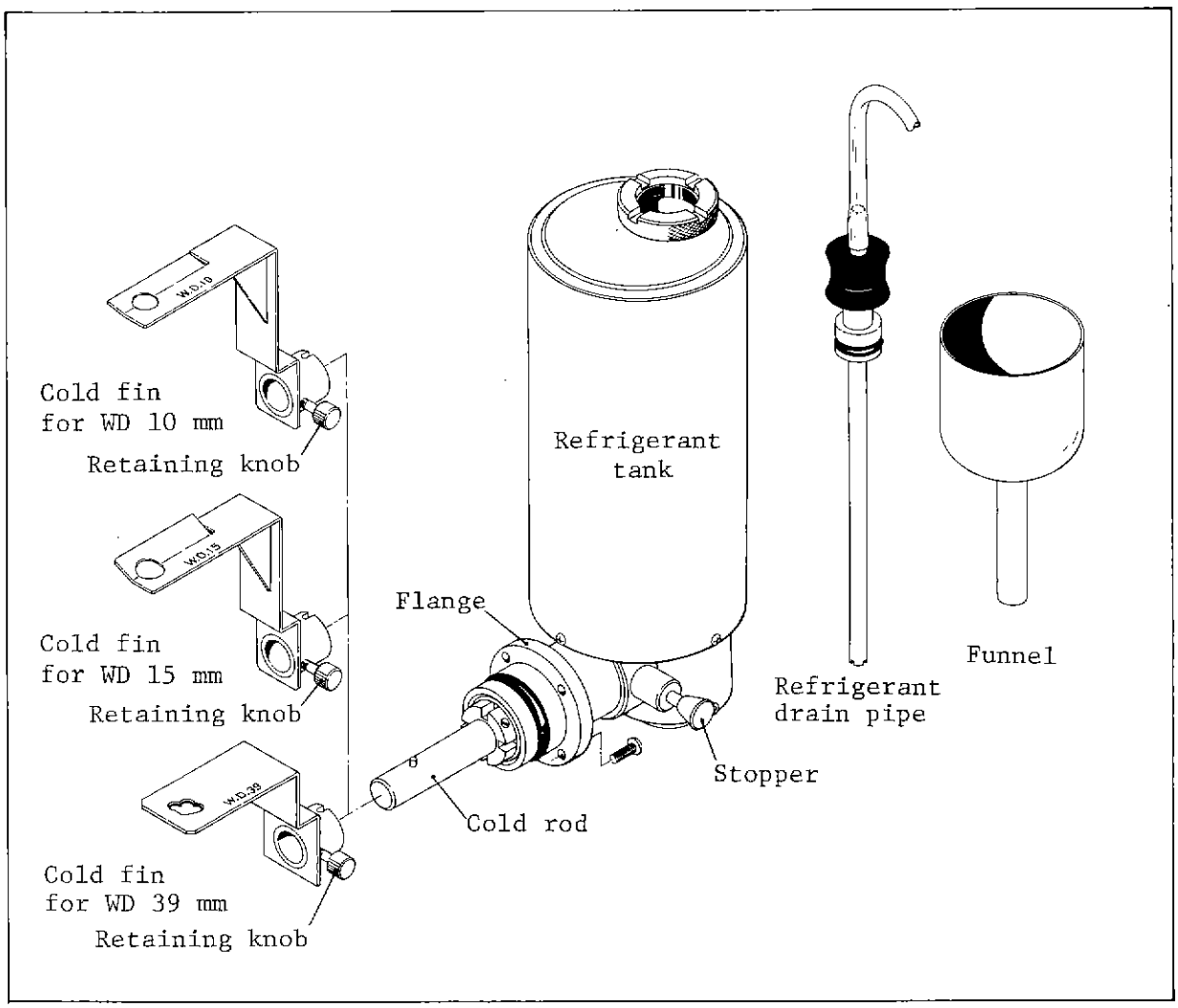


Fig. 1 Component parts

Note: To effect the above, push in the tank until it stops and then pull out the stopper and again push in the tank until it stops.

8. Slide the cold fin suitable to the desired working distance onto the cold rod so that the pin aligns with the groove and secure the fin with the retaining knob.
9. Replace the cover removed in Step 4.
10. Evacuate the microscope column (refer to the JSM-35CF instruction manual).

5. OPERATION

1. Confirm that column evacuation is complete.
2. Insert the funnel into the refrigerant tank and pour in a full measure of liquid nitrogen.
3. Replenish liquid nitrogen every 2 to 3 hours of operation.

Cautions: 1. The specimen movable range for the respective fins is as follows:

<table>
<tr><th>Fin</th><th>Specimen holder</th><th>X-movement</th><th>Y-movement</th><th>Tilt</th><th>Rotation</th><th>Z fine movement</th><th>Fin retraction</th></tr>
<tr><td rowspan="2">WD 10 mm</td><td>WD10/15</td><td rowspan="6">0 ∿ 15 mm</td><td rowspan="6">0 ∿ 25 mm</td><td>0 ∿ 10°</td><td rowspan="6">360° endless</td><td rowspan="6">±1.5 mm</td><td rowspan="3">36 mm</td></tr>
<tr><td>WD39</td><td>0°</td></tr>
<tr><td rowspan="2">WD 15 mm</td><td>WD10/15</td><td>0 ∿ 25°</td></tr>
<tr><td>WD39</td><td rowspan="3">0°</td><td rowspan="3">46 mm</td></tr>
<tr><td rowspan="2">WD 39 mm</td><td>WD10/15</td></tr>
<tr><td>WD39</td></tr>
</table>

- *When the WD 10 mm fin is set, the available working distance (WD) is 10 ∿ 39 mm.*
- *When the WD 15 mm fin is set, the available WD is 15 ∿ 39 mm.*
- *In the case of the WD 39 mm fin, the available WD is 10 ∿ 39 mm when the fin is fully retracted.*

2. If the microscope column is to be exposed to the atmosphere, insert the drain pipe fully into the tank and drain off the liquid nitrogen remaining in the tank; then return the cold fin to room temperature. If the column is exposed to the atmosphere before the fin is returned to room temperature, the fin will be frosted. In case the fin is to be returned to room temperature rapidly, use the defroster housed in the refrigerant tank. Remove the black cover at the bottom of the tank, and connect its terminal to an AC 6 V, 5 A power source.

3. When using the liquid nitrogen trap, fully push in the refrigerant tank as described in the note under Step 7, Sect. 4

(namely, move the cold fin to the electron beam passage). When the trap is not used, proceed as follows:

- *WD 39 mm fin: Retract the tank fully after pulling out the stopper.*
- *WD 10 mm and 15 mm fins: Expose the column to the atmosphere and remove the fin.*

4. *In order to obtain the backscattered electron image by using the BEI*S backscattered electron detector located at the bottom of the optical microscope proceed as follows:*
   - *WD 10 mm and 15 mm fin: Backscattered images can be obtained with the fin in use.*
   - *WD 39 mm fin: Retract the refrigerant tank fully by pulling out the stopper.*

See overleaf: 5.2.10 Film handling and processing
Flowchart A-10, Fig. 5.33

2. Pull out the yellow tab smoothly and at a constant speed. With this operation, developer (caustic jelly) spreads uniformly between the negative sheet (film) and positive sheet (print), and development begins. For the developing time (which varies according to the room temperature), refer to the instructions for the film used.
3. Detach the positive sheet from the negative film in accordance with the instructions for the film used.

   Note: In the case of Polaroid 107 Land film, discard the negative sheet. In the case of the 105 Land film, the negative film should be saved along with the positive sheet.
4. Coat the positive sheet to protect it from scratches and fading in accordance with instructions for the film used (the time allowed for applying coater after development varies according to the type of film used). In the case of the 105 Land film, the negative film must be soaked in sodium sulphite solution as soon as possible (within 3 minutes), water-cleaned, dried, and printed on printing paper by the normal enlarging technique.
5. After checking that no unexposed film is left (the white tab does not appear), unlock the back cover clamping hook to open the back cover and remove the empty film pack.
6. Load an unused film pack in the film holder, close the back cover, and secure it with the hook.

   Note: Load the film pack so that both the black and white tabs protrude from the holder. Pull out the black tab prior to the first exposure.

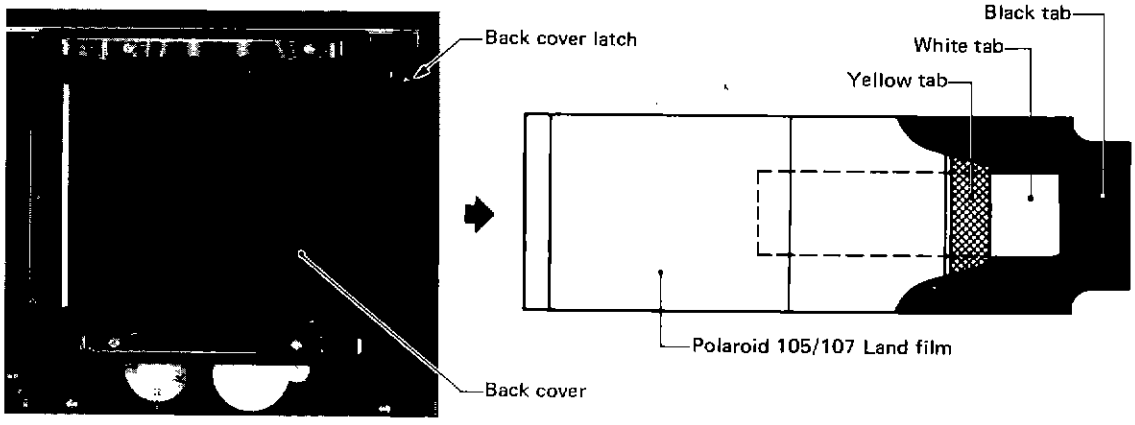


Fig. 5.34 Polaroid #405 film holder

5.2.10c Mamiya 6X7 roll film holder (MRH) (see Fig. 5.35)

1. After exposing all frames (120/220 roll film: 10/20) (the automatic stop mechanism is released), turn the take-up lever (Fig. 5.35a) until it turns freely. With this operation, the film and leader paper are rolled up on the spool.
2. Pull the back cover latch down and open the back cover.
3. Pull both spool exchange knobs (locked if turned), remove the spool on which the exposed film is

would and the one on the opposite side (for the next film), and secure the leader paper with the attached band paper.

4. Mount the unused film (wound up on a spool) on the right side and the take-up spool on the left side, secure them with the spool exchange knobs (by turning the knobs), and remove the band paper securing the leader paper.

   Note: To change the film (120 or 220 roll film), turn the film pressure plate on the back cover over, set it, and change the counter knob setting.

5. Pull out the leader paper, insert its end into the take-up spool, and roll up the leader paper with the take-up lever until the arrow on the leader paper is aligned with the start mark on the film holder (Fig. 5.35b).

6. Close the back cover and secure it with the back cover latch (the film counter indicates S), and set the film counter to 1 by turning the take-up level until it stops. The above operations complete the film exchange and the first frame of the film is ready for exposure.

   Every time an exposure is made, push the stopper release lever to the right and advance the film with the take-up lever.

7. Develop the exposed film in accordance with the instructions for the film used, dry the film, and print it on printing paper by the normal enlarging technique.

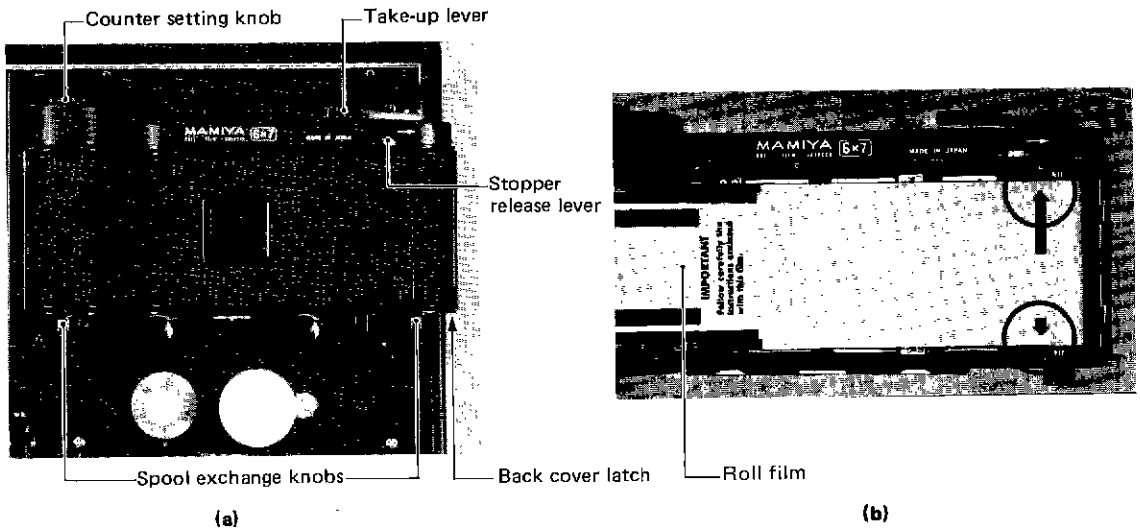


Fig. 5.35 Mamiya 6X7 roll film holder

See overleaf: 5.2.11 Film holder exchange
Flowchart A-11, Figs. 5.36 and 5.37

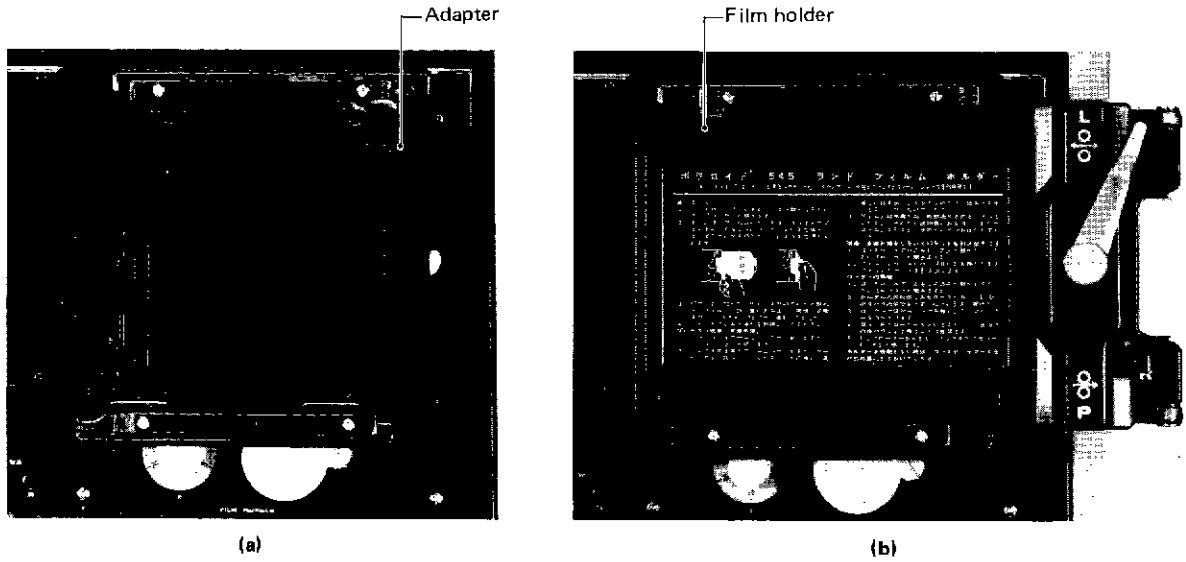


Fig. 5.37 Mounting Polaroid #545 film holder

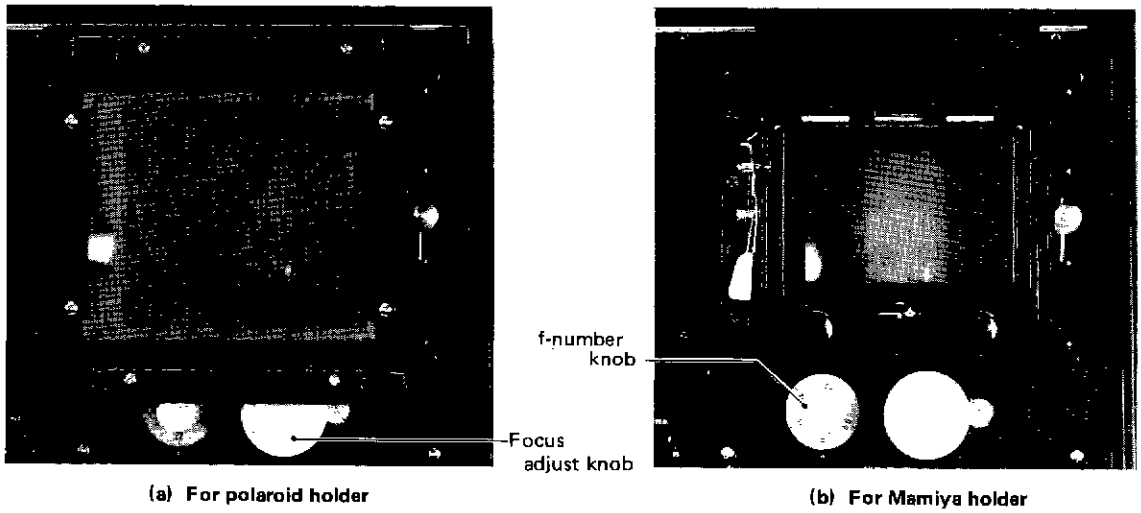


Fig. 5.38 Focus screens

set the scanning mode selection switch to — (line scanning) and set the modulation mode selection switch down (brightness modulation), respectively.

6. Push the MF button (DIS) to open the camera shutter. Then, obtain a scanning line on the focus screen by gradually turning the BRIGHTNESS knob (PHO) clockwise and shift the scanning line to the screen center with the POSITION Y knob (SCG).
7. Set the length of the scanning line on the focus screen to 120 mm with the focus adjust knob. By so doing, the camera is focused and, when the film holder is mounted in the camera, the image on the CRT is focused on the film.
8. Push the MF button (DIS) to close the camera shutter.

9. Remove the focus screen from the adapter and mount the film holder (Fig. 5.37b).
10. Insert a film pack (Polaroid 4X5 Land film – Type 52/55) into the film holder in accordance with Section 5.2.10a.

Note: The magnification of the recorded micrographs (positive sheet, negative film) is the same as the displayed magnification of the MAGNIFICATION indicator (IND) and the magnification displayed on the CRT and recorded on the micrographs.

5.2.11b Mounting Polaroid #405 film holder (PRH2)

1. Attach the adapter to the camera (PHO) (Fig. 5.39a) and secure it with the adapter securing lever (Fig. 5.36a).

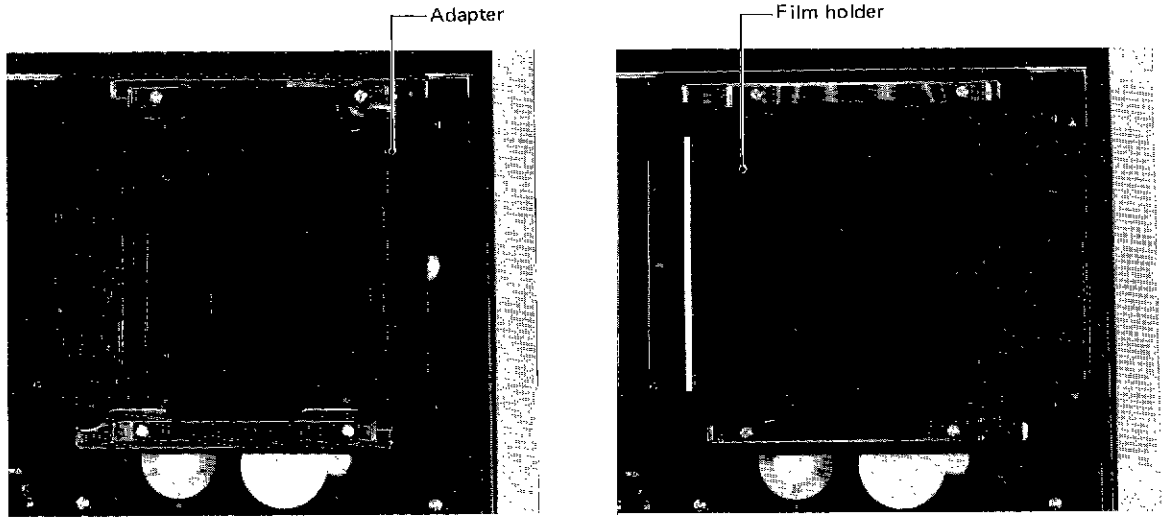


Fig. 5.39 Mounting Polaroid #405 film holder

2. Perform Steps 2 to 6 in Section 5.2.11a (mounting the focus screen and observing the scanning image).
3. Set the length of the scanning line on the focus screen to 100 mm with the focus adjust knob. By so doing, the camera is focused, and when the film holder is mounted on the camera, the image on the CRT is focused on the film.
4. Push the MF button (DIS) again to close the camera shutter.
5. Remove the focus screen from the adapter and mount the film holder (Fig. 5.39b).
6. Insert the dark slide into the film holder. Load the film pack (Polaroid 105/107 Land film) in the film holder in accordance with Section 5.2.10b.

Note: The actual magnifcation of the recorded micrographs (positive sheet, negative film) is approximately 0.83 times the magnification displayed on the MAGNIFICATION indicator (IND) and that displayed on the CRT and recorded on the micrographs. However, if the size of the

image is enlarged to 90 mm X 120 mm, the actual and displayed (recorded) magnifications become the same.

5.2.11c Mamiya 6X7 roll film holder (MRH)

1. Attach the adapter to the camera (PHO) (Fig. 5.40a) and secure it with the adapter securing lever (Fig. 5.36a).

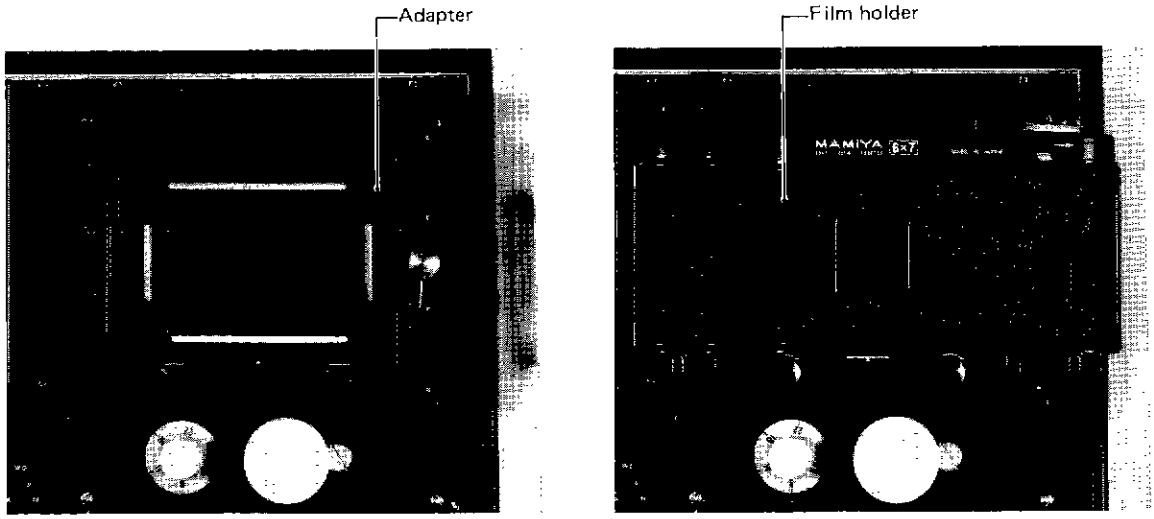


Fig. 5.40 Mounting Mamiya 6X7 roll film holder

2. Attach the Mamiya focus screen to the adapter (Fig. 5.38b).
3. Set the lens opening of the camera to f/5.6 (open) with the f-number knob.
4. Set the recording unit BRIGHTNESS knob to 0.0.
5. Set the SCAN GENERATOR unit scanning mode selection switch to ● (spot).
6. Push the MF button (DIS) to open the camera shutter. Then, produce a spot (darkest possible spot observable) on the focus screen by gradually turning the BRIGHTNESS knob clockwise.
7. Adjust the focus adjust knob so as to obtain the clearest possible (smallest) spot on the screen. By so doing, the camera is focused, and when the film holder is mounted on the camera, the image on the CRT is focused on the film.
8. Push the MF button (DIS) again to close the camera shutter.
9. Remove the focus screen from the adapter and mount the film holder (Fig. 5.40b).
10. Insert the dark slide into the film holder. Then, load the roll film (120/220) in the film holder in accordance with Section 5.2.10c.

Note: The actual magnification of the recorded micrographs is approximately 0.58 times the displayed magnification on the MAGNIFICATION indicator (IND) and that displayed and recorded on

the micrograph. However, if the size of the image is enlarged to 90 mm × 120 mm, the actual and displayed (recorded) magnifcations becomes the same.

See overleaf: 5.2.12 Shutdown
Flowchart A-12

See overleaf: 5.3 Observation method B, 5.3.1 Initial control setting
Flowchart B-1

- Y control . . . . . 12.5 mm (or as desired)
- Tilt control . . . . . 0°
- Rotation control . . . . . 000 (0°)

4. Set the anode chamber airlock knob to open the airlock valve AVI.

See overleaf: 5.3.2 Axis alignment
Flowchart B-2

Note: The significance of setting the knob at the saturation position is described in Step 6 of Section 5.2.4.

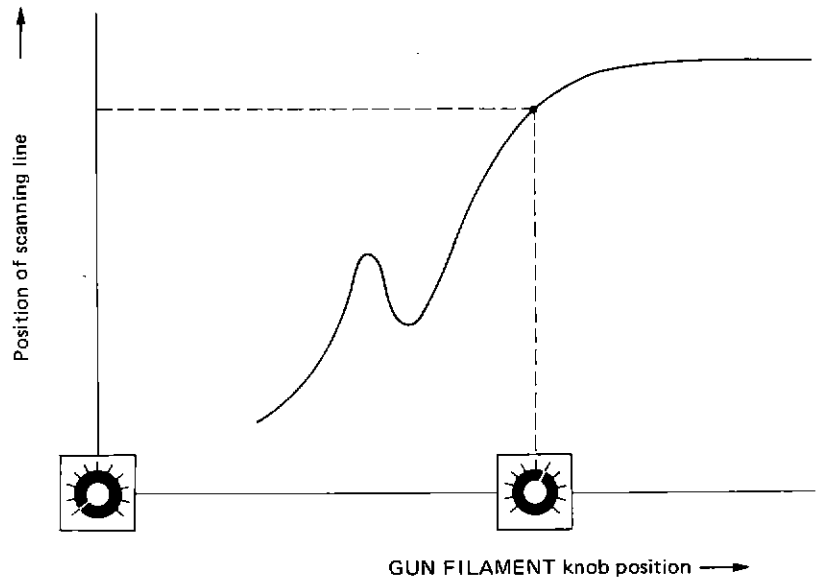


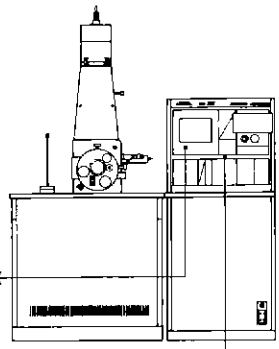
Fig. 5.41 Resetting GUN FILAMENT knob

See overleaf: 5.3.3 Checking aperture and astigmatism
Flowchart B-3

See overleaf: 5.3.4 Image observation and photography
Flowchart B-4

Special Observation Modes

[Flowchart]



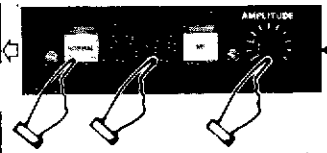
■ Y-modulated image

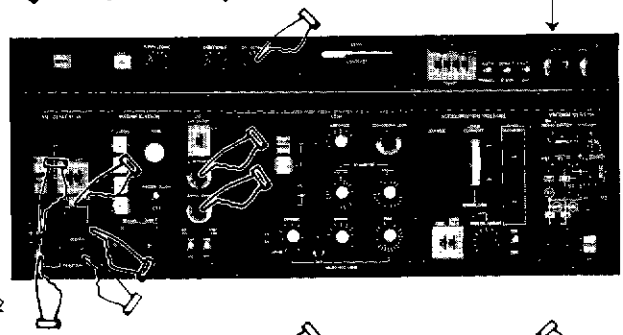
Y-MOD button · Push

AMPLITUDE knob (DIS) · · · · · · Adjust the amplitude

Y-modulated image · · · · · · · · · · · · Photograph (A-9)
(Table 5.7 · · · · Ⓨ)

NORMAL button · Push
(A conventional brightness – modulated image appears)





■ Line scanning

Scanning mode selection switch · · · · · · · · · · · · · · —

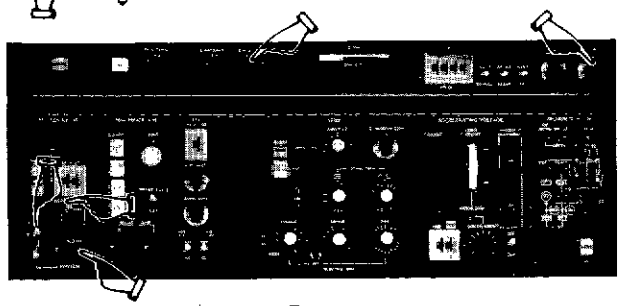
Modulation mode selection switch · · · · · · · · · · · · ⋂

SELECTED AREA switch · · · · · · · · · · · · · · · · · · ⋂

(A brightness-modulated scanning line appears on the screen.)

Scanning mode selection switch · · · · · · · · · · — ⇌ □

(The persistent image and scanning line now overlap.)



■ Spot

WIDTH knob ·
Adjust the scanning width (length of the scanning line)

BRIGHTNESS knob (DIS) · · · · · · · · · · · · · · · · ☼

POSITION X and Y knobs · · · · · · · · · · · · · · · · · · ·
Select the desired scanning position

BRIGHTNESS knob (PHO) · · · · · · · · · · · · · · · · 0.0

Scanning line Iline positioning) · · · Photograph (A-9)
(Table 5.7 · · · · · · —)

Scanning mode selection switch · · · · · · · · · · · · · · ●

Modulation mode selection switch · · · · · · · · · · · · ⋂

(A waveform is now displayed on the screen.)

SELECTED AREA switch · · · · · · · · · · · · · · · · · · ⋂

BRIGHTNESS knob (DIS) · · · · · · · · · · · · · · · · · · ·
Adjust the waveform brightness

BRIGHTNESS knob (DIS) · · · · · · · · ⋂ Obtain a spot

CONTRAST, BRIGHTNESS knobs (SEI) · · · · · · · · ·
Adjust the waveform amplitude and level

Scanning mode selection switch · · · · · · · · · · · · · ● ⇌ □

(The persistent image and spot now overlap.)

Waveform (Line profile) · · · · · · · · · Photograph (A-9)
(Table 5.7 · · · · · —)

POSITION X and Y knobs · · · · · · · · · · · · · · · · · · ·
Shift the spot as desired

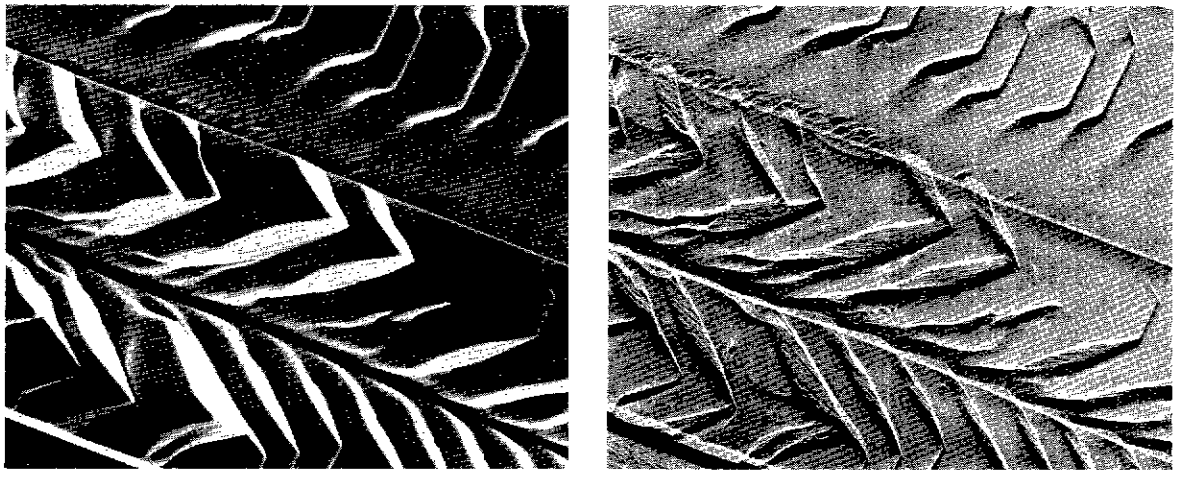
5.4 Special Observation Modes

This section describes how to obtain a Y-modulated image, a scanning line (for line profile, line positioning) and a spot. The procedures for obtaining the Y-modulated image, scanning line, etc. are carried out after first obtaining the scanning image.

5.4.1 Y-modulated images

A normal scanning image is obtained by modulating the CRT brightness with the video signal intensity, while the Y-modulated image is obtained by vertically deflecting the CRT beam in correspondence with the video signal intensity. As shown in Fig. 5.42, the Y-modulated image is more suitable for fine structure study than the brightness modulated image.

1. Push the DISPLAY unit Y-MOD button.
   A Y-modulated image at a scanning speed and number of scanning lines as shown in Table 5.4 is displayed on the CRT.
2. Adjust the amplitude of the modulated image with the DISPLAY unit AMPLITUDE knob.
3. Record the image in accordance with Section 5.2.9 (Table 5.7 ····· Ⓨ). A Y-modulated image at a scanning speed and number of scanning lines as shown in Table 5.6 is recorded.
4. Return the image to normal with the DISPLAY unit NORMAL button.



[Normal brightness modulated image] [Y-modulated image]

Fig. 5.42 Normal image (brightness-modulated image) and Y-modulated image

5.4.2 Line scanning

When the video signal obtained by scanning the specimen in the X-axis direction (horizontal direction on the CRT screen) is used to modulate the brightness of the screen, a scanning line having a brightness corresponding to the intensity of the signal is obtained. However, when the video signal is applied to the vertical

deflection circuit of the CRT, a waveform (line profile) is obtained. The brightness-modulated line scanning mode is mainly used for selecting the display position of the line profile. Furthermore, by shifting the brightness-modulated line continuously (with the POSITION Y knob – (SCG)), a scanning image is obtained. This imaging mode makes it possible to select the display position of the line profile quickly, because a scanning image can be observed without switching over the scanning mode selection switch. The line profile mode is very useful for correlating signal intensities of particular features when the line profile is exposed together with the scanning image.

5.4.2a Brightness-modulated line scanning

1. Set the scanning mode selection switch (SCG) to – (line scanning).
2. Push down the modulation mode selection switch (SCG).

   A brightness-modulated scanning line, whose scanning speed corresponds to the horizontal scanning speed when the scanning mode selection switch is set at □ (frame scanning) (see Table 5.4), is now displayed.

   Note: The scanning line can be moved up or down with the POSITION Y knob (the X knob is inoperable). However, if the modulation mode selection switch is set at the upper position (amplitude modulation) without carrying out Steps 3 and 4 in this section, the displayed line profile will not correspond to the scanning line selected with the POSITION Y knob, but rather will correspond to the horizontal line running through the center of the displayed image.
3. Push down the SELECTED AREA switch (selected area scanning).
4. While overlapping the image and the scanning line by changing over the scanning mode selection switch between the frame scanning and line scanning positions, or while displaying the image by continuously shifting the scanning line with the POSITION Y knob as described at the beginning of this section, carry out the following.
   a. Adjust the scanning width (length of the scanning line) with the WIDTH X knob.
   b. Select the scanning position with the POSITION X and Y knobs.
5. Record the displayed line in accordance with Section 5.2.9 (Table 5.7 – –).

   The exposure time is determined with the VERT thumbwheel.

5.4.2b Amplitude-modulated line scanning (Line profile)

1. Set the scanning mode selection switch (SCG) to – (line scanning).
2. Push up the modulation mode selection switch (SCG) – (amplitude modulation).

   A waveform (line profile), whose scanning speed corresponds to the vertical scanning speed when the scanning mode selection switch is set at □ (frame scanning) (see Table 5.4), is now displayed.

   Note: A line profile corresponding to the position and width of the scanning line is displayed when Step 2 is carried out after completing Section 5.4.2a. However, a line profile corresponding

to the screen center line is obtained by carrying out Steps 1 and 2 only.

3. Adjust the brightness of the waveform with the DISPLAY unit BRIGHTNESS knob.
4. Adjust the amplitude and level of the waveform with the SEI unit CONTRAST and BRIGHTNESS knobs.
5. Record the waveform in accordance with Section 5.2.9 (Table 5.7 – –).

   The exposure time is determined with the VERT thumbwheel.

5.4.3 Spot

This mode, which enables the probe to be optionally positioned on the specimen surface, is used for measuring the intensity of the emitted electrons and for X-ray analysis.

1. Turn the DISPLAY unit BRIGHTNESS knob fully counterclockwise.
2. Set the photographic recording unit BRIGHTNESS knob to 0.0.
3. Set the scanning mode selection switch (SCG) to ● (spot).
4. Push down the SELECTED AREA switch (SCG).

   Note: When the switch is pushed up, the spot will locate at the center of the screen.
5. Display the spot with appropriate brightness on the screen by turning the DISPLAY unit BRIGHTNESS knob gradually clockwise.
6. Move the spot to the desired position on the screen with the POSITION X and Y knobs (SCG) while overlapping the image and the spot by changing over the scanning mode select switch between □ (frame scanning) and ● (spot).

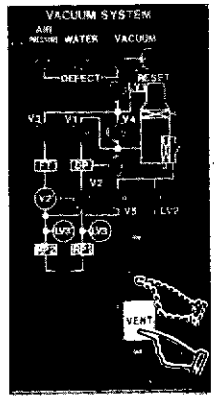
6 . MAINTENANCE

6. MAINTENANCE

This chapter deals mainly with routine and preventive maintenance in order to ensure peak instrument performance at all times. The capital letters appearing in parentheses after knobs or switches designate the control units; for details refer to the description at the beginning of Chapter 5.

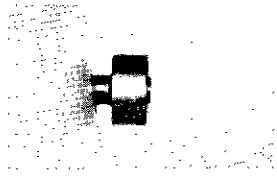
6.1 Venting and Re-evacuating the Column

This section describes the procedures for temporarily exposing the column to the atmosphere in order to (1) replace the gun filament, (2) clean the column and (3) mount certain attachments. The procedure for column re-evacuation is also described. Make it a rule to keep the time in which the column is exposed to the atmosphere as short as possible.



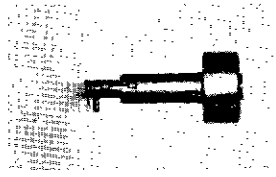
6.1.1 Venting

1. Turn the GUN FILAMENT knob (ACV) fully counterclockwise.
2. Turn off the ON/OFF switch (ACV).
3. Set the SEI/BEI switch (SEI) to the center position.
4. If there is a need to expose the anode chamber to the atmosphere (for filament replacement, etc.), close the airlock valve AV1 (Fig. 3.8) by pushing in the anode chamber airlock knob and turning it fully clockwise (about 180°). (See Fig. 4.1.)
5. Push the VENT button (VAC). By so doing, the LOAD CURRENT meter lamp will go out, and air will enter the microscope column (or only the anode chamber in the event the airlock valve was closed in Step 4).



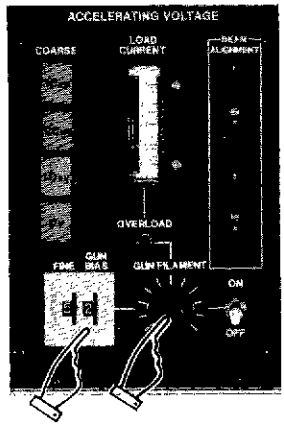
6.1.2 Re-evacuating

1. Confirm that the microscope column has been properly re-assembled.
2. Push the PUMPDOWN button (VAC). By so doing, the column (or anode chamber) will be automatically evacuated. When evacuation is completed, the LOAD CURRENT meter will light to indicate that the microscope is ready for high-voltage application.
3. If only the anode chamber has been exposed to the atmosphere, open the airlock valve by turning the anode chamber airlock knob fully counterclockwise and pulling it out after checking that the LOAD CURRENT meter has lit. With the operation the entire column is evacuated. Upon completion of evacuation the LOAD CURRENT meter lights to indicate that the microscope is ready for high-voltage application.



6.2 Replacing the Electron Gun Filament

After prolonged use, the electron gun filament becomes weak and finally burns out. The following describes the filament replacement procedures.



1. Check for filament burn-out by noting the following:
   a. The LOAD CURRENT meter reading fails to increase even when the GUN BIAS thumbwheel (ACV) is turned to 0.
   b. The LOAD CURRENT meter reading fails to vary when the GUN FILAMENT knob (ACV) is turned.

   Note: If the meter reading varies, indicating that the filament is not burnt out, and yet there is no image on the CRT, confirm that the apertures are properly inserted in the beam path and that the optical axis is properly aligned.
2. *Ven*t the anode chamber as described in Section 6.1.1.
3. Lift the hinged electron gun back (see Fig. 6.1) and cover the lower anode chamber with a plastic sheet, aluminum foil, or the like, to keep out dust, etc.

   Caution: 1. The Wehnelt unit remains hot for some time af*ter a filament burn-out. Accordingly, allow a few minutes for the unit to cool down before handling.*
   2. *Be sure to wear clean cotton or nylon gloves when handling the Wehnelt unit. Dirt, perspiration, etc. from bare hands may be a cause of high voltage discharge.*
4. Loosen the Wehnelt securing ring (turn counterclockwise) with the Wehnelt unit tool (Fig. 3.5 - a). (See Fig. 6.1 - A.)
5. Unscrew the securing ring and remove the Wehnelt from the socket (see Fig. 6.1 - B).
6. Disassemble the Wehnelt unit as described below:
   a. Turn the Wehnelt cap counterclockwise and remove it from the Wehnelt unit base.
   b. Use a screwdriver to loosen the screws securing the filament, and remove the burnt-out filament.
7. Clean the Wehnelt cap as described below (see Section 6.6).
   a. Remove any accumulated dirt from the cap, especially around the cap hole, with absorbent cotton, gauze or a cotton stick, etc. lightly smeared with fine grain metal polish.

      Caution: Keep the polish away from the theaded portion of the cap.
   b. Remove any traces of polish or dirt from the cap with absorbent cotton, gauze, etc. moistened with an organic solvent.

      Caution: Polyethylene gloves are recommended when handling the organic solvent.
   c. Prepare a stainless steel beaker, pour in some organic solvent and immerse the cap therein.

      Note: An ultrasonic cleaner (approx. 20 kHz) would be ideal for cleaning the cap.
   d. Remove the cap from the beaker and dry the cap with the handblower (Fig. 3.3 - ⑧).

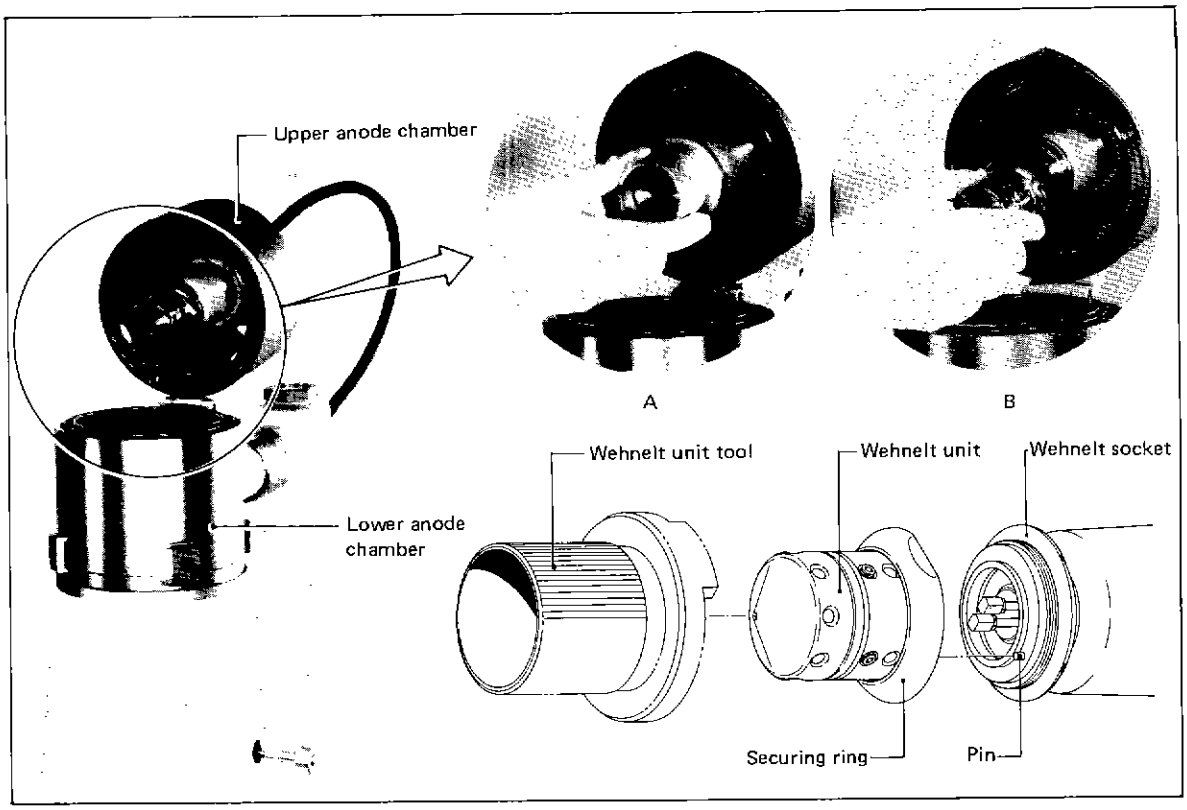


Fig. 6.1 Removing the Wehnelt unit

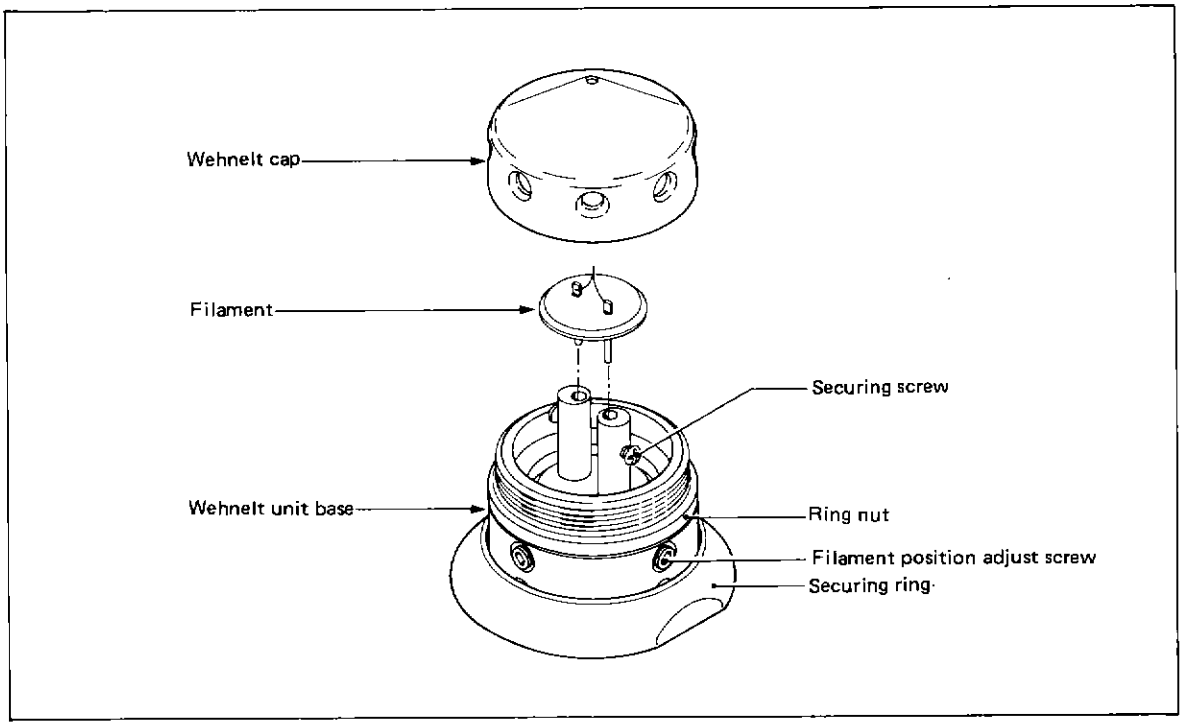


Fig. 6.2 Wehnelt unit

8. Insert a new filament into the holder and secure it with the screws.

   Caution: Be extremely careful not to touch the filament tip.

9. Apply the handblower to the Wehnelt cap to remove any traces of lint that may still be adhering thereto and screw the cap onto the Wehnelt unit base until the tip of the filament can be seen in the cap hole.

10. Align the filament tip with the center of the Wehnelt cap opening by turning the filament position adjust screws (see Fig. 6.3 - A). Then tighten the screws.

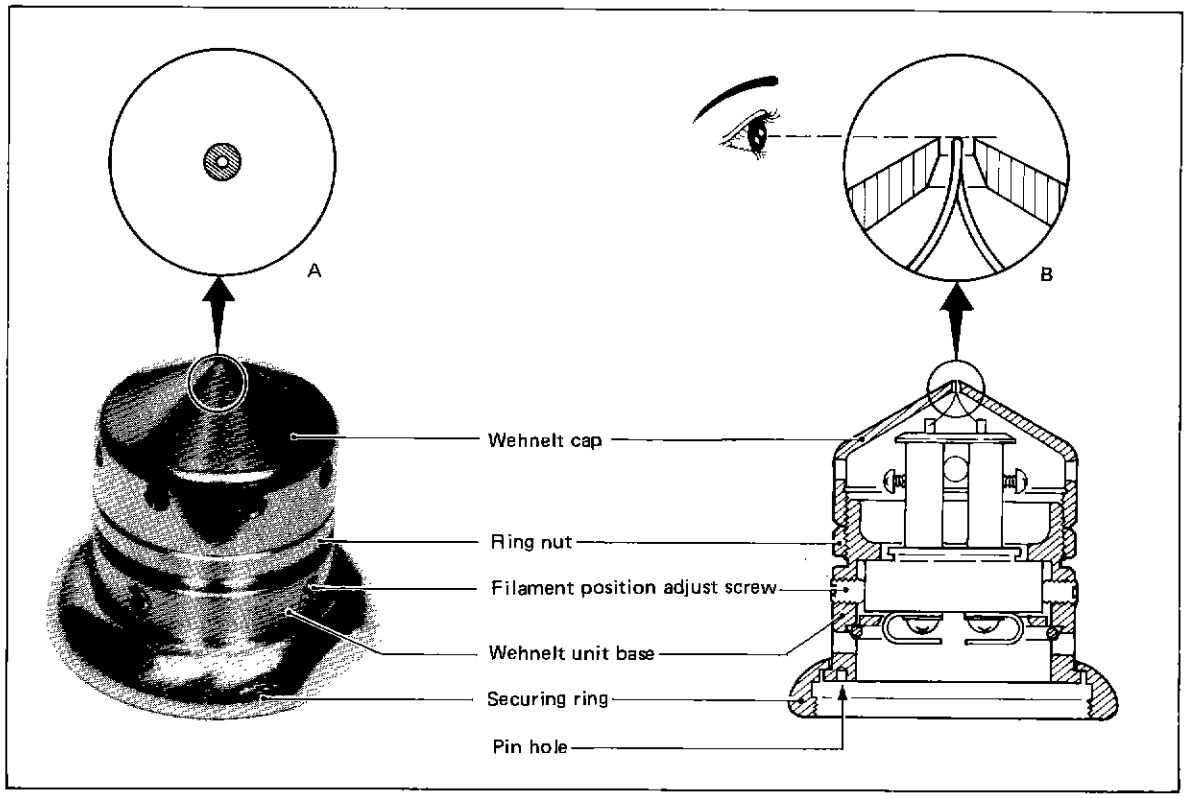


Fig. 6.3 Filament adjustment

11. Screw on the Wehnelt cap until the filament tip is flush with the apex of the cap (see Fig. 6.3 - B) and then apply a 1/8 (or 3/8) counterclockwise turn to the cap according to the selected accelerating voltage to set the filament tip in the proper position inside the Wehnelt cap apex opening (see Table 5.2). After this adjustment, secure the cap with the ring nut and confirm once again that the filament tip aligns with the center of the Wehnelt cap opening. If not, re-center it as per Step 10.

12. Align the pin hole of the Wehnelt unit base with the pin of the electron gun socket, push the Wehnelt unit into the socket as far as it will go, then screw the securing ring to secure the Wehnelt unit (without the tool).

13. Apply the handblower to the electron gun and remove all traces of lint, dust, etc. Then remove the aluminum foil covering the lower part of the anode chamber and blow out the interior just in case any

dust particles, etc. have entered. Confirm that there are no scratches or dirt on the O-ring or O-ring contact surfaces.

Note: Scratches or dirt on the O-ring or O-ring contact surfaces will result in vacuum deterioration.

14. Return the electron gun to its original position and re-evacuate the anode chamber along with the column according to Section 6.1.2.
15. Upon completion of evacuation, confirm that an image is displayed.

6.3 Replacing the Scintillator

Change the scintillator when the secondary electron image becomes noisy or when image contrast becomes weak. The procedure is as follows:

1. Set the SEI/BEI switch (SEI) to the center position so as to protect the secondary electron detector and the CRT.
2. Vent the column according to Section 6.1.1.
3. Loosen the ring nut and remove the PMT from the secondary electron detector (see Fig. 6.4).

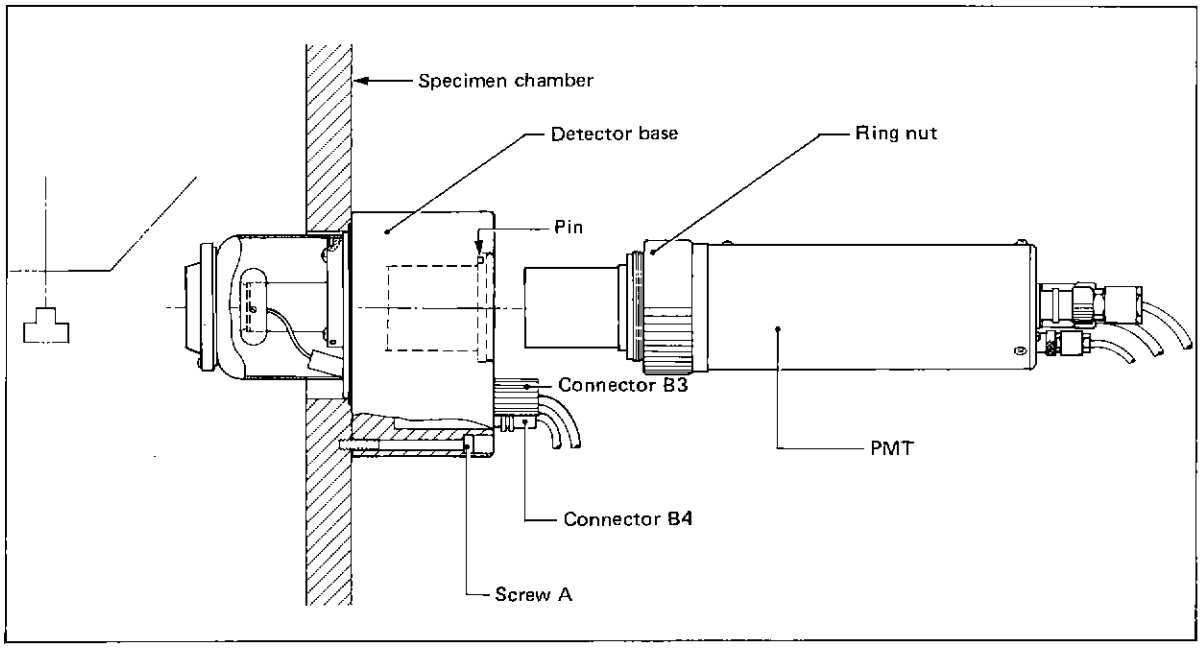


Fig. 6.4 Removing the secondary electron detector

4. Remove cable connectors B3 and B4 from the detector base.
5. Remove screws A (3) and remove the detector base from the specimen chamber.
6. Remove screw B and remove the lead wire from the collector (see Fig. 6.5).
7. Remove screws C (3) and then remove the cylinder with the collector.
8. Loosen screw D, which holds the detector high voltage lead wire, and screws E (2) on the corona ring. Remove the corona ring and scintillator from the tip of the light pipe.
9. Mount the new scintillator on the tip of the light pipe, exercising great care while doing so. Then attach the corona ring and secure it with screws E.

   Caution: Do not scratch or permit dust to settle on the scintillator or light pipe. NEVER touch the surface of the scintillator.
10. Insert the detector high voltage lead wire into the corona ring opening and secure it with screw D.

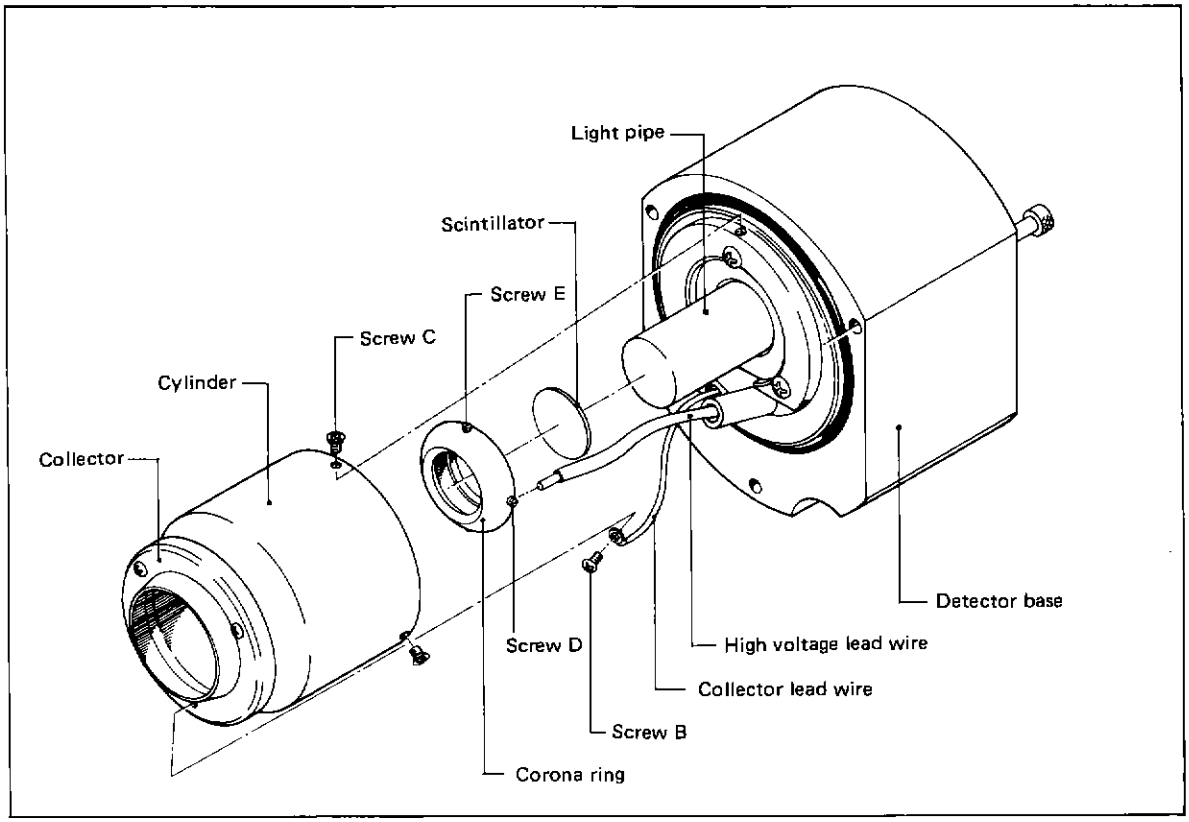


Fig. 6.5 Exploded view of the secondary electron detector

11. Return the cylinder to its original position and secure it with screw C.
12. Tighten screw B in order to connect the lead wire to the collector.

    Caution: Never use excessive force when tightening the screw; otherwise the threads will be damaged.
13. Apply the handblower (Fig. 3.3 - ⑧) to the detector to remove any traces of lint, dust, etc. and verify that there are no scratches or dirt on the O-ring or O-ring contact surfaces.

    Note: Scratches or dirt on the O-ring or O-ring contact surfaces will result in vacuum deterioration.
14. Mount the detector base in its original position in the specimen chamber and secure it with screws A.
15. Apply a very thin coat of silicone oil to the light pipe on the surface opposite the PMT.
16. Connect cable connectors B3 and B4 to their original positions.
17. Align the PMT setting pin hole with the detector base pin, mount the PMT on the detector base and secure the PMT with the ring nut.
18. Re-evacuate the column according to Section 6.1.2.

6.4 Replacing the Illumination Lamps

From time to time one of the illunination lamp filaments will burn out, necessitating lamp replacement. It is important when replacing the lamp to use a lamp having the same specification (voltage rating, type, etc.) as the lamp being replaced. Failure to comply with this requirement may lead to an electrical breakdown or other problems. Further, if any illumination lamp other than the ones described below burns out, contact your nearest JEOL Service Center for assistance.

6.4.1 Specimen chamber illumination lamp

1. Vent the entire column as per Steps 1 to 5, Hinge system, Section 5.2.3b, and open the front cover.
2. Remove the lamp holder from the specimen chamber by lightly pushing the holder into the chamber interior with a forefinger (see Fig. 4.5).
3. Remove the cap from the lamp holder and replace the lamp with a new one (see Fig. 6.6).

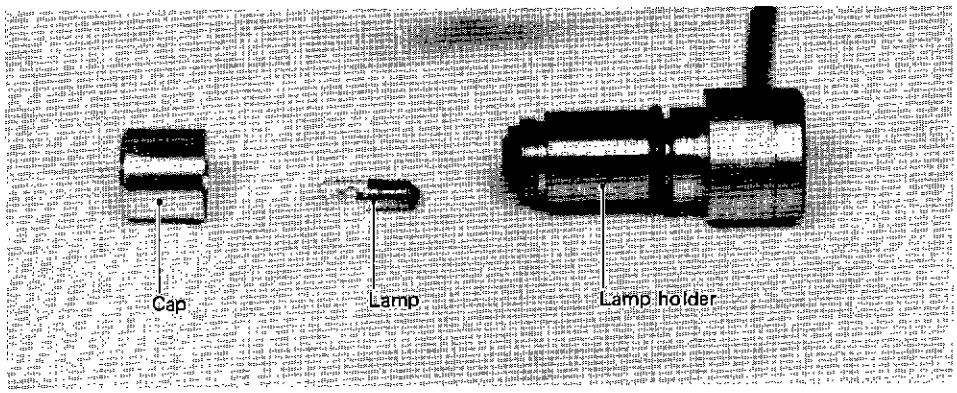


Fig. 6.6 Replacing the specimen chamber illumination lamp

4. Apply the handblower (Fig. 3.3 - ⑧) to the lamp holder to remove any traces of lint, dust, etc., and check that there are no scratches or dirt on the O-ring or O-ring contact surfaces.

   Note: Scratches or dirt on the O-ring or O-ring contact surfaces will result in vacuum deterioration.
5. Replace the cap and insert the lamp holder in its original position in the specimen chamber.
6. Close the front cover and re-evacuate the column as per Step 7, Hinge system, Section 5.2.3b.
7. Upon completion of evacuation, attach the specimen exchange chamber cap to the exchange chamber, push the vacuum control button to evacuate the chamber and, after pulling out the airlock knob, verify that the lamp lights.

6.4.2 Button lamps

1. If there is any trouble (for example, if when the VENT button (VAC) is pushed, air is admitted into the column), shut down the microscope according to Section 5.2.12.

2. Remove the lamp cap as follows:

   Insert a thin, flat piece of metal between the side edge of the lamp cap or bottom edge of the cap and the edge of the panel cut-out, depending on the lamp arrangement.

3. Remove the lamp (pull it out) with a suitable pair of tweezers and, if necessary, remove the head cap (see Fig. 6.7).

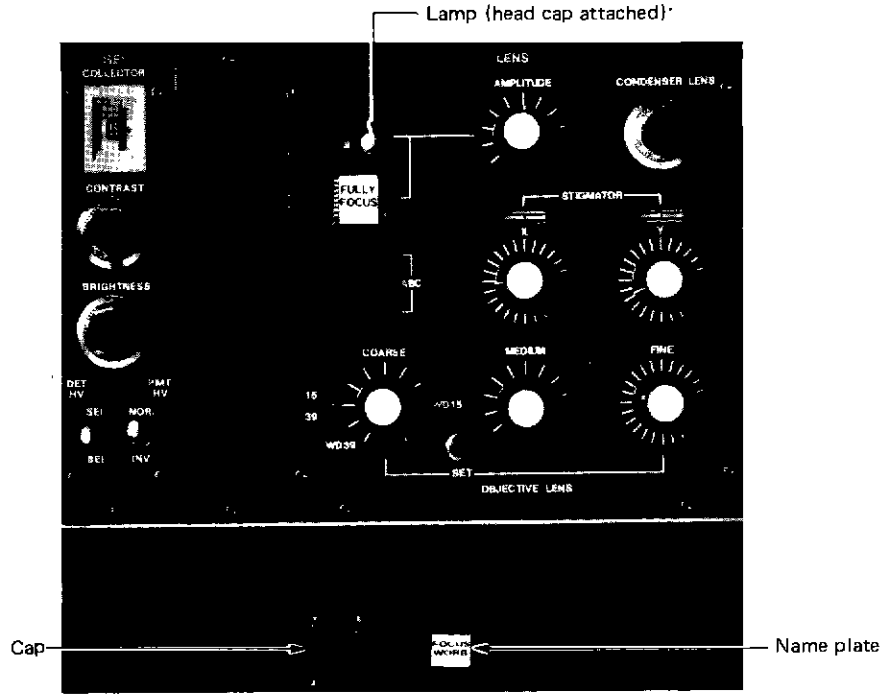


Fig. 6.7 Replacing the button lamp

4. Replace the burnt-out lamp with a new one, and replace the cap and name plate.

   Caution: Never use excessive force when replacing the cap; otherwise the cap will be damaged.

5. If the microscope has been shut down, start the microscope according to Section 5.2.2 and confirm that the lamp lights.

6.5 Oil Rotary Pump and Air Compressor Maintenance

The oil rotary pump and compressor will need replenishing with oil from time to time. Ensuring that there is sufficient oil in these units at all times is an important aspect of overall maintenance. If the oil levels are allowed to get too low, seizures and other mechanical failures may result. Further, be sure to use the grade of oil specified by this company. Furthermore, prolonged operation of the air compressor results in a clogged filter and stagnant water. Replacing the filter and draining off water must also be conducted at specified periods.

6.5.1 Oil rotary pump

■Oil replenishment

1. Check the oil level via the viewing window. If the oil level is below the ● guide mark, replenish the pump with the specified oil as follows.
2. Remove the pump box cover and remove the oil supply port cap by turning the cap countercloskwise.

   Caution: When replenishing a running pump with oil, be sure that the evacuation hose is connected to the pump.
3. Top up with oil until the oil level indicator reads as shown in Fig. 6.8.

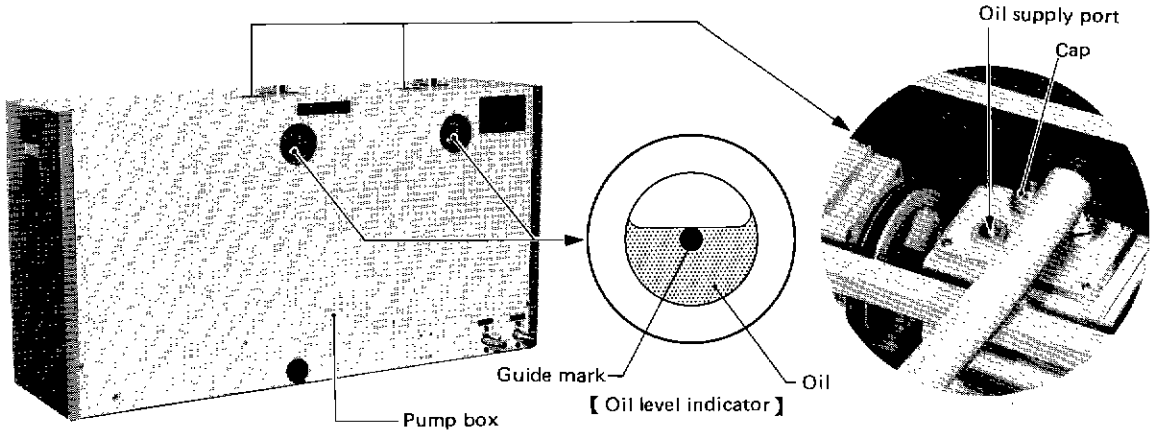


Fig. 6.8 Replenishing the pump with oil

4. Replace the cap and pump box cover.

6.5.2 Air compressor

■Oil replenishment

1. Determine the oil replenishment time.
   Replenishment is required every 40 hours of operation. However, since the compressor operates only when the reservoir pressure is low, it is sufficient to replenish the compressor with oil every one or two months. The replenishing procedure is as follows.
2. Remove the cover of the pump box and open the oil supply port cover (see Fig. 6.9).
   Caution: When replenishing the compressor with the microscope running, be sure that the evacuation hose is connected to the rotary pump.

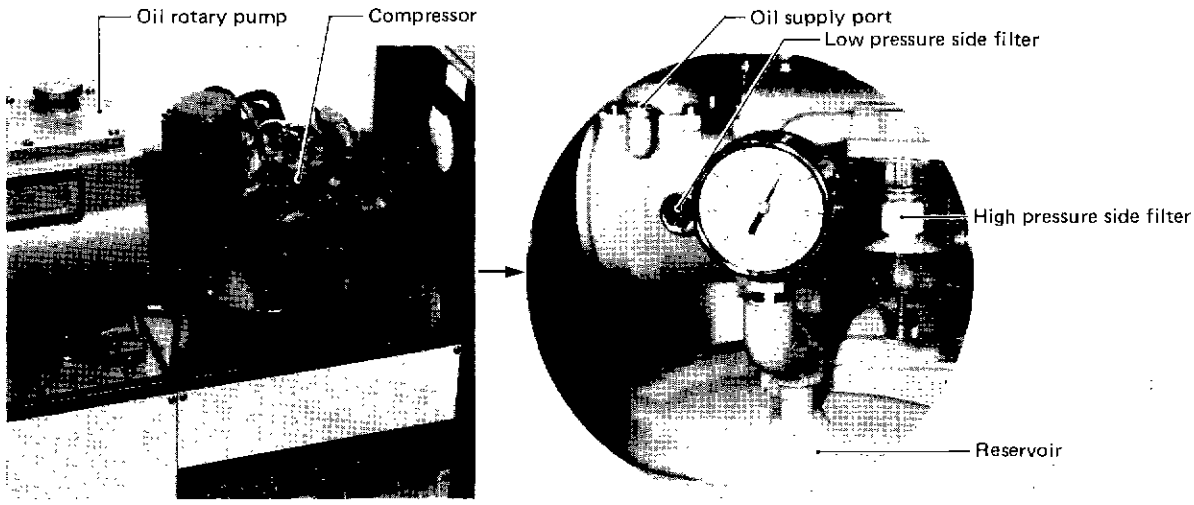


Fig. 6.9 Replenishing the air compressor with oil

3. Pour in the designated oil (Fig. 3.3 - ⑫). Approx. 5 mℓ of oil is sufficient (requires two or three fills).
4. Close the oil supply port cover and replace the cover of the pump box.

■Draining off water from the reservoir

1. Since stagnant water accumulates in the reservoir over a period of time, drain off the water every one or two months as follows.
2. Shut down the microscope according to Section 5.2.12.
3. Drain off the water by opening the drain cock. (Water will be rapidly drained owing to pressure from the reservoir.)
4. Close the drain cock immediately after the water has drained off.
5. Start the microscope according to Section 5.2.2. If the compressor pressure gauge reads approx. 3.5 kg/cm^2 or more, the compressor will stop.

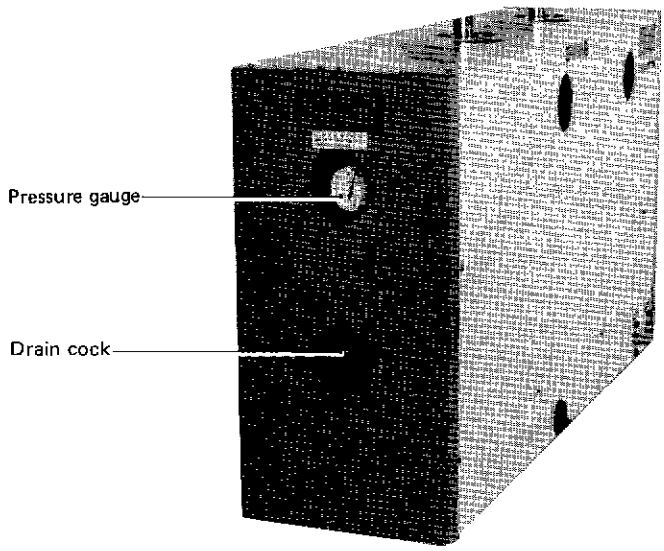


Fig. 6.10 Draining off water from the reservoir

■ **Replacing the filter**

a. **Low pressure filter** (Used to clean air)

1. Check the filter about every three months as follows.
2. Shut down the microscope according to Section 5.2.12 and remove the pump box cover (see Fig. 6.9).
3. Remove the knurled cap by turning it counterclockwise and take out the filter from the cap (see Fig. 6.11).

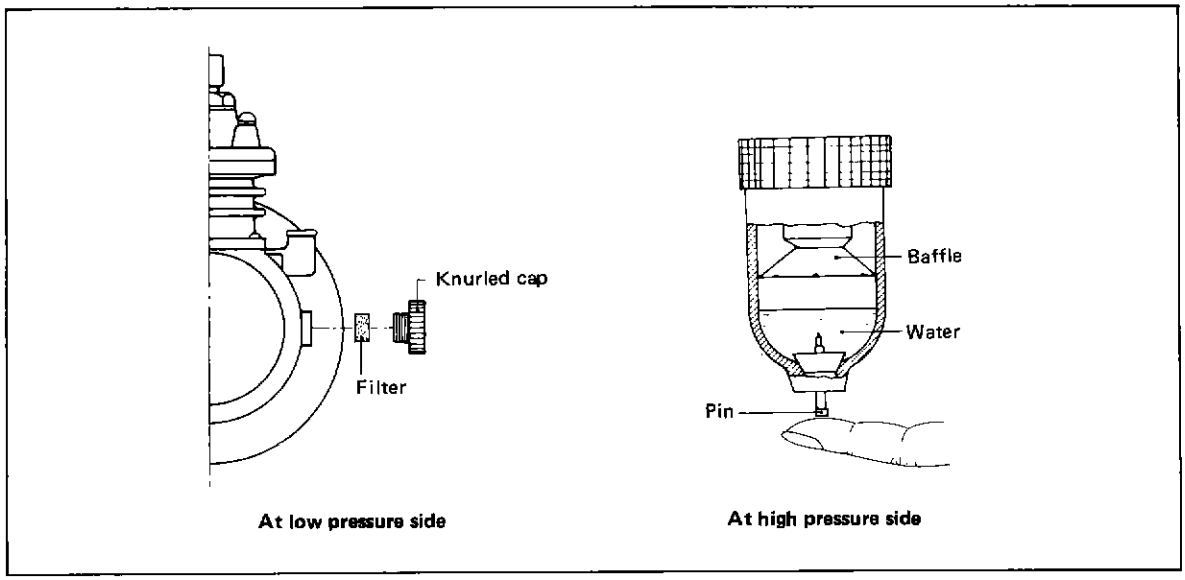


Fig. 6.11 Filter

4. If the filter is clogged with dirt, clean it with a suitable solvent and dry.
5. Insert the filter in the cap and replace the cap and the cover of the pump box.

b. **High pressure filter** (Used to remove dust and moisture from the pressurized air)

1. Check the filter about every three months as follows.
2. Shut down the microscope according to Section 5.2.12 and remove the cover of the pump box.
3. Inspect the filter. If water accumulates in the container, push the drain port pin and drain the water (see Fig. 6.11).
4. Replace the cover of the pump box.

6.6 Disassembling and Cleaning the Column

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 will increase, resolution will deteriorate, probe current will become unstable, or a normal image will not be obtained due to probe skipping, etc. (see Fig. 6.12).

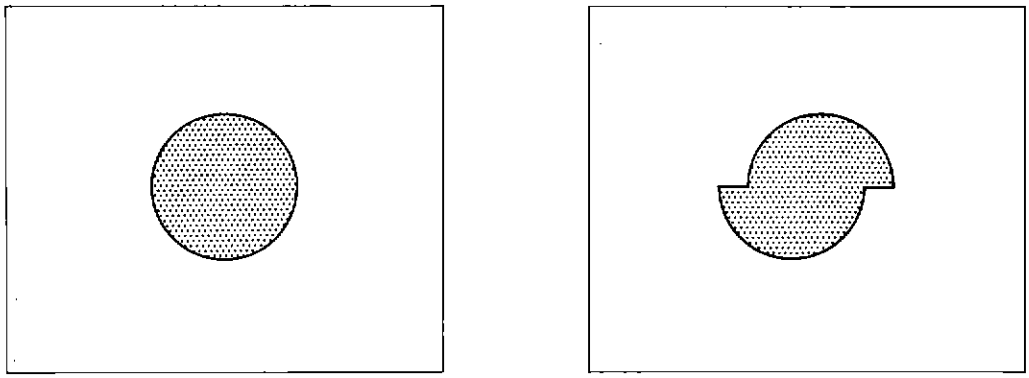


Fig. 6.12 Normal and disturbed images

In order to guard against these adverse effects, disassemble the column at regular intervals and clean or replace the various contaminated parts.

6.6.1 Precautions to be taken during column disassembly (reassembly)

6.6.1a Handling components

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.

When using wrenches, screwdrivers, tweezers or other tools necessary for removing the various parts, be extremely careful not to bend or force the parts when inserting or removing them. Do not cut any leads.

Piror to removing any of the parts, select a stout work bench and suitable matting and covering. 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 covering. In the case of heavy components, cushioning material (plastic foam, etc.) is recommended to act as a buffer.

6.6.1b 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, screws, etc., to make reassembly easier and to avoid misplacement or loss of screws.

6.6.1c 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 or reassemble the various component parts, be sure not to apply undue strain 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.

6.6.1d Points to keep in mind during disassembly

- Turn off related power supplies

Prior to disassembling the column, turn off the lens and deflection coil power supplies. To do this, set the UNATTENDED switch to its upper position. (The accelerating voltage and gun filament power supplies should have been turned off before breaking the column vacuum.)

- 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.

- Orientation notation

When reassembling the disassembled parts, be sure to install them exactly as they were before removal. This is obvious in most cases, but in the case of circular items, it is sometimes difficult to assess the exact orientation. In such cases, mark the part in question, but be sure to mark the part so as not to affect instrument performance.

6.6.1e Points to bear in mind during reassembly

- Dust removal

As each component part is being reassembled, use a 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 may come to no avail. In some cases, high voltage discharge or image quality deterioration may occur.

●O-ring and mating surface checks

Inspect the O-rings and their mating surfaces for scratches, lint, etc. If any of the O-rings are scratched, vacuum grease can be applied in some cases as a temporary measure; however, the O-rings so treated should be replaced as soon as possible. When applying the grease, apply it sparingly so as to avoid column add/or specimen contamination.

In the case of mating surface scratches, if these scratches are extremely shallow, no treatment is necessary. 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.

●Proper assembly of parts

When reassembling the parts, be sure to install them as they were before removal; otherwise parts may be damaged or image quality may be adversely affected.

6.6.2 Cleaning the column parts

6.6.2a Cleaning materials, tools, etc.

●Cleaning liquid (organic solvent)

This is used to remove grease, traces of metal polish, etc.; the cleaning liquid should be volatile, preferably non-inflammable, and should have a high solution-forming rating (high cleaning power) and 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

This is used to remove encrustation and other extraneous matter having high adhesive properties; the polish should be easy to remove with organic solvent. Keep the polish away from threaded or intricate parts as removal of the polish from such parts is difficult.

●Gauze or rayon paper (crepe or gauze type)

For applying metal polish or cleaning solvent; should be of high quality and should not release impurities when moistened with organic solvent.

●Absorbent cotton

For cleaning easily scratched parts; by wrapping the cotton around a thin stick, it can also be used for cleaning difficult-to-get-at corners and recesses. The cotton should be of high quality.

●Tooth picks, cotton swabs (about 5 mm dia.) or Q tips.

For cleaning narrow places. Any commercially available (but untreated) product is suitable.

●Brushes

For cleaning threaded parts; use saran fiber brushes or brushes whose bristles are unaffected by organic solvents.

●Tweezers

For handling small and delicate parts. Use good quality, sharp-tipped well-balanced tweezers. When

using tweezers, take care not to scratch or bend the parts.

- Scissors (Stainless steel)

  For cutting gauze, etc.

- Screwdrivers, special tools, etc.

  For disassembly or reassembly; use those contained in the instrument tool kit (Figs. 3.4 and 3.5).

- Handblower (Fig. 3.3)

  For removing dust, lint, etc. during reassembly. Use the specified air blower or a blower which ejects clean air or an inert gas (never use inflammable gas or a gas which leaves a residue).

- Beaker

  For cleaning small parts. This should be made of stainless steel or aluminum, or enamel-coated. Glass is not recommended as it is easily broken. An ultrasonic cleaner (approx. 20 kHz) would be ideal.

- Work bench or table

  Should be solid and level. If casters are used, the table should be equipped with a stop brake.

- Work gloves

  These prevent parts corrosion due to perspiration, and protects hands from damage by solvents. Any commercially available cotton, nylon or polyethylene gloves are suitable. Thin gloves are best, however, as they afford better feel and control of the operation being undertaken.

6.6.2b Cleaning methods

The cleaning method and/or procedure varies to some extent, depending on the degree of contamination and the parts to be cleaned. For example, if the contamination is not thick or has not become hard or encrusted on the part in question, organic solvent is normally sufficient to remove all extraneous matter. In cases of severe contamination, however, metal polish will be necessary. However, do not use metal polish if it is likely to affect instrument performance. Again, if the component parts to be cleaned have a high melting point, such as parts made of tantalum, molybdenum, etc., a vacuum evaporator will be required to effect removal of the contamination.

■ Cleaning method A (Using cleaning liquid)

Application: For cleaning lightly contaminated parts, parts which have little effect on performance and parts which are affected by metal polish.

For flat surfaces, moisten a piece of gauze, rayon paper or absorbent cotton (use absorbent cotton on easily scratched surfaces) with solvent and rub the surface in question until clean. In the case of holes, openings cylinder parts, recesses, etc., use cotton swabs (Fig. 6.13) and/or tooth picks wrapped in absorbent cotton.

Avoid applying solvent to components made of synthetic resin. To remove oil, etc. from intricate and/or threaded parts, immerse the parts in a breaker of solvent and clean with a brush. If the parts in question

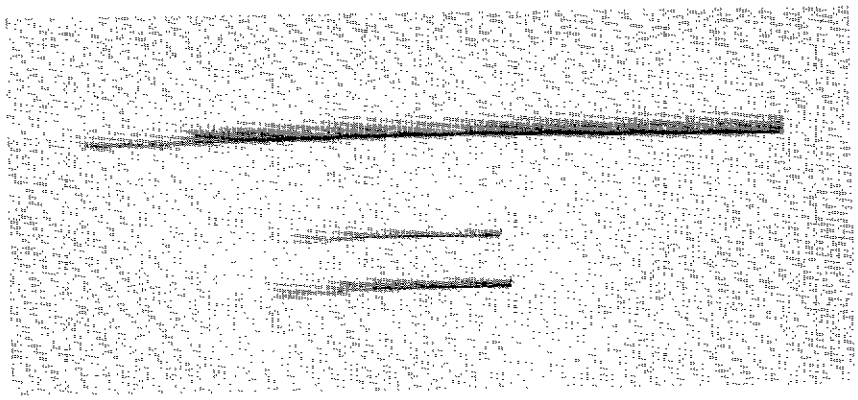


Fig. 6.13 Cotton swabs

are easily scratched, refrain from using a brush. Replace the solvent when dirty. An ultrasonic cleaner is highly effective for cleaning small parts. Wooden tweezers of the type used in photolaboratories are convenient for removing parts from the beaker of solvent. Immediately after removing the parts, remove any traces of liquid with the handblower.

■ Cleaning method B (Using metal polish)

Application: Cleaning of heavily contaminated parts (Unaffected by metal polish)

For flat surfaces, apply a small amount of metal polish to a piece of gauze, rayon paper or absorbent cotton (use absorbent cotton on easily scratched surfaces) and rub the surface in question until clean. In the case of holes, openings of cylindrical parts, awkward corners, recesses, etc., use tooth picks and/or wooden sticks wrapped in absorbent cotton. Refrain from appllying polish to intricate and/or threaded or synthetic resin parts. Also, when cleaning the apertures, we recommended the use of an absorbent cotton-wrapped stick of the same size as the aperture itself and to clean the aperture hole by rotating the stick evenly. Refrain from applying excessive rubbing force. If these recommendations are ignored, there is a possibility of pushing the aperture out of shape.

Visual inspection is adequate for confirming the removal of contamination. Remove any traces of polish with solvent. If polish is allowed to remain, it will in itself become a contaminant, completely negating the object of the task in hand.

Finally, keep the cleaned parts covered until ready for reassembly.

■ Cleaning method C (Using a vacuum evaporator)

Application: Cleaning of parts having a high melting point (tantalum, molybdenum foil, etc.)

Place the parts in a vacuum evaporator (JEE-4X) that contains a tungsten wire basket heater (0.5~0.8 mm dia), a helical heater or a high-melting point thin metal foil boat, either of which must have been cleaned by preheating under high vacuum, and subject the parts to a temperature of about 1,500°C (white heat) for several minutes under high vacuum (better than 1×10^{-4} Torr).

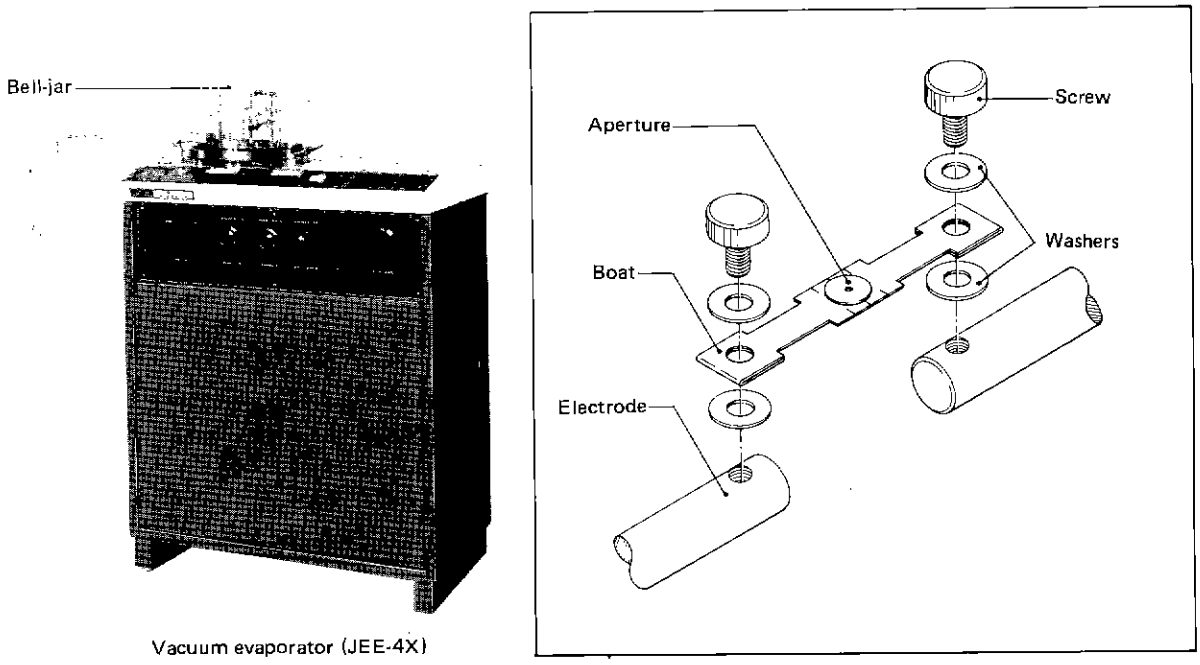


Fig. 6.14 Aperture cleaning

Avoid excessive heating as this may cause the parts to melt. On the other hand, insufficient heating will not effect adequate removal of the contamination. After heating, allow the parts in the evaporator to cool down to room temperature before exposing them to the atmosphere. This is to prevent oxidation. Replace all parts from which the contamination cannot be removed or which have become deformed or otherwise damaged. Before installing a new part, clean it as described above. The aperture cleaning procedure is as follows (Fig. 6.14).

1. Break the vacuum of the evaporator bell-jar and remove the bell-jar.
2. Attach the boat (held between washers) to the electrodes.
3. Replace the bell-jar and pump the jar to better than 1×10^{-4} Torr.
4. Heat the boat by passing a current of 30 amps for about one minute.
5. Allow three minutes to elapse before breaking the bell-jar vacuum.
6. Break the bell-jar vacuum and remove the bell-jar.
7. Place the aperture in the boat.

   Caution: Use tweezers to handle the foil and be sure not to bend or deform it.
8. Repeat Steps 3 to 6.
9. Remove the aperture. This completes cleaning the aperture.

See overleaf, Sect. 6.6.3 and Table 6.1

5. Remove the high voltage cable from the two clamps.
6. Turn the securing ring until the slot aligns with the pin. Then pull out the evacuation connecting pipe from the anode chamber.
7. Remove the clamps by unscrewing screws A (4).
8. Remove the lower anode chamber (along with upper anode chamber including the porcelain insulator) by lifting the lower anode chamber. Be careful not to tip over the anode chamber. The upper and lower anode chambers can be separated by removing two screws from the hinge.
9. Turn the anode counterclockwise and remove it. When cleaning up to the anode chamber flange , omit the following steps.
10. Remove screw B and then pull out the anode chamber airlock knob from the shaft (see arrow, Fig. 6.16).
11. Remove cable plug A1 (protruding from the deflection cylinder flange) from the console outlet.
12. Lift the magnetic shield straight up (be sure to free plug A1 by pulling it in through the slot).
13. Remove screws C (4) and remove the clamps.
14. Screw the lens lifting tools (Fig. 35-d) in the anode chamber flange and pull the flange straight up to remove the intermediate cylinder. Remove the tools.

■**Disassembling the condenser lens and 2nd deflection system cylinder** (see Fig. 6.17)

1. Remove cable plugs A2 and A3 (protruding from the condenser lens) from the console outlets.
2. Remove screws D (4) and remove the clamps.
3. Remove the condenser lens.

   Caution: When removing the lens, exercise care so as not to drop it.

4 Remove screws E (3) and pull out the pole piece (see arrow in Fig. 6.17).
5. Unscrew the upper cap nut and remove the upper aperture disk .
6. Remove cable plugs A5 and A6, which are protruding from the deflection system cylinder, from the console outlets.
7. Unscrew screws F (3) and pull the deflection system cylinder straight out.

   Caution: Be extremely careful not to damage the cylinder when handling it, because it is precision-machined and has many coils around it.

■**Disassembling the objective lens and specimen chamber** (see Fig. 6.18)

1. Remove cable plug A10, which is protruding from the aperture selector assembly, from the console outlet.
2. Loosen the ring nut and remove the aperture selector (see arrow in Fig. 6.18).
3. Set the tilt control to 0° and the WD selector to 39 mm (Fig. 4.5).

   Caution: This step is very important. Opening the front cover before performing this step will cause damage to the specimen holder, stage, or other specimen chamber parts.

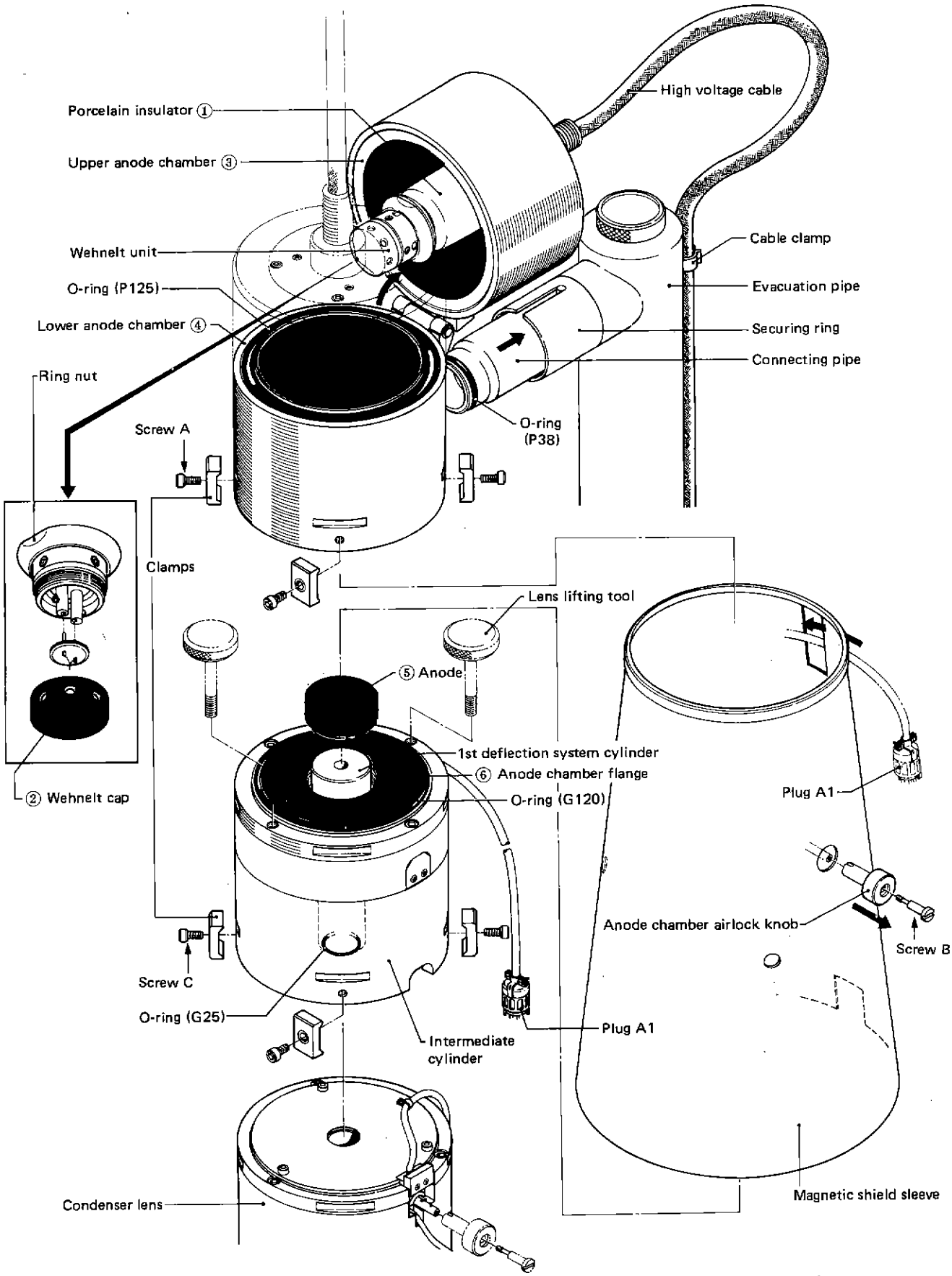


Fig. 6.16 Disassembling the electron gun, anode chambers and intermediate cylinder

See overleaf, Fig. 6.17

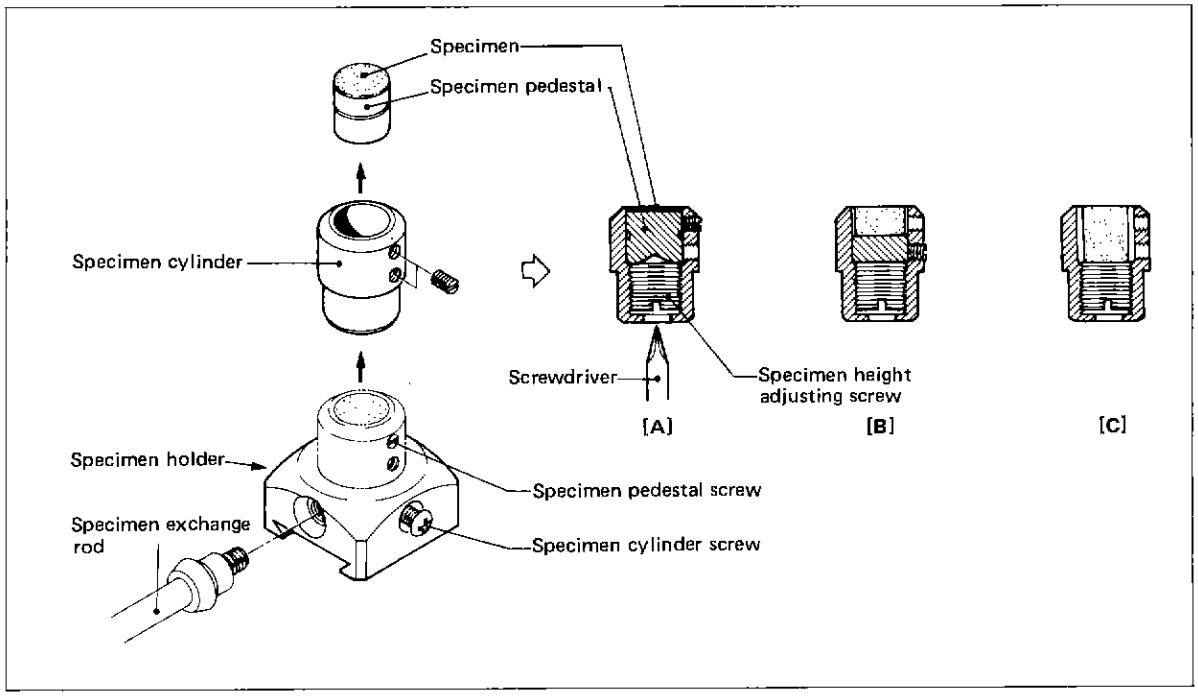


Fig. 5.2 Exchanging specimen on WD15 specimen holder

■ WD39 specimen holder (see Fig. 5.3)

1. Insrt a screwdriver in the bottom of the specimen holder, raise the used specimen by turning the height adjusting screw, and remove the used specimen along with the screw (Fig. 5.3–A).
   If the specimen cylinder is not used (Fig. 5.3–B), remove the used specimen by pushing it out from the bottom of the specimen holder (if the specimen is secured with the specimen cylinder screw, loosen the screw first).
   Notes: 1. The specimen can be exchanged with the cylinder attached to the holder (Fig. 5.3–A). However, if it is difficult to do so, remove the specimen cylinder by loosening the cylinder screw, and replace it after the specimen has been exchanged.
   2. Use organic solvent to remove the specimen secured with silver conductive paint from the height adjusting screw or holder. Polish the upper surface of the height adjusting screw and the bottom part of the holder, as necessary.
2. After checking the specimen size (see Table 5.1), secure the specimen horizontally to the height adjusting screw with silver conductive paint. Perform metallic coating (conductive processing) with a vacuum evaporator if necessary. If the cylinder is not used (Fig. 5.3–B), use a proper spacer or secure the specimen with the cylinder screw so that the surface of the specimen is flush with the top of the specimen holder.
3. When the specimen cylinder is used, screw the height adjusting screw with the specimen secured into

the cylinder and adjust the screw with a screwdriver so as to make the specimen surface flush with the upper surface of the specimen cylinder.

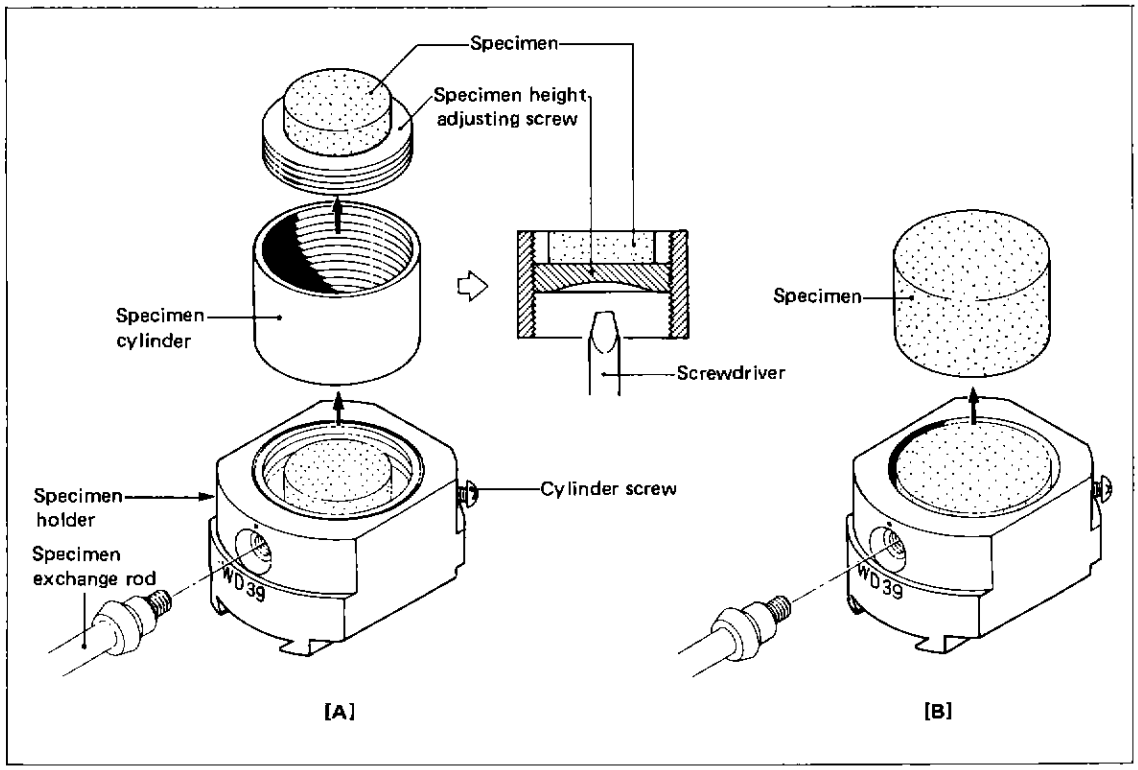


Fig. 5.3 Exchanging specimen on WD39 specimen holder

5.2.3b Inserting (Removing) the specimen holder into (from) the specimen chamber

■ Airlock system

1. Set controls of each unit as follows:

   a. ACCELERATING VOLTAGE unit

   - GUN FILAMENT knob ..... Fully counterclockwise
   - ON/OFF switch ..... OFF

   b. SEI Unit

   - SEI/BEI switch ..... Center position

2. Set the specimen stage controls as follows:

   - X control ..... 7.5 mm
   - Y control ..... 12.5 mm (or as desired)
   - Tilt control ..... 0°
   - Rotation control ..... 000 (0°)

3. Set the working distance to 15 mm or 39 mm according to the type of the specimen holder in use (see Table 4.1) and then the OBJECTIVE LENS: COARSE knob according to the selected working distance (15 or 39).

   Turn the WD selector (Fig. 4.5) fully clockwise to change the working distance to 15 mm from 39 mm (...), and turn it ... counterclockwise to change the working distance from 39 mm to 15 mm.

   Caution: The following items must be checked when changing the working distance from 39 mm to 15 mm. Changing the working distance in any other way will result in damage to the specimen holder, specimen stage, and component parts inside the specimen chamber.

   - *When the WD15 specimen is mounted on the specimen stage:*
     - *If the optical microscope (OM) is also used, its objective lens must be fully retracted.*
   - *When the WD39 specimen is mounted on the specimen stage:*
     - *The optical microscope must not be used.*
     - *Set the tilt control to 0°*

4. In inserting the specimen holder into the specimen chamber (skip this step during removal), screw the specimen exchange rod through the specimen exchange chamber cap into the specimen holder as shown in Fig. 5.4.

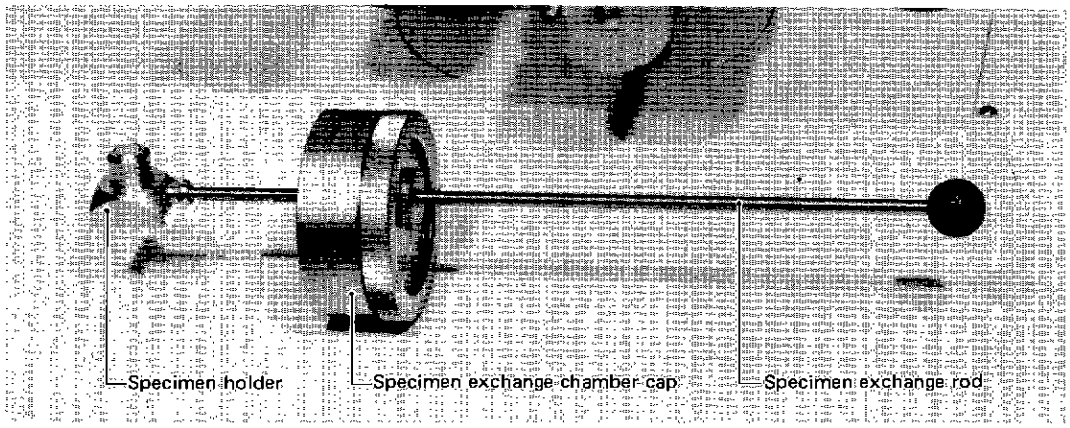


Fig. 5.4 Specimen holder secured to specimen exchange rod

5. To insert the specimen holder into the specimen chamber, position the specimen exchange chamber cap with the specimen holder so that the working distance mark (either WD15 or WD39) corresponding to the specimen holder and the specimen surface face upward as shown in Fig. 5.5. Then, pull the specimen exchange rod out (the rod will be secured).

   (To remove the specimen holder from the specimen chamber, orient the exchange chamber cap according to the specimen holder in use and pull the specimen exchange rod out.)

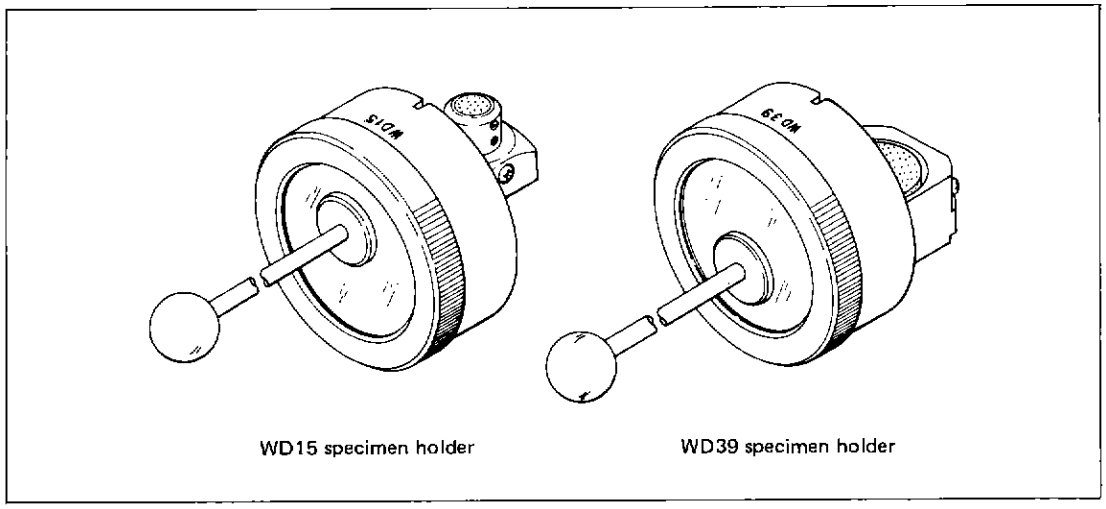


Fig. 5.5 Positioning the specimen exchange chamber cap and specimen holder

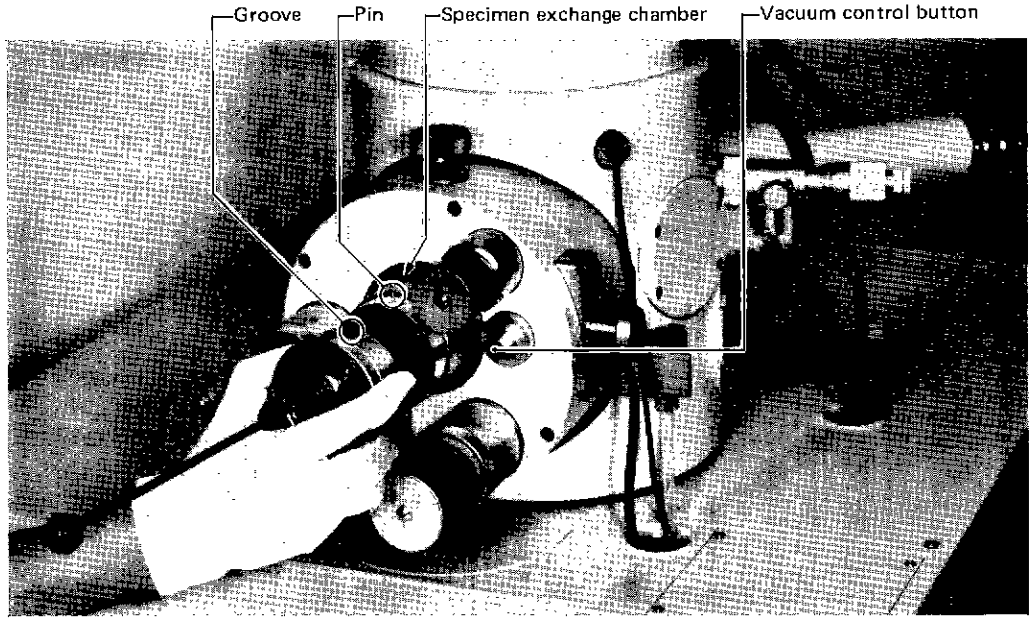
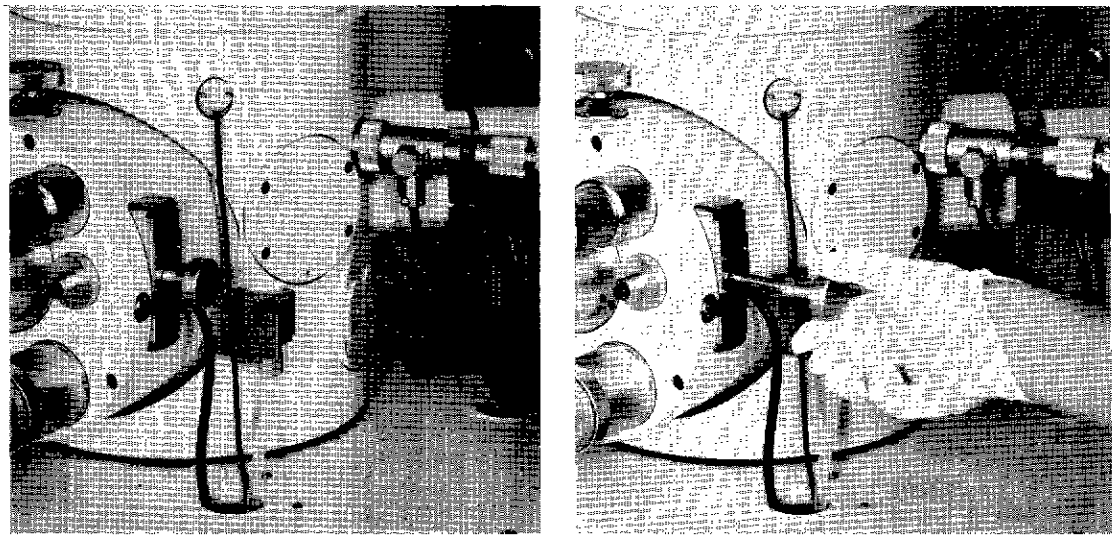


Fig. 5.6 Mounting the specimen exchange chamber cap

6. Mount the exchange chamber cap on the specimen exchange chamber so that the groove and the pin are lined up as shown in Fig. 5.6. Then, push the vacuum control button to evacuate the specimen exchange chamber. The lamp in the button will go out in approximately 30 seconds, indicating the completion of evacuation.
7. After evacuation is completed, pull the specimen exchange chamber airlock knob out to open the airlock valve AV2 (Fig. 3.8 and Fig. 5.7a ⇒ b).



(a) Airlock valve ..... Closed (b) Airlock valve ..... Open

Fig. 5.7 Operation of the chamber airlock knob

8. Insert the specimen holder into the holder mount of the specimen stage as shown in Fig. 5.8 by pushing the specimen exchange rod while observing the specimen holder through the specimen exchange chamber cap window. Then, unscrew the exchange rod and pull it all the way out.
(To remove the holder from the specimen chamber, screw the end of the exchange rod into the holder, pull the exchange rod all the way out, and store the specimen holder in the specimen exchange chamber.)

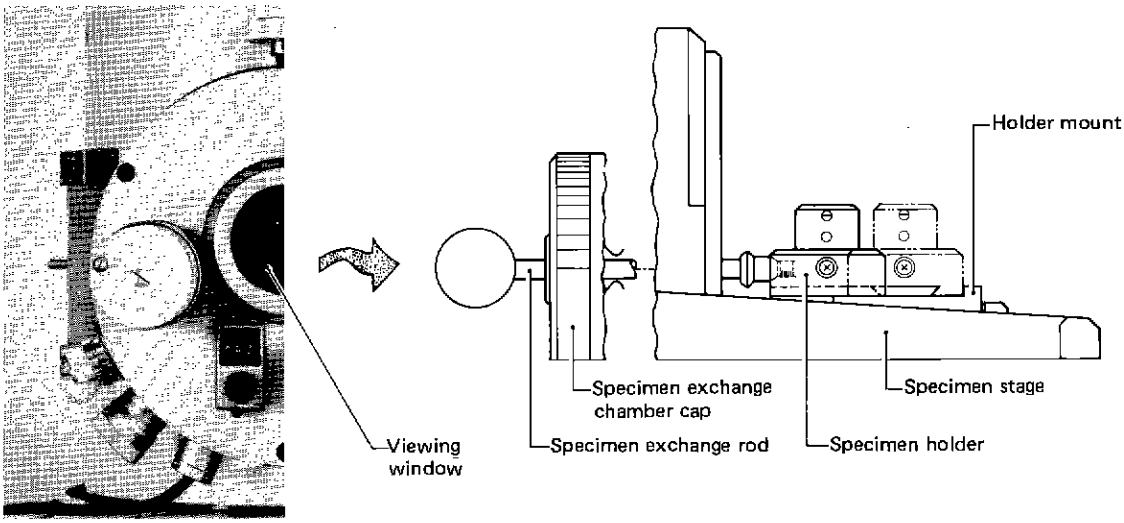


Fig. 5.8 Mounting (Removing) the specimen holder on the specimen stage

9. Push the specimen exchange chamber airlock knob in to close the airlock valve. Then, push the vacuum control button again (the button lamp lights) to vent the specimen exchange chamber.
10. Remove the exchange chamber cap from the chamber, then remove the holder from the exchange rod, and place the cap on the table so as to prevent it from rolling off.

Note: Remove the specimen exchange chamber cap from the specimen exchange chamber at all times except when it is used to exchange the specimen.

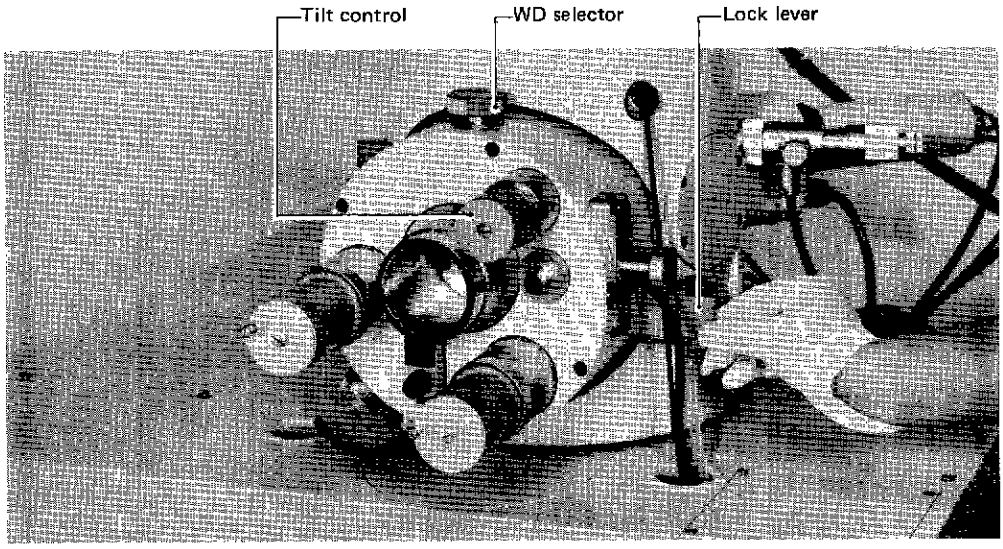
■ Hinge system

1. Set controls of each unit as follows:
   a. ACCELERATING VOLTAGE unit
      - GUN FILAMENT knob ..... Fully counterclockwise
      - ON/OFF switch ..... OFF
   b. SEI unit
      - SEI/BEI switch ..... Center position
2. Set the tilt control to 0° (the specimen stage will be set in a horizontal position).

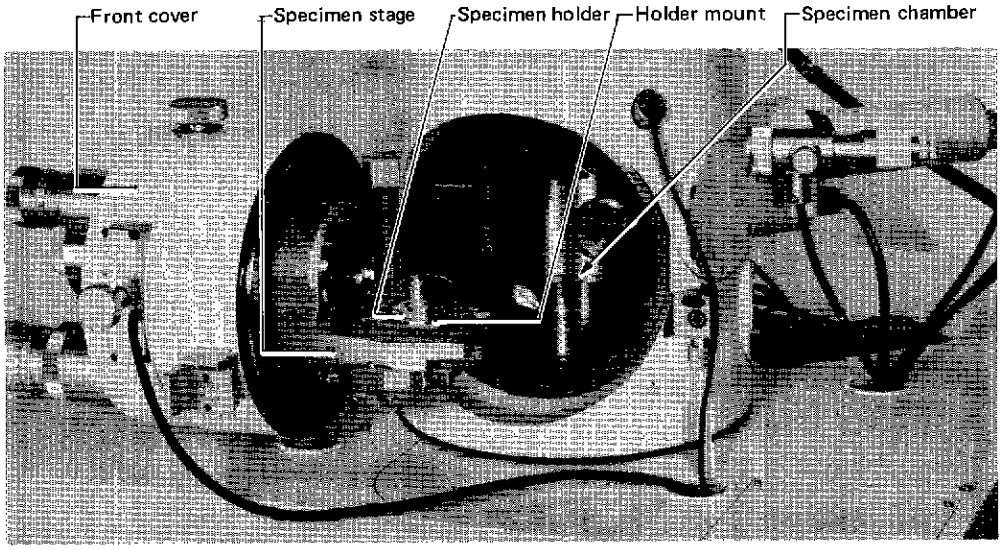
   Caution: Always set the tilt control to 0° prior to opening or closing the front cover (specimen stage); otherwise the holder, stage, and internal parts of the chamber will be damaged.
3. Turn the WD selector fully clockwise ( ) to set the working distance to 39 mm and set the OBJECTIVE LENS: COARSE knob to 39.
4. After checking that the anode chamber airlock knob is pulled out (open), push the VENT button (VAC) (the lamp lights) to vent the column to the atmosphere.

   Since the specimen chamber cannot be exposed to the atmosphere with the anode chamber airlock knob pushed in (closed), turn the knob fully counterclockwise and pull it prior to pushing the VENT button.
5. Pull the lock lever forward as shown in Fig. 5.9a. Then, open the front cover (hinge mechanism) as shown in Fig. 5.9b.
6. Remove the specimen holder from the holder mount by pulling it forward.

   Note: The front cover must also be opened/closed to replace the specimen chamber lamp, disassembly, cleaning, and installing attachments.
7. After checking Steps 2 and 3, close the front cover (push it in until it is latched). Then, push the PUMPDOWN button (VAC) (the button lamp lights) to re-evacuate the column. When evacuation is completed (when the column pressure reaches the specified value), the LOAD CURRENT meter (ACV) lamp lights.



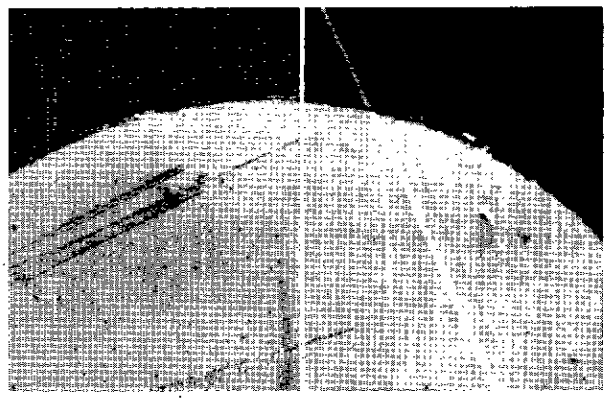
(a) Front cover · · · · · · · · · · · · · · · Closed



(b) Front cover · · · · · · · · · · · · · · · Open

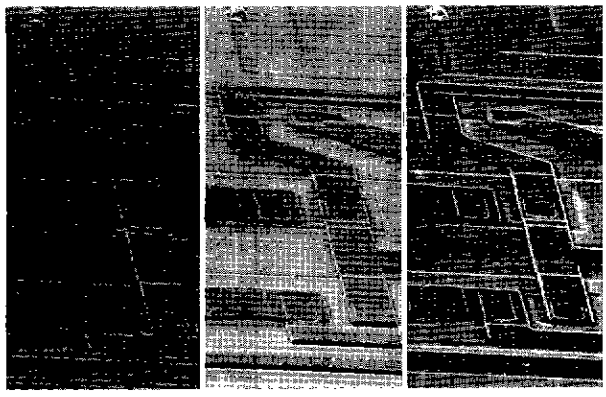
Fig. 5.9 Opening and closing the front cover

See overleaf: 5.2.4 High voltage generation
Flowchart A-4



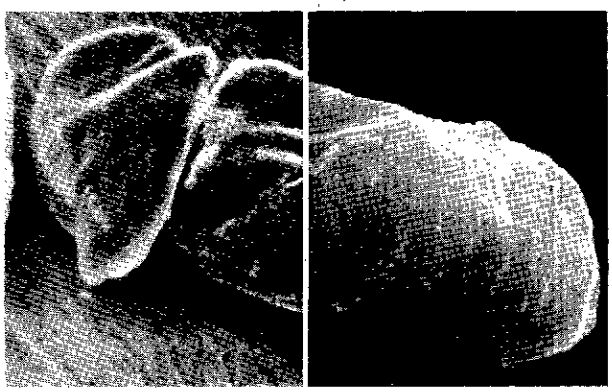
[Accel. volt.: 5 kV] [Accel. volt.: 35 kV]

(a) Metal pieces with different atomic numbers



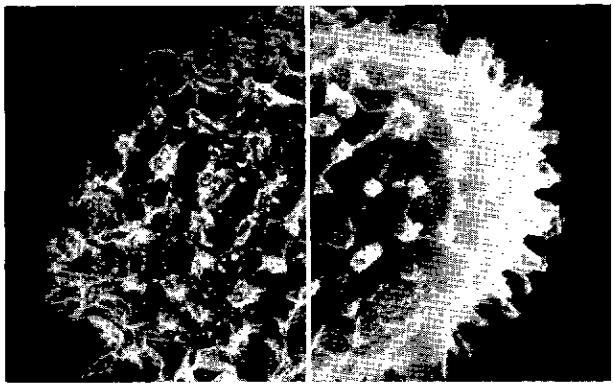
[Accel. volt.: 5kV] [Accel. volt.: 6 kV] [Accel. volt.: 12 kV]

(b) Integrated circuit (IC)



[Accel. volt.: 10 kV] [Accel. volt.: 25 kV]

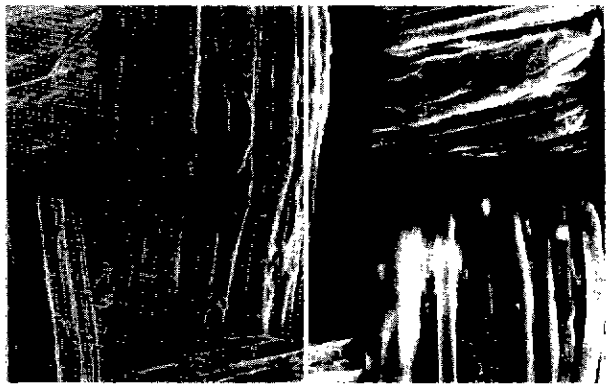
(c) Starch



[Accel. volt.: 5 KV] [Accel. volt.: 25 kV]

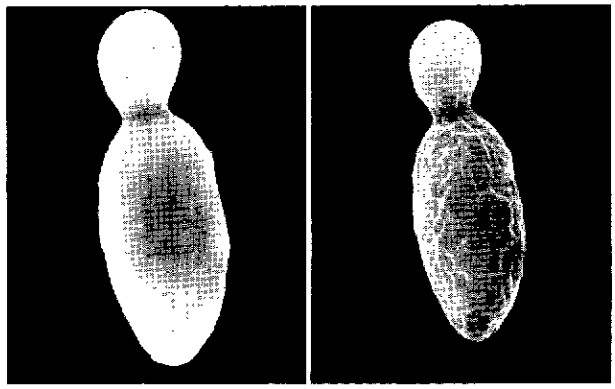
(d) Bacterium spore

Fig. 5.10 Secondary electron image variation with different accelerating voltages



[Accel. volt.: 5 kV] [Accel. volt.: 25 kV]

(a) Charge-up effect (silk fiber)



[Before irradiation] [After irradiation]

(b) Damage due to electron beam (yeast fungus)

Fig. 5.11 Effects caused by electron beam irradiation

35C–1

VOLTAGE indicator).

Note: The accelerating voltage must be selected according to the type of specimen and purpose of observation. This step selects the accelerating voltage before high voltage is generated.

4. Set the GUN BIAS thumbwheel (ACV) to 3 (gun bias setting), and if the accelerating voltage in use had been higher than 30 kV, adjust the Wehnelt cap (see Section 6.2). The gun bias and the Wehnelt cap position must be adjusted according to the selected accelerating voltage as indicated in Table 5.2 below.

Note: As the reading of the thumbwheel indicator increases, the gun bias increases.

Table 5.2 Gun bias setting and Wehnelt cap adjustment

Accelerating voltage	Under 10 kV	10 – 20 kV	20 – 30 kV	Over 30 kV
GUN BIAS thumbwheel	0 or 1	2	3	4
Wehnelt cap	A 1/8 counterclockwise turn from the level position. *			A 3/8 counterclockwise turn from the level position

* The level position refers to the position in which the filament tip is level with the top of the Wehnelt cap. The Wehnelt cap adjustment procedure is described in Section 6.2.

5. Set the ON/OFF switch (ACV) to ON to generate high voltage (accelerating voltage). The accelerating voltage is displayed on the ACC VOLTAGE indicator (IND) and the detector current shown in Table 5.3 is read on the LOAD CURRENT METER (ACV).

Table 5.3 Accelerating voltage and detector current

Accelerating voltage	5 kV	10 kV	15 kV	20 kV	25 kV	30 kV	35 kV
Detector current	5 μA	10 μA	15 μA	20 μA	25 μA	30 μA	35 μA

6. While observing the LOAD CURRENT meter (ACV), gradually turn the GUN FILAMENT knob (AVC) clockwise until the meter reading ceases to increases (saturation point). Refer to Fig. 5.12. When the GUN FILAMENT is set to the saturation point, a stable electron beam is obtained and the load current (detector current plus emission current) is read on the meter.

Caution: Setting the GUN FILAMENT knob beyond the saturation point will shorten the service life of the electron gun filament. Therefore, check the saturation point after prolonged use of the probe or when high voltage (accelerating voltage) is switched. If the meter reading fails to increase when the GUN FILAMENT knob is turned clockwise, the filament may be open. Check the filament in accordance with Section 6.2.

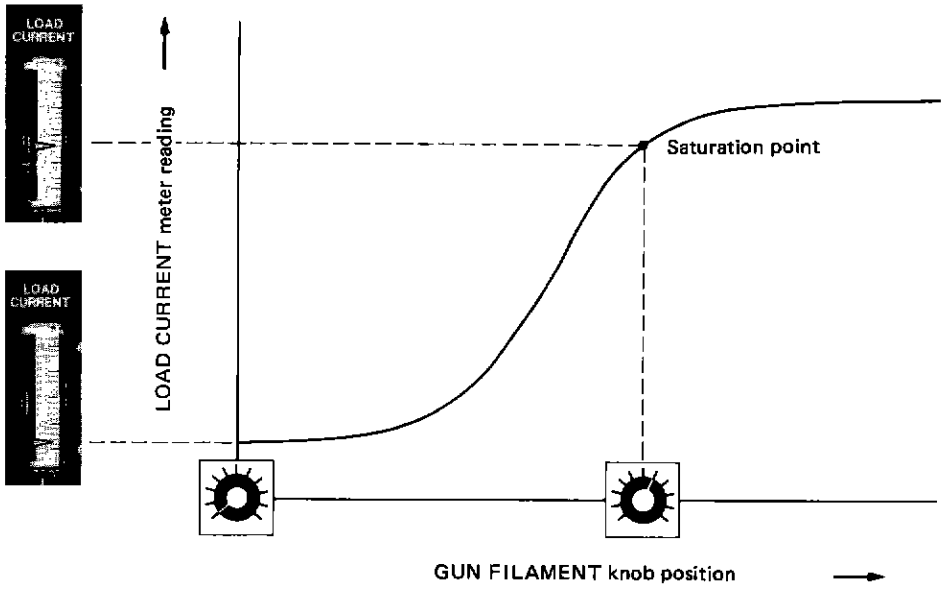


Fig. 5.12 Setting the GUN FILAMENT knob

See overleaf: 5.2.5 Axis alignment
Flowchart A-5

(line profile) to the lower edge of the CRT screen (DIS), and adjust the brightness of the scanning line with the DISPLAY unit BRIGHTNESS knob.

4. Set the SEI unit CONTRAST knob (10-turn potentiometer) to 2.0. Check that the scanning line on the CRT screen moves up and down as the knob is turned slightly back and forth.
   If the scanning line does not move, repeat the above operation while gradually turning the CONTRAST knob clockwise, and set the knob where the change in the scanning line position can be observed.
   If the scanning line still does not move with the above operation, repeat the operation with the ACCELERATING VOLTAGE unit BEAM ALIGNMENT knobs set at 12 o'clock. If this operation should also fail, check the aperture in accordance with the instructions given at the beginning of this section.
5. Align the scanning line on the CRT screen with the position shown in Fig. 5.13 with the BRIGHTNESS knob (SEI).
6. Move the scanning line as far up as possible with the ACCELERATING VOLTAGE unit BEAM ALIGNMENT (upper two) knobs (for tilting electron gun beam). If the scanning line moves to the upper edge of the CRT screen, bring it down by turning the CONTRAST knob (SEI) counterclockwise and repeat the above operation.

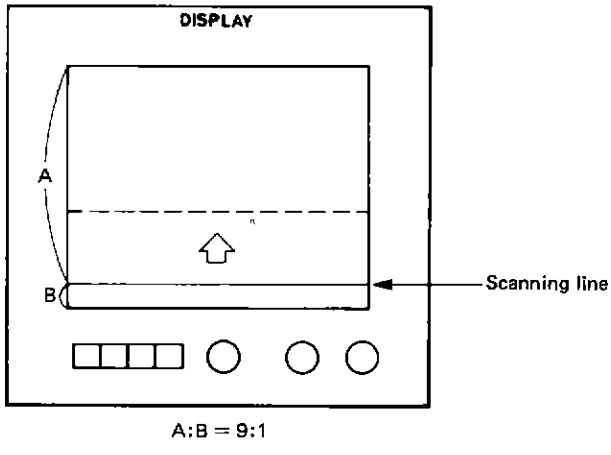


Fig. 5.13 Electron gun axis alignment

5.2.5b Lens axis alignment

1. Set the SEI/BEI switch to BEI to protect the detector (backscattered electron detection).
2. Set controls of each unit as follows:
   - LENS unit
     - CONDENSER LENS knob 0.0
   - MAGNIFICATION unit
     - COARSE button, FINE knob 20X

- PROBE SCAN/EXT switch ..... PROBE SCAN

■ SCAN GENERATOR unit

- Scanning mode selection switch ..... □ (frame scanning)

■ DISPLAY unit

- CONTRAST knob ..... Fully clockwise ↻

3. Check that a bright circular image approximately 10 mm in diameter appears on the CRT screen (DIS). Adjust the SEI unit CONTRAST and BRIGHTNESS knobs for a clear image.
4. Insert the axis alignment tools (see Fig. 3.5–e) into the alignment screws as shown in Fig. 5.1.4. Then, adjust the screws so that the circular image A comes to the center of the CRT screen as shown in Fig. 5.15. Leave the axis alignment tools in the alignment screws until axis alignment is completed.

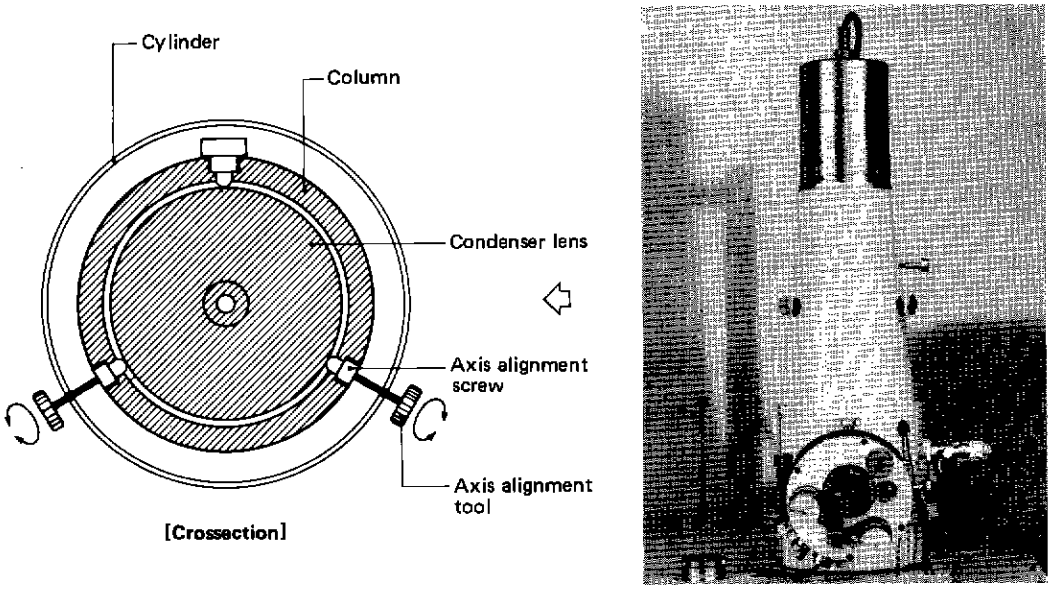
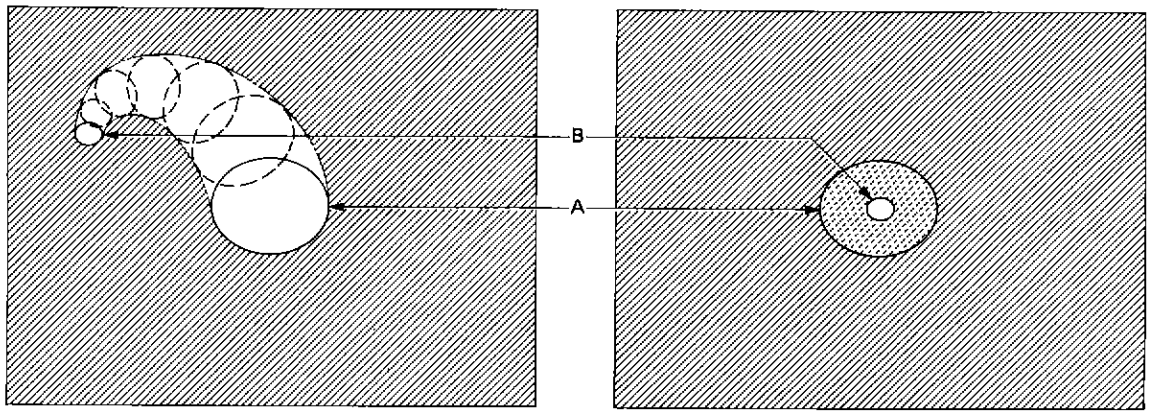


Fig. 5.14 Using the axis alignment tools

5. Push the ACCELERATING VOLTAGE: COARSE 0 V button to set the accelerating voltage to 5 kV. When this button is pushed, the circular image A on the screen changes for approximately 30 seconds as shown in Fig. 5.15. Then, the circular image B with a constant position and size appears. If the axis is out of alignment, circular image A and circular image B are not concentric as shown in Fig. 5.15a. When this occurs, align the axis in accordance with the following procedures. Set the magnification to 60X, check that the axis is aligned, and if aligned, skip Steps 6 to 8.
6. Adjust the ACCELERATING VOLTAGE unit BEAM ALIGNMENT (lower two) knobs (for electron beam horizontal shift) so that the circular image B shown in Fig. 5.15a comes to the screen center.
7. Push the ACCELERATING VOLTAGE: COARSE 20 kV button (ACV) to set the accelerating voltage to 25 kV.



(a) Before alignment (b) After alignment

Fig. 5.15 Lens axis alignment

8. Repeat Steps 4 to 7 for a better axis alignment with the magnification set to 60X.
9. Repeat the electron gun axis alignment in accordance with Section 5.2.5a.

See overleaf: 5.2.6 Scanning image observation
Flowchart A-6, Fig. 5.16

- OBJECTIVE LENS: MEDIUM knob ..... 12 o'clock

■ SEI unit

- CONTRAST knob 1.5
- BRIGHTNESS knob 0.0

■ MAGNIFICATION unit

- COARSE 10^1 button ..... Push
- PROBE SCAN/EXT switch ..... EXT

■ SCAN GENERATOR unit

- RAPID 2 button ..... Push
- Scanning mode selection switch ..... □ (frame scanning)

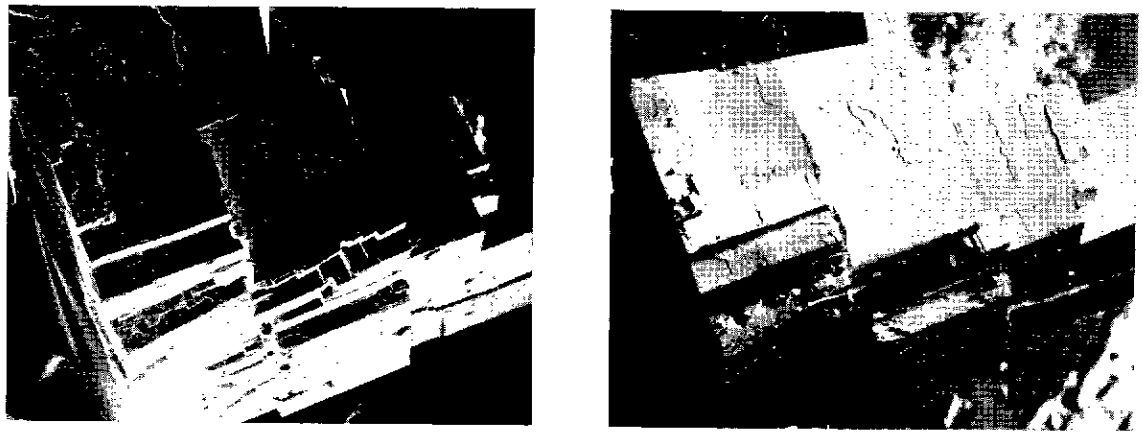
■ DISPLAY unit

- CONTRAST, BRIGHTNESS knobs ..... 12 o'clock

2. Set the SEI/BEI switch (SEI) to SEI to display the secondary electron image. (Set the switch to BEI to display the backscattered electron image.)

Since there is a considerable difference between a secondary electron image and a backscattered electron image as shown in Fig. 5.17, they must be used according to the observation purpose.

A secondary electron image is most suitable for observing the specimen surface because it is shadowless and of high resolution.

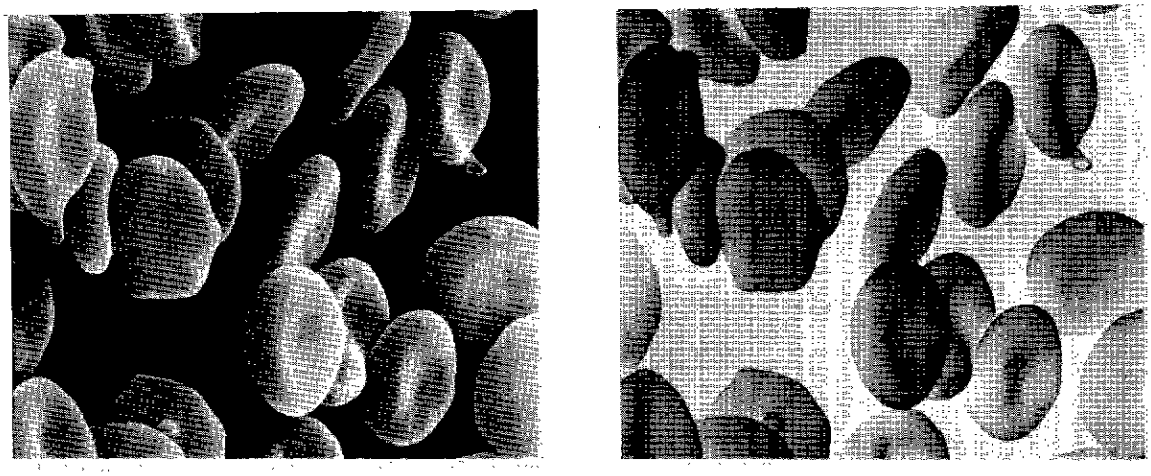


[Secondary electron image] [Backscatterd electron image]

Fig. 5.17 Comparison of secondary electron image and backscattered electron image Specimen: Galena

3. Set the NOR/INV switch (SEI) to NOR (normal contrast image). To display an inverted contrast image, set the switch to INV. When the switch is set to INV, the video signal polarity is reversed and a negative picture is displayed as shown in Fig. 5.18. A positive picture can be obtained when an inversed contrast

image is recorded on negative film. This can be used to make slides.



[Normal contrast image – positive picture] [Inverted contrast image – negative picture]

Fig. 5.18 Comparison of normal contrast image (positive picture) and inverted contrast image (negative picture) Specimen: Red blood corpuscles

4. Gradually turn the SEI unit BRIGHTNESS knob clockwise until the raster becomes faintly visible on the CRT (DIS) (background setting).
5. Set the PROBE SCAN/EXT switch (MAG) to PROBE SCAN.

   Note: If this switch is set at EXT for a long time, one spot on the specimen may be altered by the beam. Therefore, keep the probe irradiation time as short as possible when this switch is set at EXT.
6. Adjust the SEI unit CONTRAST knob to display an optimum contrast image as shown in Fig. 5.19a (double-printing with the line profile).

   Adjust the BRIGHTNESS knob (SEI) to obtain optimum brightness as shown in Fig. 5.19b. Adjust contrast and brightness for the best image. In this section, contrast and brightness are adjusted with the SEI unit CONTRAST and BRIGHTNESS knobs. For photography, the DISPLAY unit CONTRAST and BRIGHTNESS knobs are used.

   Note: Normally, image contrast can be adjusted with the CONTRAST knob alone. However, in X-ray analysis when a high probe current is used, a large number of electrons are emitted from the specimen. When using the secondary electron image, the detector may become saturated so that it cannot be controlled by the CONTRAST knob alone. When this occurs, set the COLLECTOR thumbwheel to a lower value to decrease the collector voltage, keeping the number of secondary electrons entering the detector at optimum.
7. Adjust the OBJECTIVE LENS: MEDIUM knob (LEN) so that a clear image is obtained. If no astigmatism is present, the in-focus and clearest image as shown in the upper row (Fig. 5.20) can be obtained

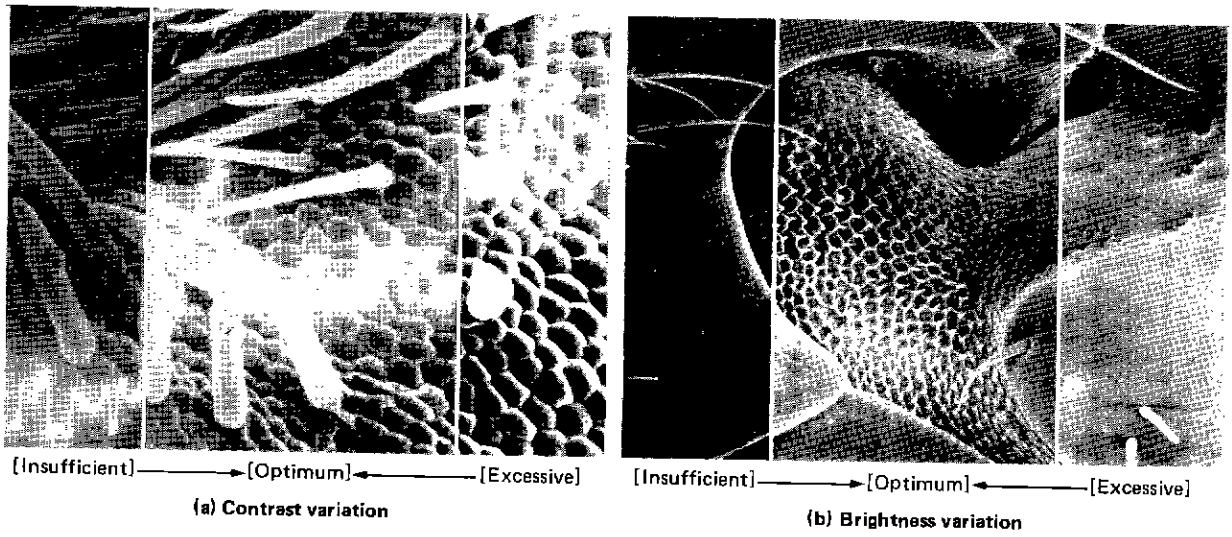


Fig. 5.19 Adjusting contrast and brightness

with the knob. If astigmatism is present, as shown in the lower row (Fig. 5.20), the image will be indistinct even at the optimum focus position. When the knob is turned through the optimum focus position, the image appears to flow in one direction and then in a direction at right angles to the said direction. Astigmatism must be corrected for in accordance with Section 5.2.8.

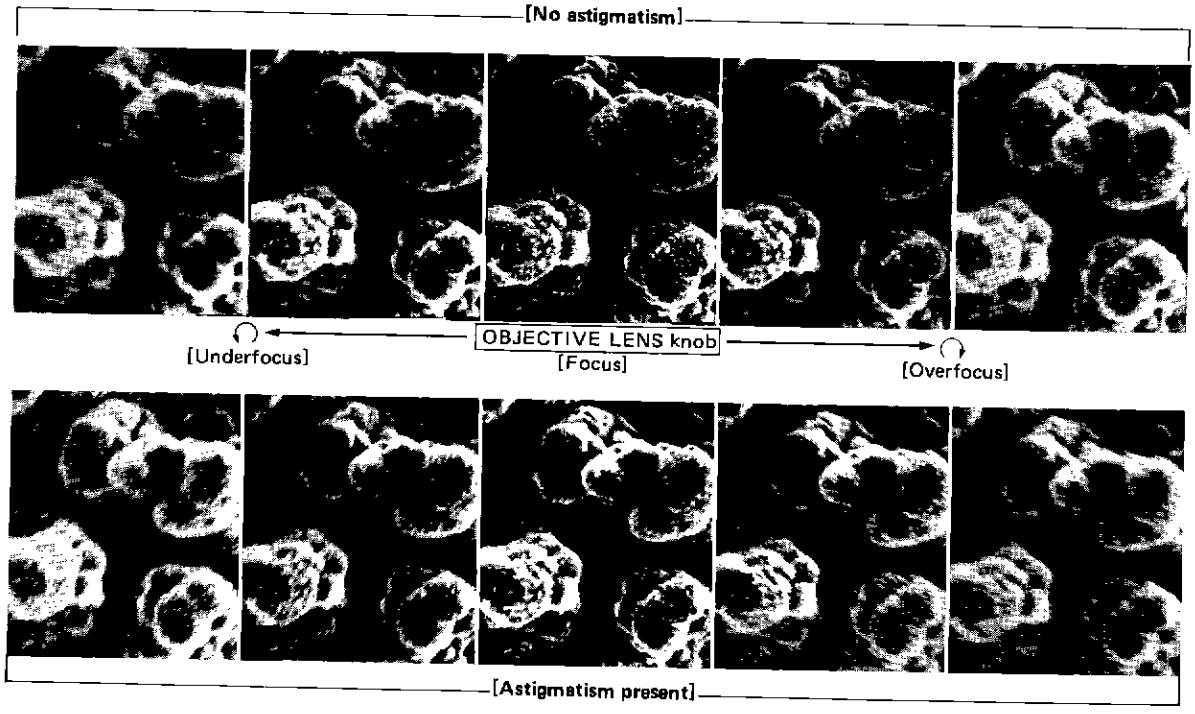


Fig. 5.20 Focusing and effects of astigmatism

8. Select the desired field with the specimen stage X and Y controls; if necessary, change the specimen orientation with the rotation control (Fig. 4.5 and Fig. 4.6). When the rotation control is turned clockwise, the specimen turns clockwise (360°) and the image turns clockwise as shown in Fig. 5.21. The rotation angle θ is given by $\theta = 0.36N$ where N is the counter reading. When the optimum specimen orientation is selected, lock the knob.

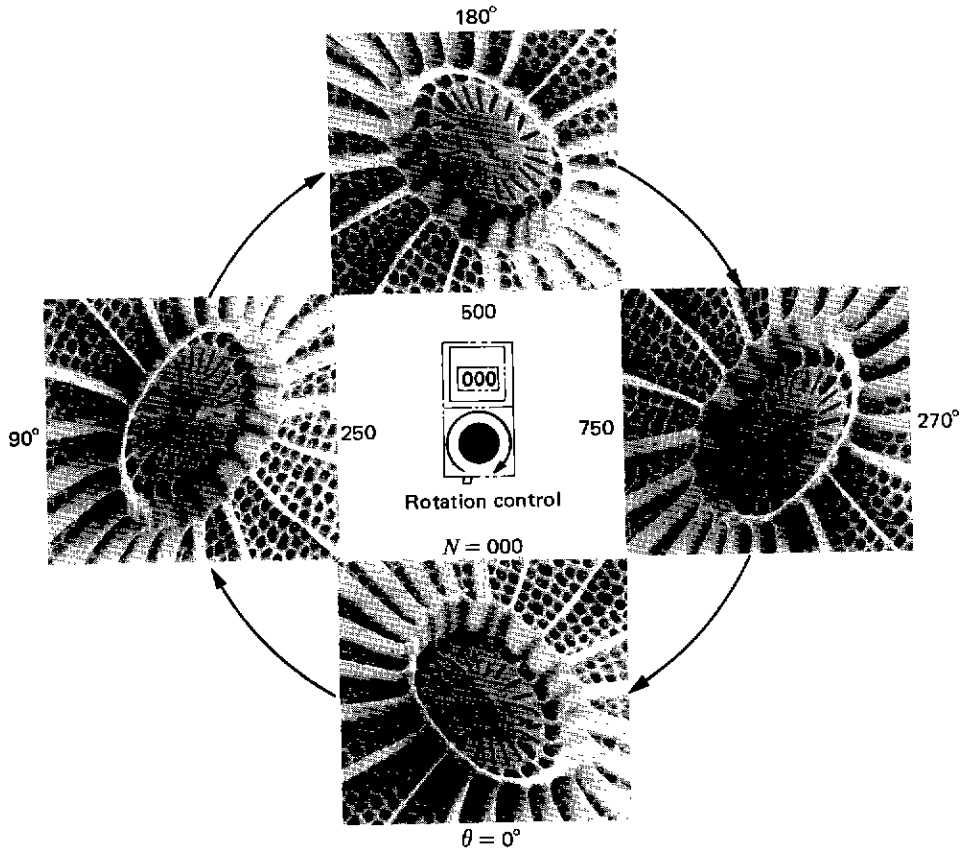


Fig. 5.21 Specimen rotation Specimen: Diatom

9. If necessary, tilt the specimen 45° around the Y-axis or to the desired angle with the specimen stage tilt control. (This is for stereoscopic observation from a oblique direction of a fine structure which cannot be observed from a horizontal direction only. This is also effective in observing a low signal specimen because the signal intensity increases when a flat specimen is tilted.)

Push the LENS unit FULLY FOCUS button (the button lamp lights). Slowly turn the AMPLITUDE knob clockwise to correct differences in focus between the left and right portions of the image as shown in Fig. 5.22 to focus the probe along the specimen surface. Then, readjust the focus with the OBJECT LENS: MEDIUM knob.

Note: When the WD39 specimen holder is used, the specimen cannot be tilted if the working distance

is set at 15 mm, nor can the specimen be tilted if the optical microscope (OM) is used. If the specimen is tilted in such cases, the specimen holder, specimen stage and internal components of the specimen chamber will be damaged.

Note: Stereoscopic image

Take two micrographs of the same field at different tilt angles as shown in Fig. 5.23. Then, observe them through a commercially available stereo-viewer. The difference between the two tilt angles should be selected so as to lie within the optical angle range (approx. 14°), the actual difference depending on the unevenness and overlap of the specimen. A large difference is required for smooth specimens.

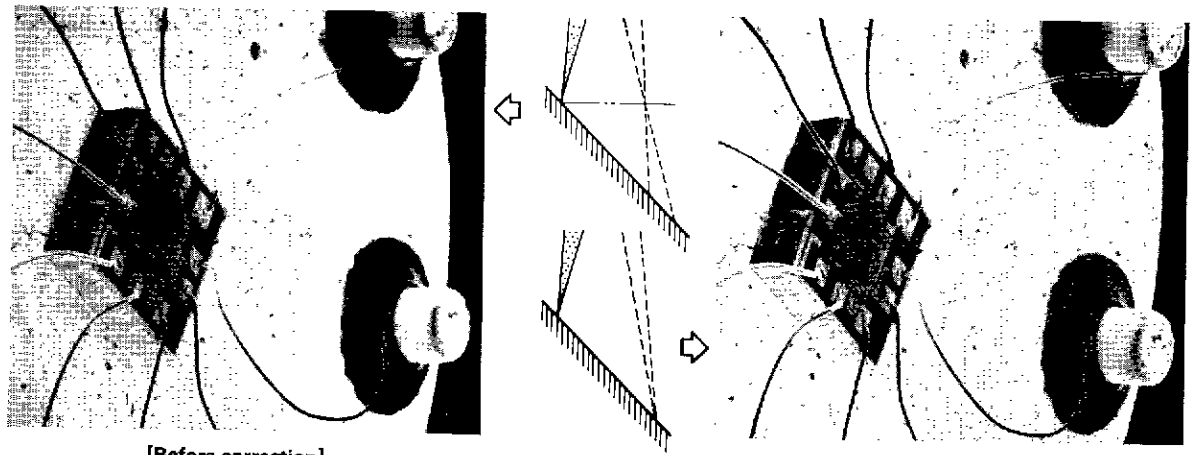


Fig. 5.22 Correcting focus for tilted specimen Specimen: Integrated circuit

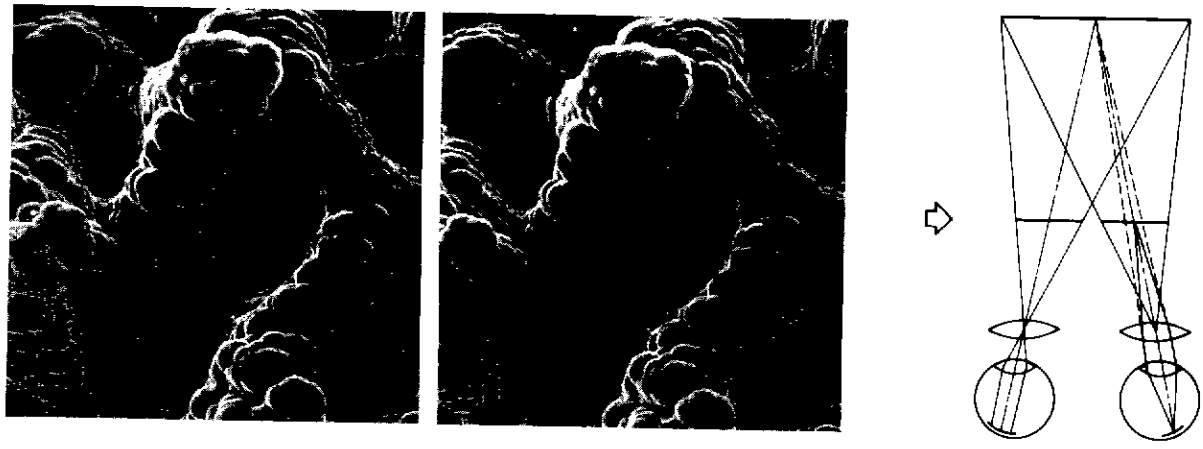


Fig. 5.23 Stereoscopic image Specimen: Graphite
Difference between tilt angles: 5 degrees.

10. Obtain the desired magnification with the MAGNIFICATION: COARSE button and FINE knob (MAG). The set magnification is displayed on the indicator unit MAGNIFICATION indicator. If a high magni-

fication is set, select the field by finely shifting (30 μm) the scanning position with the IMAGE SHIFT (X, Y) knobs (MAG).

11. Select the scanning speed for observation (continuous scanning) in accordance with Table 5.4.

Table 5.4 Selecting scanning speed for observation

Select button	Frame speed (sec/frame)	Number of scanning lines (lines/frame)	Scanning mode	Purpose
RAPID 2 (SCG)	0.04 (1*[1])	533 (1,000*[1])	Interlaced full scanning	Normal observation (still image)
RAPID 1 (SCG)	0.1	500 (200*[1])	Reduced area scanning	For observing low signal fields
SLOW 1 (SCG)	5	1,000	Full area scanning	For observing low signal fields and focusing and correcting astigmatism at high magnifications and adjusting signal processor units.
SLOW 2 (SCG)	25	625		
MF*[2] (DIS)	0.5 – 500	———		For observation under the same conditions as for single frame scanning

*1 *The values enclosed in parentheses are used only when the MAGNIFICATION: COARSE 10[1] button (MAG) is pushed.*

*2 *The frame (vertical scanning) speed and the horizontal scanning speed can be set separately with the VERT, HOR thumbwheels (SCG). The number of scanning lines varies according to combinations of the VERT, HOR thumbwheels. Since the photographic recording system shutter opens when this button is pushed, push this button only after the dark slide has been inserted into the film holder.*

A fast frame (vertical scanning) speed is recommended for direct observation of an image on the CRT because the image is clear and flicker-less. The selected area scanning (15 mm × 15 mm – full scanning on the CRT) as shown in Fig. 5.24 is useful to obtain a clear image in a low signal field and is especially effective with the RAPID 2 button pushed. The RAPID 1 button is for reduced area scanning. The selected area scanning is performed in accordance with the following procedures:

a. Set the SELECTED AREA switch (SCG) to its lower position

b. Limit the field (change the scanning range) as desired with the WIDTH: (X, Y) knobs (SCG).

c. Shift the position to be limited as desired (change the scanning position) with the POSITION (X, Y) knobs (SCG).

12. Readjust the image contrast and brightness with the SEI unit CONTRAST and BRIGHTNESS knobs.

Note: For photography, the SEI unit CONTRAST and BRIGHTNESS knobs are set in conjunction with the CONTRAST and LEVEL indicators (IND). In this case, subsequent adjustment of image contrast and brightness is performed with the DISPLAY unit CONTRAST and BRIGHTNESS knobs.

13. Precisely focus the image with the OBJECT LENS: MEDIUM, FINE knobs (LEN). At low magnifications, adjustment of the MEDIUM knob is sufficient. At high magnifications, however, both FINE and MEDIUM knobs must be used.

If the image moves when the focus is changed, perform the procedures given in Section 5.2.7 to correct

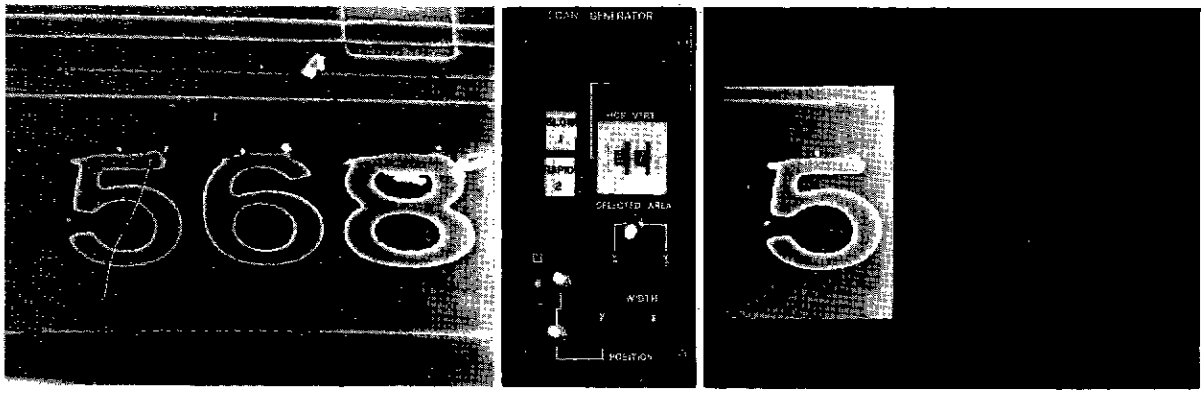
		dia.	the 10 mm or 15 mm working distance
	11	15 mm	32 mm dia.
5-9	Table 5.1	28 ∿ 33 mm	10 mm
5-12	5	(the WD indicator LED39 lights)	28 ∿ 32 mm
	5	fully	Delete.
			Delete.

5-32

Insert the following between lines 2 and 3.

Note: If the MAC ON/OFF switch is turned on, the correct magnification will be displayed on the indicator unit, no matter where the WD position is, by the automatic magnification correction unit. The magnification range is 20× ∿ 180,000×. If the focus is re-adjusted after pushing the CLEAR (LEN) button, the more correct magnification can be displayed. In the minimum magnification 10× is necessary, turn off the itch and set WD to 39 mm.

the aperture position.



[Full area scanning] [Selected area scanning]

Fig. 5.24 Full area scanning and selected area scanning Specimen: Silicon wafer

14. If necessary, select the automatic brightness control (ABC) mode. When the field of view is moved, the video signal may change to a large extent, resulting in a large change of the image brightness. Under such conditions, the ABC mode ensures the nearly constant image brightness without any adjustment of the brightness control. In the cases below, however, the ABC mode cannot be applied; therefore, before carrying out the operation, push the ABC: OFF button (LEN).
    - NOR/INV switch (SEI) . . . . . INV (inverted contrast image)
    - Scanning mode selection switch (SCG) . . . . . • (spot) or – (line scanning)

    a. Push the RAPID 1 or RAPID 2 button on the SCAN GENERATOR unit (scanning speed selection).

    b. Obtain the desired contrast and brightness of the image with the SEI unit CONTRAST and BRIGHTNESS knobs.

    c. Push the LENS unit ABC: ON button (the built-in lamp flickers to indicate that the ABC is operating.)

    Cautions: *1. Do not tamper with the CONTRAST and BRIGHTNESS knobs (SEI) under this condition.*

    2. If the CONDENSER LENS knob is being set at an excessively weak excitation, the image may not appear. In this case, immediately push the ABC: OFF button and change the condenser lens excitation.

    d. Locate the other desired field of view and observe the image.

    Since the brightness, set by step b, is stored, the image brightness always remains constant whatever field of view is located (RAPID 1 and RAPID 2).

    When the SLOW 1, SLOW 2, or PHOTO button (SCG) is pushed, re-push the ABC: ON button after locating the desired field of view. The image brightness remains nearly constant.

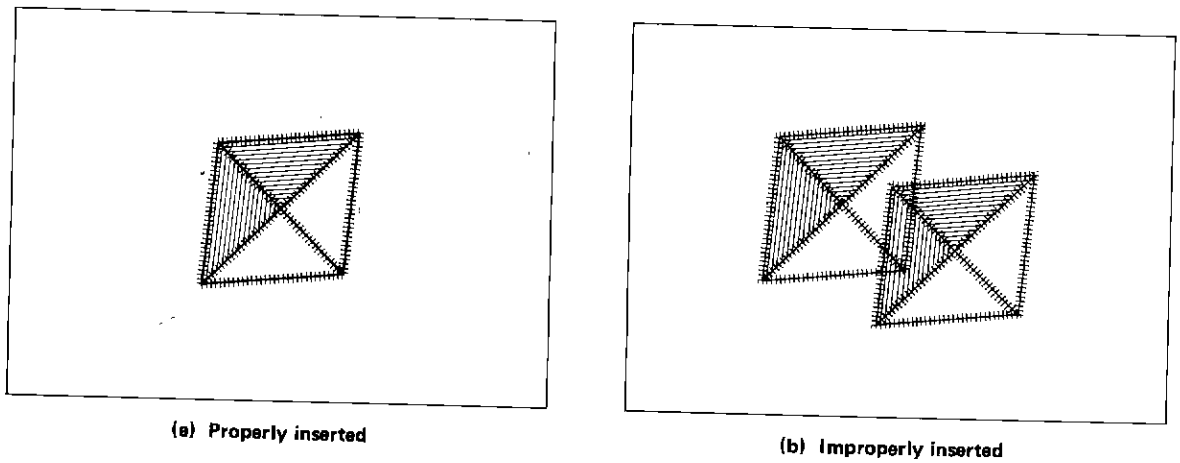
    Notes: *1. Since the image brightness is not stored for a long period in the ABC mode, the same*

image brightness cannot be obtained when the SLOW 1, SLOW 2, or PHOTO button is pushed. Accordingly, the use of the ABC mode is recommended for field-of-view selection only.

2. *When the amplitude (contrast) and level (brightness) of the waveform of the image video signal is adjusted (WAVEFORM MONITOR button (DIS) pushed) in the ABC mode, the image with the brightness, originally set up, is restored by pushing the NORMAL button (DIS) in the case of RAPID 1, RAPID 2, or SLOW 1 mode.*
3. *When the ABC: ON button is pushed with the SLOW 1, SLOW 2 or WAVEFORM MONITOR button pushed, the ABC: ON button lamp flickers and then remains lit.*

See overleaf: 5.2.7 Aperture centering
Flowchart A-7, Table 5.5, Fig. 5.25

2. Push the RAPID 2 button (SCG).
3. Change the aperture diameter (normally, position 2: 240 μm dia.) with knob 1 in accordance with the general description given at the beginning of this section.
4. Focus the image with the OBJECTIVE LENS: MEDIUM knob (LEN).
5. Bring a feature in the image to the center of CRT (DIS) screen with the X and Y controls.
6. Push the LENS unit FOCUS WOBB button ( ) and set the AMPLITUDE knob to the 10 o'clock position . If the feature remains approximately in the screen center as shown in Fig. 5.26a, the aperture is properly inserted into the beam path. If the feature shifts as shown in Fig. 5.26b (at an interval of approx. 0.3 sec), the aperture position is off center. Loosen the lock nut shown in Fig. 5.25, adjust knobs 2 and 3 so as to minimize the shift of the feature, and tighten the lock nut.



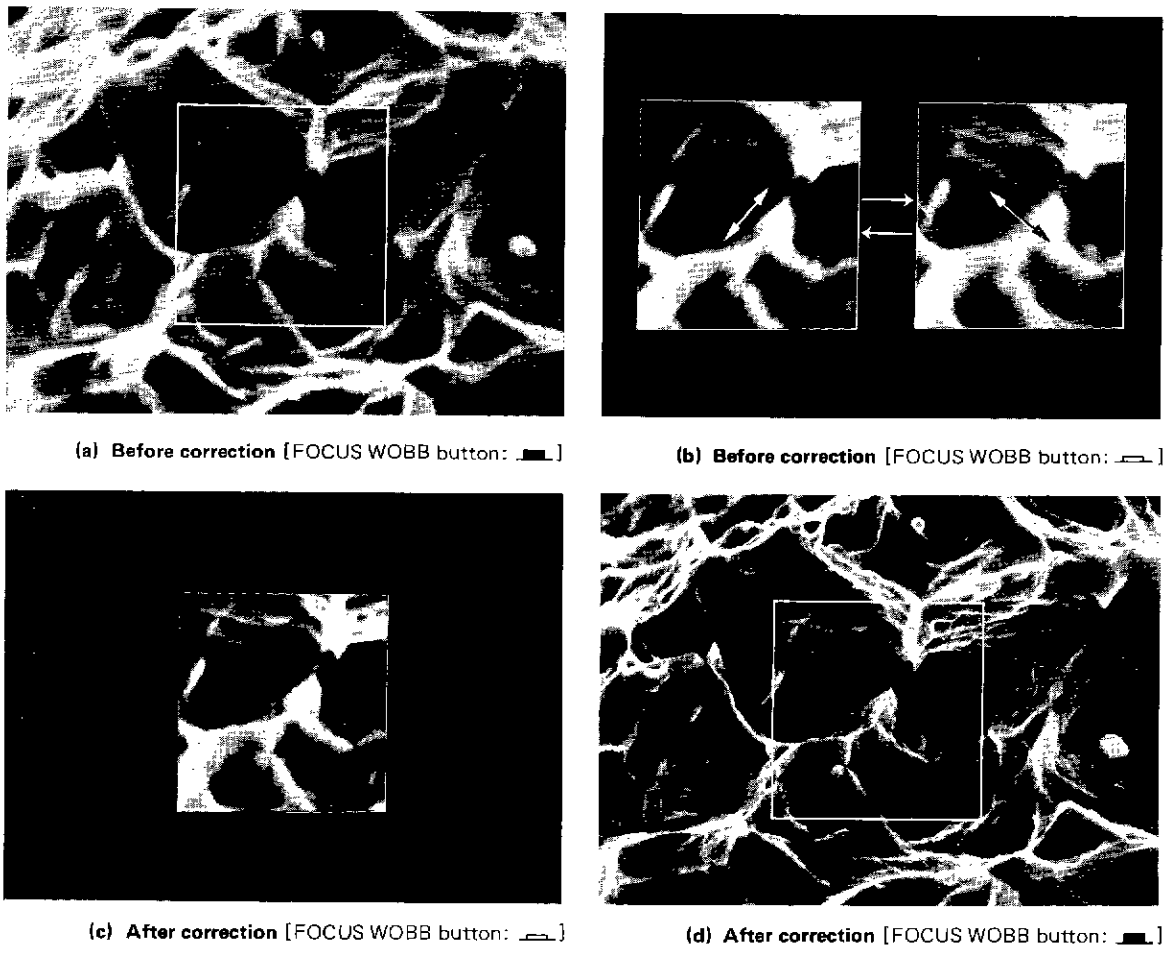
(a) Properly inserted

(b) Improperly inserted

Fig. 5.26 Aperture centering

7. Push the FOCUS WOBB button again to release it ( ).
8. Focus the image with the OBJECTIVE LENS: MEDIUM knob.

See overleaf: 5.2.8 Astigmatism correction
Flowchart A-8, Fig. 5.27



(a) **Before correction** [FOCUS WOBB button: ▬]

(b) **Before correction** [FOCUS WOBB button: ▭]

(c) **After correction** [FOCUS WOBB button: ▭]

(d) **After correction** [FOCUS WOBB button: ▬]

Fig. 5.28 Astigmatism correction Specimen: Fractured surface of brass

10. Manipulate the STIGMATOR: X and Y knobs alternately so that directional image blurring (astigmatism) disappears (Fig. 5.28c).

    When astigmatism is corrected, the image focus is equalized in all directions, but the image will still be somewhat blurred.

11. Check that no astigmatism appears while gradually turning the AMPLITUDE knob counterclockwise. Then, turn the knob fully counterclockwise and leave it there (the image is focused).

    If astigmatism is not completely corrected, image blurring will appear as the AMPLITUDE knob is turned. Make a fine adjustment with the X and Y knobs.

12. Push the FOCUS WOBB (LEN) again ▬ (the button lamp goes out) and precisely focus the image with the OBJECTIVE LENS: MEDIUM and FINE knobs.

    A clear image without astigmatism can be obtained through precise focusing (Fig. 5.28d).

    Note: Contaminated internal components of the column will make it difficult to eliminate astigmatism. If necessary, disassemble and clean the column as described in Chapter 6, Maintenance.

See overleaf: 5.2.9 Scanning image photography
Flowchart A-9, Fig. 5.29

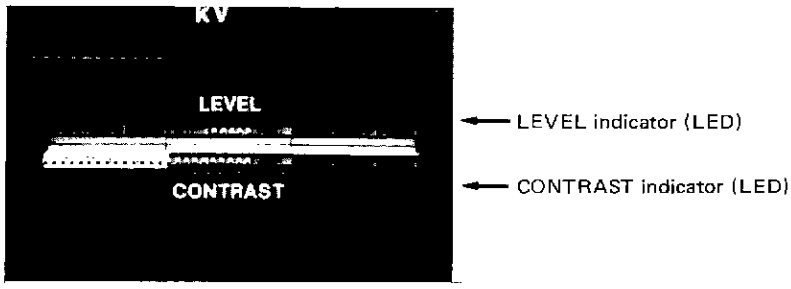


Fig. 5.29 Determining the exposure with the LED indicators

■ Determining the exposure by monitoring wavefom

1. Push the SCAN GENERATOR unit SLOW 1 button.
2. Push the DISPLAY unit WAVEFORM MONITOR button. The waveform of the video signal and bright-up six lines with 1V intervals will be displayed on the viewing CRT.
3. Adjust the amplitude and level of the waveform with the SEI unit CONTRAST and BRIGHTNESS knobs so that the peak of the waveform is at 5 V and the minimum level at 0 V when one frame is scanned (Fig. 5.30).

   Note: The exposure can also be determined for the desired portion of the field in the line scanning mode (Section 5.4.2b).
4. Push the DISPLAY unit NORMAL button to return the scanning mode to normal frame scanning.
5. Adjust contrast and brightness of the image on the CRT with the DISPLAY unit CONTRAST and BRIGHTNESS knobs.

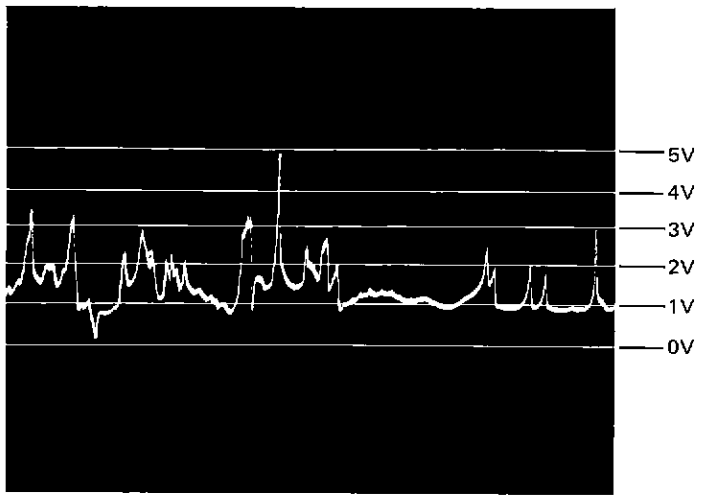


Fig. 5.30 Determining the exposure by monitoring waveform

5.2.9b Setting photography conditions

Before photography, it is necessary to set the scanning speed, the lens opening (f-number) of the camera, and the photographic recording unit CONTRAST and BRIGHTNESS knobs, taking into consideration the type of film and image, etc. The horizontal and vertical scanning speeds for photography are not related to the viewing scanning speeds and are set with the HOR and VERT thumbwheels (SCG). One frame scanning is started by pushing the PHOTO button (SCG).

1. Set the SCAN GENERATOR unit HOR and VERT thumbwheels to 6 and 6 or 6 and 7. When the HOR and VERT thumbwheels are set to 6 and 6, the horizontal scanning speed and the vertical scanning (frame) speed during photography will be 40 msec/line and 50 sec/frame, respectively, and the number of scanning lines will be 1,250 lines/frame as shown in Table 5.6. When these thumbwheels are set to 6 and 7, the horizontal scanning speed will be 40 msec/line and the vertical scanning speed will be 100 sec/frame, respectively, and the number of scanning lines will be 2,500 lines/frame (this equals the resolving power of the CRT).

   Note: Each of the HOR and VERT thumbwheels is numbered from 0 to 9. However, for normal photography, the above settings are suitable. The relationship between the number of scanning lines and the scanning speed is as shown in the following expression:

$$\textit{Number of scanning lines (lines/frame)} = \frac{\textit{Vertical scanning speed (sec/frame)}}{\textit{Horizontal scanning speed (sec/line)}}$$

Table 5.6 Scanning speed and number of scanning lines

HOR thumbwheel	Horizontal scanning speed (msec/line)	VERT thumbwheel	Vertical scanning speed (sec/frame)	Number of scanning lines (lines/frame)
0	2	0	0.5	250
1	4	1	1	250
2	10	2	2.5	250
3	10	3	5	500
4	20	4	10	500
5	40	5	25	625
6	40	6	50	1,250
7	100	7	100	1,000
8	250	8	250	1,000
9	500	9	500	1,000

2,500

2. Set the f-number adjust knob (for adjusting the lens opening of the camera), and CONTRAST and BRIGHTNESS knobs (Fig. 5.31) by referring to Table 5.7. For these knob settings, select adequate conditions for the specimen being examined after some trials.

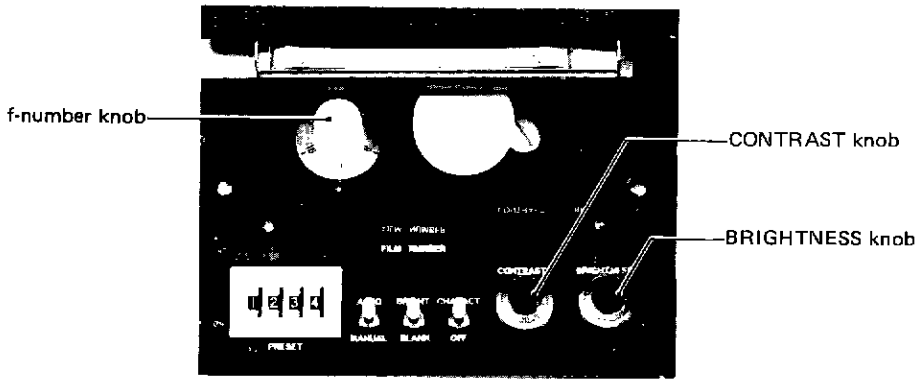


Fig. 5.31 Photographic recording unit and knobs used for setting photography conditions

Table 5.7 Photography conditions

Thumbwheel HOR	Thumbwheel VERT	Film holder	Film	Film speed ASA	Film speed DIN	Image mode	f-number knob f/	Knob settings CONTRAST	Knob settings BRIGHTNESS
6 (1,250 lines/frame) or 6 (2,500 lines/frame)	6 (1,250 lines/frame) or 7 (2,500 lines/frame)	PRH Polaroid #545 film holder	Polaroid 4X5 Land film – Type 55	50	18	□ Ⓨ –	5.6	6.0	7.0 9.0 10.0
			Polaroid 4X5 Land film – Type 52	400	27	□ Ⓨ –	11		5.0 7.0 10.0
		PRH2 Polaroid #405 film holder	Polaroid 105 Land film	75	19	□ Ⓨ –	5.6		5.0 7.0 10.0
			Polaroid 107 Land film	3,000	36	□ Ⓨ –	22		5.0 7.0 10.0
		MRH Mamiya 6X7 roll film holder	120/220 roll film – Type SS	100	21	□ Ⓨ –	8		5.0 7.0 10.0
			120/220 roll film – Type SSS	200	24	□ Ⓨ –	8 or 11		5.0 7.0 10.0

□: Frame scanning, Ⓨ: Y-modulation, –: Line scanning.

5.2.9c Data recording

For facilitating identification and storage of the exposed film, the acclerating voltage, magnification, film number and micron marker (including the micron indicator) are record on the film at the same time as the image is photographed. This section describes the type of recording data, display selection, and film number setting.

■Data recording and display selection

1. Set the CHARACT/OFF switch (PHO) to CHARACT or OFF as per the following requirements.
   - ●To record all the data, set the switch to CHARACT (Fig. 5.32a).
   - ●To record all the data except magnification, set the switch to its center position (Fig. 5.32b).
   - ●To record the image only, set the switch to OFF (in this case, omit Step 2) (Fig. 5.32c).
2. Set of the BRIGHT/BLANK switch (PHO) to BRIGHT or BLANK as per the following conditions.
   - ●If the data displayed area at the bottom of the micrograph is dark, set the switch to BRIGHT so as to display the data in white characters (Fig. 5.32a).
   - ●If the data displayed area at the bottom of the micrograph is bright, set the switch to BLANK so as to display the data in black characters (Fig. 5.32d).
   - ●If the data display area comprises both bright and dark portions, or when continuous photography is to be done while changing the field, set the switch to its center position between BRIGHT and BLANK so as to display the data in white on a black background (Fig. 5.32e).

■Data readout

The data displayed on the viewing CRT (recorded on the micrograph) is grouped in five sets of blocks as follows:

- ●□ □ kV (accelerating voltage in kilovolts)
- ●X □ □ □ □ □ □ (magnification) Direct readout is applicable to RRH only; PRH2: Approximately 0.83 times the displayed magnification; MRH: Approximately 0.58 times the displayed magnification).
- ●□ □ □ □ (film number) The last 2 digits count the number of exposures.
- ● ⊏═══⊐ (micron marker) The length of the micron marker is displayed on the micron indicator in micrometers; viz., □ □ □ □. □ U (μm).
- ●The last group (JEOLS, or any 5 letters or numbers) can be changed by our service personnel upon request.

■Film number setting

Skip following steps if the film number has already been set and resetting is not required.

1. Set the AUTO/MANUAL switch (PHO) to MANUAL.
2. Set the 4-digit number (0000 – 9999) of the PRESET thumbwheel (PHO) indicators to the number to be recorded on the film.
3. Set the AUTO/MANUAL switch to AUTO. The same number as on the RESET thumbwheel indicators (film number) is displayed on the FILM NUMBER indicator, and is ready to be printed on the film. The last two digits automatically advance in accordance with the subsequent number of exposures, but the first two digits do not change automatically. When the settings of the PRESET thumbwheels are changed, the first two digits of the FILM NUMBER indicator change simultaneously,

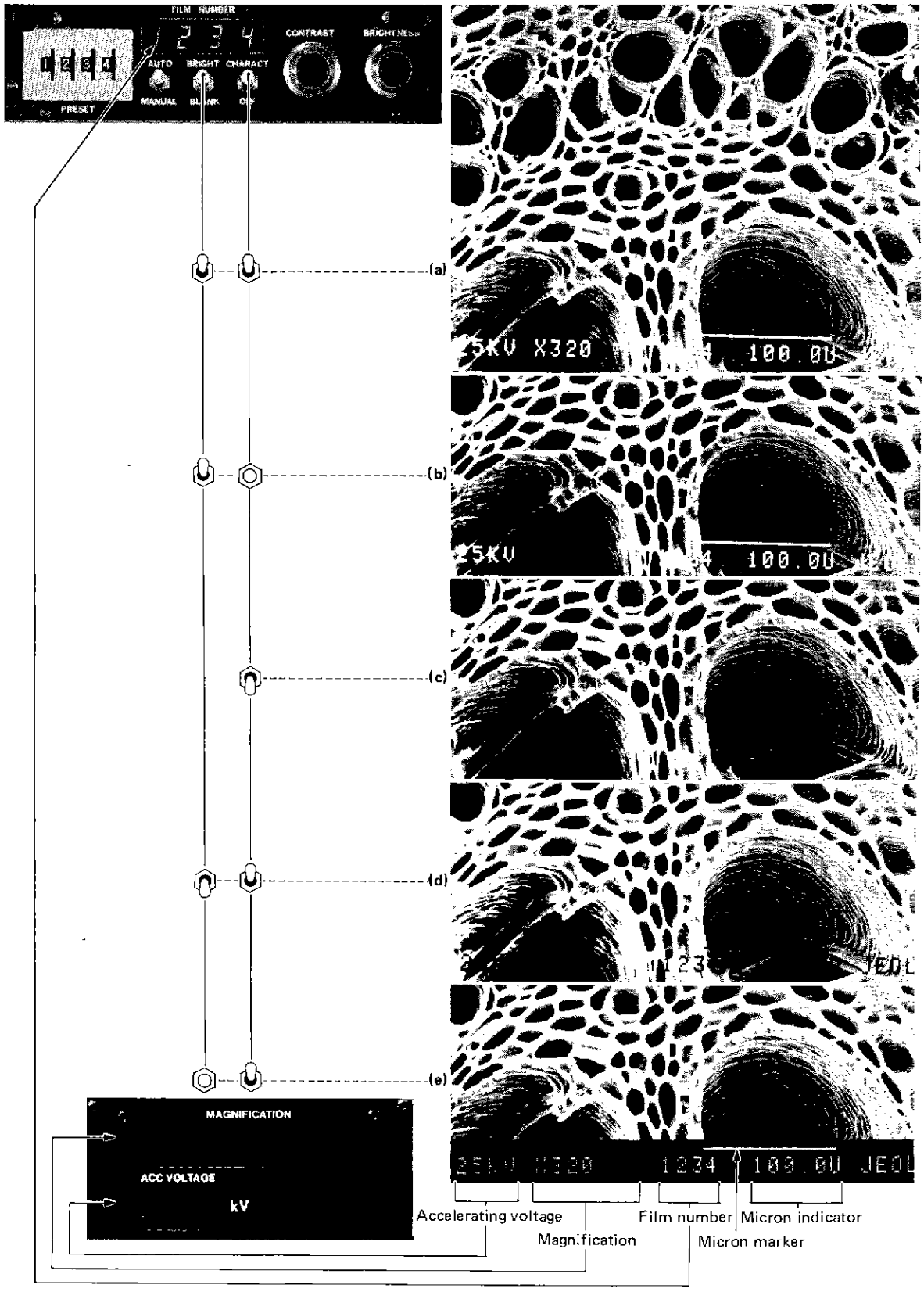


Fig. 5.32 Recording data

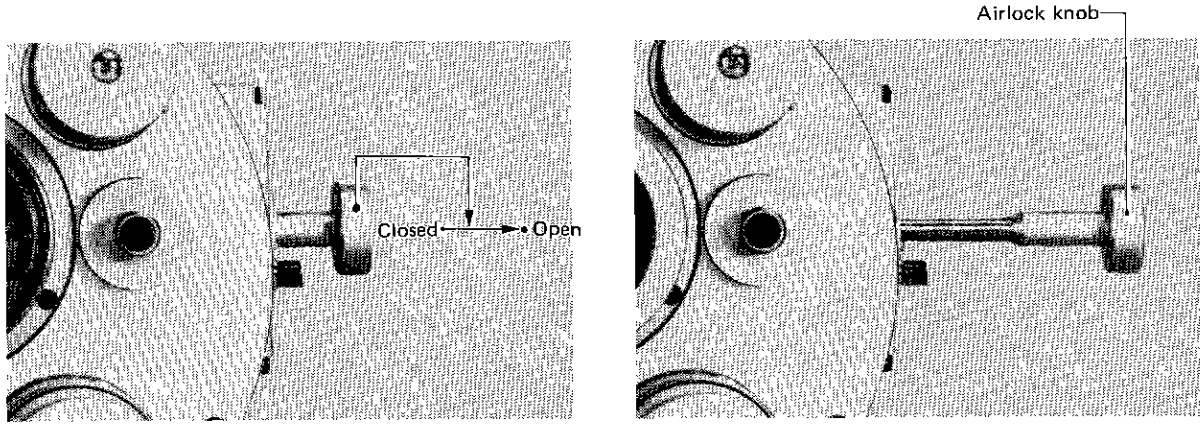
but the last two digits remain unchanged. When the switch is set to MANUAL, the counting stops and the same number is displayed and recorded. To change the film number with the switch set at MANUAL, the PRESET thumbwheels must be reset and the switch must be temporarily set to AUTO.

5.2.9d Photography

This section describes procedures for photographing the CRT image. For handling the film holders (special order), refer to their respective operation instructions.

1. Prepare the film loaded in the film holder (PRH: Pull out the film pack; PRH2: Pull out the black tab only for the first picture; MRH: Roll up the film).
   If a dark slide is inserted in the film holder (PRH2, MRH), pull it out.
2. Adjust the OBJECTIVE LENS: MEDIUM and FINE knobs (LEN) to precisely focus the image.
3. Push the SCAN GENERAOR unit PHOTO button (the lamp lights). When this button is pushed, the camera shutter opens, the one frame scanning at the scanning speed set with the HOR and VERT thumbwheels (SCG) starts, and the scanning image along with data is exposed on the film. Upon completion of scanning (recording) (the PHOTO button lamp goes out), the camera shutters automatically closes, the scanning mode returns to its original scanning for observation (continuous scanning), and, when the AUTO/MANUAL switch (PHO) is set at AUTO, the film number advances by 1.
   Note: If the DISPLAY unit MF button is pushed (the button lamp lights) instead of the PHOTO button, multiple exposure (lap photographing) of the scanning images in the same field is possible (useful for photographing X-ray images). With the camera shutter open, scanning at the recording scanning speed is repeated as many times as desired. To close the shutter, push the MF button again (the button lamp goes out). The camera shutter closes upon completion of the current frame scanning, and the scanning mode returns to the viewing mode.
4. If photography is to be continued, prepare the next film (PRH: Replace the film pack; PRH2: Pull both the white and yellow tabs; MRH: Roll up the film) and repeat Steps 2 and 3.
   To terminate photography, insert the dark slide into the film holder (PRH2, MRH).
   Note: For double exposure of normal scanning image and line profile, photograph without replacing (or winding up) the film.

Index number	Part name	Function/Operation



[Airlock valve . . . . . Closed] [Airlock valve . . . . . Open]

Fig. 4.7 Operating specimen exchange chamber airlock knob

⑧	Vacuum control pushbutton	This pushbutton controls opening/closing of the vacuum valve when evacuating the specimen exchange chamber and venting it to the atmosphere. In exchanging the specimen, when the button is pushed after attaching the exchange chamber cap to the specimen exchange chamber, vacuum valve V5 (Fig. 3.8) closes, and the exchange chamber is evacuated. The lamp in the button goes out after about 30 seconds indicating completion of evacuation. When the button is pushed again, vacuum valve LV2 (Fig. 3.8) opens, the lamp lights, and air is admitted to the exchange chamber to restore it to atmospheric pressure.
⑨	Lock lever	This is the lock lever for the front cover which is integrated with the specimen stage (Fig. 4.8). The front cover must be opened to exchange specimens on the 76 mm dia. × 20 mm hgt. specimen holder (specimens on this holder cannot be exchanged via the airlock system) or to mount an attachment in the specimen chamber. To open the front cover, vent the entire column to the atmosphere, set the tilt control to 0° (the WD control must also be set to 39 mm if the optical microscope OM is installed), then pull the lock lever. When closing the front cover, first check that the tilt control is set at 0° (if OM is installed, also check that the WD control is set at 39 mm), then close the cover (the front cover locks when it is pushed).

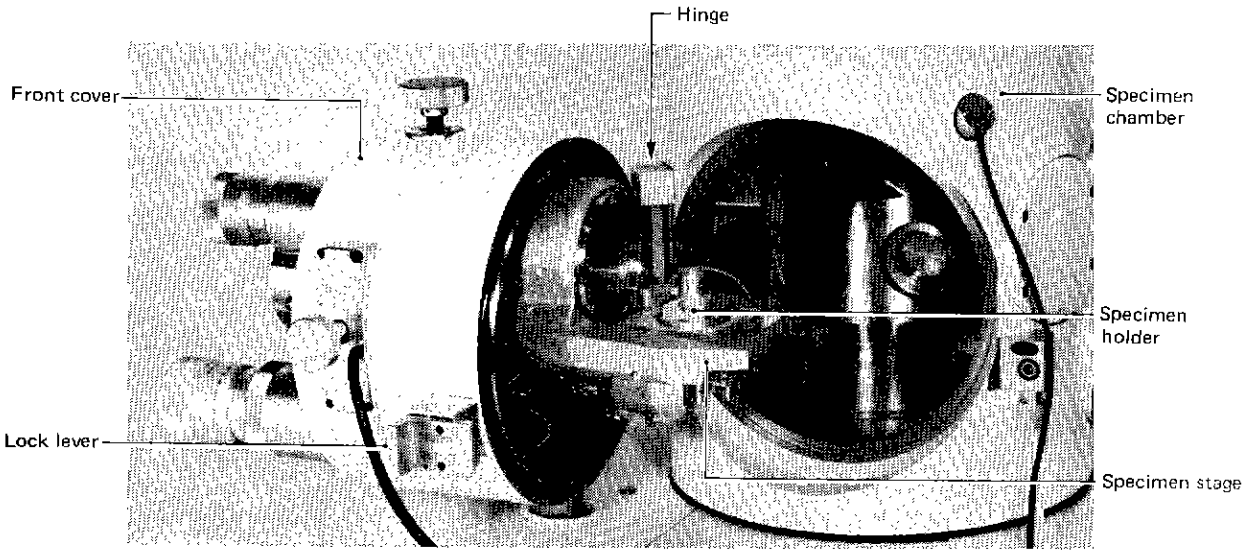


Fig. 4.8 Opening the front cover

See overleaf, Sects. 4.2, 4.2.1, 4.2.2, 4.2.2a and Figs. 4.9, 4.10.

Index number	Part name	Function/Operation
		air compressor reservoir. When the reservoir pressure drops to below 3.5 kg/cm^2, the lamp lights and the air compressor starts automatically.
	WATER lamp	This lamp lights and the vacuum system automatically stops when the temperature of the water-cooled area of the oil diffusion pump exceeds 60°C. Turning the key switch on the master power supply panel to VACUUM will not start the vacuum system in this state, and the lamp will remain lit. The vacuum system can be restarted when the temperature of the water-cooled area drops to 60°C with the cooling water running.
	VACUUM lamp	This lamp lights when the pressure in the column rises beyond the specified value. If the pressure rises (vacuum deterioration) while the instrument is in operation, all valves (solenoid valves and pneumatic valves, Fig. 3.8) close automatically except V2, and this lamp lights. In this case, after the cause has been determined and the necessary repairs made, depress the RESET button to re-start evacuation.
②	VACUUM RESET pushbutton	This pushbutton is used to re-start the vacuum system after the cause of vacuum deterioration has been removed (vacuum deterioration is indicated by the DEFECT: VACUUM lamp). When this button is pushed in a normal state, the column automatically returns to the high vacuum state.
③	Vacuum system indicators	Indicate which vacuum system solenoid valves and pneumatic valves are open and which are closed and the operating state of the pumps by lamps (Fig. 3.8 and Table 3.1). When the lamps are lit, valves are open and the oil diffusion pump DP and oil rotary pumps RP1/RP2 are in operation.
④	VENT pushbutton	This pushbutton is used to temporarily vent the column to the atmosphere. Air is admitted into the column prior to commencing the electron gun filament replacement and column cleaning. When this button is pushed, the built-in lamp lights (lamps in the PUMP DOWN button and LOAD CURRENT meter go out), and air is admitted into the anode chamber only if the anode chamber airlock valve AV1 (Fig. 3.8) is closed. However, air is admitted into the entire column if AV1 is open.
⑤	PUMPDOWN pushbutton	This button is used to evacuate the column which has been temporarily vented to the atmosphere. When this button is pushed, the built-in lamp lights (the VENT button goes out).

Index number	Part name	Function/Operation
		If the airlock valve AV1 (Fig. 3.8) is closed, the anode chamber is automatically evacuated. If the AV1 is open, the entire column is evacuated. When the specified vacuum has been reached, the LOAD CURRENT meter lamp lights to indicate that the instrument is ready for high voltage application; however, if the AV1 is closed, open it. The button is usually pushed in.
4.2.2b	**ACCELERATING VOLTAGE unit**	
①	ACCELERATING VOLTAGE: COARSE pushbuttons	Change the electron probe accelerating voltage (high voltage) in 4 stages. When any of the 0 V, 10 kV, 20 kV and 30 kV button is pushed, the built-in button lights and the high voltage (kV) corresponding to the sum of the voltage indicated by the pushed button and the voltage selected by the FINE thumbwheel switch is generated and applied to the electron gun as the accelerating voltage (up to 39 kV). The accelerating voltage can be read on the ACC VOLTAGE indicator and is recorded on film.
	FINE thumbwheel switch	This thumbwheel switch is used to select the accelerating voltages between the COARSE button selected values. The switch divides the voltage between the button selected and the next lower button value into 10 steps. Numbers on the indicator 0 – 9 correspond to 0 – 9 kV.
②	GUN BIAS thumbwheel switch	Changes over the electron gun bias in 10 steps. When the indicator reading increases, the bias increases. The bias is set according to the selected accelerating voltage.
③	GUN FILAMENT knob	Controls the heating current of the electron gun filament. When the knob is gradually turned clockwise from its counterclockwise position while high voltage is being generated, the electron beam is emitted from the electron gun and the reading of the LOAD CURRENT meter increases. With the knob set at the utmost counterclockwise position, no heating current flow through the filament. Set the knob at the saturation position where the LOAD CURRENT meter does not deflect; never turn it any further (turning the knob beyond the saturation position will shorten the service life of the filament). When not observing images, turn the knob fully counterclockwise and set it there.
④	ON/OFF switch	Switch for the high voltage (accelerating voltage) circuit and the electron gun filament heating circuit. When this switch is OFF, the ACCELERATING VOLTAGE: COARSE button lamp goes

Index number	Part name	Function/Operation
		out and the high voltage is disconnected (heating of the filament is also stopped). When set ON, the high voltage selected by the ACCELERATING VOLTAGE: COARSE button and the FINE thumbwheel switch is supplied to the electron gun as the accelerating voltage.
⑤	OVERLOAD lamp	This lamp lights to indicate that the high voltage circuit is in an overload condition due to high voltage discharge, etc. When this lamp lights, discontinue taking micrographs.
⑥	LOAD CURRENT meter	This meter (full scale 400 μA) indicates the load current of the high voltage (accelerating voltage) circuit. If the GUN FILAMENT knob is set to its extreme counterclockwise position (the electron gun filament is not heated), the meter indicates the detecting current; i. e., the accelerating voltage divided by 10^9 ((V)/1 $\times$ 10^9 (Ω)). When the knob is turned clockwise to the saturation position, the electron beam is emitted from the electron gun, and the meter indicates the sum of the emission current and the detecting current.
⑦	BEAM ALIGNMENT knobs	These four knobs align the axis of the electron optical system by controlling the current that flows into the deflection coils located beneath the anode chamber. When the upper two knobs are turned either counterclockwise or clockwise from their center positions, current starts to flow into the deflection coils and the tilt of the electron beam entering the condenser lens changes. When the lower two knobs are turned either counterclockwise or clockwise from their center positions, current starts to flow into the deflection coils and the electron beam entering the condenser lens shifts horizontally.
4.2.2c	**LENS unit**	
①	FOCUS WOBB pushbutton	This pushbutton is for easily monitoring astigmatism. When this button is pushed (built-in lamp flickers) after the image is focused with the OBJECTIVE LENS knobs with the RAPID 2 button pressed, two slightly out-of-focus images (over-focus and under-focus images) are alternately displayed on the CRT (this button can be released by pushing it again). The AMPLITUDE knob is used to adjust the amount of defocusing of the two images so that the astigmatism can be most clearly observed (the two images can be seen flowing at right angles to each other).
②	FULLY FOCUS pushbutton	Uniformly focuses the image of the surface of the tilted specimen. When this button is pushed, the built-in lamp lights

Index number	Part name	Function/Operation
		and the entire image field can be focused regardless of the tilt of the specimen (this button is released by pushing it again).
③	ABC:	
	ON pushbutton	This button is used for automatic brightness control. When the button is pushed, the image brightness is maintained constant even when the field of view is moved. Before pushing this button, set the image brightness and contrast at the desired level. In the RAPID 1 and RAPID 2 modes, the image brightness is automatically compensated for change in the field of view. In other scanning speeds, push this button after locating the desired field (useful for selecting the field of view).
	OFF pushbutton	Used for releasing the ABC mode.
④	AMPLITUDE knob	Adjusts the amount of defocusing of the under- and over-focused when the FOCUS WOBB button is pushed. When the knob is turned fully counterclockwise, the amount of defocusing of the two images becomes nil. The defocusing at the upper and lower image edges due to specimen tilt can be also compensated with this knob when the FULLY FOCUS button is pushed. With the knob at the utmost counterclockwise position, in this case, focusing is achieved with respect to the horizontal plane only.
⑤	STIGMATOR (X, Y) knobs	Vary the stigmator strength in the X and Y directions, respectively. The LEDs indicate the knob rotated direction. When both LEDs are unlit, the potentiometer is set at the center position.
⑥	CONDENSER LENS knob	This 10-turn potentiometer (with a stop) adjusts the probe current by varying the condenser lens current. When the knob is turned clockwise, the probe current is reduced and the probe diameter becomes smaller. This knob is normally set at a dial reading of 7.0.
⑦	OBJECTIVE LENS:	
	COARSE, MEDIUM, FINE knobs	These knobs are used for focusing the image by varying the objective lens current (COARSE knob: rotary switch with 11 contacts, MEDIUM knob: one-turn potentiometer, FINE knob: 10-turn potentiometer). The COARSE knob is set according to the working distance in use. The other two knobs are adjusted so that the image is the clearest for observation (the MEDIUM knob is used for coarse adjustment and the FINE knob is used for fine adjustment). The state in which the image is properly

Index number	Part name	Function/Operation
		focused is called "in-focus". The out-of-focus state generated by turning the knob clockwise from the "in-focus" position is called "over-focus" and the opposite state is called "under-focus".
⑧	SET button	Used for improving the accuracy of the MAC (optional attachment).
⑨		
4.2.2d	**SEI unit**	
①	COLLECTOR thumbwheel switch	Varies the voltage (−500 V to V) of the detector collector and thereby controls the amount of secondary electrons entering the scintillator. The collector voltage is raised when the indicator (0 – 9) is set to a higher number. A setting of or more will normally result in the best secondary electron image. In X-ray analysis, etc. where a high probe current is required, the indicator is set to 5 or less to avoid photomultiplier saturation and prolong the service life of the scintillator and photomultiplier (PMT).
②	CONTRAST knob	This knob (10-turn potentiometer with a stop) adjusts the image contrast by varying the supply voltage to the photomultiplier (PMT) (the gain and amplitude of the video signal changes). As a rule, the knob is set with CONTRAST indicator or waveform monitor (WFM).
③	BRIGHTNESS knob	This knob (10-turn potentiometer with a stop) adjusts the image brightness by varying the DC level of the video signal. Usually, the knob is set with the LEVEL indicator.
④	DET HV lamp	Lights to indicate that high voltage (+10 kV for accelerating secondary electrons striking the scintillator) is being supplied to the scintillator of the detector. This lamp lights when the SEI/BEI switch is set to SEI.
⑤	PMT HV lamp	Lights to indicate that high voltage (adjusted with the CONTRAST knob and supplied to the photomultiplier dynode chain) is being supplied to the photomultiplier (PMT) of the detector. This lamp lights when the SEI/BEI switch is set to either SEI or BEI (will go out if the switch is set to the midway position).

Index number	Part name	Function/Operation
⑥	SEI/BEI switch	On/off switch for the high voltage to the scintillator and the photomultiplier of the detector. When this switch is set to SEI, the DET HV lamp and the PMT HV lamp are lit (high voltage is supplied to both the scintillator and the phtomultiplier) and the secondary electron image can be displayed. When set to BEI, the PMT HV lamp lights (the scintillator is grounded and high voltage is supplied only to the photomultiplier) and the backscattered electron image can be displayed. When the switch is set to the midway position, both lamps go out and both high voltage supplies to the scintillator and the photomultiplier are disconnected (for X-ray analysis and higher probe current, the switch is set to the midway position or BEI to protect the detector). When the type of image to be displayed is changed, the CONTRAST and BRIGHTNESS knobs must be re-adjusted with the CONTRAST and LEVEL indicators.
⑦	NOR/INV switch	Changes the polarity of the video output signal. When set at NOR, a normal (positive) scanning image is displayed. When set at INV, an inverse contrast (negative) image is displayed. Inverse contrast images can be photographed as positive images if negative film is used, a facility which is useful when making slides.
4.2.2e	**MAGNIFICATION unit**	
①	MAGNIFICATION:	
	COARSE pushbuttons	These pushbutton selects the decimal factor for setting the magnification. When the button is pushed, the built-in lamp lights. The magnification is set by the product of the decimal factor selected by the COARSE pushbutton (10, 10^2, 10^3 and 10^4 buttons) and the numerical value selected by the FINE knob and the image magnification can be read on the MAGNIFICATION indicator and printed on film. This magnification is applicable to images photographed using a Polaroid #545 Film Holder; not applicable to images photographed using other film holders. Furthermore, the image on the 10″ CRT is displayed 1.5 times the above magnification.
	FINE knob	The FINE magnification knob (full turn) further varies the magnification selected by the COARSE button in 24 steps. The numerical values of each step of this knob vary with the working distance (WD) as shown in Fig. 4.11.

Index number	Part name	Function/Operation

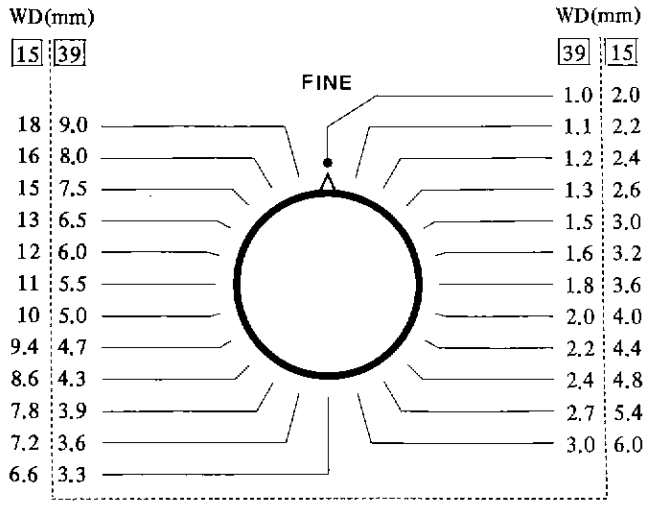


Fig. 4.11 Numerical values for FINE knob

②	PROBE SCAN/EXT switch	Scans and stops the electron probe. When the switch is set at PROBE SCAN, the sawtooth current flows through the deflection coils (for probe scanning and image fine shifts) located above the objective lens, and the probe scans in synchronization with the CRT. With the switch set at EXT, the electron probe stops on the specimen (CRT scanning continues). The EXT position is also used for axis alignment and X-ray analysis (point analysis). The switch is usually set at PROBE SCAN.
③	IMAGE SHIFT (X, Y) knobs	Electrically fine-shift the field of view up to 30 μm in the X and Y directions. When the knobs are turned either counter-clockwise or closkwise from their center positions, current starts to flow in the deflection coils located above the objective lens, the probe scanning area shifts, and the field of view changes. These knobs are used to select the field of view at high magnifications.

4.2.2f SCAN GENERATOR unit

①	SLOW (1, 2) and RAPID (1, 2) pushbuttons	These repeated mode scan buttons select the scanning speeds for visual observation in four steps. The scanning speed most suitable for the magnification, specimen, or research purpose is selected by pushing the corresponding button (the built-in lamp lights) to select the field of view and make various adjustments. When the RAPID 1 button is pushed, a reduced area (75 mm X 75 mm on the 10″ CRT) is scanned at a frame speed (vertical scanning speed) of 0.1 sec/frame, which

Index number	Part name	Function/Operation
		is suitable for visual observation of the field of view with relatively weak signals (when this button is pushed, the scanning range is reduced and the intensity of signal is increased). When the RAPID 2 button is pushed, the full area is interlace-scanned at a frame speed of 0.04 sec/frame (1 sec/frame if the MAGNIFICATION: COARSE 10^1 button is pushed), and a still image is observed. When the SLOW 1 or SLOW 2 button is pushed, the full area is scanned at a frame speed of 5 sec/frame or 25 sec/frame. These two buttons are used when a scanning speed nearly equal to that in the recording mode is required (for example, for determining the accurate exposure and adjusting the signal processors), when the signal intensity is excessively low (for example, the X-ray image), and for visual observation of the image at high magnifications (for example, selection of the field of view, focusing and correction of astigmatism at high magnifications).
②	PHOTO pushbutton	This single scan button for recording is interlocked with the camera shutter of the photographic recording system. When the button is pushed (the built-in lamp lights), the camera shutter opens, and the single frame scan at the scanning speed corresponding to the settings of the HOR and VERT thumbwheel switches (regardless of RAPID 1, RAPID 2, SLOW 1 and SLOW 2 buttons) begins and the image is displayed on the CRT and the data (accelerating voltage, magnification, film number, micron marker, and 5 characters are printed out on film. Upon completion of the single scan (the lamp goes out), the shutter closes automatically and repeated scanning continues.
③	HOR, VERT thumbwheel switches	Independently set the horizontal scanning speed and vertical scanning (frame) speed for recording (PHOTO button and MF button serve as triggers). The horizontal scanning speed is selected between 2 to 500 msec/line by varying numbers (0 – 9) on the HOR thumbwheel switch, and the vertical scanning speed is selected between 0.5 to 500 sec/frame by varying numbers (0 – 9) on the VERT thumbwheel switch. For a normal recording, HOR and VERT switches are set at 6 and 6 (HOR: 40 msec/line, VERT: 50 sec/frame) or 6 and 7 (HOR: 40 msec/line, VERT: 100 sec/frame), respectively.
④	SELECTED AREA switch	Switch for the selected area scanning. When this switch is set to its lower position, a selected area scanning image of the scanning range set by the WIDTH (X and Y) knobs can be obtained (full scan on the 10″ CRT 135 mm × 180 mm to

Index number	Part name	Function/Operation
		15 mm × 15 mm), and the position of the selected area scanning image can be shifted as desired with the POSITION (X and Y) knobs (the switch is usually set to its upper position for full scanning). At the scanning speed for visual observation, especially when the RAPID 2 button is pushed (RAPID 1 button is for the reduced area scanning), the scanning image becomes blurred and the fine structure cannot be revealed (because accurate focusing and astigmatism correction is difficult) if the signal intensity is insufficient due to the selected field of view or as a result of increased magnification. Therefore, the scanning area should be kept to a minimum to increase the signal for accurate focusing.
⑤	WIDTH (X and Y) knobs	Select the scanning area in the selected area scanning mode. The X knob is also used to vary the scanning width in the line scanning mode.
⑥	POSITION (X and Y) knobs	Shift the scanning area in the selected area scanning mode. Also used to move the scanning line up and down in the line scanning mode.
⑦	Scanning mode selection switch	Selects frame scanning, line scanning (amplitude modulation and brightness modulation) and spot scanning. When set to □ for normal frame scanning, a scanning image at the speed set by the SLOW and RAPID buttons or HOR and VERT thumbwheel switches is displayed. When set to — for line scanning, a line profile (waveform of the video signal) is displayed if the modulation mode selection switch is set to its upper position. A brightness modulated line (a scanning line which is brightness-modulated by the video signal) is displayed if the modulation mode selection switch is set to its lower position. When set to • for spot scanning, the probe beam can be stopped at any selected spot on the specimen (the probe position can be checked by the scanning image and the spot), which can be used for X-ray analysis and measurement of intensity of the emitted electrons.
⑧	Modulation mode selection switch	Selects the modulation mode for line scanning. When set to its upper position for amplitude modulation line scanning (line profile), electrons emitted from the specimen are captured by the detector and their quantitative changes are displayed on the CRT as a waveform. When the switch is set to its lower position for brightness modulation line scanning, a scanning line having a brightness corresponding to quantitative changes in the emitted electrons is displayed on the CRT (this mode can

See overleaf, Sects. 4.2.3, 4.2.3a and Fig. 4.12.

Index number	Part name	Function/Operation
4.2.3b	**DISPLAY unit**	
①	10″ CRT	High resolution, long persistence type CRT for visual observation (screen area 135 mm × 180 mm). A scanning image 1.5 times the display magnification can be displayed and a contrast and brightness suitable for visual observation can be adjusted by the CONTRAST knob and BRIGHTNESS knob.
②	NORMAL pushbutton	This button is used to observe normal scanning image. When this button is pushed, the built-in lamp lights, the WAVEFORM MONITOR button or Y-MOD button is released and a normal scanning image is displayed (the built-in lamp goes out).
③	WAVEFORM MONITOR pushbutton	This button is used to correctly determine the image contrast (amplitude: 5 V), brightness (level: 0 V), etc. When this button is pushed (the built-in lamp lights), the video signal waveform is displayed on the CRT. The amplitude and level of the waveform can be read from the six reference lines (0 – 5 V) (this button is released by the NORMAL button).
④	Y-MOD pushbutton	When this button is pushed (the built-in lamp lights), the vertical deflection signal of the CRT is modulated by the video signal, and a Y-modulation image is thereby obtained (this button is released by the NORMAL button). Amplitude of the modulation image is adjusted by the AMPLITUDE knob. Much more detailed discrimination than the normal scanning image (brightness modulation image) can be made and is used to observe the fine structure of the specimen.
⑤	MF pushbutton	Multiexposure button, interlocked with the camera shutter of the photographic recording system. When this button is pushed ⎓ (the built-in lamp lights), the camera shutter opens, the same operation as when the PHOTO button is pushed begins, and scanning at the scanning speed for recording is repeated. When the button is pushed again ▬ (the built-in lamp goes out), the camera shutter closes upon completion of the current frame scanning, and the scanning speed returns to that for visual observation. This button is used to record X-ray images having a low signal intensity or to observe the image at the scanning speed for recording (repeated scanning).
⑥	AMPLITUDE knob	Adjusts the amplitude of the Y-modulation image obtained by pushing the Y-MOD pushbutton. The amplitude, which is corresponding to the contrast of the brightness modulation image, can be changed optionally.
⑦	CONTRAST knob	Adjusts the image contrast on the 10″ CRT. A contrast suitable

Index number	Part name	Function/Operation
		for visual observation can be obtained by setting the knob near its 12 o'clock position.
⑧	BRIGHTNESS knob	Adjusts the image brightness on the 10″ CRT. A brightness suitable for visual observation can be obtained by setting the knob near its 12 o'clock position.
4.2.3c	**Photographic recording system**	
①	5″ CRT	Ultra-high resolution, short persistence type CRT for recording (screen area 69 mm × 92 mm, 42° deflection, flat-face type). When the Polaroid #545 film holder (RPH) is used, the scanning image matching the display magnification can be recorded (the scanning image of about 0.77 times the display magnification will be displayed on the CRT). If the Polaroid #405 Film Holder (PRH2) and Mamiya 6 × 7 Roll Film Holder (MRH) are used, the scanning image of about 0.83 and 0.58 times the display magnifiation can be recorded. The CRT focus can be adjusted by the CSI FOCUS control accessible when the DISPLAY unit is removed.
②	Camera	High performance camera used exclusively for recording the scanning image (focal length: 77.3 mm, lens opening: f/5.6 – 22). A synchronous solenoid shutter interlocked with the probe scanning is incorporated. The PHOTO button or MF button is pushed to record. Three types of film holders are available for this camera (option) : PRH Polaroid #545 Film Holder (Polaroid 4 × 5 Land film – type 52/55), PRH2 Polaroid #405 Film Holder (Polaroid Land film – type 105/107), and MRH Mamiya 6 × 7 Roll Film Holder (120/220 film); each holder is used with the respective adapter.
③	Focusing knob	Adjusts the camera focus. The camera focus must be adjusted by the focus screen when exchanging the film holder.
④	f-number adjust knob	Adjusts the camera f-number (lens opening). Setting of f-number (f/5.6, 8, 11, 16, 22) depends on the film speed (ASA/DIN).
⑤	PRESET thumbwheel switches	Used to preset the film number in 4 digits independently. Numbers on the indicaotrs (0000 – 9999) correspond to those of the FILM NUMBER indicator and the film number in the data printed on film.
⑥	FILM NUMBER indicator	Provides a 4-digit digital display for film number (1 2 3 4). When the AUTO/MANUAL switch is set to AUTO, the first two digits follow change-over of numbers on the corresponding PRESET thumbwheel switch indicators, and the last two digits

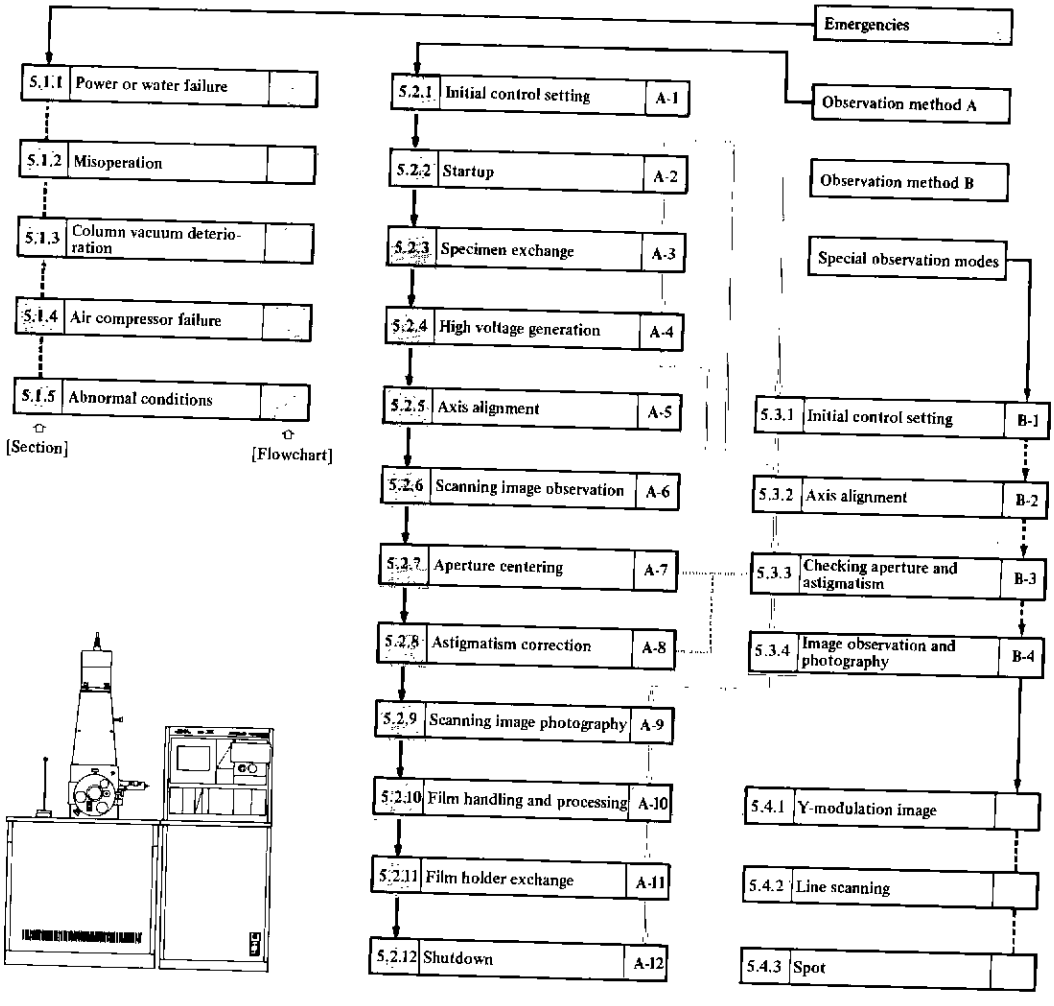
Index number	Part name	Function/Operation
		are automatically set according to the number of exposures (for re-setting the last two digits, set the AUTO/MANUAL switch to MANUAL, change the corresponding numbers on the PRESET thumbwheel switch indicators, then set the AUTO/MANUAL switch to AUTO again). When the AUTO/MANUAL switch is set to MANUAL, all four digits follow the manual change-over of the PRESET thumbwheel switches. These numbers can be printed out on film when recording.
⑦	AUTO/MANUAL switch	Automatic/manual change-over switch for film number setting.
⑧	BRIGHT/BLANK switch	Used to change the display format of the data displayed on the CRT and printed out on film when recording. When this switch is set to BRIGHT, the displayed data becomes bright and is displayed in white characters (this format is suitable when the data display zone at the lower part of the image is dark). When set to BLANK, the data is displayed in black characters (this format is suitable when the data display zone is bright). When set to the midway position, the data is displayed in white characters on a black background (this format is suitable when the brightness of the data display zone is not uniform or when continuous photography is carried out while varying the field of view).
⑨	CHARACT/OFF switch	Selects type of data to be printed out on the film. When this switch is set to CHARACT, all data shown in Fig. 4.12 (ex. of recorded data); that is, the accelerating voltage 25 KV, magnification X 320□□□, film number 1234, micron marker ═══, and micron indicator □100. 0 U (unit U represents μm), and the length of the micron marker are displayed along with the image and up to five characters JEOLS (letters or numbers)* are displayed and printed out. When set to OFF, only the image is displayed. When set to the midway position, all the above data except for the magnification is displayed and printed out along with the image. * The instrument is shipped with the digits JEOLS already set, which may be changed, upon request, by our service personnel on the installation site.
⑩	CONTRAST knob	The 10-turn potentiometer (with a stop) which adjusts the image contrast on the 5″ recording CRT. The knob is set to 6.0 for normal photography, and may be changed as necessary.
⑪	BRIGHTNESS knob	The 10-turn potentiometer (with a stop) which adjusts the image brightness on the 5″ recording CRT. Setting of this knob must be varied according to the film speed and the scanning speed.

5. OPERATION

5. OPERATION

This chapter covers the startup, shutdown and emergency procedures for the instrument, and the image observation and recording methods. Special observation techniques are also dealt with including Y-modulated image display. Two operating procedures are described. One is a comprehensive procedure required to be followd after reassembling the instrument or when operating the instrument when the operating conditions are unknown, and the other is a routine operating procedure to be used when the instrument has already been adjusted for proper conditions. The former procedure is very useful as a practice procedure for operators unfamiliar with the instrument and is designated as observation method A. The latter procedure is designated as observation method B. Furthermore, the abbreviated form of the various component units as shown in parentheses is used hereafter for convenience.

- DISPLAY unit (DIS)
- SCAN GENERATOR unit (SCG)
- ACCELERATING VOLTAGE unit (ACV)
- LENS unit (LEN)
- MAGNIFICATION unit (MAG)
- Photographic recording unit (PHO)
- Indicator unit (IND)
- SEI unit (SEI)
- VACUUM SYSTEM unit (VAC)



See overleaf: 5.1 Emergencies Flowchart

5.1.4 Air compressor failure

If the air compressor runs continuously for 30 minutes or longer, the instrument will stop automatically.

1. Check and repair the instrument.
2. Turn the GUN FILAMENT knob (ACV) fully counterclockwise.
3. Set the ON/OFF switch (ACV) to OFF.
4. Set the SEI/BEI switch (SEI) to its center position.
5. Start the instrument in accordance with Section 5.2.2.

5.1.5 Abnormal conditions

Shut down the instrument immediately, make necessary checks and repairs, then restart in accordance with the following steps:

1. Set the key switch on the master power supply panel to OFF.
2. Check and repair the instrument.
3. Turn the GUN FILAMENT knob (ACV) fully counterclockwise.
4. Set the ON/OFF switch (ACV) to OFF.
5. Set the SEI/BEI switch (SEI) to its center position.
6. Start the instrument in accordance with Section 5.2.2.

See overleaf: 5.2 Observation method A, 5.2.1 Initial control setting
Flowchart A-1

- AUTO/MANUAL switch . . . . . MANUAL
- BRIGHTNESS knob 0.0

3. Set the stage controls as follows:
   - X control . . . . . 7.5 mm
   - Y control . . . . . 12.5 mm (or as desired)
   - Z control . . . . . 0 mm
   - Tilt control . . . . . 0°
   - Rotation control . . . . . 000 (0°)
4. Check that the anode chamber airlock valve (AV1) is open.

See overleaf: 5.2.2 Startup Flowchart A-2

See overleaf: 5.2.3 Specimen exchange
Flowchart A-3, Fig. 5.1, Table 5.1

- ● Film number: □□□□
- ● Micron marker (0.1 – 1000.00 μm): ▭
  □□□□. □(μm) – micron indicator.
- ● 5 characters: □□□□□(set as you desired by JEOL).
- ■ Film holder: Special order (MRH, PRH, RRH2).

2.8 Vacuum System

- ■ Control: Fully automatic (manually operable).
- ■ Working pressure: 10^{-4} Pa (10^{-6} Torr) order.
- ■ Pumpdown time
  - ● Entire column: Within 10 min.
  - ● Anode chamber: Within 1 min.
  - ● Specimen exchange chamber: Within 30 sec.
- ■ Vacuum gauge: Pirani gauges, 2 (one each for anode chamber and specimen chamber).
- ■ Vacuum valves: Pneumatic and electromagnetic valves.
- ■ Vacuum pump
  - ● Oil rotary pumps: 100 ℓ/min, 2 pumps.
  - ● Oil diffusion pump: 400 ℓ/sec, 1 pump.
- ■ Air compressor: For pneumatic valves, 1 unit.

2.9 Safeguards

- ■ Safety devices against power failure, water failure, vacuum deterioration, and misoperations: Built-in.
- ■ Unattended operation system: Built-in.

Brez nadzorstva

2.10 Installation Requirements

2.10.1 Power supply and cooling water

- ■ Power supply: 100 V, 50/60 Hz, single phase, 20A.
- ■ Ground terminal: Less than 100 Ω, 1
- ■ Cooling water
  - ● Flow rate: 1.5 ℓ/min or more.
  - ● Water pressure: 0.08–0.25 MPa (0.8–2.5 kg/cm^2).
  - ● Water temperature: 20 ±5°C.
  - ● Faucet: Outer diameter 14 mm (1/2″ hose), 1 faucet.
  - ● Drain: 1.

2.10.2 Installation room

- Minimum Dimensions: 2,600 mm (W) × 2,600 mm (D) × 2,000 mm (H).
- Entrance and exit: 800 mm (W) × 1,800 mm (H) minimum.
- Room environment
  - Temperature: 20 ±5°C.
  - Relative humidity: Not greater than 60%.
- External AC magnetic field: Not greater than 0.3 μT (3 mG) .... at WD: 15 mm and 35 kV.
- External vibration: Not greater than 3 μm (at higher than 5 Hz vibration).

2.10.3 Dimensions and weight (mm and kg)

Table 2.2 Dimensions and weight

	Width	Depth	Height	Weight
Console	750 (30″)	1,100 (44″)	1,800 (71″)	400 (890 ℔bs)
Operation and display system	600 (24″)	1,010 (40″)	1,200 (47″)	130 (290 ℔bs)
Pump box	900 (36″)	250 (10″)	500 (20″)	100 (220 ℔bs)

2.11 Guarantee

This instrument is guaranteed for one full year from the date of completion of installation, except for defects resulting from natural disaster or careless handling. Defects in materials and workmanship will be repaired without charge at the installation site.

Note: These specifications are subject to change without notice due to improvements made to the instrument.

3. COMPOSITION AND CONSTRUCTION

3. COMPOSITION AND CONSTRUCTION

This chapter deals with instrument composition, layout, and construction to the extent required for operating purposes.

3.1 Composition and Layout

The instrument consists of a console (including column), an operation and display system, a pump box, etc. as shown in Fig. 3.1. For detailed dimensions, refer to Sect. 2.10.

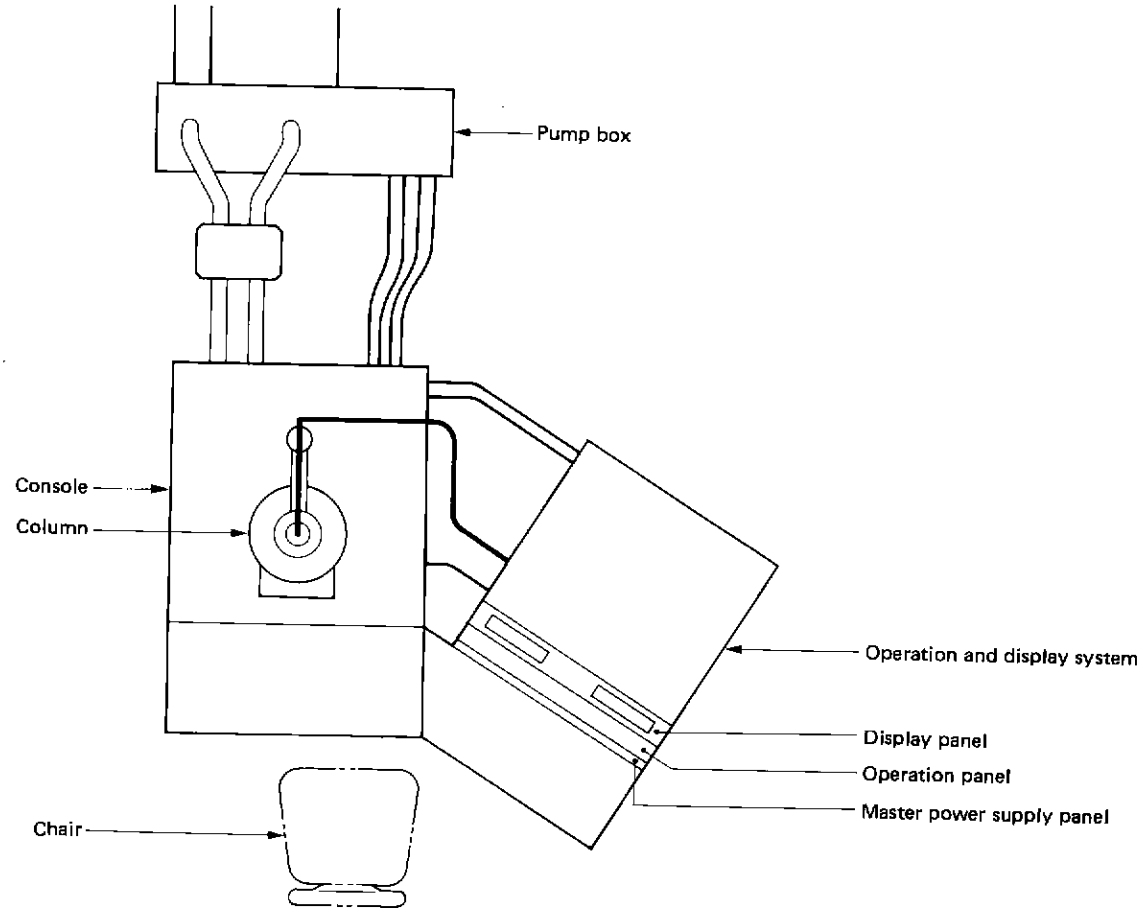


Fig. 3.1 Layout

3.2 Accessories

This section lists standard accessories for the instrument. However, the quantity and shape, etc. of the accessories are subject to change. Though not all the tools are actually used by the customer, the complete set of tools should be carefully maintained because they are required for maintenance.

Index No.	Name	Figure	Quantity	Purpose
①	Electron gun filaments complete with containers	3.2	24	Spares
②	Condenser lens upper aperture (disk)		2	Spares
③	Condenser lens lower aperture (disk)		2	Spares
④	Objective lens aperture foils with container		2	Spares
⑤	Scintillators with containers		2	Spares
⑥	Specimen pedestals		100	For WD15 specimen holder
	a. 10 mm dia. × 5 mm hgt.		50	For thick specimens
	b. 10 mm dia. × 10 mm hgt.		50	For thin specimens

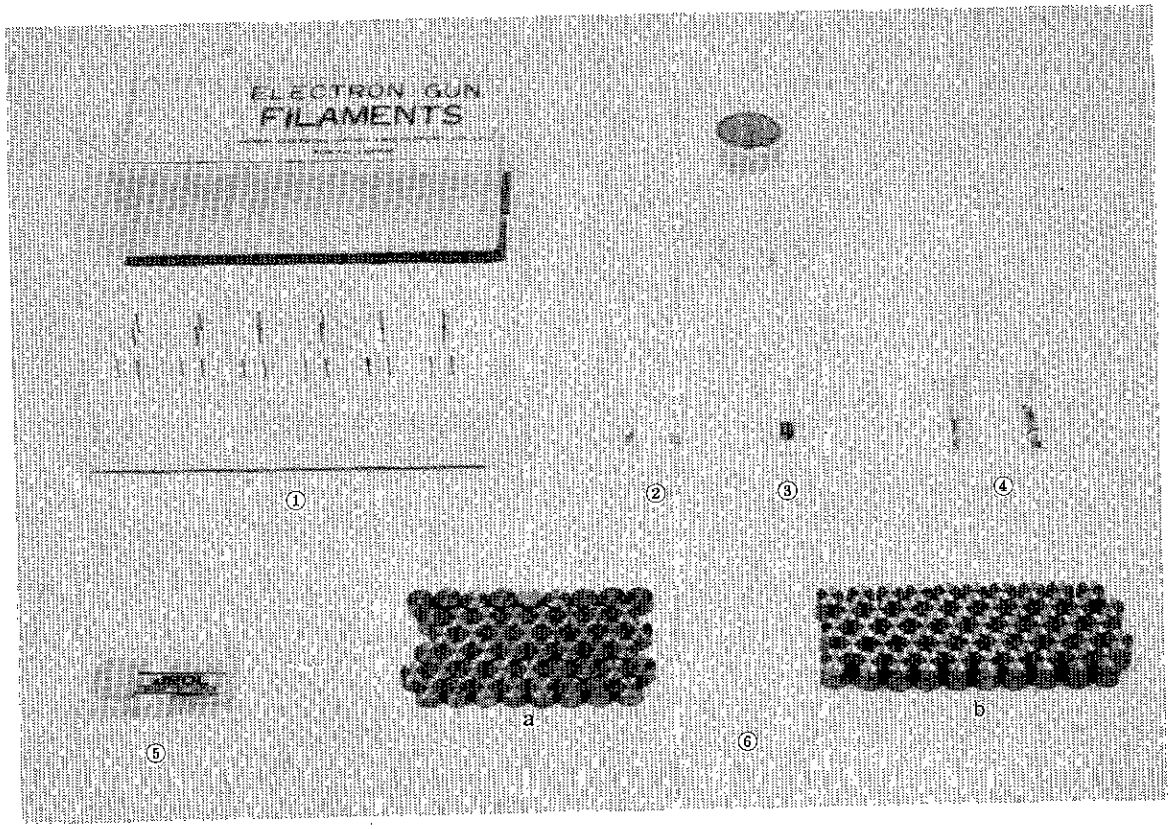


Fig. 3.2 Accessories (1)

Index No.	Name	Figure	Quantity	Purpose
⑦	Circuit-tester	3.3	1 set	For circuit check
⑧	Handblower		1	For cleaning
⑨	Vacuum grease		1 tube (28 g)	For 0-rings on movable parts
⑩	Conductive paint		1 bottle (20 g)	For holding specimen
⑪	Fine-grained metal polish with container		1 can	For cleaning
⑫	Injector filled with compressor oil		1	For replenishment
⑬	Fuses and lamps		1 set each	Spares

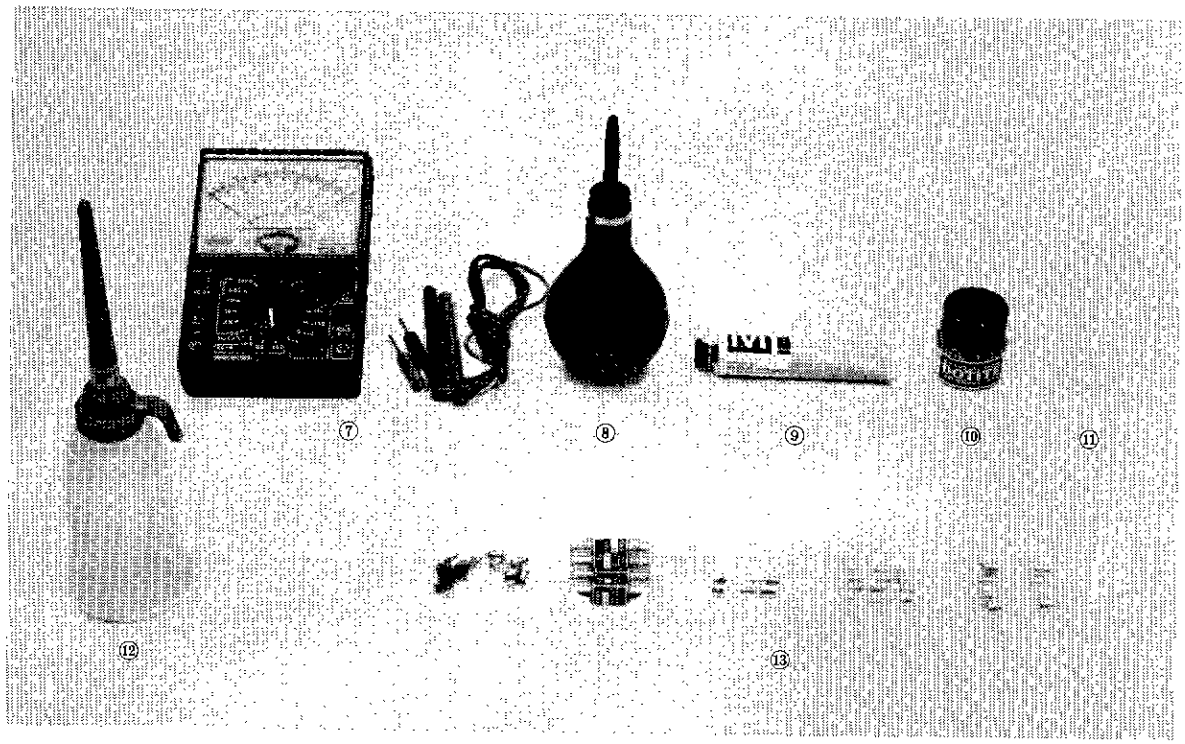


Fig. 3.3 Accessories (2)

Index No.	Name	Figure	Quantity	Purpose
⑭	Standard tools	3.4	1 set	For disassembling and reassembling the column

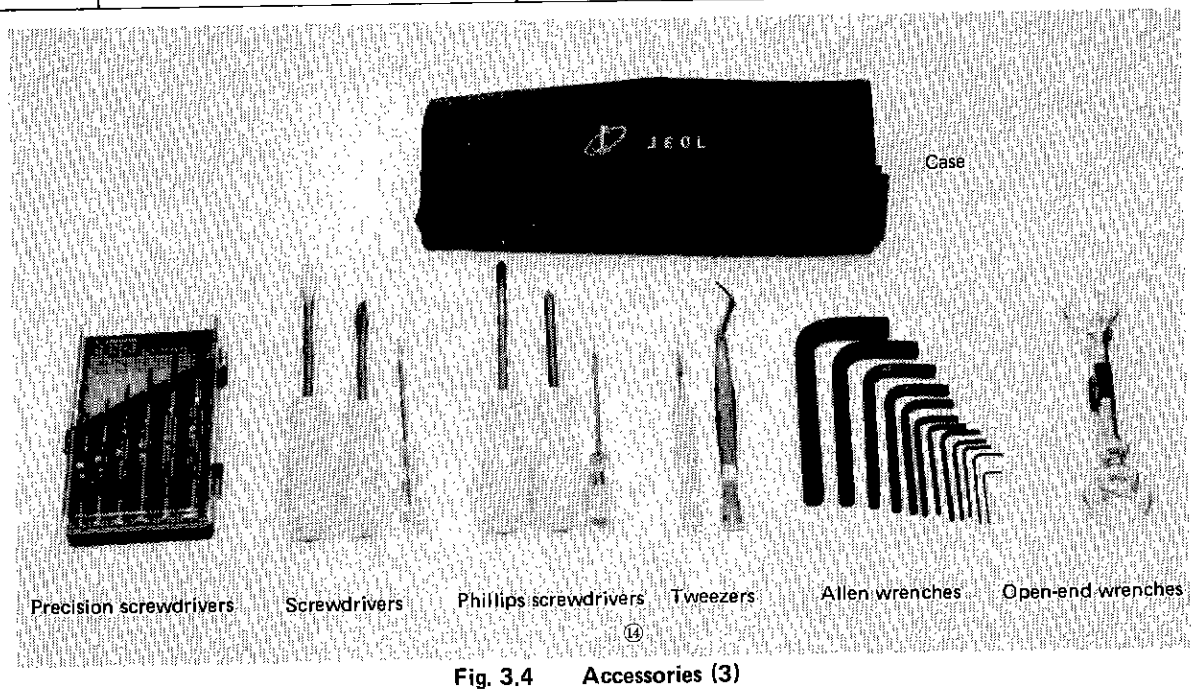
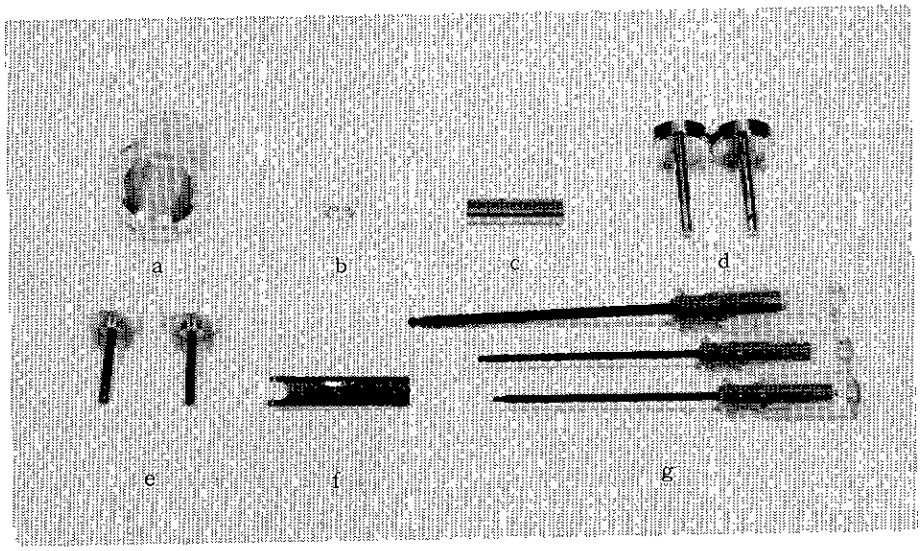


Fig. 3.4 Accessories (3)

⑮	Special tools with case	3.5	1 set	For disassembling and reassembling the column
	a. Wehnelt unit tool		1	Used to remove the Wehnelt when replacing the electron gun filament



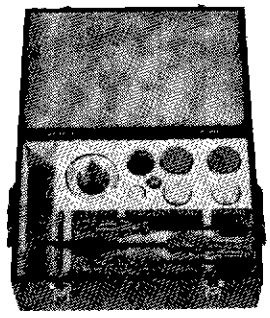


Fig. 3.5 Accessories (4)

Index No.	Name	Figure	Quantity	Purpose
⑮	b. Objective lens protective cylinder tool	3.5	1	For removing and reinstalling the protective cylinder
	c. Aperture foil setting tool		1	For mounting the objective lens aperture foil on the aperture selector
	d. Lens lifting tools		2	For disassembling and reassembling the column
	e. Axis alignment tools		2	Used to align the condenser lens
	f. Aperture holder tools		1	Used to remove the condenser lens aperture holder from the pole piece and reinstall it
	g. Hex screwdrivers		1	Used to loosen and tighten screws where access is restricted

See overleaf, Sect. 3.3 and Figs. 3.6, 3.7

3.4 System diagrams

The vacuum, compressed air, cooling water and electrical systems are shown in the following schematic and block diagrams.

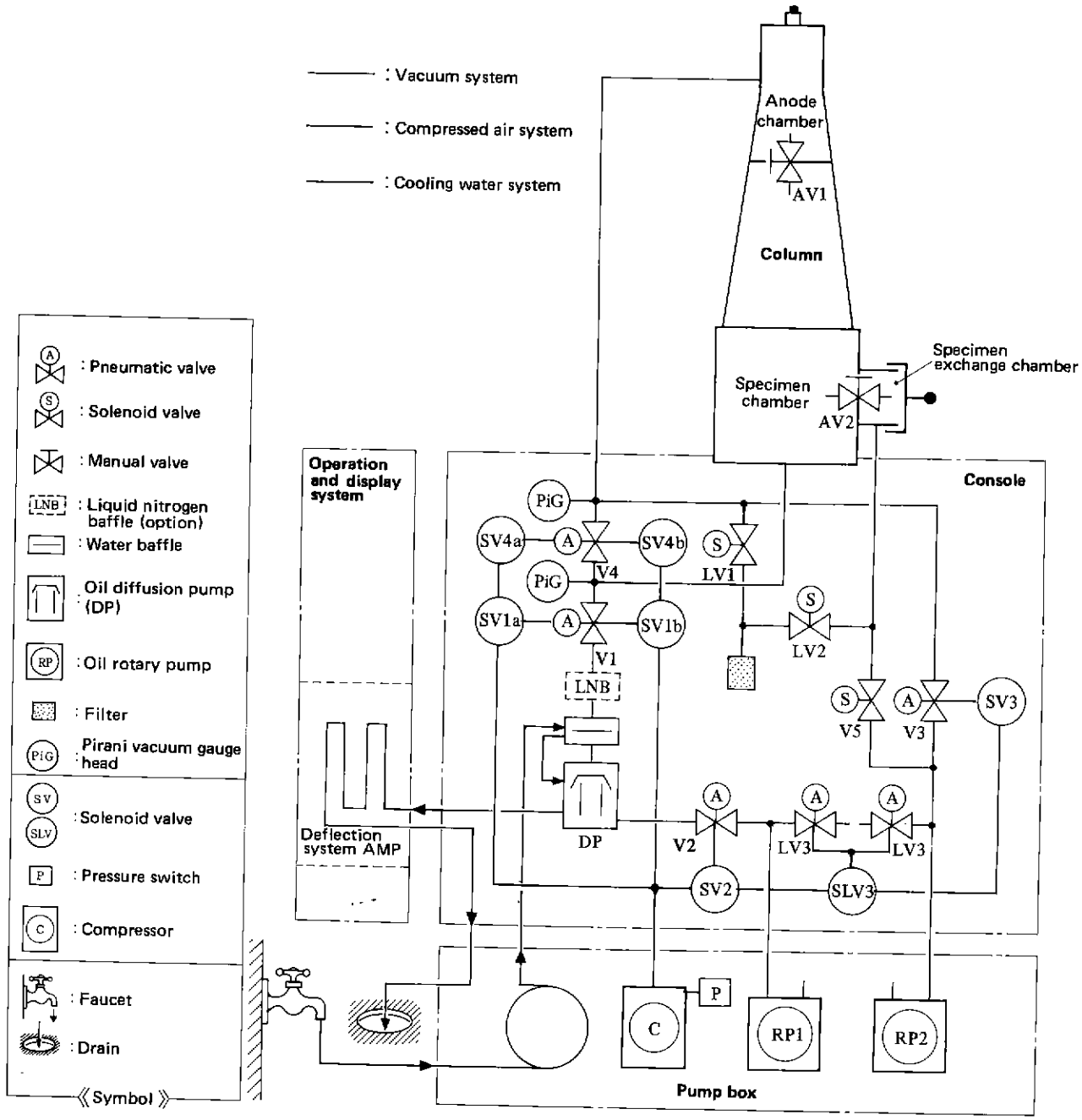


Fig. 3.8 Vacuum, compressed air, and cooling water systems

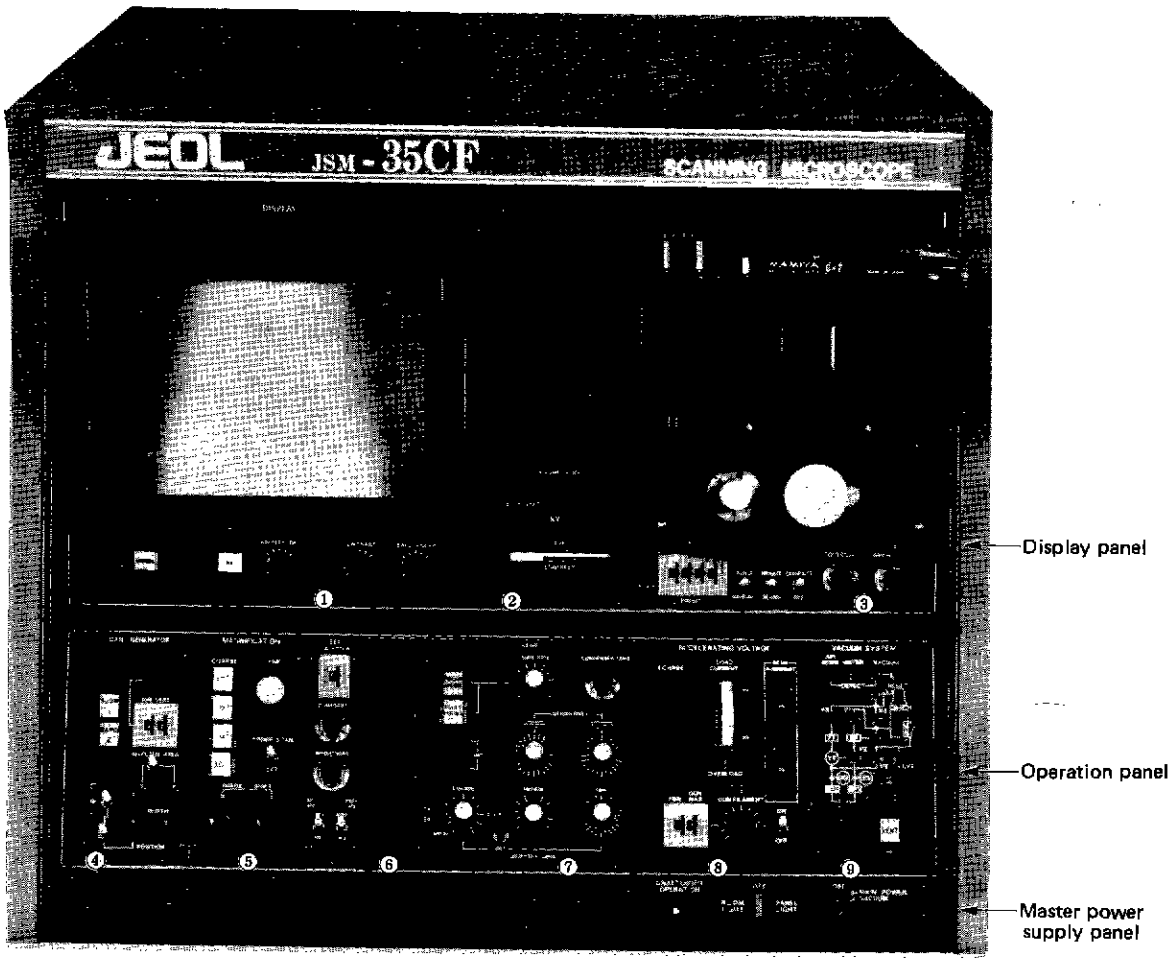
Table 3.1 Chart showing open/close state of vacuum valves (⋈ : Open, ⋈ : Closed)

Operation \ Vacuum valves	AV1	AV2	V1	V2	V3	V4	V5	LV1	LV2	LV3	LV3′
● Instrument startup	⋈	⋈	⋈	⋈	⋈	⋈	⋈	⋈	⋈	⋈	⋈
Startup/shutdown	⋈	⋈	⋈	⋈	⋈	⋈	⋈	⋈	⋈	⋈	⋈
● Instrument shutdown	⋈	⋈	⋈	⋈	⋈	⋈	⋈	⋈	⋈*	⋈	⋈
● Inserting specimen holder into specimen chamber	⋈	⋈	⋈	⋈	⋈	⋈	⋈	⋈	⋈	⋈	⋈
Specimen preparation	⋈	⋈	⋈	⋈	⋈	⋈	⋈	⋈	⋈	⋈	⋈
● Removing specimen holder from specimen chamber	⋈	⋈	⋈	⋈	⋈	⋈	⋈	⋈	⋈	⋈	⋈
	⋈	⋈	⋈	⋈	⋈	⋈	⋈	⋈	⋈	⋈	⋈
● Admitting air into column	⋈	⋈	⋈	⋈	⋈	⋈	⋈	⋈	⋈*	⋈	⋈
VENT	⋈	⋈	⋈	⋈	⋈	⋈	⋈	⋈	⋈*	⋈	⋈
Venting column interior to the atmosphere	⋈	⋈	⋈	⋈	⋈	⋈	⋈	⋈	⋈*	⋈	⋈
PUMP-DOWN	⋈	⋈	⋈	⋈	⋈	⋈	⋈	⋈	⋈*	⋈	⋈
● Evacuating column											
● Admitting air into anode chamber	⋈	⋈	⋈	⋈	⋈	⋈	⋈	⋈	⋈*	⋈	⋈
VENT	⋈	⋈	⋈	⋈	⋈	⋈	⋈	⋈	⋈*	⋈	⋈
Replacing electron gun filament	⋈	⋈	⋈	⋈	⋈	⋈	⋈	⋈	⋈*	⋈	⋈
PUMP-DOWN	⋈	⋈	⋈	⋈	⋈	⋈	⋈	⋈	⋈*	⋈	⋈
● Evacuating anode chamber											

* *This valve opens when a specimen is exchanged and closes when the instrument is shut down.*

See overleaf, Fig. 3.9

3.5 Configuration of Control Units



① DISPLAY unit
② Indicator unit
③ Photographic recording system
④ SCAN GENERATOR unit
⑤ MAGNIFICATION unit
⑥ SEI unit
⑦ LENS unit
⑧ ACCELERATING VOLTAGE unit
⑨ VACUUM SYSTEM unit

Fig. 3.10 Operation and display system

4. DESCRIPTION OF COLUMN AND OPERATION SYSTEM

4. DESCRIPTION OF COLUMN AND OPERATION SYSTEM

This chapter describes the function and operation of the controls required for operating the JSM-35CF.

4.1 Column

The index numbers correspond to the numbers following the part names shown in Fig. 3.6.

Index number	Part name	Function/Operation
①	Anode chamber airlock knob	This knob operates airlock valve AV1 (Figs. 3.8 and 4.1), thereby isolating the anode chamber from the remainder of the column so as to admit air into the anode chamber only for filament replacement, etc. To close the airlock valve, push in the knob as far as it will go and turn it fully clockwise (about 180°); to open the valve, turn the knob fully counterclockwise and pull it out as far as it will go. *Note: If when pushing the knob in, force is required, turn the knob slightly clockwise and continue pushing in.*
②	Axis alignment screws	Use for precision axis alignment of the electron optical system (Fig. 4.2). Adjustable with the axis alignment tools (Fig. 3.5-e); adjusting the screws shifts the condenser lens.
③	Objective lens aperture selector Knob 1	(Fig. 4.3) This knob changes over the objective lens aperture in three steps (100, 240, 600 μm). When a large diameter aperture is used, the probe current increases and depth of the field (depth of focus) decreases. By clicking the knob through 1 → 2 → 3 on the graduated scale (by turning the knob clockwise), 100 → 240 → 600 μm diameter apertures are respectively positioned in the beam path. To change over the apertures through 3 → 2 → 1, pull the knob out as far as it will go and turn it fully counterclockwise (3 → 2) and repeat the same operation, (2 → 1).
	Knobs 2, 3	These knobs are used to horizontally shift the aperture position to accurately align the aperture with the beam path. The lock nut on knob 2 keeps the knob from turning after adjustment by turning the nut clockwise.
④	Specimen exchange rod	This rod is used to transfer the specimen holder from the atmosphere into the specimen chamber (under high vacuum) via the specimen exchange chamber (airlock chamber)

See overleaf, Figs. 4.4, 4.5, 4.6 and Table 4.1.

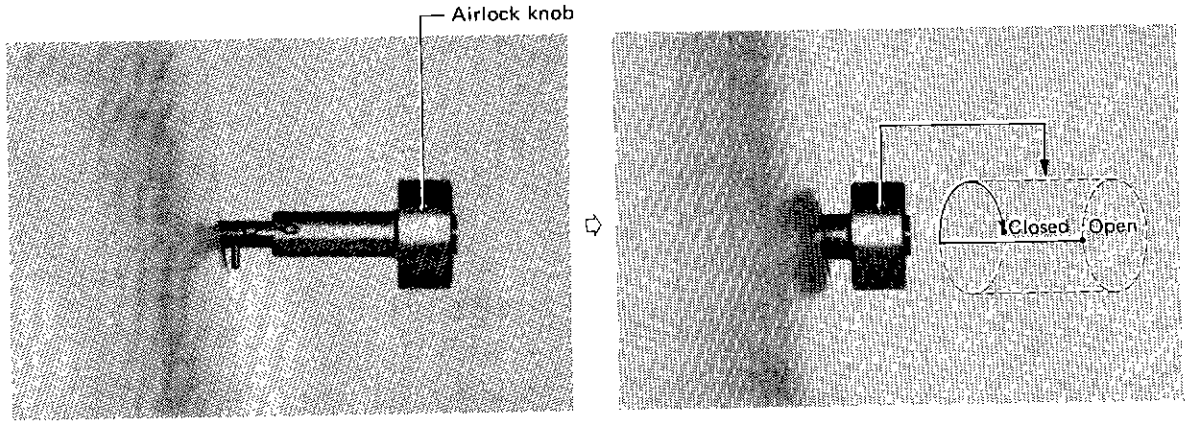


Fig. 4.1 Operating anode chamber airlock knob

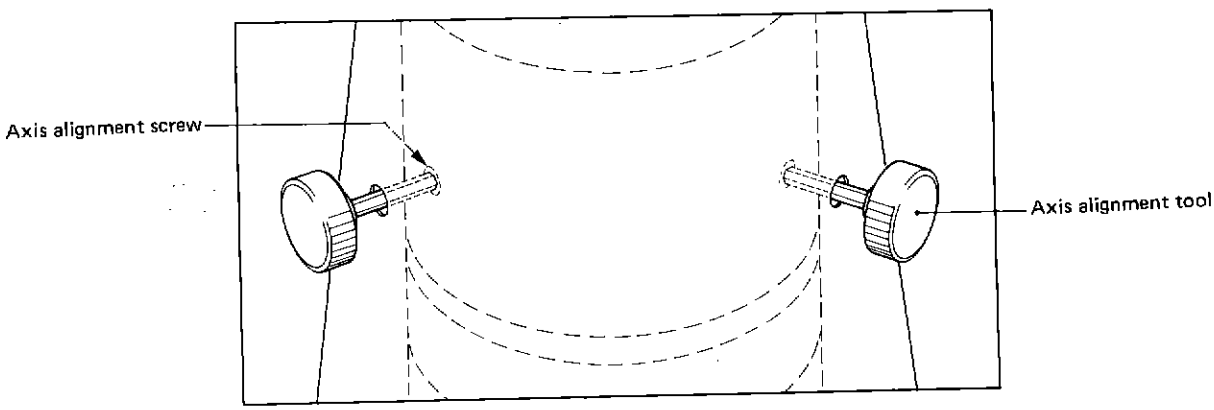


Fig. 4.2 Condenser lens alignment

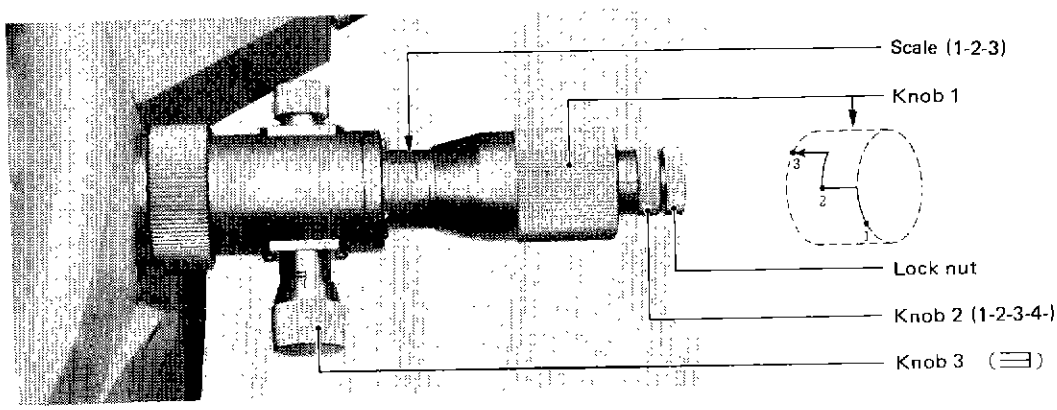
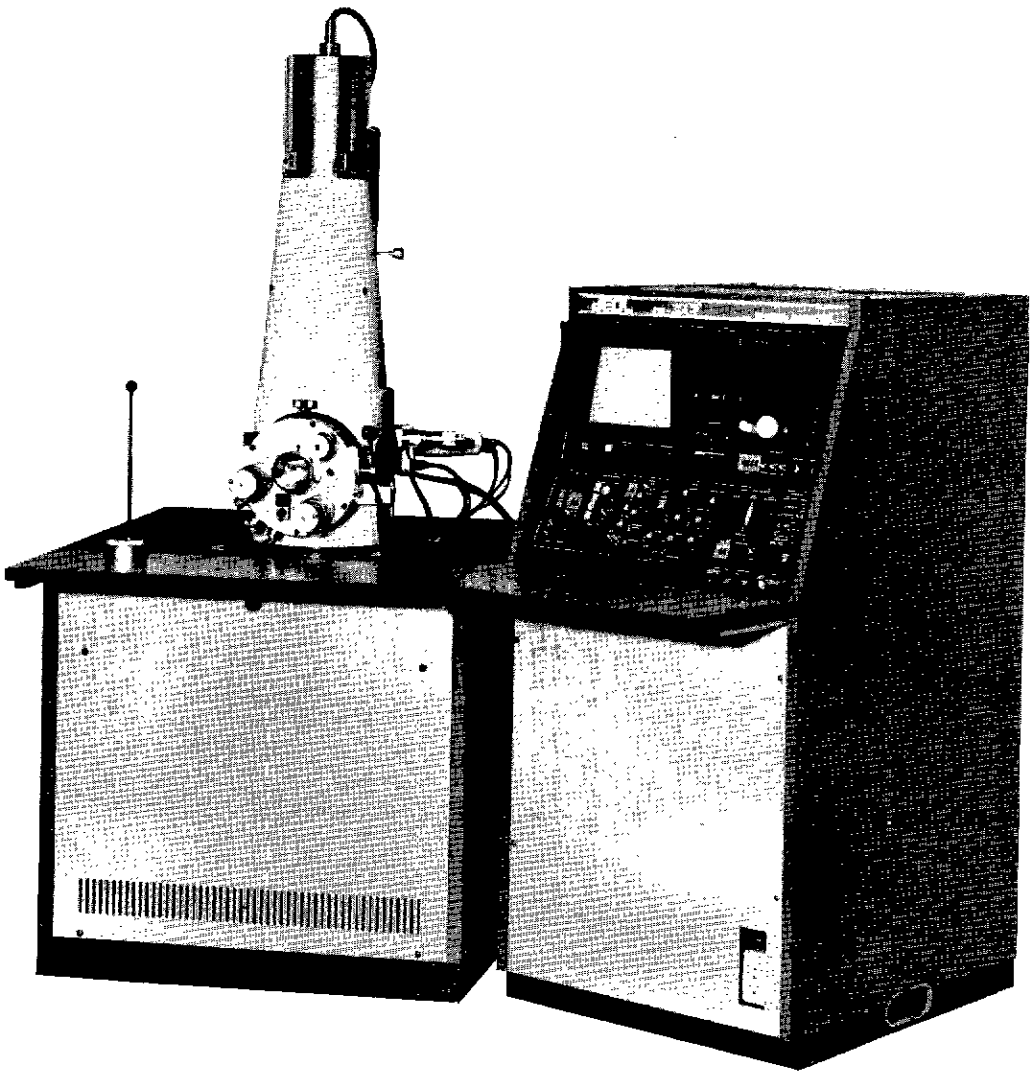


Fig. 4.3 Objective lens aperture selector

JSM-35CF SCANNING MICROSCOPE



To the user:

This instruction manual covers the operating procedures for the basic JSM-35CF Scanning Microscope. That is to say, if the instrument delivered to your institution has been modified in any way to satisfy your specific research requirements, certain aspects of the manual will require certain (minor) amendments. If in any doubt, please contact your nearest JEOL Service Center.

CONTENTS

1 . GENERAL

I. GENERAL

1.1 Introduction

The JSM-35CF is a high-performance scanning electron microscope developed for straightforward and simple operation. When combined with various attachments, the microscope is capable of obtaining nearly any type of signal from the specimen (see Fig. 1.1). The microscope can also be used as an electron probe micro-analyzer.

Simple operation and maintenance is assured by the fully automated vacuum system, by electronic circuitry taking full advantage of the latest advances in electronic engineering, and by a column and control units of logical and compact design. Start-up, shutdown, observation and photography can all be performed by simple, one-shot operations. Automatic focus compensation for changes in accelerating voltage, working distance and magnification is always preserved. Magnification display spontaneously reacts to changes in accelerating voltage and working distance. Furthermore, the current magnification and accelerating voltage are digitally displayed with LEDs (light emitting diodes), and when photographing, this data is recorded together with the film number and micron marker for easy identification of micrographs. In addition, the use of ultra-high resolution CRTs allows observation of clear high magnification images and also provides low magnification images having detailed information.

Provided with these and many other features, the JSM-35CF is an ideal scanning electron microscope in terms of practicability and performance. The basic system is complete with a Y modulation device and wave-form monitor which allow observation of Y modulated images and input signal waveforms. With the addition of optional attachments, the user can set the specimen in a specific ambient environment (such as heating or cooling), tilt the specimen, or subject it to stress conditions. With these capabilities, the JSM-35CF has extended applications in research, education and quality control.

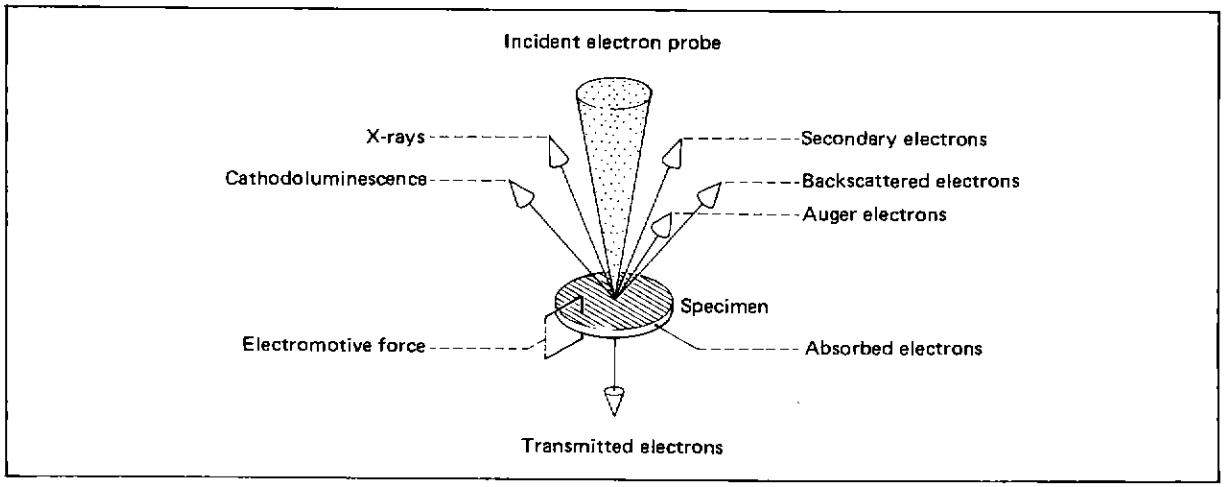


Fig. 1.1 Signals available from specimen

Table 1.1 lists the type, function and application of the major attachments (optional). For attachments not listed in the Table, See the specification sheets or catalog pertaining to the particular item. Attachments marked 1* are required for expanding the microscope for use as an electron probe microanalyzer. The operation manuals for attachments marked 2* are attached at the back of this manual regardless of whether your instrument is equipped with them or not.

Table 1.1 Major attachments

Type	Designation	Function and application
■ Electron guns		
LBG1 LBG2 LBG3	LaB_6 Cathode Gun	Thermionic emission type electron guns using LaB_6 in the cathode. Compared with electron guns using a tungsten hair-pin filament, the LaB_6 gun gives 5 to 10 times higher brightness, has a service life as long as 500 hours, and features improved resolution (50 Å for LBG1 and LBG2, and 40 Å for LBG3 in the secondary electron image mode).
■ Specimen holders and stages		
LSH	Large Specimen Holder	Accepts large-size specimens (up to 76 mm dia. × 20 mm hgt.) which cannot be mounted on the standard specimen holder (accommodates an up to 10 mm dia. × 10 mm hgt. or mm dia. × 20 mm hgt. specimen).
SHIC	Specimen Holder for Integrated Circuit	Allows observation of the surface potential distribution of semiconductor devices in the secondary electron image mode. When used with an Electromotive Force Amplifier (EMF), electron-beam-induced electromotive force images can be observed.
TH	Tensile Holder	Allows the application of tensile force to fiber specimens or the like. By using this holder, specimen deformation or fracture can be observed continuously or in a series of steps.
CRU1	Cryo-Unit	Allow the surface structure of biological specimens to be observed in a frozen state without special chemical treatments (such as fixing or dehydrating). Furthermore, the internal structure of biological specimens can be observed by cutting the specimen in the preliminary cooled chamber. Cryo-Unit CRU2 is provided with a sputtering mechanism for coating the specimen with gold or gold-palladium alloy and a mechanism for transferring the specimen to the specimen stage without exposing the coated specimen to the atmosphere.
CS2	Cooling Stage	Allows the surface structure of biological specimens to be observed in a nearly native state by only freezing without special chemical treatments or vacuum evaporation.

Type	Designation	Function and application
HS1 HS2	Heating Stage	Heat metal, etc. specimens to the specified temperature (HS1: up to 1100°C, HS2: up to 450°C). Changes in the specimen can be directly observed while being heated. A TV Scanning Device (TVS) allows dynamic behavior of heated specimens to be continuously observed. By using any commercially available video tape recorder (VTR), said dynamic behavior can be recorded on tape.
TS1 TS2	Tensile Stage	Exert tensile stress on the specimen (TS1: up to 200 kg, TS2: up to 50 kg). Specimen deformation or fracture due to the stress can be observed continuously or in a series of steps. Moreover, the TS1 stage can compress the specimen, and the TS2 can twist the specimen.
■ X-ray spectrometers		
ADS[1]* SDS[1]* DDS[1]* FCS[1]*	Dispersive Spectrometer	When combined with the scanning electron microscope, the spectrometer allows the microscope to be used for X-ray analysis of micro-regions. These spectrometers are of the wavelength dispersive type (fully focusing linear type). The ADS, SDS and DDS have two analyzing crystals, while the FCS (4 Crystal X-ray Spectrometer) has four analyzing crystals.
EDS[1]*	Energy Dispersive Type X-ray Spectrometer	When used with the scanning electron microscope, the X-ray spectrometer allows microscope expansion to a multichannel microanalyzer for X-ray analysis of micro-regions.
■ Detectors, ammeters and amplifiers		
	Backscattered Electron Detector	A paired semiconductor device for detecting backscattered electrons. By using this detector, the backscattered electron image can be displayed as a composition or topographic image.
CLD[2]* CLDIR	Cathodoluminescence Detector	Used to detect the photons emitted when the surface of a cathodoluminescent specimen is scanned by an electron probe. Detected signal are displayed as a cathodoluminescence image (CLD: covers visible light region, CLDIR: covers infrared region).
SDU	Supplementary Detector Unit	Enables simultaneous observation of two types of images, for example, a secondary electron image and cathodoluminescence image when used with the built-in detector.
TED[2]*	Transmitted Electron Detector	Detects electrons transmitted through the specimen in order to display a scanning transmission electron microscope (STEM) image. Compared with conventional transmission electron microscope (CEM), thicker specimens can be observed at higher contrast and damage to the specimen

Type	Designation	Function and application
		due to electron beam bombardment is extremely small. In addition to scanning images, the instrument equipped with the transmitted electron detector displays scanning electron diffraction patterns.
AEM[1*,2*]	Micro-Micro Ammeter	Used for measuring the specimen absorbed current (from 1×10^{-12} to 1×10^{-5} A). This ammeter can also be used as a probe current monitor for X-ray analysis and also used to set the electron emission of the gun filament and to align the illumination system.
DMA[1*]	Digital Micro Ammeter	Digitally displays the output from the Micro-Micro Ammeter (AEM) by A/D conversion. The digital output can be printed out by using an ORTEC printing system (option).
AEI[2*]	Absorbed Current Amplifier	Amplifies absorbed current (electrons absorbed by the specimen) which varies depending on specimen topography and its atomic number. The amplified output can be displayed as an absorbed electron image.
EMF	Electromotive Force Amplifier	When used with the specimen holder for integrated circuits (SHIC), this unit displays the electromotive force distribution in semiconductor devices.
■ Signal processors		
GMC[2*]	Gamma Control Circuit	Suppresses large amplitudes and expands small amplitudes of video signals so that detailed images may be obtained at optimal contrast.
IMS[2*]	Image Selector	Allows different kinds of images to be displayed simultaneously on two CRT's (one in optional unit DU7) for comparison and evaluation. Two types of signals can also be combined to display a mixed image.
VCA[2*]	Video Control Amplifier	Selectively amplifies desired frequency components of video signals to clearly observe specific specimen structures which may otherwise be affected by high contrast of other structures.
■ Control units		
BST[1*]	Beam Stabilizer	Installed in a scanning microscope system with X-ray spectrometers to regulate the probe current, thereby ensuring the accuracy of X-ray analysis.

Type	Designation	Function and application

■ **Image analyzers**

MPA	Micro-Particle Analyzer	Calculates the area percentage of metallic precipitates and the number, diameter and area of particles from scanning images. Direct analysis of video signals greatly reduces measurement time and minimizes error. Prompt data processing is ensured by special logic circuits and a built-in microprocessor.

■ **Display and recording units**

DU7[2]*	7″ Display Unit	7″ CRT used together with the standard CRT for simultaneous display of different types of images. The CRT is driven by the scan generator of the instrument, and images to be displayed are selected by the image selector (IMS).
MDD[2]*	Multi Display Device	Permits two or four types of image to be simultaneously displayed on the same CRT. However, one or two image-selectors (IMS) are necessary depending on the number of displayed image types.
SRT[2]*	Scan Rotation and Tilt Correction Unit	Rotates the scanning image on the CRT without changing the orientation of the specimen by rotating the direction of probe scanning. This unit also compensates for image distortion due to specimen tilting.
STD	Stereo Display Device	Allows three dimensional display of dynamic behavior of specimens to be observed by several people on a color TV monitor. The image can be photographed in color or monochrome, or continuously recorded using a color VTR (NTSC system, option). When photographed in monochrome, the image is viewed through a stereoviewer. For color observations, red and green filters must be used.
TVS[2]*	TV Scanning Device	When used with the specimen heating stage (HS1/HS2) or tensile stage (TS1/TS2), dynamic behavior of the specimen can be immediately observed on a TV monitor. Dynamic

Type	Designation	Function and application
		variations in the specimen can be recorded on any commercially available VTR.
MRH[2]*	Mamiya Roll Film Holder	A 6 cm × 7 cm roll film holder (120/220 roll film). This holder is used with the recording system camera for recording images displayed on the ultra-high resolution, non-persistence CRT.
PRH[2]* PRH2[2]*	Polaroid Film Holder	PRH – 4″ × 5″ film holder (Polaroid Land 4″ × 5″ film) PRH2 – 3 1/4″ × 4 1/4″ film holder (Polaroid Land film type 105/107). These holders are used with the recording system camera for photographing images on the ultra-high resolution, non-persistence CRT.
■ Power supply and cabinet		
SDT[2]*	Step-Down Transformer	A power transformer used when input power of 100 V AC (single-phase) for the scanning microscope is not available (available input voltage: 120, 200 or 240 V).
SPS1, 3[2]*	Supplementary Power Supply	A regulated power supply installed in the supplementary cabinet (SCB·S) for supplying power to various attachments.
SCB·S[2]*	Supplementary Cabinet	A cabinet accommodating various attachments. A supplementary power supply (SPS1, 3) must be installed to supply power to the attachments.
■ Attachments for vacuum system		
LNB[2]*	Liquid Nitrogen Baffle	A baffle for blocking the backstream of oil vapor from the oil diffusion pump (DP).
LNT[2]*	Liquid Nitrogen Trap	This device is required for X-ray analysis of light elements. Protects the specimen from contamination due to electron bombardment.
JVG-N3	Ionization Vacuum Gauge	Used for measurement of pressure in various vacuum instruments and devices as well as in the column (measurement range: 1×10^{-3} to 1×10^{-7} Torr).
■ Specimen preparation tools		
JEE-4X	Vacuum Evaporator	Used to coat and/or shadow the specimen by evaporating various metal alloys or carbon in the vacuum. Combined with various attachments (rotating and tilting stage, etc.) for expanded applications.
EE-RTS	Rotating and Tilting Specimen Stage	Mounted on the vacuum evaporator, this stage rotates or tilts rough surface specimens for uniform surface coating.
JPCD-3	Critical Point Drying Apparatus	Used to dry biological specimens without being affected by surface tension, retaining a state close to its native state using critical point drying method.

1.2 Principles of Scanning Electron Microscopy

The growing popularity of scanning electron microscopes has brought their development to a stage where unskilled operators unfamiliar with operating principles and physical construction can operate the instrument with sufficient reliability and efficiency. The JEOL JSM-35CF is no exception. Boasting fully automated, sophisticated performance, the JSM-35CF is designed for simple, straightforward operation from the human engineering point of view.

Even so, a rudimentary knowledge of how a microscope works, its structure, etc. is a distinct advantage. The following, therefore, attempts to fill this need simply and concisely. Those desirous of a more in-depth knowledge of the subject, can avail themselves of the many books on scanning electron microscopy available on the market.

1.2.1 Basic principles

1.2.1a Comparison of the scanning electron microscope and the optical microscope

The scanning electron microscope (SM) and optical microscope (OM) have the same basic function of rendering visible objects which are too small to be seen by the naked eye. However, substantial differences begin with their illuminating beams. The SM employs an electron beam, while the OM uses natural light (including the ultraviolet region). Other major differences are derived from this point, which are summarized in Table 1.2.

Table 1.2 Comparison of the scanning electron microscope and the optical microscope

Item	Scanning electron microscope	Optical microscope
Illuminating beam	Electron beam (wavelength: 0.06 Å ~ ∞)	Light beam (wavelength: 2,000 to 7,500 Å)
Medium	Vacuum	Atmosphere
Lens	Electron lens (for probe demagnification)	Optical lens (for image enlargement)
Resolution	Secondary electron image:	Visible region: 2,000 Å
		Ultraviolet region: 1,000 Å
Depth of field *	30 μm (at 1000X)	About 0.1 μm
Magnification	10X to 180,000X (continuous)	10X to 2,000X (by changing lenses)
Focusing	Electrical	Mechanical
Obtainable images	Secondary electron and backscattered electron images (by the basic instrument)	Transmitted and reflected images
Contrast	Geometrical shape, physical and chemical properties	Absorption and reflection of the light (color and brightness)
Monitor	CRT (cathode ray tube)	Direct observation or screen projection

* *In scanning electron microscopy, the term "depth of focus" is also used interchangeably. In this manual, the term "depth of field" is used; the "depth of focus" when used for optical microscopes and conventional transmission electron microscopes represents the "depth of field" multiplied by the magnification used.*

Though the scanning electron microscope has restrictions in operation and application due to its illuminating beam (electron beam) and its operating medium (vacuum), its illuminating beam and operating medium are effective to obtain a variety of information from specimens by utilizing the many available attachments (several tens of attachments). Among these, the X-ray spectrometer, backscattered electron detector, transmitted electron detector, heating/cooling/tensile stages and semiconductor-device specimen holder can greatly contribute to research activities when used in appropriate combinations.

While the conventional transmission electron microscope (CEM) is analogous to the optical microscope, the scanning electron microscope is in many respects not so. These respective microscopes have their inherent merits and demerits. The transmission electron microscope boasts very high resolution, which can reach approximately 1 Å in the case of lattice images. Consequently, very high magnifications (close to 1 million times) can be obtained, contributing greatly to such fields as molecular structure research. However, this is obtainable for very thin specimens only (only a few hundred angstrom thick). If a specimen is relatively thick, transmission of electrons is very difficult, resulting in a substantial loss of resolution (only one plane within the specimen at a time is imaged). In other words, electron microscopes of this type are useful only for very thin specimens. In addition, specimen preparation takes tremendous time and a great deal of skill, and the preparations required before observation is possible can result in the loss of conditions to be observed. Also, the contrast mechanism includes many complicated parameters, such as scattering absorption, diffraction and phase difference. While these parameters are very effective to determine physical properties of the specimen, they introduce many factors not directly connected to the basic role of the microscope (producing an enlarged image of a small object). In addition, a wide range of knowledge is required for interpreting the resultant image.

On the other hand, the scanning microscope (SEM) permits not only observation of very fine details (high resolution) but also good focus over a wide range of specimen surfaces (large depth of field). It also produces clear images of specimens ranging from objects visible with the naked eye to structures as small as several tens of angstroms (images are similar to those as seen by the naked eye). Furthermore, since image contrast is varied according to the shape or composition of the specimen, the scanning electron microscope provides useful information about the specimen. In addition, there are fewer restrictions on specimen size and type, which simplifies specimen preparation. In its basic structure, a scanning electron microscope may be thought of as a combination of TV camera and TV monitor, but a significant difference lies in that the specimen is observed under high vacuum. Fig. 1.2 illustrates the formation of images in the scanning electron microscope, transmission electron microscope and optical microscope.

Since the CRT has a much higher resolution (69 mm/2,500 line = 0.028 mm per line) than the human eye (0.1 mm), the image on CRT can be enlarged considerably. The enlargement magnification M_1, in the equation below, reaches approximately 3.6 times.

$$M_1 = \frac{d_1}{d_{\mathrm{CRT}}} \qquad \cdots\cdots (2)$$

Further enlarging of the CRT image is useful for determining the resolving power.

Another important feature of viewing three dimensional characteristics of specimens is discussed below. Optical microscopes are limited to the observation of sliced specimens or the top surface of uneven specimens. This is due to the fact that in order to obtain good resolution, the aperture angle of the lens must be relatively large; however, this makes the depth of field very shallow, and light cannot penetrate comparatively thick specimens. With transmission electron microscopes, specimens must be extremely thin; the electron penetrating power depends on the velocity of the electron beam (at usual accelerating voltages observation is limited to specimens thinner than 1000 Å). With thick specimens, only their contours are observable. Viewing images obtained by transmission electron microscopy differs from viewing those obtained by other methods in that the former must be studied using through-focus methods, continuum sectioning method etc. Furthermore, contrast mechanisms in transmission electron microscopy are very complicated and require sophisticated study.

With scanning electron microscopes, on the other hand, the depth of field is very great and, in turn, images show a striking resemblance to those viewed by the unaided dye, especially secondary electron images. Furthermore, image interpretation is comparatively simple. In addition, shadowless illumination (eliminating topographic shadows) allows not only three-dimensional observation of specimens, but also clear observation of the environs of protruding spikes.

Now, let us assume that an electron probe is focused on a particular point of the specimen by an aberration-free electron lens, the probe size is negligibly small, and a spot image is displayed on the CRT. If the specimen is moved along the lens axis between Q′ and Q″ without going out of focus, the limit of $\overline{Q'Q''}$ (the depth of field) is determined by eye resolution d_1 and magnification M. This depth of field is given by the following equation, as seen from Fig. 1.4a.

$$D_1 = \frac{d_1}{M\alpha} \qquad \cdots\cdots (3)$$

where α is the aperture angle.

However, no electron lens is free from aberration, the electron source can never be a point, and we cannot neglect the influence of probe diameter. Fig. 1.4b illustrates this for probe diameter d_2. If the specimen Q is moved to Q′ or Q″, it will produce an aberration circle $2r$ in diameter, which will exceed the range d_1/M. In other words, if the specimen is moved to Q′ or Q″, an out-of-focus effect will be observed after a certain specimen position. From the figure, the actual depth of field is given by $D_2 = D_1 - 2a$, from which the following equation is obtained:

$$D_2 = \frac{d_1}{M\alpha} - 2\left(\frac{d_2}{2\alpha}\right) = \left(\frac{d_1}{M} - d_2\right)\Big/\alpha \qquad \cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots \quad (4)$$

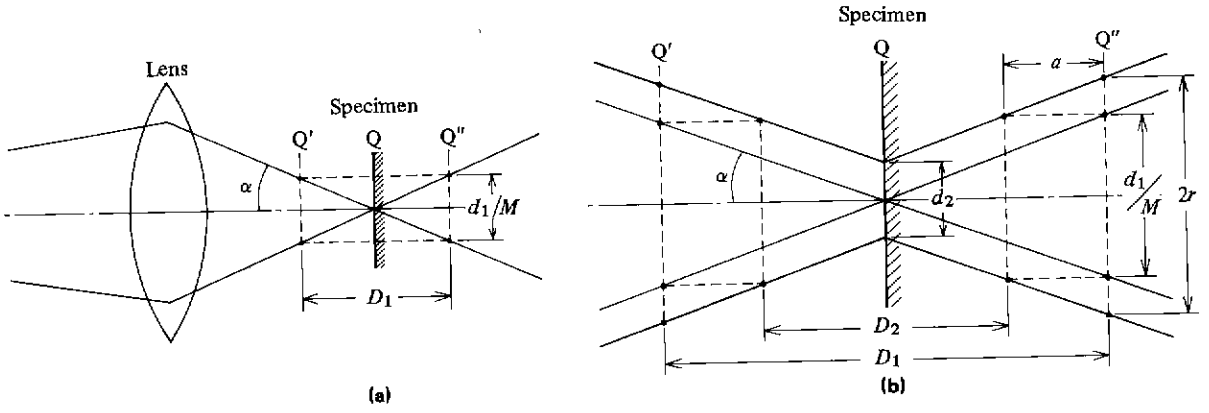


Fig. 1.4 Depth of field

For example, assuming magnification M to be 1,000, the resolution of the human eye 0.1 mm, the probe diameter d_2 100 Å and the aperture angle of the lens α 0.003 rad., the resultant depth of field D_2 will be 30 μm; that is, if we display an image of a hemispherical object on the CRT under the above conditions, an image of 6 cm diameter will be sharply focused from top to bottom. The relationship between depth of field and magnification in this condition is plotted in the graph shown in Fig. 1.5.

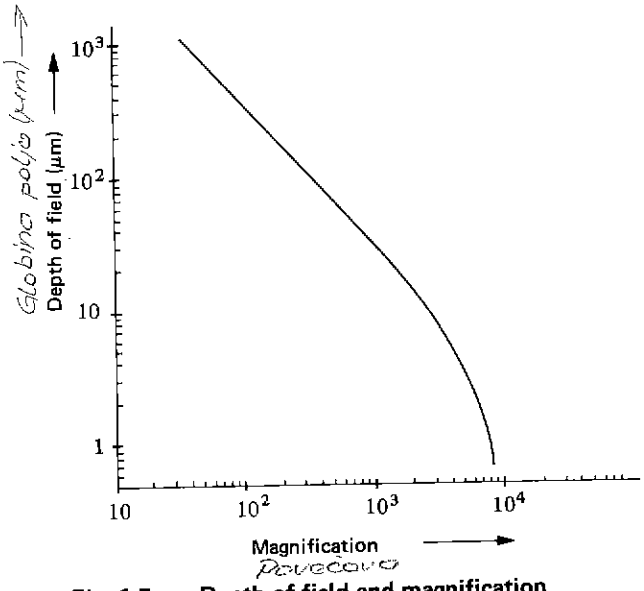


Fig. 1.5 Depth of field and magnification

1.2.1c Principle of the electron lens and aberration

It is essential in scanning electron microscopy to use a finely focused electron probe to scan the

specimen surface, thus necessitating aberration-minimized electron lenses. In general, electron lenses are classified into the magnetic and electrostatic types, which employ axially symmetric magnetic and electric fields, respectively, and special types (for example, a quadrupole or octupole lens). Generally, the magnetic field type is most commonly used, because of its low aberration and ease in handling. Therefore, we deal with the magnetic type lens only.

When an electron moves in a magnetic field, it experiences no external force so long as it moves parallel to the field, but does when it moves perpendicular to the field. This external force causes the electron to be driven on a plane perpendicular to the plane which includes the direction of the electron and that of the lines of magnetic force. If the flux density of the magnetic field is constant, the path of electron will describe a circle on the perpendicular plane, the radius "r" of which is determined by centrifugal force mv^2/r and acting electromagnetic force evB, as given in the equation below (see Fig. 1.6a):

$$r = \frac{mv}{eB} = \frac{v}{\eta B} \qquad (5)$$

where
- m: mass of electron
- v: velocity of electron
- e: Electronic charge
- B: Magnetic flux density
- η: Specific charge of electron e/m (constant).

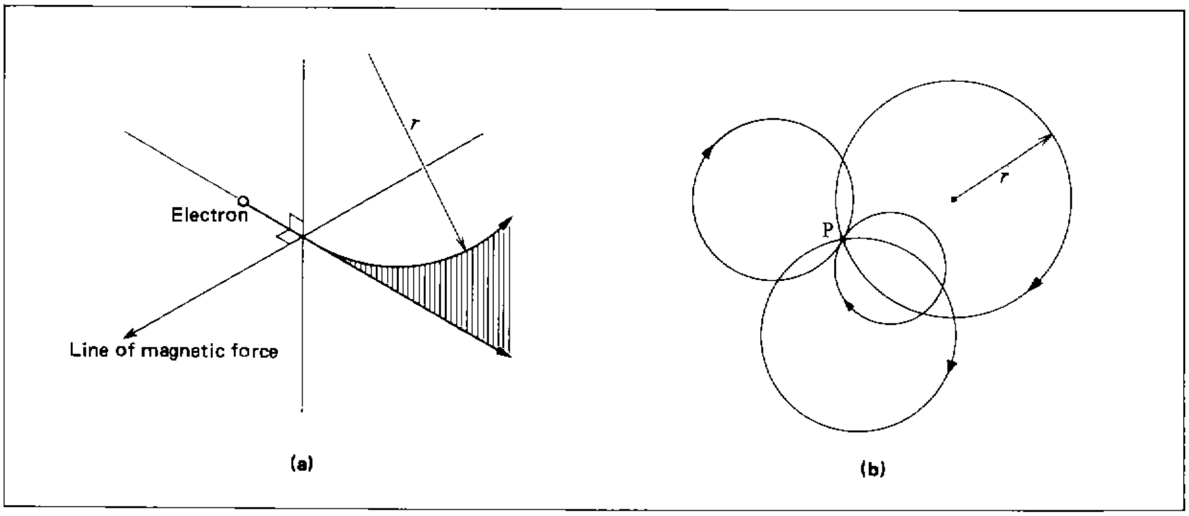


Fig. 1.6 Circular orbit of electron

As clear from this equation, the radius of the circular orbit described by the electron is proportional to velocity of the electron provided that the magnetic field intensity is constant (i.e., a uniform magnetic field). Now, let us assume that a number of electrons are simultaneously emitted at different velocities and in different directions from point P on a plane perpendicular to the uniform magnetic field. In this case,

each electron will return to the original point P after drawing a circular orbit with a radius proportional to its velocity, as shown in Fig. 1.6b. The time τ required for one revolution is given as follows:

$$\tau = \frac{2\pi r}{v} = \frac{2\pi}{\eta B} \quad \cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots \quad (6)$$

If the magnetic flux density is constant, time τ will also be constant, and all the electrons emitted at a given time will return to the original point P simultaneously; i.e., the angular velocity is always constant.

Assuming that an electron is emitted at a given angle against a uniform magnetic flux, the electron will describe a helical orbit which is formed by the vectors of rectilinear motion along the magnetic flux and circular motion perpendicular to the flux. As shown in Fig. 1.7, if an electron is emitted from origin P at velocity v and angle α against uniform magnetic field H, the electron will describe a helical orbit "a", which is determined by velocity component v_x (parallel to the magnetic flux) and rotating velocity component v_y (perpendicular to the magnetic flux), and will intersect the magnetic flux at point P′. If we consider the velocity components v_x and v_y separately, radius r of the circular orbit by v_y is given as follows using equation (5), since $v_y = v \sin \alpha$:

$$r = \frac{v}{\eta B} \sin \alpha \quad \cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots \quad (7)$$

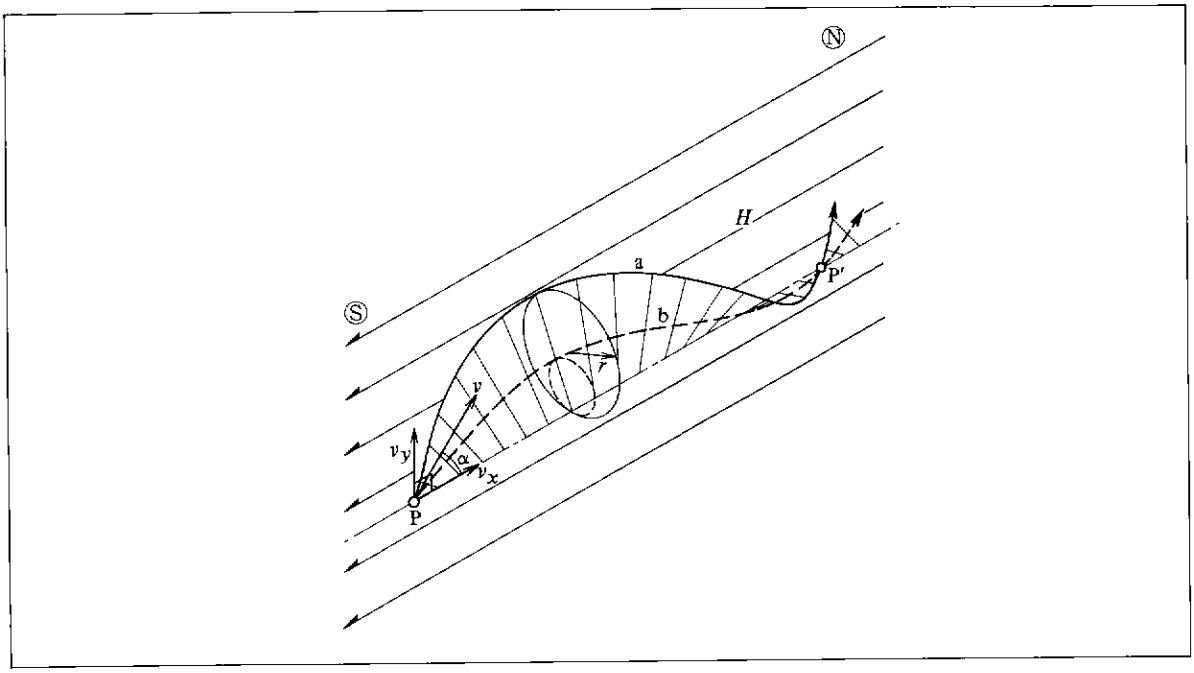


Fig. 1.7 Trajectories of electrons emitted obliquely in a uniform magnetic field

In the case of scanning electron microscopes, near-axis electrons are used and thereby α is extremely small. Thus, the velocity of electrons moving along the magnetic flux is given by:

$$v_x = v \cos \alpha \fallingdotseq v \quad \cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots \quad (8)$$

Therefore, if two electrons are emitted simultaneously from origin P, they will describe orbits "a" and "b" respectively, and meet again at P′ (Fig. 1.7). This is the basic principle of electromagnetic focusing through a uniform magnetic field.

The distance d between points P and P′ on the line of magnetic force is given as:

$$d = \nu_x \tau = \frac{2\pi\nu}{\eta B} \quad \cdots\cdots (9)$$

This distance is known as the nodal distance. Compared with equation (5), this equation gives distance d equal to the circumference of the orbit drawn by an electron moving at velocity ν perpendicular to the line of magnetic force. The orbits drawn by electrons emitted in a vacuum is illustrated in Fig. 1.8. The principle that all electrons emitted from a point will meet at another point after describing their orbits is similar to the principle of optical convex lenses.

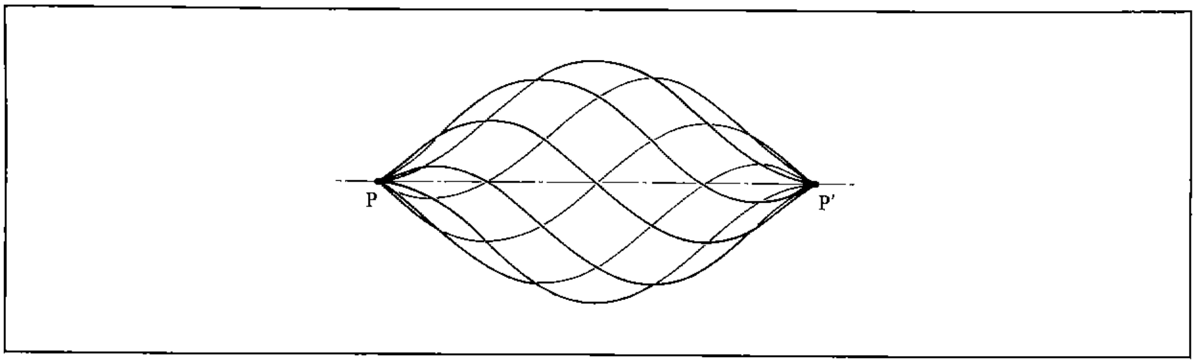


Fig. 1.8 Electron movement in a uniform magnetic field

This similarity is limited, however, since in an aberration-free optical convex lens, all light parallel to the optical axis of the lens converges at a point on the back focal plane, while electrons in a uniform magnetic field do not show this convergence.

Magnetic type electron lenses can be classified into those that use multi-layer coils (coreless solenoid) (Fig. 1.9a), those that use coils enclosed with soft iron to reduce leakage of magnetic flux and concentrate the

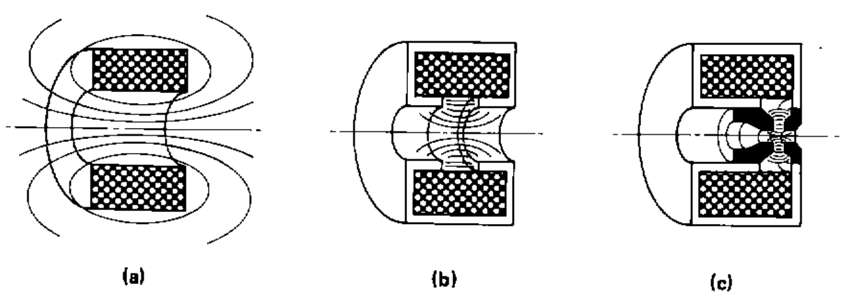


Fig. 1.9 Magnetic electron lenses

magnetic field on the inner gap of the iron core (Fig. 1.9b) and those that use coils enclosed with soft iron and concentrate the magnetic field on the small gap of the inserted pole pieces (Fig. 1.9c). Since high resolution is required in scanning electron microscopes, the core and pole piece type is usually employed. The operation of these electron lenses may be illustrated by several horse-shoe magnets arranged symmetrically about an axis. All the parallel electron beams incident to the curved magnetic field converge on a single point. Fig. 1.10 illustrates the trajectory of electrons passing through the magnetic field of an electron lens. Though the path of the electron beam does not coincide with that of light passing through an optical lens, the results are essentially the same. As shown in the figure, the electron travels rectilinearly, crosses the axis, moves through the magnetic field along a helical orbit, approaches the axis, crosses the axis again, and proceeds straight

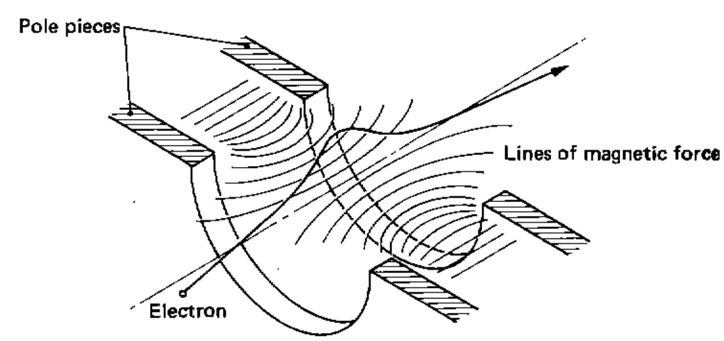


Fig. 1.10 Electron trajectory in the magnetic lens

forward. This action is quite similar to the focusing of an optical convex lens, and nearly the same if we disregard the circular motion.

A magnetic electron lens, which concentrates the magnetic flux within a very narrow area, forms a so-called "thin lens", and the magnetic field near the axis shows a bell-shape distribution. Fig. 1.11 illustrates the magnetic field distribution and image-formation by an electron lens, in which the focal length f and rotation angle θ are given by the following equations:

$$\left.\begin{aligned} \frac{1}{f} &= \frac{\eta}{8V}\int_{-\infty}^{+\infty} B^2(x)\,dx \\ \theta &= \sqrt{\frac{\eta}{8V}}\int_{-\infty}^{+\infty} B(x)\,dx \end{aligned}\right\} \quad \cdots\cdots \quad (10)$$

where V: accelerating voltage.

In order to obtain a very short focal length f, the magnetic flux density B must be relatively large. Since $B \propto NI$ (ampere-turn), the current to be supplied to the coil must be increased. Furthermore, since the aforementioned electron lens has the same function as an optical thin convex lens, the following equations are obtained.

$$\left.\begin{aligned} \frac{1}{a} + \frac{1}{b} &= \frac{1}{f} \\ M &= \frac{b}{a} \end{aligned}\right\} \quad \cdots\cdots \quad (11)$$

where M: demagnification ratio ($M < 1$).

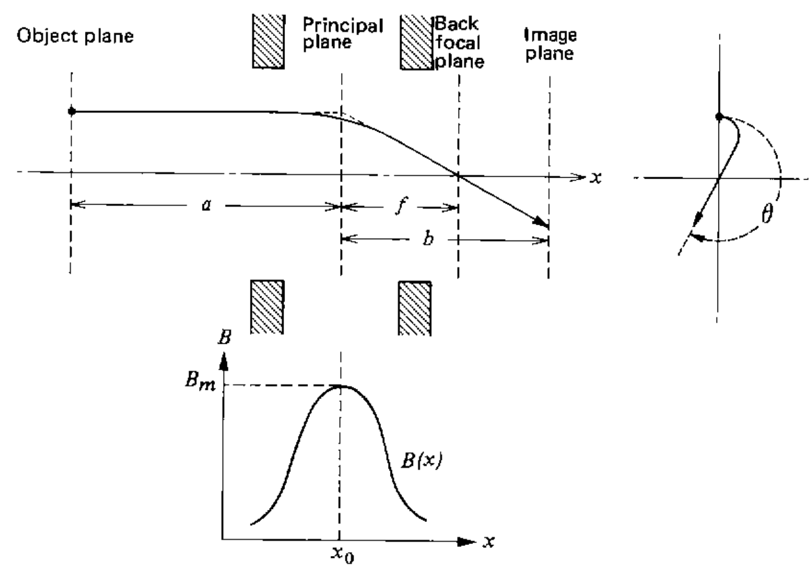


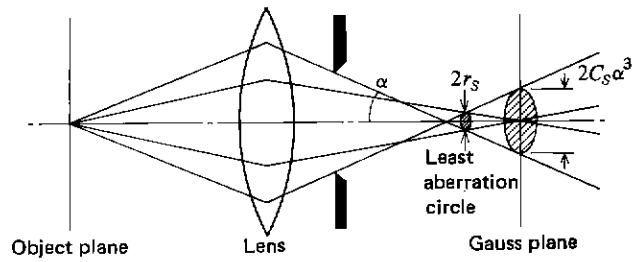
Fig. 1.11 Magnetic field distribution and image formation in the magnetic lens

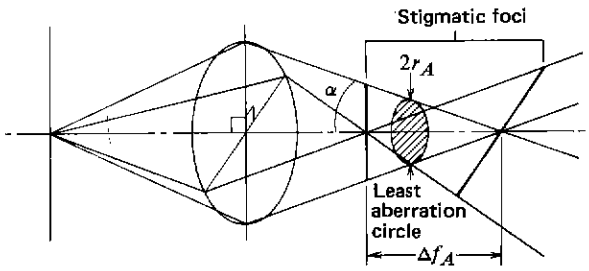
While the discussion above has given the theoretical principle of the electron lens, we can not neglect the influence of aberration in actual lenses. If we could get an ideal, aberration-free lens, and if we neglected the wave property of electrons, the diameter of the electron probe could be reduced by lowering the ratio of b/a to increase resolution. However, actual electron lenses are influenced by geometric aberrations (spherical aberration, coma, astigmatism, curvature of field, distortion), by diffraction aberration, by chromatic aberration and by other aberrations inherent in electron lenses due to field asymmetry (axial astigmatism and anisotropic aberration).

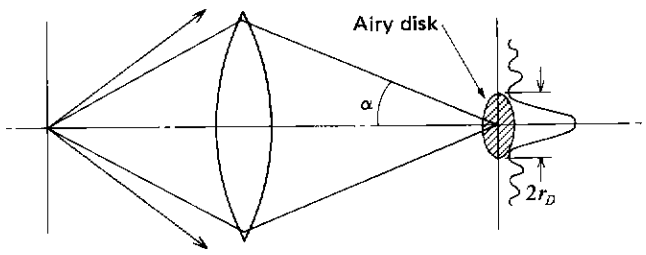
Table 1.3 lists the type of aberrations (axial) which have a marked influence on electron optical imaging. The radius of the aberration circle (see illustration) and ways to minimize these aberrations are also given. Spherical aberration is caused because the off-axis beam bends more than the near-axis beam, and requires the closest consideration when designing electron optical systems.

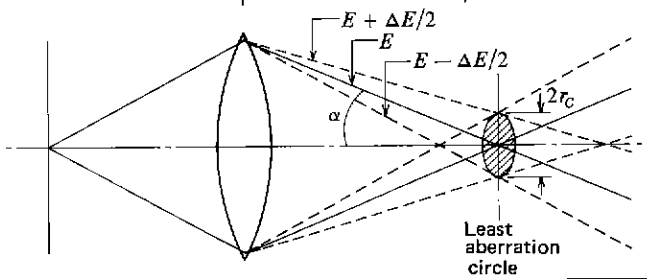
Table 1.3 Electron lens aberrations

Aberration	Type	Radius of aberration circle	
Geometric aberration	**Spherical aberration**	$2r_S = \frac{1}{2} C_S \alpha^3$	The spherical aberration coefficient C_S can be lowered by increasing the magnetic field intensity in the pole piece gap. Placing a suitable-sized circular aperture in the electron beam path reduces the beam divergence angle α and, in turn, reduces spherical aberration (if α is made very small, the diffraction aberration becomes important).
Asymmetric aberration	**Axial astigmatism**	$2r_A = \Delta f_A \alpha$	Astigmatism is caused by the following: Poor quality material Low machining accuracy Dirty electron beam path A stigmator is used to remove astigmatism (the spacing of stigmatic foci Δf_A becomes zero).
Wave optical aberration	**Diffraction aberration**	$2r_D = 1.22 \frac{\lambda}{\alpha}$	This aberration can be reduced by making α larger. However, making the beam devergence angle larger will increase spherical aberration. There are an optimum aperture angle consistent with the spherical and diffraction aberrations (use of a shorter wavelength electron beam is not suitable for secondary electron images).
Aberration due to instability	**Chromatic aberration**	$2r_C = C_C \alpha \frac{\Delta E}{E}$	Improving stability $\Delta E/E$ for the accelerating voltage (lens current) reduces this aberration. The coefficient C_C can be lowered by increasing the magnetic field intensity in the pole piece.









Astigmatism is caused by lens field asymmetry resulting in differing lens strengths in two orthogonal directions (partially affected by electrostatic charge-up due to contaminated components). This aberration can be eliminated by using a stigmator. Diffraction aberration is inherent in optical and electron lenses due to the wave-like motion of light and electron beams. So long as a lens is used, the electron beam cannot be concentrated, in a strict sense, on a single point, but forms a circle known as an Airy disk. Also, since diffraction aberration is inversely proportional to aperture angle α, and spherical aberration is proportional to α^3, a compromise must be made in the correction of these aberrations. The minimum radius of the obtainable aberration circle r_{min} is shown in Fig. 1.12, which also gives the optimal aperture angle α_{opt}. Chromatic aberration, caused by fluctuations in accelerating voltage and lens current, can be minimized by regulating the power supply.

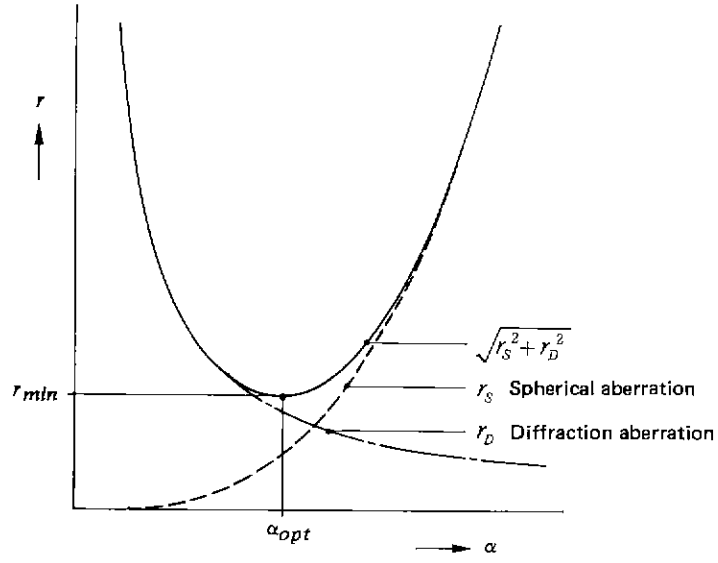


Fig. 1.12 Minimum aberration circle and optimal aperture angle

1.2.1d Interaction between electron beam and specimen

Since an electron is a charged particle, it has a strong interaction with the specimen (due to Coulomb interaction). When an electron beam impinges on a specimen, it is scattered by atomic layers near the surface of the specimen. As a result, the direction of electron motion changes and its energy is partially lost.

Once an incident electron (primary electron) enters a substance, its direction of motion is influenced by various obstructions (multiple scattering), and follows a complicated trajectory which is far from a straight line. This is illustrated in Fig. 1.13. Also, when electrons with the same energy are incident on the specimen surface, a portion of electrons is reflected in the opposite direction (back scattered) and the remainder is absorbed by the specimen (exciting X-rays or other quanta in the process). If the specimen is sufficiently thin, the electrons can pass all the way through the specimen (transmitted electrons, scattered or non-scattered).

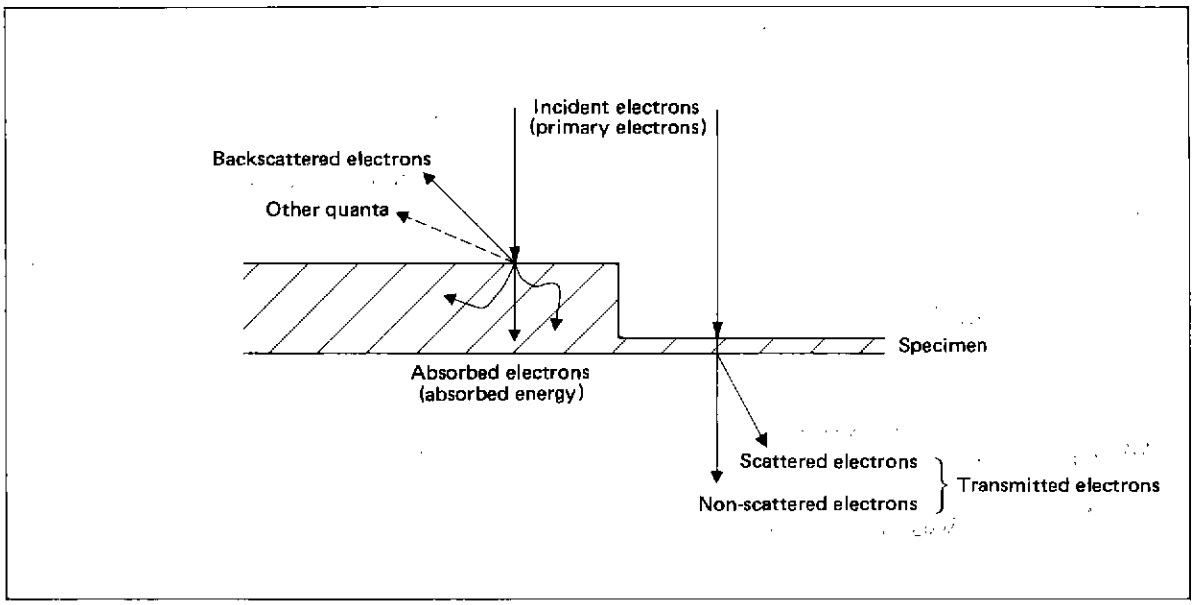


Fig. 1.13 Interaction between incident electron and specimen

The penetration and diffusion of incident electrons inside a specimen are illustrated in Fig. 1.14. As shown in the figure, if an element of the specimen has a low atomic number, the incident electrons will

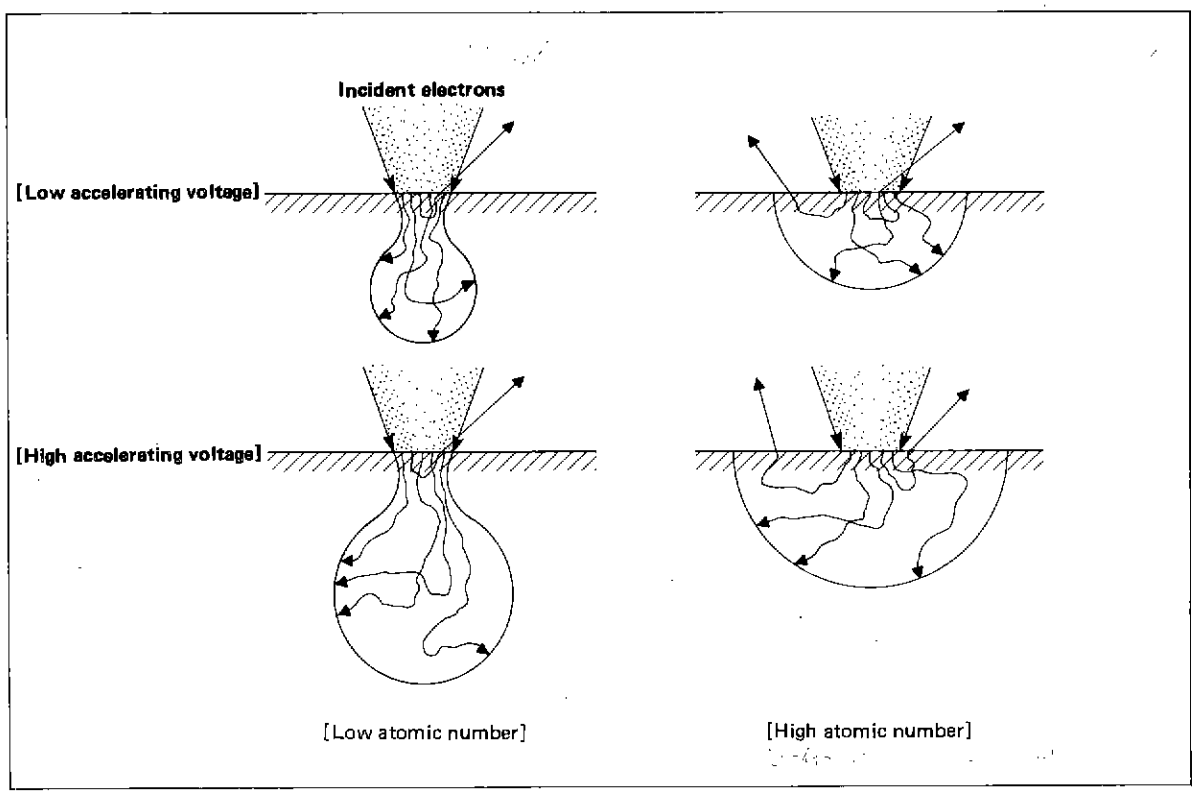


Fig. 1.14 Diffusion of incident electrons (from Duncumb and Shields)

show a tear-drop shaped diffusion, while if the element has a high atomic number, the incident electrons will show a hemispheric diffusion. Higher accelerating voltages expand the diffusion area much deeper. In the course of diffusion, the incident electrons gradually lose their energy until absorbed by the specimen (detected as absorbed current). In this process, low-energy secondary electrons are ejected. Furthermore, a portion of incident electrons are reflected outside the specimen, without losing much of their energy. In addition, the Auger effect causes Auger electrons to be ejected, which are used to analyze elements very near the specimen surface (JEOL JAMP Auger Scanning Microscope employs this Auger effect). When incident electrons collide with constituent atoms of the specimen, most of electron energy is converted to heat, but a portion of it is consumed to produce X-rays, visual and infrared cathodoluminescence together with secondary and Auger electrons. If the specimen is a transistor, integrated circuit or other semiconductor device, the electron probe irradiating the junction will create electron-hole pairs or carriers. By collecting these carriers, an electromotive force image can be obtained.

Quanta (secondary electrons, backscattered electrons, X-rays and so on) carry information which describes the nature of the specimen (its atomic number, elemental distribution, topography, surface potential distribution, magnetic domain, chemical and crystallographic characteristics, etc.). This information is converted into a video signal and displayed on a CRT as a scanning image. Table 1.4 lists the relation between the types of scanning image and obtainable information. An important application, quantitative and qualitative analysis by the electron probe microanalyzer, is included in the case of X-ray images.

Table 1.4 Types of scanning images and major information

Types of scanning image	Major information	Detectors and instruments
Secondary electron image	Surface structure, potential distribution, magnetic domain	Scintillator-PMT detector
Backscattered electron image	Composition, topography, magnetic domain, crystalline state	Paired semiconductor detector
Transmitted electron image	Composition, crystalline state	Scintillator-PMT detector
Absorbed electron image	Composition, topography	Absorbed current amplifier
Auger electron image	Elemental distribution of surface	Auger scanning electron microscope
Cathodoluminescence image	Visible or infrared luminescence	PMT detector
X-ray image	Elemental distribution	X-ray spectrometer
Electromotive force image	Electromotive force distribution in semiconductor devices	Electromotive force amplifier

The depth at which various signals are generated due to electron beam-specimen interaction indicates the diffusion area of the signals in the specimen in addition to the local chemistry of the specimen. Fig. 1.15 shows the range and spatial resolution of various signals. Secondary electrons mainly indicate information about the surface of a specimen. Since secondary electrons do not diffuse much inside the specimen, they are most suitable for observing the fine-structures of the specimen surface. That is to say, sharp scanning images with high resolution can be expected from secondary electrons, because of the smaller influence on resolution by their diffusion.

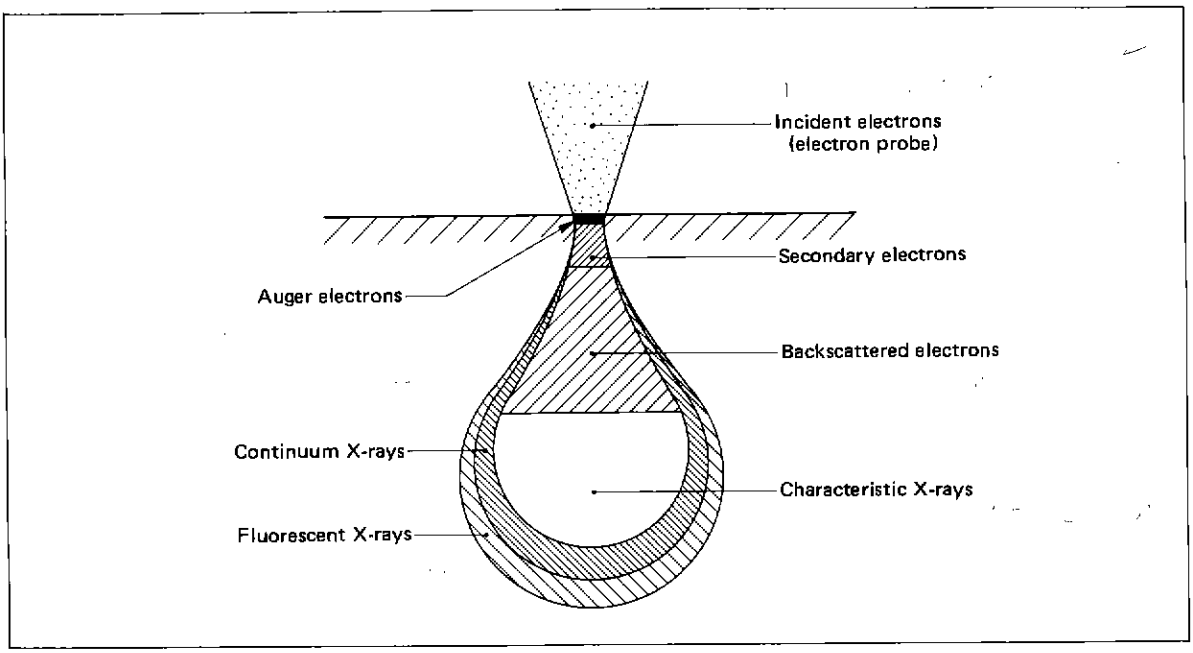


Fig. 1.15 Depth of quantum generation and spatial resolutions of various quanta (from Goldstein)

Fig. 1.16 shows the energy distribution (spectrum) of emitted electrons. The vertical axis represents intensity N of emitted electrons relative to incident electrons, while the horizontal axis represents the ratio of emitted electron energy E (eV) to incident electron energy E_0 (eV).

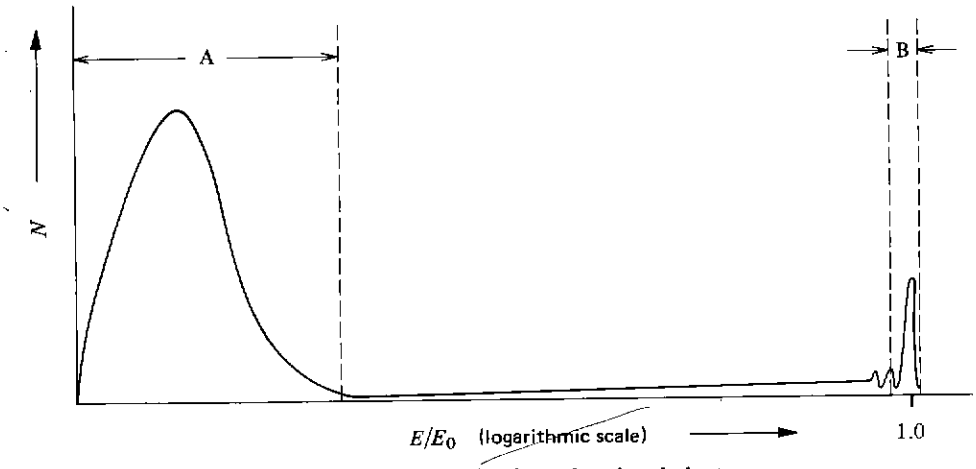


Fig. 1.16 Energy distribution of emitted electrons

In the figure, region A indicates the energy distribution of low energy secondary electrons (true secondary electrons). Its energy ranges from 0 to some tens of eV. Region B indicates the distribution of reflected electrons. The peak emission energy is very close to $E/E_0 = 1.0$, i.e., equal to the energy of incident electrons. The region between A and B is the background formed by backscattered electrons, including Auger electrons.

The small peaks located near the boundary of region B indicates plasma excitation.

The emission yield of secondary electrons depends on energy E_0 of incident electrons. As shown in Fig. 1.17, this emission yield peaks at a certain incident energy. In the figure, the vertical axis represents secondary electrons emission yield δ, which is the ratio of secondary electron current I_s to incident electron current I_p (probe current). The horizontal axis gives energy E_0 of incident electrons. Since the incident electron energy is determined by the accelerating voltage, the emission yield of secondary electrons also depends on the accelerating voltage. If we consider the emission yield δ as an output/input gain, the emission of secondary electron in the region above $\delta = 1.0$ can be thought of as the current amplification.

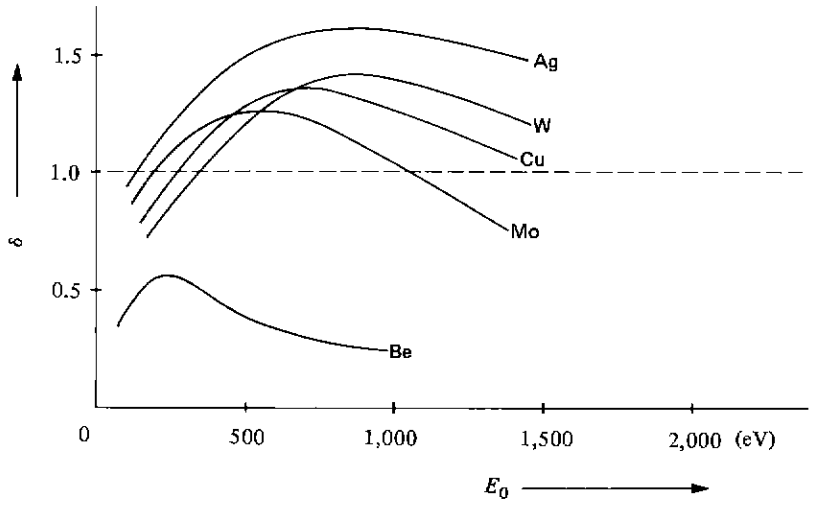


Fig. 1.17 Secondary electron yield versus accelerating voltage

As the incident electron energy increases, the probability of incident electrons colliding with elemental components of the specimen and releasing secondary electrons also increases. In other words, as the incident energy increases, the emission of electrons from the specimen also increases. However, as the energy increases beyond a certain level, the incident electrons penetrate deeper into the specimen with the result that the specimen-derived electrons use up most of their energy to reach the specimen surface. Consequently, the electron emission yield decreases. Therefore, the peak secondary electron emission yield δ_{max} occurs at a specific energy level of the incident electrons. Fig. 1.18 shows the relation between δ_{max} and the work function for various elements. It will be noted that δ_{max} varies from element to element; however, δ_{max} increases somewhat with increasing atomic number. The dashed line in the figure indicates the correlation between the work function and δ_{max} (some elements fairly deviates from the correlation line). In general, elements of the copper and iron groupes have a larger δ_{max}; alkaline metals and alkaline earth metals have a smaller δ_{max}. Oxides, chlorides and alloys give a very large δ_{max}, with particular oxides exceeding a value of 10 (MgO: $\sim$16). In addition, the secondary electron emission yield becomes even larger when the specimen surface is contaminated or affected with adsorbed gas. With certain materials, δ_{max} increases slightly

with increasing temperature.

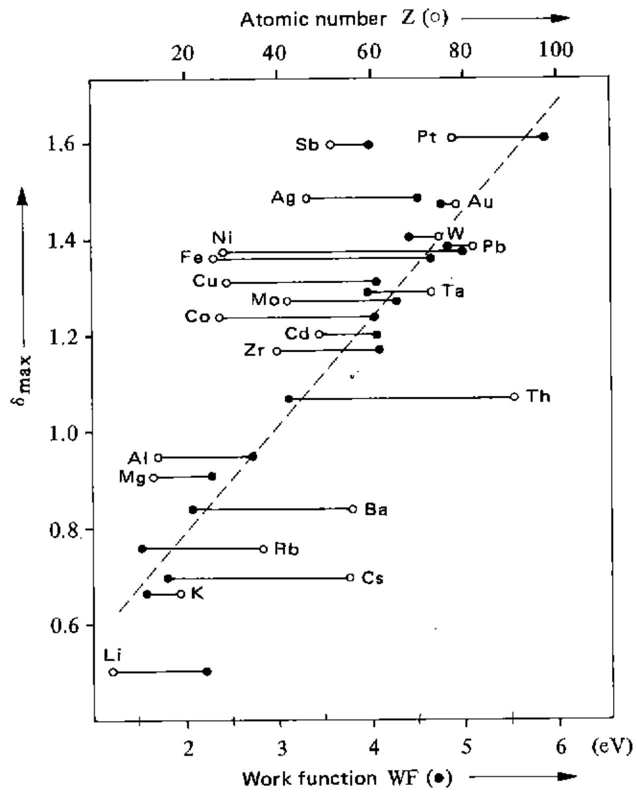


Fig. 1.18 **Maximum secondary electron yield δ_{max} and work function of various elements**

As described, most energy consumed by incident electrons inside a specimen is converted into heat. As a result, the specimen temperature increases at the point of irradiation, and heat sensitive specimens may be subject to thermal damage. When a sufficiently large specimen is irradiated by the electron probe, the temperature rise at the point of irradiation Θ_m (°C) is approximately as follows (from Castaing):

$$\Theta_m = 1.14 \times \frac{i_A V}{C d} \ (°\mathrm{C}) \qquad \cdots\cdots (12)$$

where i_A : specimen absorbed current (μA)

V : accelerating voltage (kV)

C : thermal conductivity (cal cm^{-1} sec^{-1} deg^{-1})

d : electron probe diameter (μm).

Assuming 0.1 μm as the electron probe diameter, Fig. 1.19 indicates the relationship between temperature rise at the beam irradiating point and thermal conductivity of the specimen for accelerating voltages 10 kV (——), 20 kV (– – –) and 30 kV (– – –). As shown in the figure, if the accelerating voltage of the electron probe is 10 kV and a glass specimen absorbes 0.0001 μA of the current, the temperature will rise approximately 7°C.

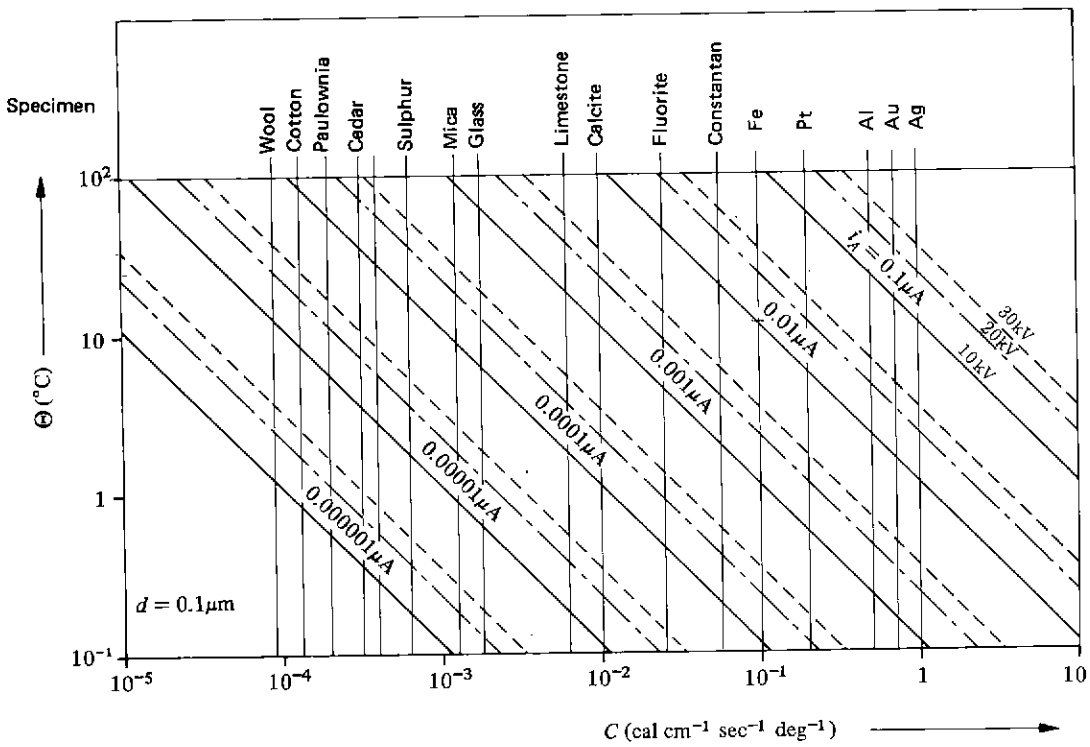


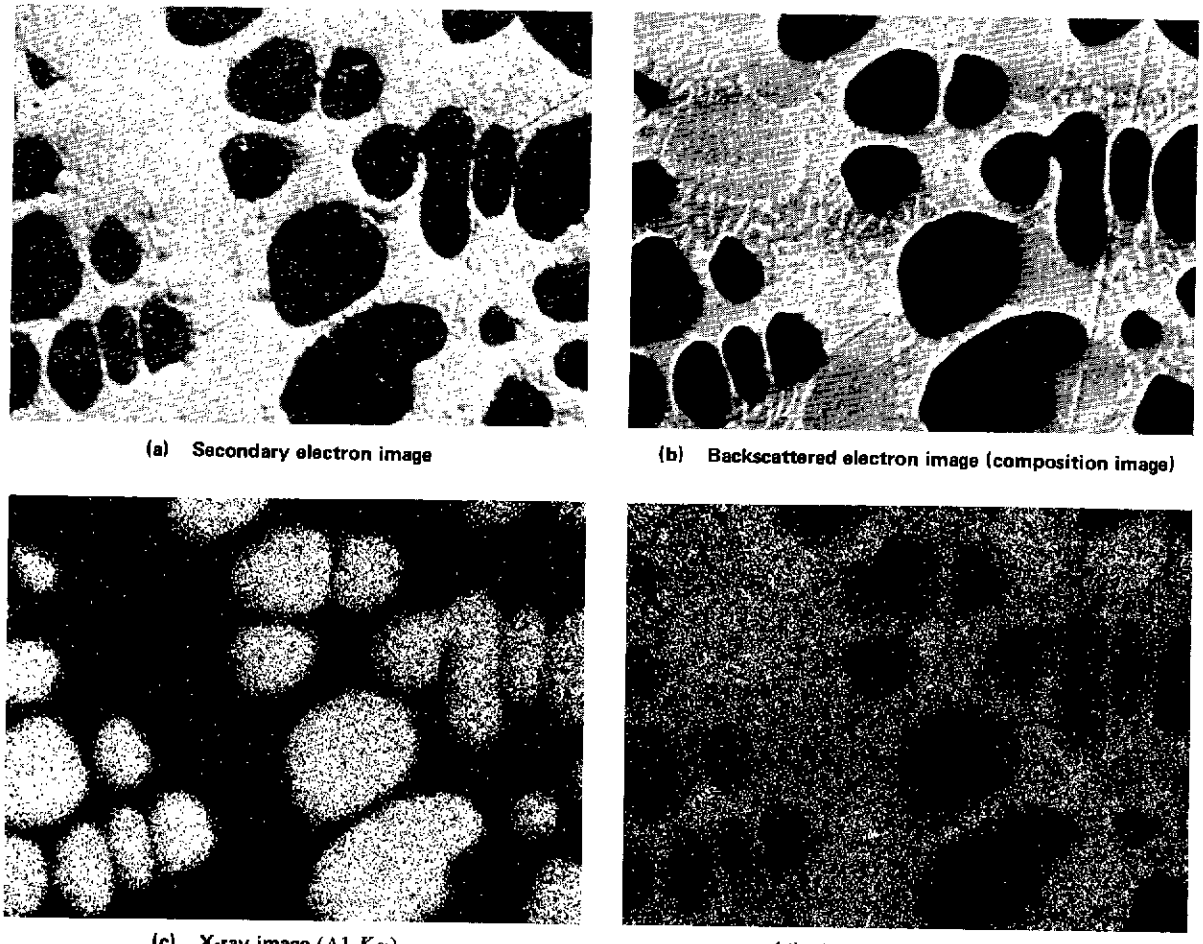
Fig. 1.19 Temperature rise versus thermal conductivity

1.2.1e Image formation and contrast mechanism in the secondary electron image mode

In order to verify the existence of a substance and recognize its shape, the image contrast must be well defined. In other words, even if a system boasts extremely high resolution, if image contrast is poor, it would be extremely difficult to determine the existence of a substance, let alone recognize its shape. Accordingly, sufficient image contrast is an indispensable factor in image formation.

In optical microscopes, image contrast is basically determined by the absorption of light at each location of the specimen. It is also partially influenced by reflected light, and certain microscopes employ phase difference. In transmission electron microscopes, the image contrast is mainly determined by the absorption of scattered electrons. For crystalline specimens, diffraction contrast plays the main role, while at extremely high magnifications, phase contrast has the influence on image formation. The mechanism of contrast formation in scanning electron microscopy clearly differs from those mentioned above. Image contrast is mainly determined by variations in the number of locally emitted secondary electrons, i.e., the difference in secondary electron emission yields relating to specimen composition and topography. For semiconductor specimens, image contrast is determined by the potential distribution of its surface, while, for magnetic specimen, contrast is determined by magnetic domain distribution.

In Fig. 1.20, a secondary electron image of Al–Sn–Pb alloy (polished surface) is compared with a backscattered electron image (composition image) and X-ray images (Al $K\alpha$, Sn $L\alpha$). The backscattered electron image was photographed using a BEI backscattered electron detector and the X-ray image was



(a) Secondary electron image

(b) Backscattered electron image (composition image)

(c) X-ray image (Al $K\alpha$)

(d) X-ray image (Sn $L\alpha$)

Specimen: Al-Sn-Pb alloy

Fig. 1.20 Secondary electron image compared with backscattered electron and X-ray images

photographed using an X-ray spectrometer (wavelength dispersive type). As shown, differences in the composition of the specimen surface produce differences in the secondary electron emission yield (Fig. 1.18), which in turn determines image contrast. Since the secondary electron detector detects some backscattered electrons and additional secondary electrons excited by these backscattered electrons in addition to the true secondary electrons (as shown in Fig. 1.21), the secondary electron image reflects the influence of backscattered electrons. This also results in contrast for secondary electron images.

The world of scanning microscopy may be regarded as a monochromatic world in which the differences in composition (differences in secondary electron emission yields) are identified by differences in brightness, The topography of the specimen surface is also identified by brightness of the image. Fig. 1.22 (a and b) illustrates the emission of secondary electrons and the electron diffusion region depending on the angle of incidence. Secondary electrons absorbed by the specimen before escaping from the specimen surface can be directed outward by tilting the specimen. Fig. 1.22c illustrates this process. When the incident electron probe is tilted by angle θ relative to the normal of the specimen, secondary electrons produced at depth x travel along

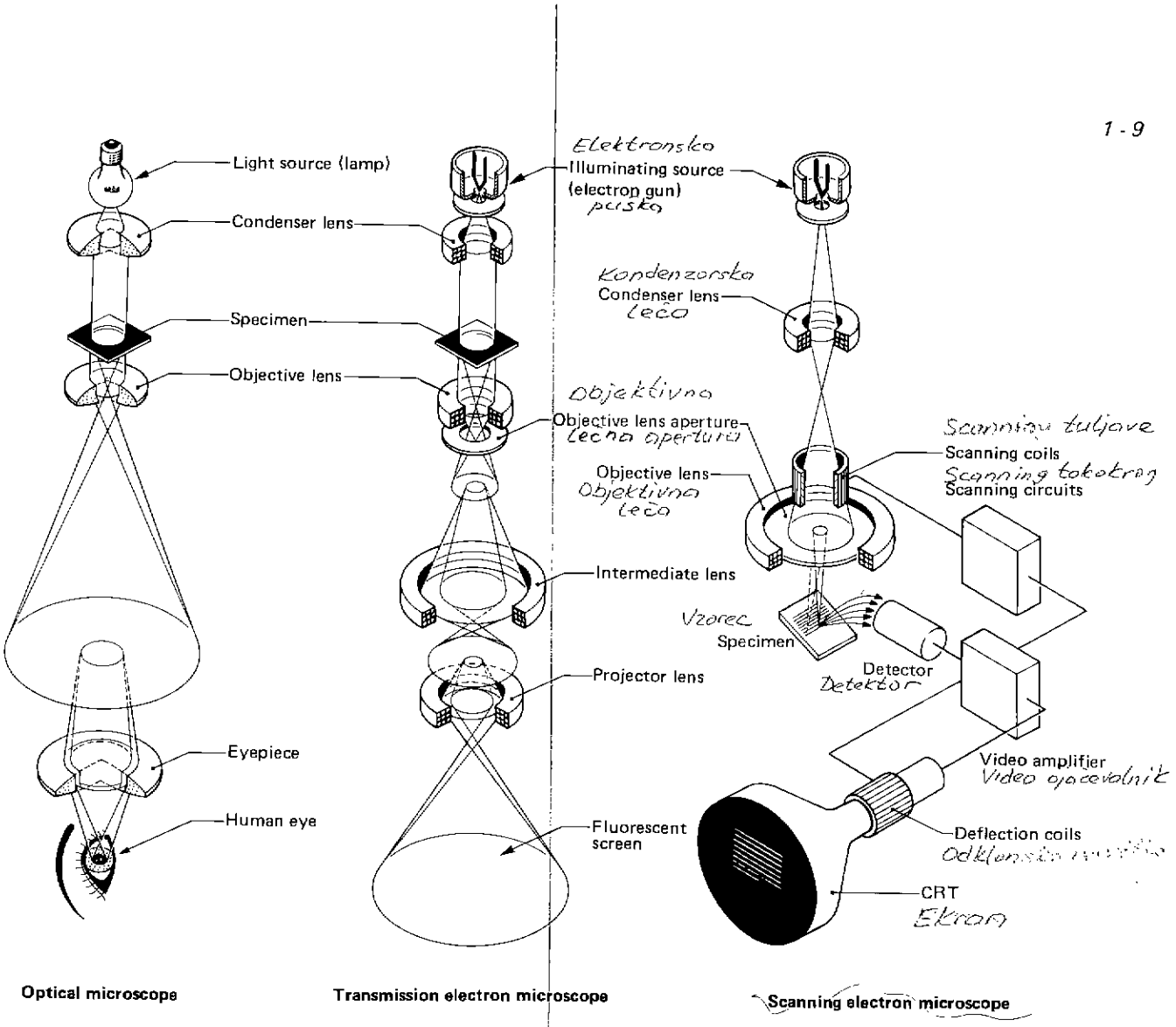


Fig. 1.2 Image formation

1.2.1b Resolution and depth of field

The quality of images is largely determined by the resolving power of the microscope, which is the best possible performance as limited by instrument parameters. The resolving power is defined as the shortest distance between two points which can be recognized as two different images. To check the resolving power, the resolution achieved on micrographs is measured (the shortest distance between two points recognizable on the micrographs).

In optical microscopes, the aberrations inherent in lenses (geometrical aberrations such as spherical or chromatic aberration) can be eliminated almost entirely, and thus the resolving power is determined largely by the diffraction aberration. The scanning electron microscope operates on very different principles of image formation, and the resolving power is determined accordingly. With the scanning electron microscope, the surface of the specimen is scanned by a finely focused electron probe (accelerated electron beam), and a signal obtained from the specimen is displayed on a CRT, which is scanned synchronously with the electron probe. More detailed information about the specimen may be obtained by using a finer electron probe, but

this results in decreased probe current and lower resolving power (the resolving power is determined by the diameter of the electron probe and the quantity of signals obtained from the scanned specimen). The relationship between probe diameter and probe current is shown in Fig. 1.3. Accordingly, the resolving power is limited by the performance of the electron gun.

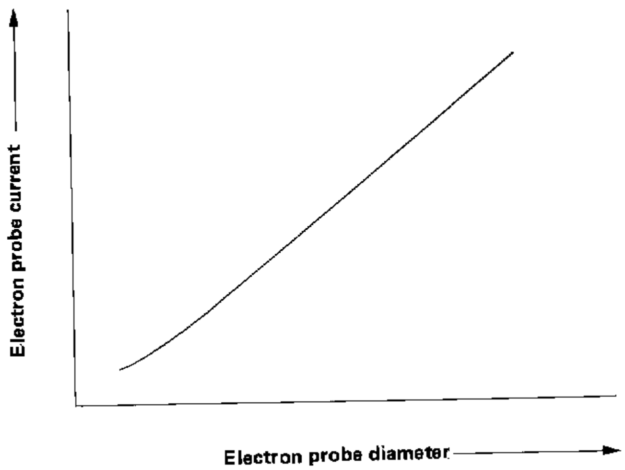


Fig. 1.3 Diameter of electron probe and probe current

Furthermore, the resolving power of the scanning electron microscope is restricted by certain factors, such as the electrical and mechanical stability of the electron-optical system, the S/N ratios of the detector and video amplifier, the stability of the scanning circuits and the performance of the recording system or CRT. On the other hand, the resolution of the image depends on the type and state of the specimen, operating conditions of the instrument (electron probe diameter and current), the number of scanning lines, the magnification, the photographing conditions and so on. In order to ensure optimal resolution for the specimen of interest, therefore, careful consideration must be given to specimen preparation, observation and photographing conditions, instrument maintenance (routine inspection and cleaning) and photographic processing. Considering a single factor such as magnification, if we are to identify the resolution d of an image with the naked eye, it must be enlarged to the magnification whose minimum value, i.e. the effective magnification M, is determined by the resolution d_1 of the human eye (approximately 0.1 mm) as given below:

$$M = \frac{d_1}{d} \qquad \cdots\cdots \qquad (1)$$

Assuming 100 Å as the resolving power of the scanning electron microscope, the image must be magnified at least 10,000 times to identify the said resolving power. Considering another factor, the number of scanning lines, since the ultra-high resolution CRT has a resolution of 2,500 lines per frame for a frame size of 69 X 92 mm, it would naturally be most efficient to use the number of scanning lines equal to that of the CRT (for example, a horizontal scanning speed of 40 msec/line and a vertical scanning speed 100 sec/frame).

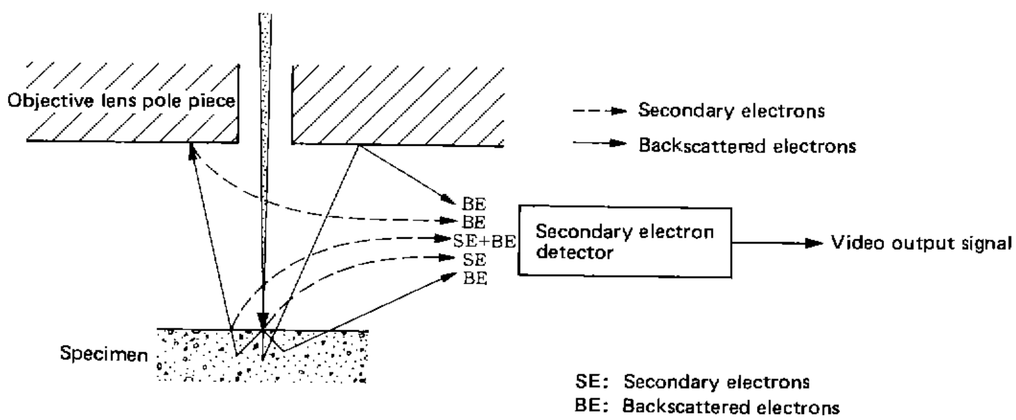


Fig. 1.21 Information contained in a secondary electron image

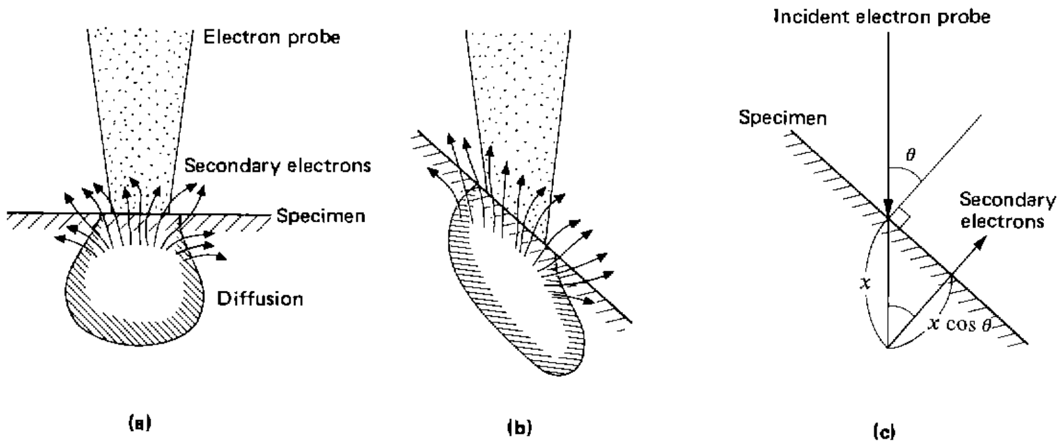


Fig.1.22 Secondary electron emission as a function of specimen tilt angle

the shortest distance $x \cos \theta$ to the specimen surface. Different from reflected electrons or X-rays, the range of emitted secondary electrons is limited to the area adjacent to the point of incidence. Furthermore, it can be assumed that secondary electrons are uniformly produced on the X axis, provided that the path of incident electrons within the specimen follows the X axis and that their energy loss can be neglected. However, since secondary electrons may have very little energy, they may not reach the specimen surface if $x \cos \theta$ is too large. The range of secondary electrons for each specimen is determined by its specific secondary electron absorption coefficient. Under this condition, the total quantity of secondary electron emission I can be given by the equation below:

$$I \doteqdot K \frac{1}{\cos \theta} \qquad \cdots\cdots (13)$$

where K: proportional constant.

The quantity of emitted secondary electrons is minimal when the electron beam is incident perpendicular to the specimen surface, and increases as the electron beam is tilted. The image contrast for certain surface structures, such as a shelf, spike and cylindrical structures, is shown in Fig. 1.23. The contrast mechanism can be understood in terms of beam incidence angle and electron diffusion (shaded area).

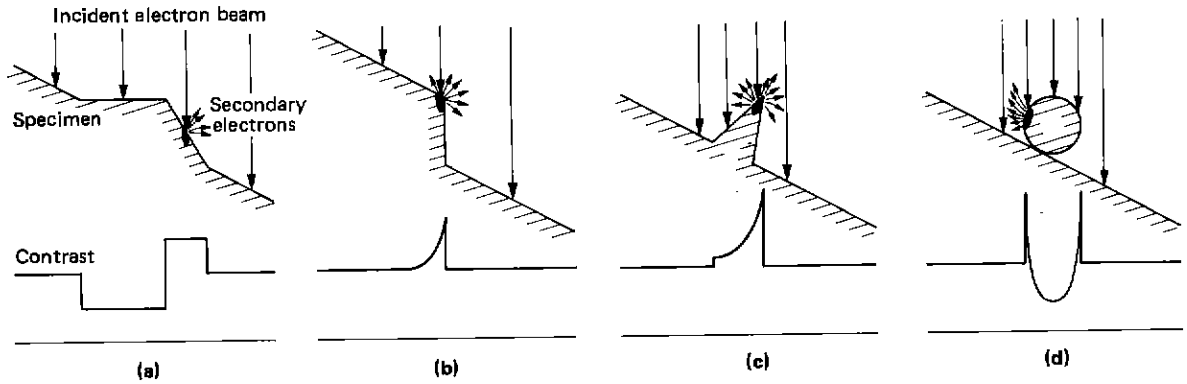
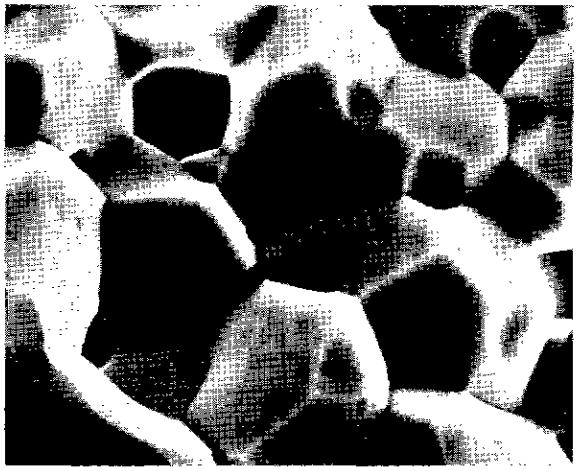


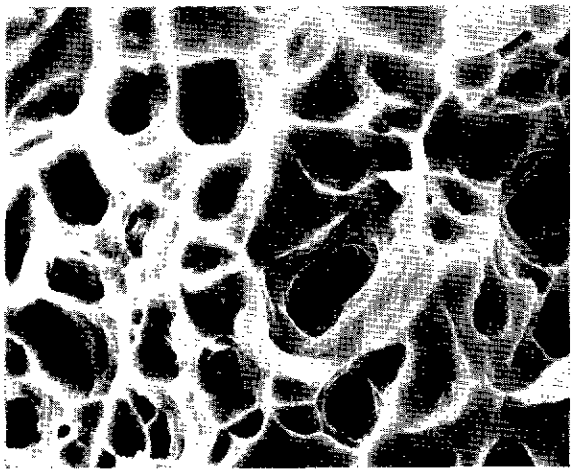
Fig. 1.23 Contrast formation by geometrical configuration of specimen surface

Micrographs of specimens having various geometrical configurations are shown in Fig. 1.24. Photo (a) shows contrast related to tilt angle and edges, while photo (b) shows contrast related to edges and projections. Photos (c) and (d) show, respectively, contrast related to spikes and spherical structures and contrast related to tilt angle and cylindrical structures. These photos cover the major types of contrast found in scanning images. Viewed from a different standpoint, image contrast may be broadly classified into that determined by the tilt angle of the specimen and that determined by the edge effect. The former is illustrated in Fig. 1.25, and the latter (including the influence of accelerating voltage) is shown in Fig. 1.26. Fig. 1.25 shows the necessity of selecting an appropriate tilting angle and orientation for the specimen in order to ease observation and establish adequate contrast. Clearly, normal incidence observation (vertical illumination) be avoided if possible. Fig. 1.26 indicates that the edge effect (circumference is bright while details in the central portion are not so clear) is particularly enhanced at high accelerating voltages. This can be suppressed by lowering the accelerating voltage. If the required magnification is within a range in which the resolving power is not the question, observation at lower accelerating voltages is preferable.

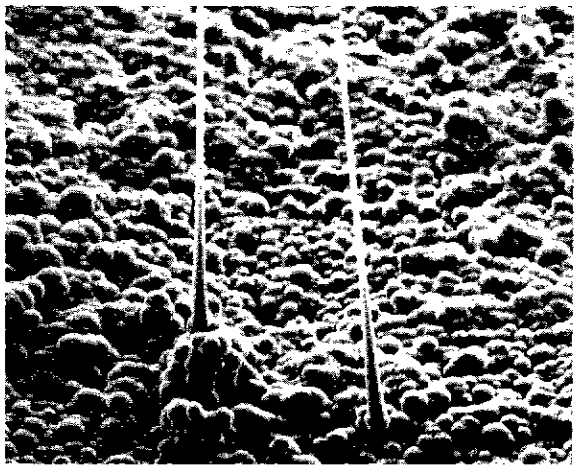
As discussed previously, secondary electron images can be obtained by shadowless illumination. However, to avoid confusion in interpreting the images, characteristics of secondary electron images will be compared with those of backscattered electron images. For secondary electron images, all electrons emitted omnidirectionally from the specimen (partially including backscattered electrons) are detected, and video signal output reflects variations in the number of emitted electrons caused by scanning (Fig. 1.27a). Thus, the secondary electron image carry information obtained from all facets of the specimen (this is equivalent



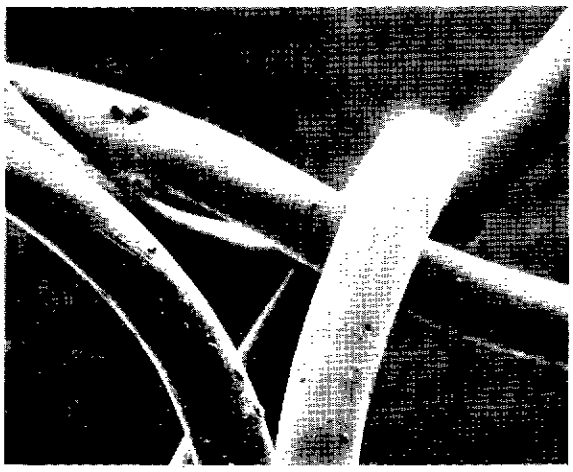
(a) Ferrite



(b) Fractured surface of aluminum

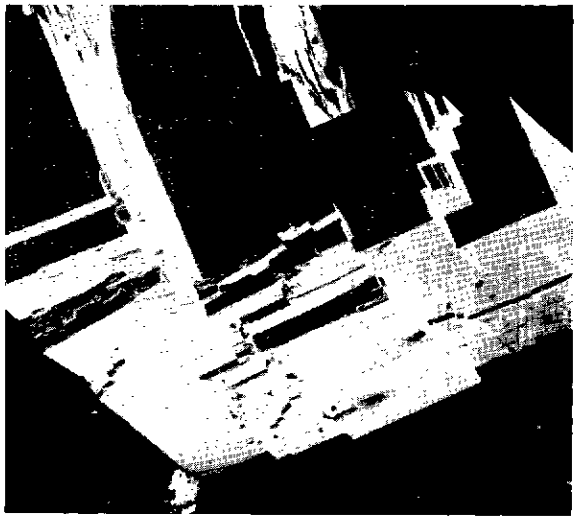


(c) Boron whisker

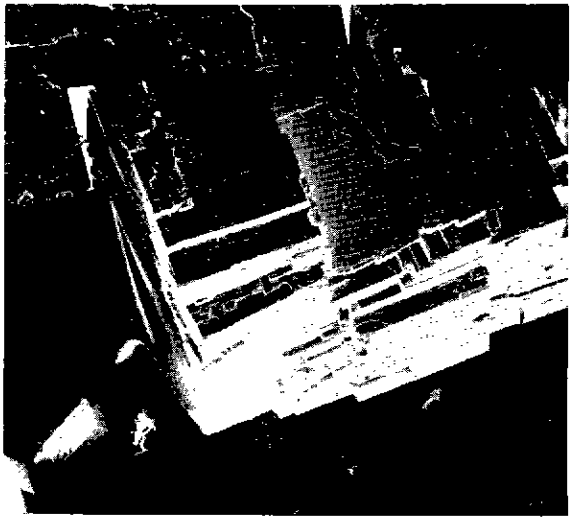


(d) Synthetic fibers

Fig. 1.24 Examples of contrast formed by various shapes of specimen

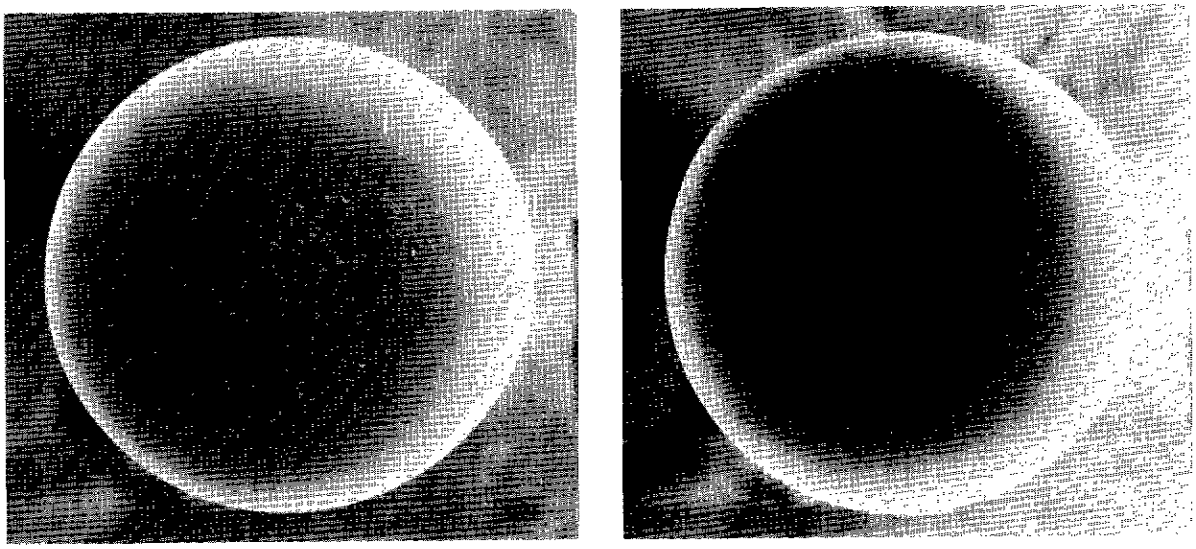


(a) 45°-tilt



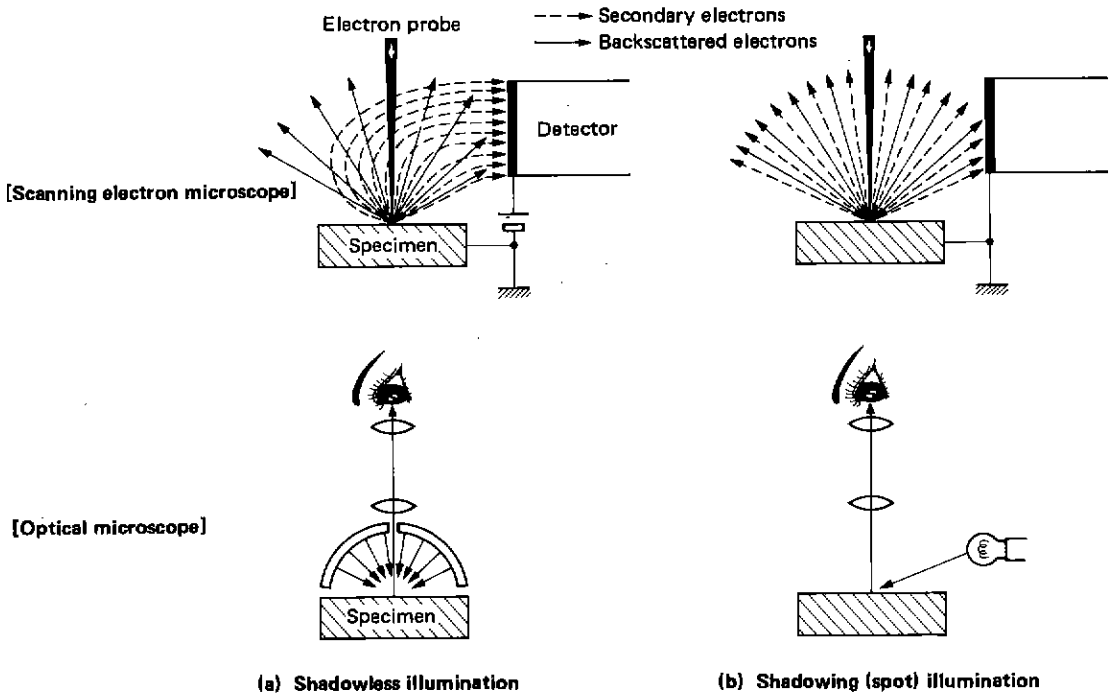
(b) 60°-tilt

Fig. 1.25 Contrast variation as a function of specimen tilting angle Specimen: Galena



(a) Low accelerating voltage (b) High accelerating voltage

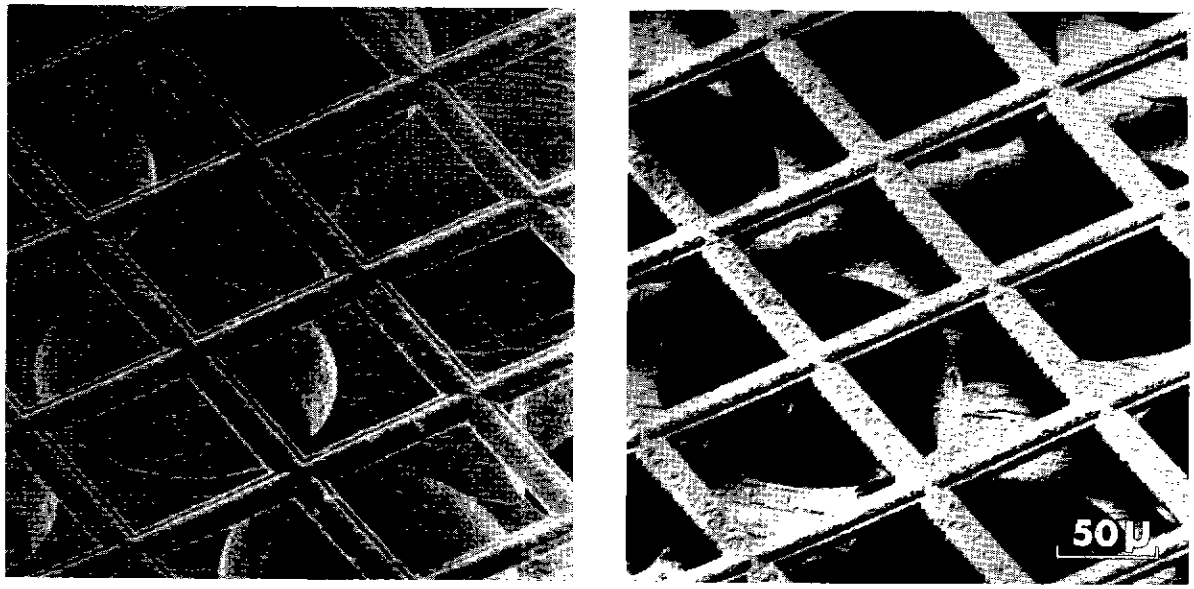
Fig. 1.26 Edge effect due to accelerating voltage Specimen: Glass particle



(a) Shadowless illumination (b) Shadowing (spot) illumination

Fig. 1.27 Illuminating methods

to shadowless illumination in optical microscopes). For backscattered electron images (Fig. 1.27b), the video signal output indicates variations in electrons reflected in one direction only; i.e., towards the detector (this is equivalent to shadowing (or spot) illumination in optical microscopes). A secondary electron image and backscattered electron image of stacked three grids are compared in Fig. 1.28.



(a) Secondary electron image

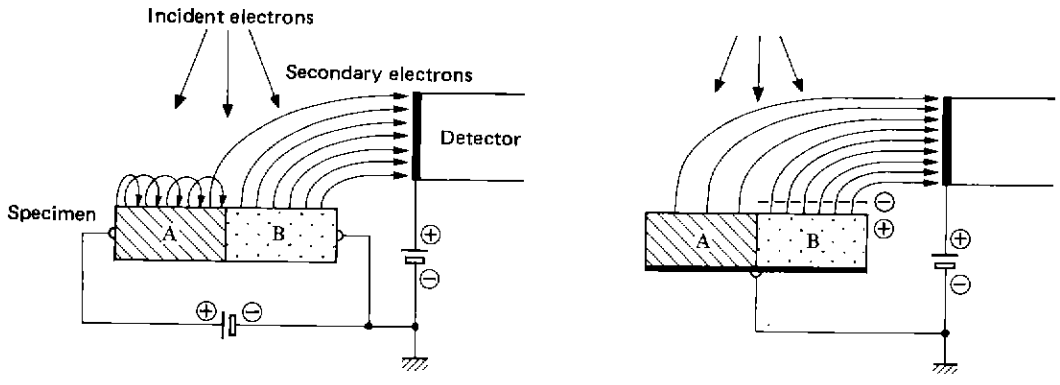
(b) Backscattered electron image

Fig. 1.28 Difference in illumination effect between secondary electron image and backscattered electron image

Specimen: Grids

The secondary electron image provides approximately equal contrast for the top, middle and bottom grids, while the backscattered electron image shows strong shadowing over the entire picture: shadows from the top grid appears on the middle grid and the bottom grid is nearly unobservable.

If local difference in electrical potential is present on the specimen surface, so-called voltage contrast will appear. This contrast also appears when parts of a specimen are locally charged because of poor electrical conductivity (this effect can be suppressed to some extent by lowering the accelerating voltage). Fig. 1.29a illustrates typical secondary electron emission when a bias voltage is applied between parts A and B of the specimen. Since the energy of secondary electrons is very low, emission of secondary elections can be

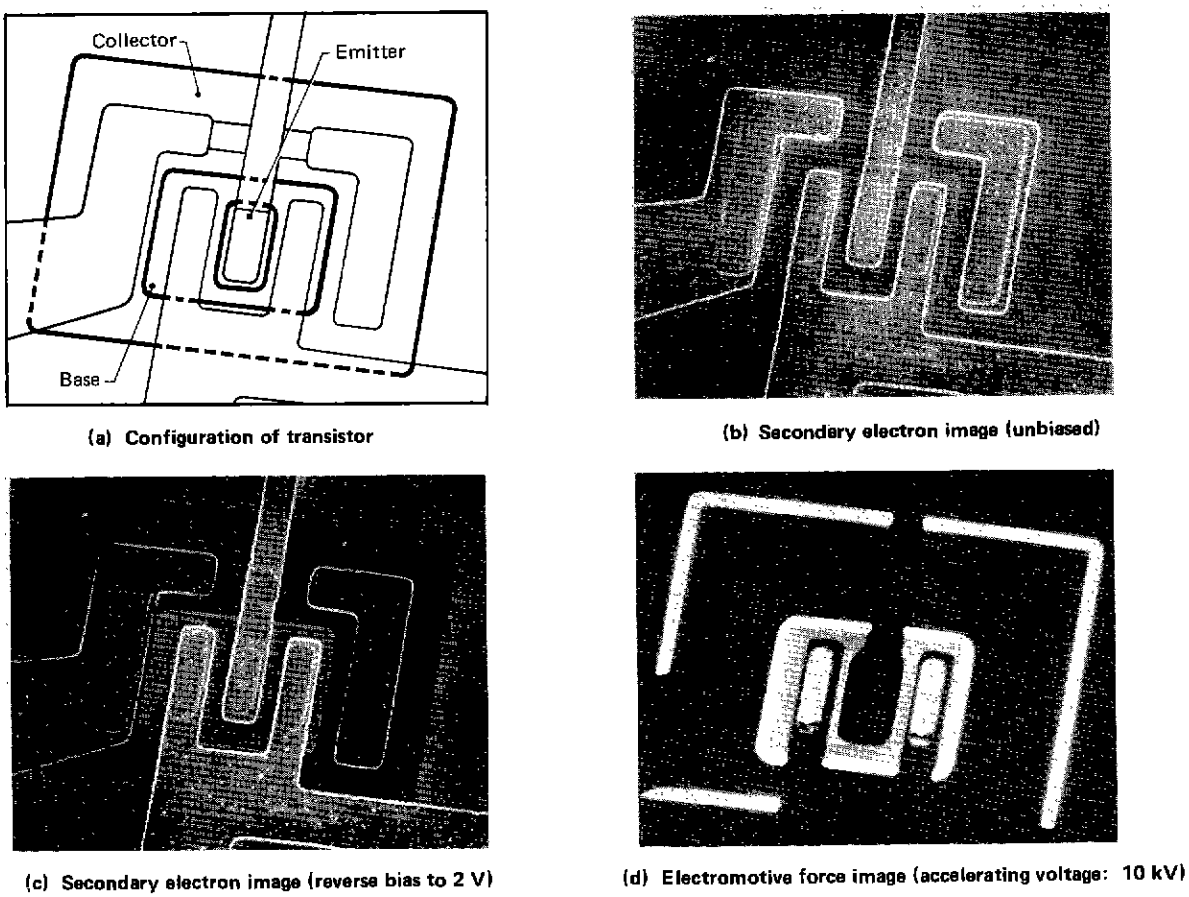


(a) When biased

(b) When partially charged.

Fig. 1.29 Voltage contrast formation

suppressed to the extent that the detector can hardly detect them by supplying only a few volts of positive potential to part A. This effect can be advantageously applied to semiconductor research. Fig. 1.30c shows the secondary electron image of a transistor in an integrated circuit. When the p-n junction is illuminated with the electron beam, electron-hole pairs are created at the beam incident point and thereby an electromotive force is generated. This force can be measured or recorded as an electromotive force image using an amplifier (Fig. 1.30d). Fig. 1.29b illustrates the emission of secondary electrons from charged part B of the specimen. In this case, negative electric charge is accumulated on the surface of part B, increasing the apparent potential difference from the detector. Thus, emission of secondary electrons from part B increases to an abnormal extent compared with that from part A.



(a) Configuration of transistor

(b) Secondary electron image (unbiased)

(c) Secondary electron image (reverse bias to 2 V)

(d) Electromotive force image (accelerating voltage: 10 kV)

Fig. 1.30 Voltage contrast and electromotive force image Specimen: Integrated circuit

Fig. 1.31 shows an example of abnormal contrast due to charging. This abnormal contrast can be suppressed to a certain extent by lowering the accelerating voltage or vacuum evaporating certain metals (gold, platinum, etc.) uniformly over the specimen. This metal coating also protects the specimen from heat damage due to beam irradiation (see Fig. 1.19). In order to coat the specimens evenly, specimens are rotated during coating. A sputtering device is also useful for this purpose.

Fig. 1.31 Abnormal contrast due to charging Specimen: Synthetic fibers

Finally, let us briefly discuss the process of image formation in the scanning electron microscope (Fig. 1.32). The electron beam emitted from the electron gun is focused on the specimen surface by an electron lens. The total quantity of electrons reaching the specimen surface is given by the difference between the total of electrons emitted and the total of electrons blocked by apertures in the beam path. The number of electrons impinging on the unit area of the specimen is determined by the diameter of the electron probe. Using a smaller diameter aperture near the center of the lens increases the depth of field but decreases the quantity of irradiating electrons.

The probe is moved horizontally by supplying the current to horizontal scanning coils located in the electron beam path. The probe moves vertically when the current is supplied to the vertical scanning coils. By supplying sawtooth wave currents (the horizontal and vertical scanning signals) to horizontal and vertical scanning coils, the probe position gradually moves diagonally, and as shown in Fig. 1.33a this determines one scanning line. By making the period of the horizontal scanning sawtooth wave very short while leaving the period of the vertical sawtooth wave constant, a large number of scanning lines can be obtained as shown in Fig. 1.33b. The relationship between the period; i.e., vertical scanning speed (also known as frame speed), horizontal scanning speed and number of scanning lines is determined by the equation below:

$$\text{Number of scanning lines (lines/frame)} = \frac{\text{Vertical scanning speed (sec/frame)}}{\text{Horizontal scanning speed (sec/line)}} \quad \cdots\cdots\cdots \quad (14)$$

The secondary electrons emitted from various positions of the specimen surface as the specimen is scanned by the electron probe are detected by the secondary electron detector (located near the specimen) and the signal induced in the detector is sent to the video amplifier where it is amplified and level-controlled to obtain an optimum contrast and brightness image on the CRT. In the video amplifier, the video signal is

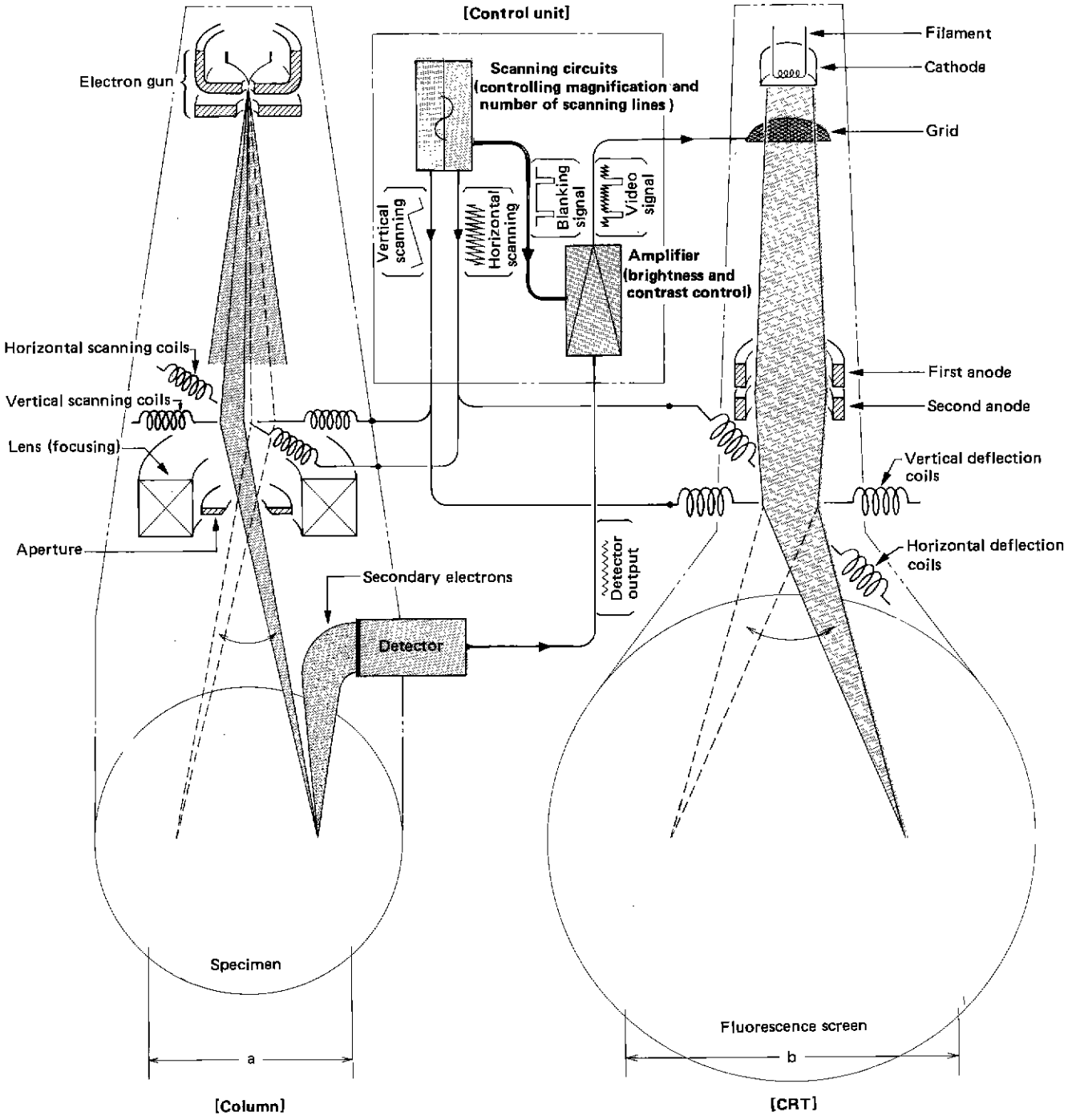


Fig. 1.32 Formation of secondary electron image

modulated by a blanking signal synchronized with the scanning signal in order to blank out retrace from the picture (the CRT is momentarily cut-off so as to blank out the image corresponding to the dashed lines in Fig. 1.33b). The video output signal is then supplied to the control grid of the CRT which is synchronized

with probe scanning. The signal modulates the raster brightness, thereby displaying a scanning image. In other words, variations in secondary electron emission over various positions of the specimen are displayed as variations in brightness on the CRT.

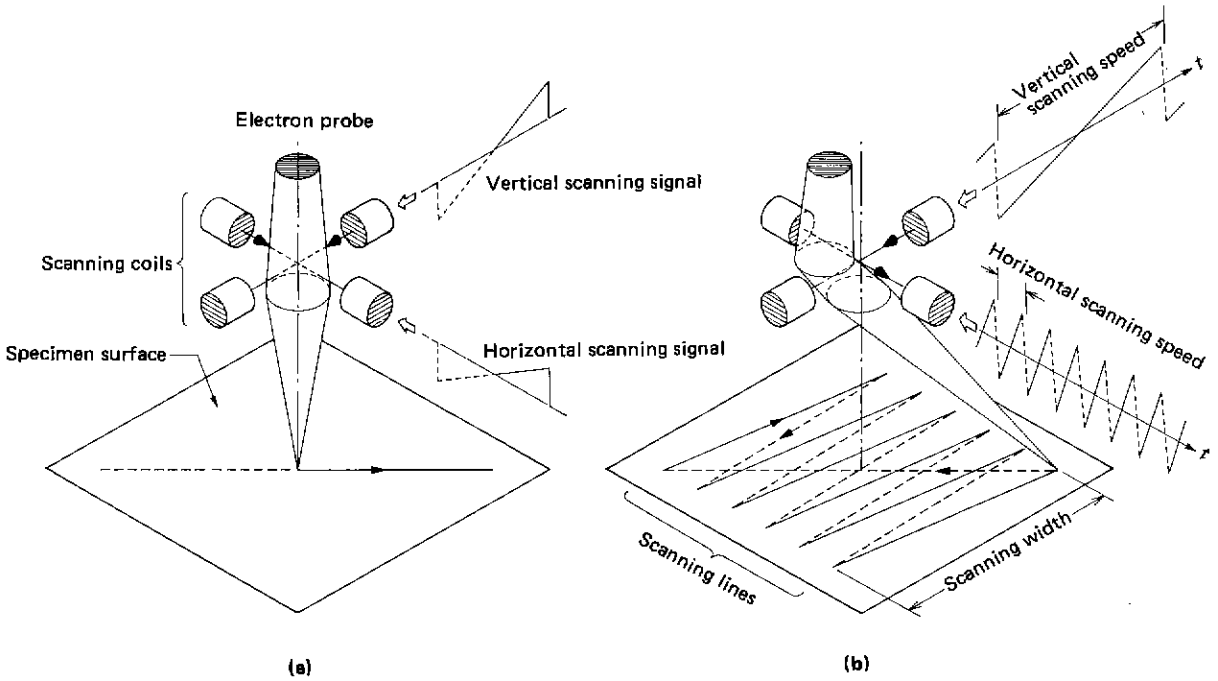


Fig. 1.33 Probe scanning

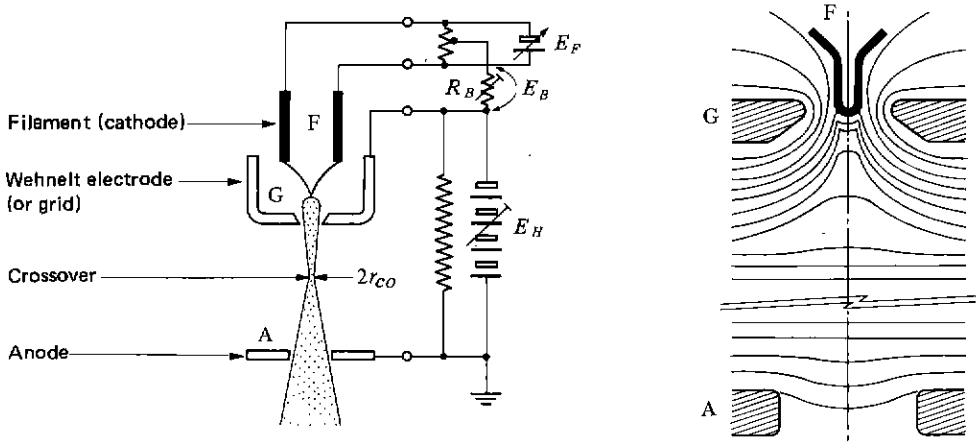
The minimum discernible area of the image; i.e., picture elements on the CRT, is determined by the number of scanning lines, while the number of effective scanning lines is determined by the resolution of the CRT. For example, if a CRT has a 2,500-line resolution within a 50 × 50 mm area, a single picture element is equal to 0.02 × 0.02 mm = 0.0004 mm^2 (total number of picture elements in the area: 6,250,000), which is sufficiently fine to retain sharpness of the picture even when the image is enlarged as much as 10 times (the limit of area which the human eye can directly discriminate is assumed to be approximately 0.2 × 0.2 mm). Since the magnification M of the scanning image is given by the ratio of image width b of the CRT picture area to scanning width a of the electron probe ($M = b/a$), the desired magnification can be obtained by controlling the amplitude of scanning signals in the scanning circuit.

1.2.2 Outline of instrument design

1.2.2a Electron gun

Essential requirements for the electron-source of a scanning electron microscope are high brightness, a small source area (a point-source is preferred) and high stability, especially that of the velocity of emitted electrons. These requirements are met by several types of electron guns, which may vary in composition details, but are basically composed of three electrodes, as shown in Fig. 1.34a (thermionic emission electron gun).

The hot cathode F shown in the figure is normally a hair-pin filament. Considering the work function (WF), melting point, vapor pressure, mechanical strength and so on, tungsten is usually chosen for the filament material, but in special cases LaB_6 is used. Electrode G (also known as the Wehnelt) is equivalent to the control grid in a vacuum tube, while electrode A is equivalent to the plate or anode. The characteristics of the electron source are determined by the shape and position of F, G and A, and the relation between their electric potentials. When a higher brightness and finer source is required, a field emission electron gun may be used. When a high negative potential from the accelerating power source E_H is applied to the filament and a current from the heating power source E_F flows through the filament, thermionic electrons are emitted from the tip of filament and are accelerated by the filament-anode potential. At the same time, a voltage drop across the bias resistor R_B supplies a bias potential for the Wehnelt. In this case, the potential distribution between the respective electrodes; i.e. the equipotential planes, form a kind of electrostatic cathode lens as shown in Fig. 1.34b, by which electrons are focused to a point from which they are emitted as the electron



(a) Electron gun configuration (b) Equipotential planes

Fig. 1.34 Generation of electron beam

beam. This point of focus is known as the crossover. The diameter of the crossover $2r_{CO}$ is regarded as the size of the electron-source. The wavelength λ of the emitted electron beam is calculated as given below.

$$\lambda = \frac{12.261}{\sqrt{V}\sqrt{1 + 9.7880 \times 10^{-7} V}} \fallingdotseq \frac{12.26}{\sqrt{V}} \text{ (Å)} \quad \cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots (15)$$

At 30 kV, the wavelength of electrons is approximately 0.07 Å.

The electron gun used in JSM scanning electron microscopes is designed to minimize the diameter of the crossover and to obtain high brightness. However, the position of the filament must be carefully adjusted to ensure proper performance. The stability of the electron source greatly depends on negative-feedback by self-biasing. However, the power source must be properly regulated and the instrument must be designed to minimize the possibility of minute discharging. Furthermore, when the filament is heated gradually, the quantity of emitted electrons reaches its limit (saturation) in accordance with space charge. This heat level must be maintained to produce a stable electron beam (however, excessive heating of the filament is wasteful, and merely shortens the life of the filament).

1.2.2b Electron lens

Electron lenses are used to demagnify the crossover (electron source) formed in the electron gun and focus the electron probe to scan the specimen surface under the desired condition. Fig. 1.35 illustrates a 2-stage demagnification lens system with a condenser lens and an objective lens, in which the lenses are assumed to be thin and free from aberration.

In Fig. 1.35a, the crossover ($2\,r_{co}$) is demagnified by the condenser lens and is reduced further by the objective lens to obtain a probe ($2r_p$) focused on the specimen (α: aperture angle, β: beam divergence angle). The total demagnification ratio M_T is given by the product of the demagnification ratio of lenses M_{CL} and M_{OL}, as shown below:

$$M_T = M_{CL}\, M_{OL} = \frac{b_{CL}\, b_{OL}}{a_{CL}\, a_{OL}} \quad \cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots (16)$$

An 100 Å probe is obtainable by reducing an 100 μm diameter crossover to 1/10,000. Since a_{CL} is fixed, the focal length of each lens must be varied in order to demagnify the electron probe focused on the specimen at fixed working distance b_{OL}. Actually, the focal length of condenser lens f_{CL} is set very short, and that of the objective lens f_{OL} is adjusted so as to focus the electron probe on the specimen. This is shown in Fig. 1.35b. In this case, as seen in the figure, the total quantity of electrons reaching the specimen; i.e., the probe current, is reduced since only a few of the electrons radiated from the crossover image ($2r'_{co}$) with a divergence angle 2β pass through the aperture. To obtain an even smaller probe diameter, the working distance WD must be made shorter (set the specimen closer to objective lens) and the probe must be focused by varying the focal length of the objective lens (in this case, the probe current will show almost no change).

The configuration shown in Fig. 1.35a (or b) is preferred when the magnification is comparatively low. This, however, depends on the type of specimen (its secondary electron emission yield) and the specimen

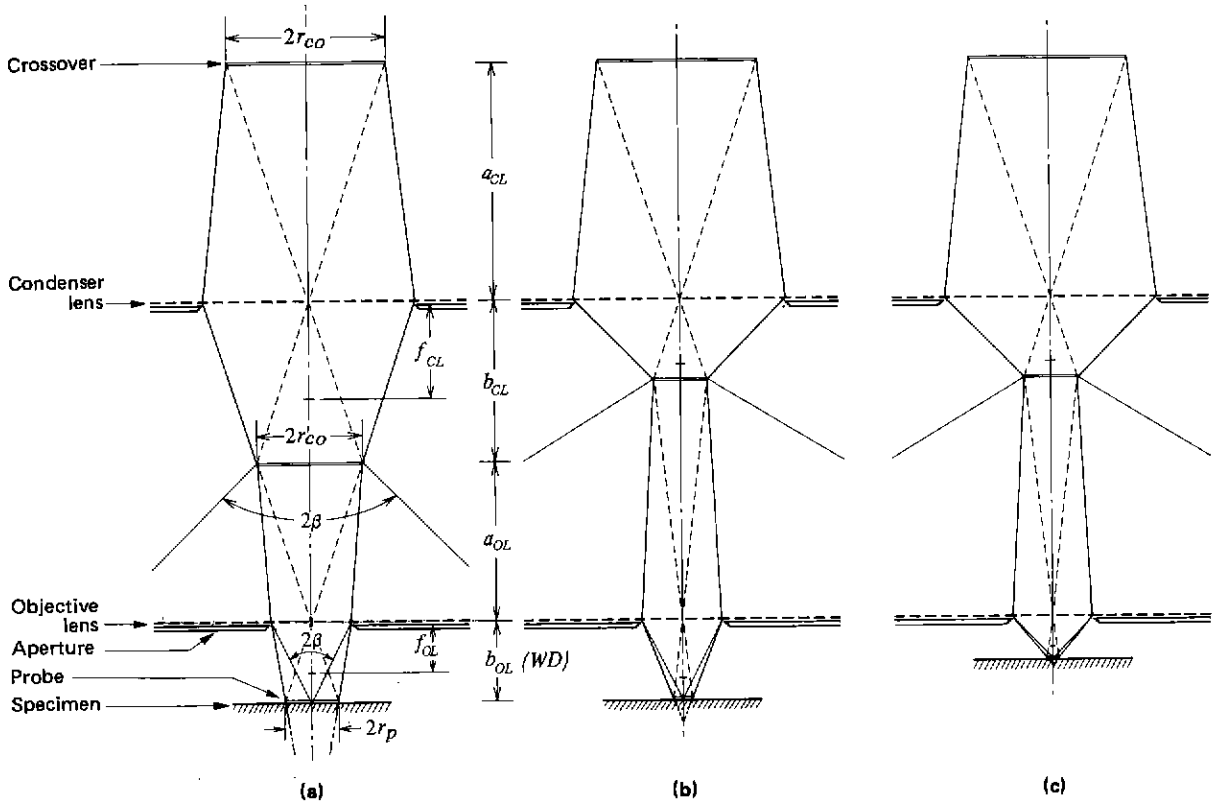


Fig. 1.35 Demagnifying lens system

topography. The configuration shown in Fig. 1.35c is preferred when the magnification is high, because of its capability to produce a very small probe diameter. Furthermore, the depth of field can be increased by reducing the diameter of the aperture, but this reduces the probe current available on the specimen surface. These relations are indicated in Table 1.5. The relationship between probe diameter, probe current, depth of field and magnification is shown in Figs. 1.3 and 1.5.

Table 1.5 Focal length, working distance, and aperture size

	f_{CL}/f_{OL}	Working distance	Aperture size
	long/short → short/long	long → short	large → small
Probe diameter	large → small	large → small	———
Resolution	low → high	low → high	———
Applicable magnification	low → high	low → high	———
Depth of field	———	deep → shallow	shallow → deep
Probe current	high → low	———	high → low

1.2.2c Scanning coils

The deflection coils (or solenoid) used to scan the electron probe over the specimen are called the

scanning coils. In principle, these coils function similarly to the alignment deflection coils and image shifting deflection coils. Thanks to their high quality, the scanning coils used in JSM scanning electron microscopes are capable of rapid scanning for observation, as well as slow scanning for photography. Together with other deflection coils, the scanning coils are installed in the deflection system cylinder.

Fig. 1.36 illustrates the operation of opposing coils L_1 and L_2. When a sawtooth wave current i from sawtooth wave generator SWG is supplied to the coils, an uniform magnetic field H (magnetic fluxes having the same intensity and direction) exerts force F on moving electrons, thereby shifting them away from center. With the velocity of electrons kept constant, the extent of shift is determined by the intensity of the magnetic field; i.e., magnetic flux density B (which depends on the number of coil windings and the current) as seen by equation (5). The direction of shift depends on that of the coil current.

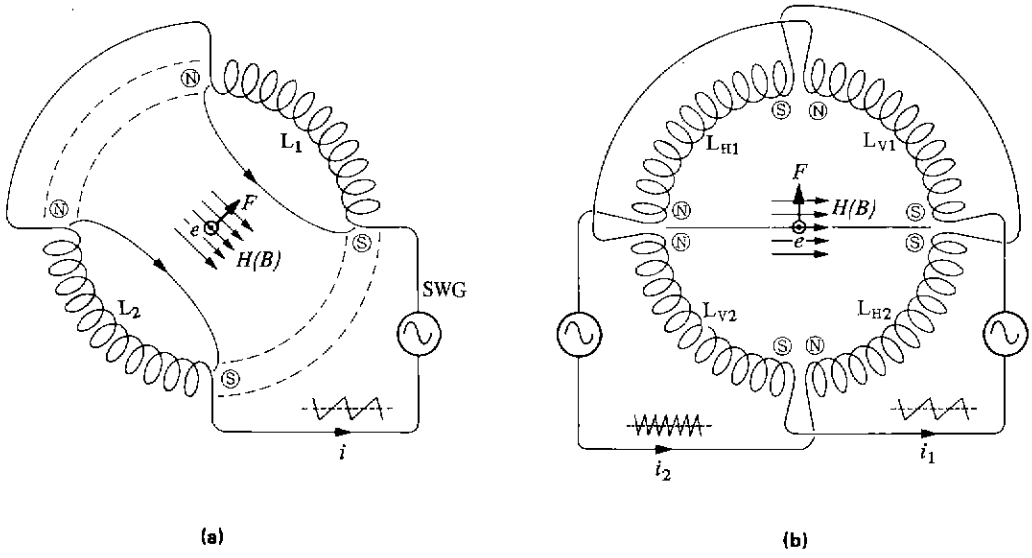


Fig. 1.36 Probe scanning

In actual probe scanning, since the probe must be driven in two orthogonal directions, another coil-pair is installed at right angles to the first coil-pair as shown in Fig. 1.36b. In the figure, if current i_1 (supplied to vertical scanning coils L_{V1} and L_{V2}) is equal to current i_2 (supplied to horizontal scanning coils L_{H1} and L_{H2}), a composite magnetic field $H(B)$ exerts force F on the electrons, thereby shifting them away from center. When direction of the composite magnetic field is changed by varying the ratio of i_1 to i_2 and/or the polarity of these currents, the direction of electron probe movement is changed accordingly. Movement is equal to the vector sum of movement caused by the two control currents supplied independently to the two coil-pairs. When two sawtooth waves of different periods are supplied as shown in the figure, horizontal scanning is repeated in vertical steps until vertical scanning is also completed. In other words, when the probe scans the entire surface of the specimen as shown in Fig. 1.33b, an image will be written on the CRT. The number of scanning lines for one image is determined by the combination of the vertical and horizontal scanning speeds.

1.2.2d Specimen chamber

Three basic requirements for any well-designed specimen chamber are good specimen (or specimen holder) stability, smooth stage motion for efficient selection of the field of view (X-, Y-, Z- movement, rotation, and tilt), and quick, easy specimen exchange. In high-performance scanning electron microscopes, the specimen chamber must be completely isolated from external vibrations which can deteriorate resolution, and the desired field of view must be precisely located. Furthermore, Specimen exchange for the JSM-35C is carried out via the airlock chamber without breaking the column vacuum.

Another important requirement of sophisticated specimen chambers is the capability for accommodating various attachments for expanded applications; for example, X-ray spectrometers for quantitative and qualitative specimen analysis, a backscattered electron detector for observation of composition and topographic images, a transmitted electron detector for observation of transmitted electron images, a cathodoluminescence detector for observation of cathodoluminescent substances, and a semiconductor specimen holder for obtaining images of potential distributions and electromotive force in integrated circuits. The standard JEOL scanning electron microscope is equipped with a secondary electron detector and a standard specimen stage. However, various other attachments including those mentioned above can be incorporated.

1.2.2e Secondary electron detector

The secondary electron detector effectively collects secondary electrons (including some backscattered electrons) emitted from an irradiated specimen surface, amplifies the detected electrons, and converts them into the video signal. The secondary electron detector used in JSM-35C is of the scintillator-photomultiplier type.

Fig. 1.37 is a simplified diagram of the detection of electrons emitted from a specimen. The solid arrows (——►) in the figure represent high-energy 'backscattered' electrons while the dashed arrows (----►) represent low energy 'secondary' electrons. If the specimen is sufficiently thick, there will be a measurable difference between backscattered electrons and incident electrons. This difference can be attributed to the absorbed electrons and is measured by absorbed current I_A. An absorbed electron image can be formed from variations in the absorbed current.

The secondary electron detector is composed of a scintillator, a light pipe and a photomultiplier(PMT). The scintillator is provided with a collector (a kind of Faraday cage). Backscattered electrons have sufficient energy (nearly equal to the primary energy) to excite the scintillation material. However, secondary electron energy is very low (several eV) and cannot excite light in the scintillator; therefore their energy must be accelerated up to approximately 10 kV so that the electrons can be detected. The applied high potential is also very effective to collect omnidirectionally emitted secondary electrons. The collector functions as an electrostatic shield to isolate the specimen chamber from the high-potential scintillator and is used to control the quantity of secondary electrons, which enter the detector, by varying the collector voltage (between −500

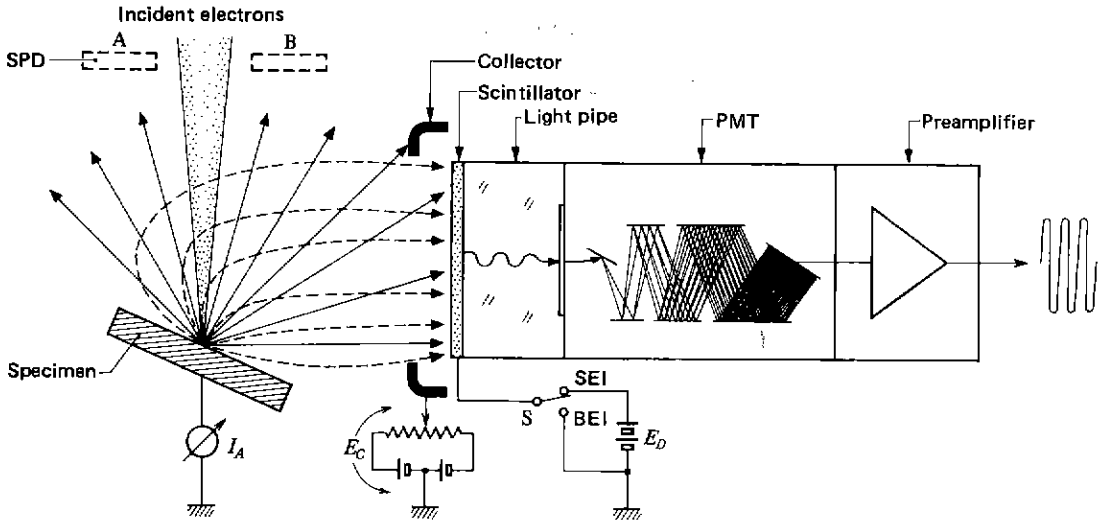


Fig. 1.37 Detection of emitted electrons

and +500 V). This also protects the detector from saturation and damage. When switch S (Fig. 1.37) is set at BEI, the scintillator is grounded, and only backscattered electrons can be detected (backscattered electron image observation). In this case, however, the quantity of backscattered electrons which can reach the scintillator is limited, and image quality is poor. The use of a paired semiconductor detector just above the specimen (SPD in Fig. 1.37) to collect backscattered electrons makes it possible to obtain a high-quality topographic image (when subtracting signals – A–B) or compositon image (when adding signals – A+B).

The photoemissions generated in the scintillator is led to the PMT cathode via the light pipe and creates a cascade of electrons in the PMT. The resulting PMT output is first amplified by a preamplifier, further amplified by the video amplifier, and finally displayed on the CRT as a scanning image synchronized with the probe scan.

1.2.2f Display and photographic recording systems

Signals input to the display system are simultaneously displayed on a large, long-persistence viewing CRT for visual observation or on an optional TV monitor, and on a short-persistence high-resolution recording CRT for photography. Image recording is made as follows: selecting the field of view and the magnification, and focusing the image on the viewing CRT and determining the conditions for photographing and recording the scanning image.

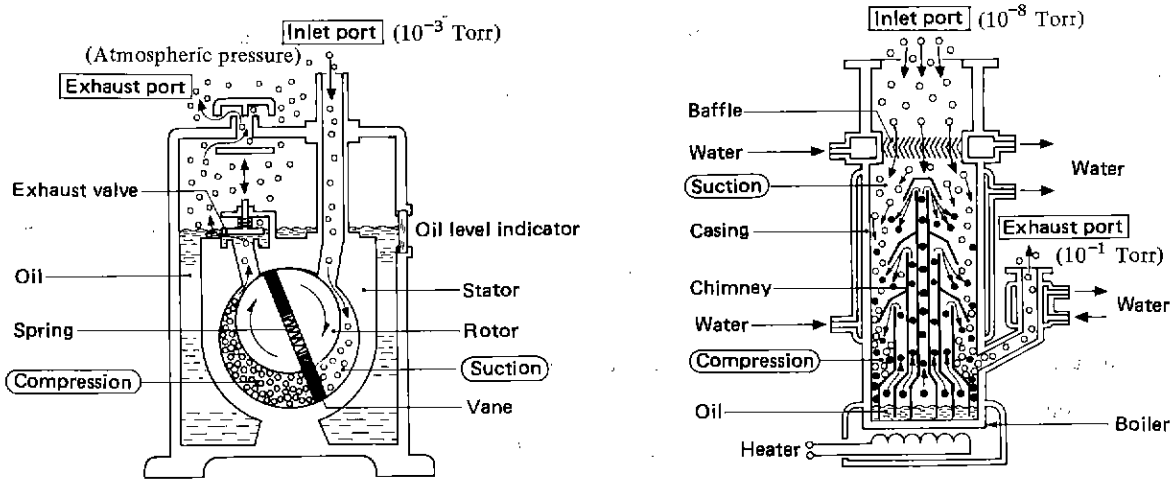
The brightness and contrast of the scanning image can be optimized by using respective exposure meters. When using an Automatic Contrast/Brightness Control Unit (optional), no readjustment for optimal image contrast and brightness is required even when the field of view is changed. The recording CRT displays

various data such as accelerating voltage, magnification, film number and a micron marker superimposed on the image (in black or white digits, or white digits on dark background). The photographic recording system is basically a box camera with a high resolution tandem lens, and employs an automatic exposure mechanism synchronized with the probe scan. A Polaroid #545 Film Holder (Polaroid 4 X 5 Land film), Polaroid #405 Film Holder (Polaroid 105/107 Land film) and MAMIYA 6 X 7 Roll Film Holder (120/220 film) are available. For the film number, the lower 2 digits increment automatically with each exposure but all digits can be preset manually.

1.2.2g Vacuum system

To minimize the interference of extraneous particles with the electron beam, the column vacuum must as perfect as possible. In a scanning electron microscope the pressure inside the column should be below 10^{-5} Torr. Higher column pressures can result in high-tension discharges and specimen contamination. To achieve the required pressure, the scanning electron microscope is usually evacuated by an oil rotary pump and an oil diffusion pump.

Fig. 1.38a shows the structure of a Gaede oil rotary pump. The pump interior is placed in a housing containing oil. Oil serves to lubricate the pump and make it airtight. When the rotor is rotated in the direction of the arrows, the air in one crescent chamber is compressed above atmospheric pressure. As a result, air is pumped out through the exhaust valve. Simultaneously, air enters the other crescent chamber ready for the next compression. That is to say, two pumping processes take place with each revolution of the rotor. Moreover, since the currently employed rotary pump is of two-stage type, vibration and exhaust noise levels are extremely low. However, the attainable pressure by this pump is limited to about 10^{-3} Torr (pumping speed: several tens liters/min), so it cannot be used as the final vacuum pump in the scanning electron microscope. It is basically employed for rough pumping and to maintain back-pressure in the diffusion pump.



(a) Gaede oil rotary pump

(b) Oil diffusion pump

Fig. 1.38 Structures of vacuum pumps

Fig. 1.38b shows the structure of an oil diffusion pump composed of a heater/boiler, water-cooled casing, jet chimney and a water-cooled baffle to keep oil from backstreaming. The oil vapor heated by the boiler is led into the chimney and is jetted from the nozzle at supersonic speed toward the wide low-pressure space. By so doing, the gas molecules from the column diffuse into the oil jet stream and the intermingled gas is compressed by kinetic energy of the jet flow and is transferred to the exhaust port. The jetted oil vapor is condensed by the water-cooled casing and the condensed oil drains back into the boiler. The low-boiling point contents in the recovered oil are removed by by evaporation (fractionation). Oil diffusion pumps use an auxiliary rotary pump to provide initial low pressure (below 10^{-1} Torr). The oil diffusion pump can maintain approximately 10^{-8} Torr (pumping speed: several hundreds of liters/sec), and pressure can be further lowered by using traps.

Vacuum pressures can be measured by various methods. The method suitable for a particular application should be selected according to the levels of pressure to be measured, the type of gas and the purpose of the measurement. Ordinarily, a hot-cathode ionization vacuum gauge is used for precise pressure measurements, but it is not suitable for automatic vacuum system control in scanning electron microscopes because it cannot be used under atmospheric pressure. Therefore, a Pirani gauge is used for the vacuum system of the JSM-35CF. Fig. 1.39 shows the bridge circuit of a constant-voltage Pirani vacuum gauge. The Pirani tube and a dummy tube are encased under identical conditions. The opening of the Pirani tube is connected to the vacuum vessel (the column) while the dummy tube remains sealed as a reference vacuum. These tubes are designed to have approximately equal resistances at room temperature. Resistors R_1 and R_2 produce heat in proportion to a voltage supplied by a regulated power supply. The temperature rise of the resistances depends on ambient conditions. If there are gas molecules in the vicinity of the resistors, they may hamper temperature rise by heat conduction; in other words, the temperature of resistors R_1 and R_2 will vary with the ambient pressure. If the resistance of R_3 and R_4 are equalized at some low pressure, the bridge is balanced. The bridge will become unbalanced when the ambient pressure is increased, and a measurable current will flow through the ammeter (the maximum current is adjusted by R_5). This method can be used to measure pressure continuously from 1 atmosphere, and the vacuum level can be monitored by the ammeter.

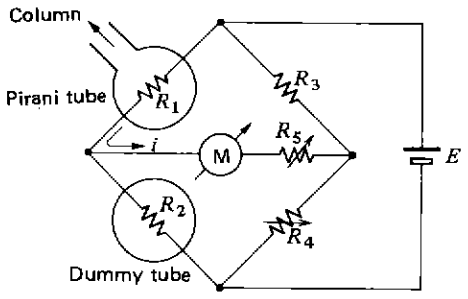


Fig. 1.39 Principle of the Prirani gauge

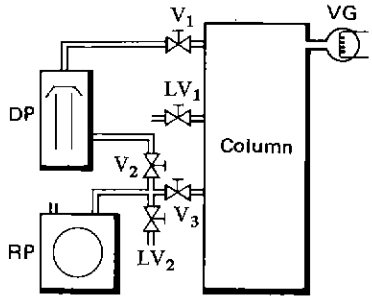


Fig. 1.40 Basic vacuum system

A basic vacuum system is composed of an oil rotary pump (RP), an oil diffusion pump (DP) and five manual valves (Fig. 1.40). The pumping-down procedure starts with valves V_1, V_2, V_3 and LV_1 closed, and LV_2 open.

- Start . . . . . 1. Close leak valve LV_2 and turn on the RP switch.
  2. Open valve V_2 and turn on the DP heater.
- Evacuation . . . . . 1. Close valve V_2 and open V_3 for roughing (down to $\sim 10^{-2}$ Torr).
  2. Close V_3, and open V_2 and V_1 to attain operating pressure (down to $\sim 10^{-5}$ Torr).
- Leaking and re-evacuation . . . . . 1. Close V_1 and open LV_1 to admit air into the column.
  2. Close LV_1 and re-evacuate.
- Shutdown . . . . . 1. Close V_1 and turn off the DP heater.
  2. Close V_2, turn off the RP and open LV_2.

The vacuum system of an scanning electron microscope usually has two oil rotary pumps, an oil diffusion pump, and many solenoid and pneumatic valves, which are automatically controlled by several vacuum gauges (VG) and timers.

1.2.2h Electrical system

The electrical circuits of a scanning electron microscope consists of following parts: high-voltage circuits (electron beam acceleration), lens circuits (excitation of electron lenses), deflection circuits (probe scanning and CRT beam deflection), video circuits (secondary electron detection, and control and amplification of video signal, and image display) and miscellaneous circuits (electromagnetic alignment, image fine shifting, astigmatism correction, data display, gun filament heating, and vacuum system control). All circuits of the JSM Scanning Microscope, including the high-voltage circuit, are based on solid state electronics for ensuring high reliability and easy maintenance.

Fig. 1.41 shows the basic circuitry for high-voltage generation (beam acceleration) used in the JSM scanning electron microscope.

In the figure, when OSC (blocking oscillator) output drives the base of transistor TR_1, collector current i_1 flows in the primary windings L_1 of the step-up transformer. Thereby, current i_2 is induced in the secondary windings L_2 and a high frequency voltage e_0 is produced across it. This voltage is doubled by a voltage doubling rectifier and filtered to remove ripple. The filtered negative high-voltage ($-E_{HV}$: $\sim 2\, e_0$ (rms)) is supplied to the electron gun (consisting of filament F, grid G, and anode A). The voltage output is regulated as follows: a fraction of the output voltage is fed back to a difference amplifier AMP via a high resistance R_F, is compared with the reference voltage $+V_{ref}$, and the amplified output is supplied to the base of transistor TR_2 to control emitter current i_1 ($+V_c$ is collector voltage). The desired high voltage output (accelerating voltage) is obtained by adjusting potentiometer RV which varies the AMP output. The beam current (emission current) is varied by bias resistor R_B. The high-frequency input of the high-voltage circuit allows the use of small filter capacitors, thereby ensuring safety operation and permitting theuse of a compact

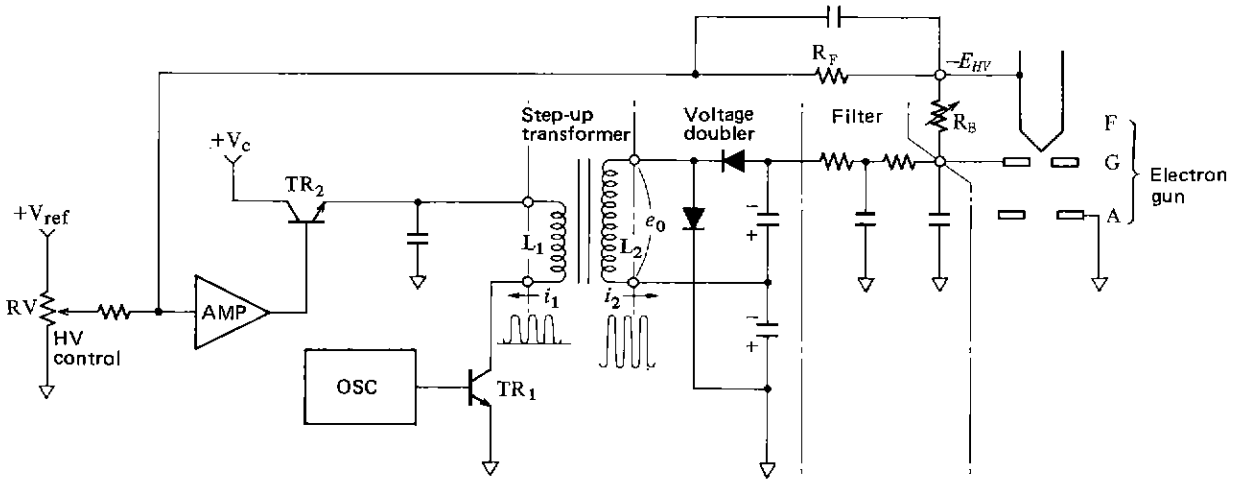


Fig. 1.41 High-voltage circuit

high voltage generator.

Fig. 1.42 shows the basic current regulator circuit for lens excitation. The voltage generated by lens current flowing across a resistor is applied to a difference amplifier and is compared with reference voltage $+V_{ref}$. The difference between these two voltages is used to control the AMP output so as to regulate the lens current.

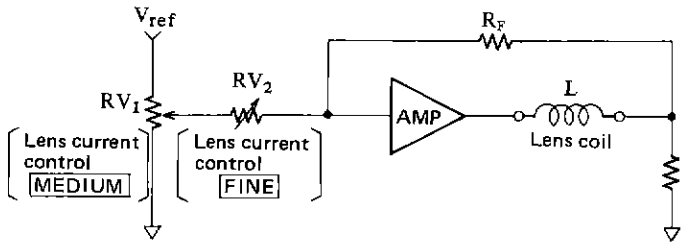


Fig. 1.42 Lens circuit

The AMP output is coarse-controlled by potentiometer RV_1 (MEDIUM) and fine-controlled by RV_2 (FINE), in order to obtain the desired excitation condition (for the condenser lens, only potentiometer RV_1 is used).

Fig. 1.43 shows the basic sawtooth wave generator circuit for probe scanning and CRT beam deflection. The sawtooth signals, whose frequency is determined by the input pulses (square wave sync signal), are supplied to the deflection coils. The major component of this circuit is a Miller integrator composed of amplifier AMP, capacitor C and resistor R. The gate transistor TR is turned on and off by a square wave signal supplied to the base. The resultant voltage caused by charging and discharging capacitor C is supplied to the AMP as the bias source. Capacitor charging and discharging characteristics are determined, respectively, by the product of C and R and that of C and the internal resistance of the TR. The AMP then outputs sawtooth waves to terminal A. The frequency of these sawtooth waves is determined by the sync signal and

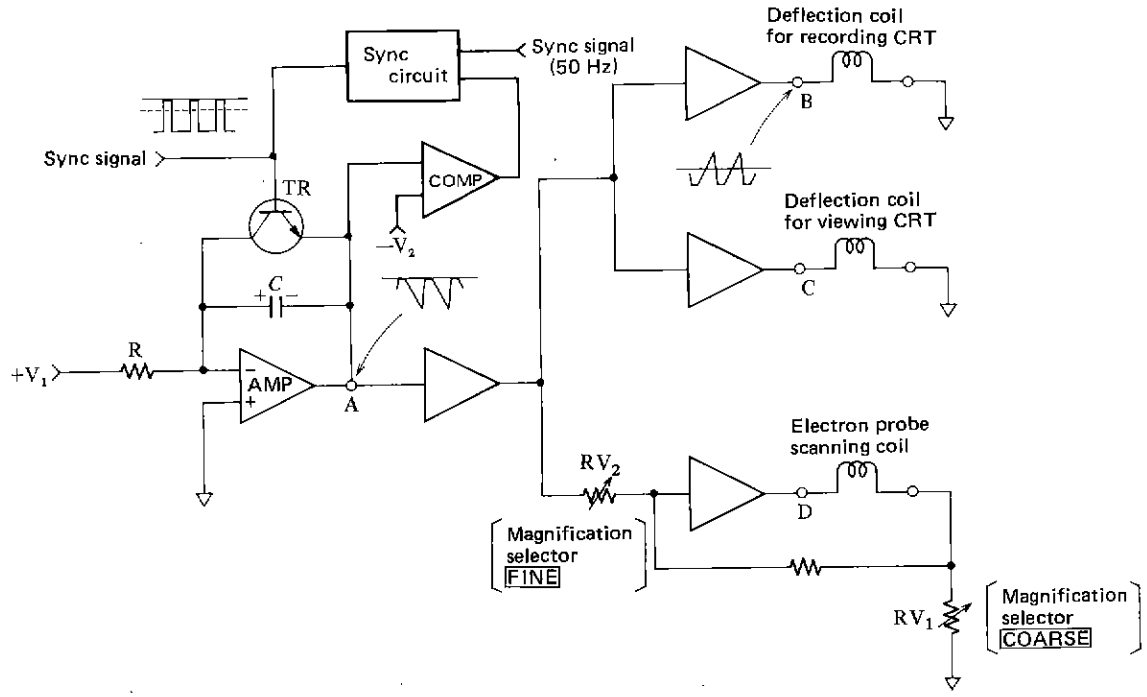


Fig. 1.43 Deflection circuit

$+V_1$, and their amplitude is determined by $-V_2$ (COMP stands for the comparator). The signal output from the Miller integrator is supplied through the sawtooth wave amplifier to a deflection power amplifier in each deflection circuit in order to drive the recording and viewing CRT deflection coils and the electron probe scanning coils. Sawtooth current flowing in terminals B, C and D scans the CRT beam and electron probe. The magnification of the scanning image is varied by changing the probe scanning range; that is, potentiometers RV_1 (COARSE) and RV_2 (FINE) are adjusted to control the waveform amplitude, and consequently, the coil current.

Fig. 1.44 is a schematic diagram of the video signal circuits which covers stage from the detection of secondary electrons up to the formation of video signal. Secondary electrons emitted from the specimen are detected by the scintillator-photomultiplier (PMT), and are supplied to the preamplifier (AMP) after being converted into electric signals. The preamplifier matches impedance between the PMT and the SEI unit to improve the signal-to-noise ratio. The detector output signal is processed depending on the polarity of image to be displayed (NORMAL: positive or INVERSE: negative) using the POLARITY switch before the signal goes to the video amplifier.

The COLLECTOR circuit protects the scintillator and PMT from saturation when the emission of secondary electrons increases. By setting the switch to a negative potential, the quantity of secondary electrons allowed to enter the scintillator is limited. When this switch is set to a positive potential, the quantity of electrons is increased. The CONTRAST circuit, which varies the gain of the PMT, controls the amplitude of video signals by changing the supply voltage to the PMT and thereby controls image contrast. The BRIGHTNESS

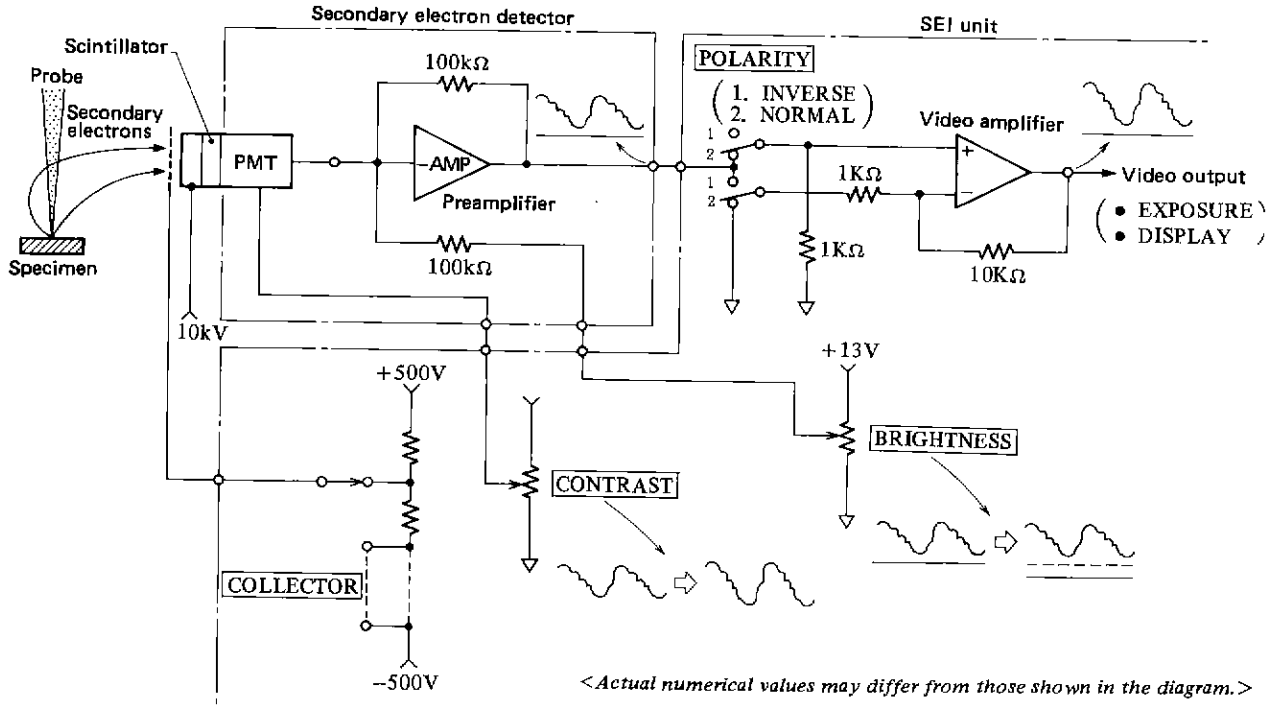


Fig. 1.44 Video signal circuit (1)

circuit, which varies the DC level of input signals to the preamplifier, controls image brightness by changing the waveform level of video signals. Video signal output is supplied to the exposure meter circuits (indicator unit) and the image display circuits (DISPLAY/photographic-recording units) (the exposure meter circuits are not shown in this figure.).

Fig. 1.45 shows a schematic diagram of the video display unit (DISPLAY unit), composed of a video

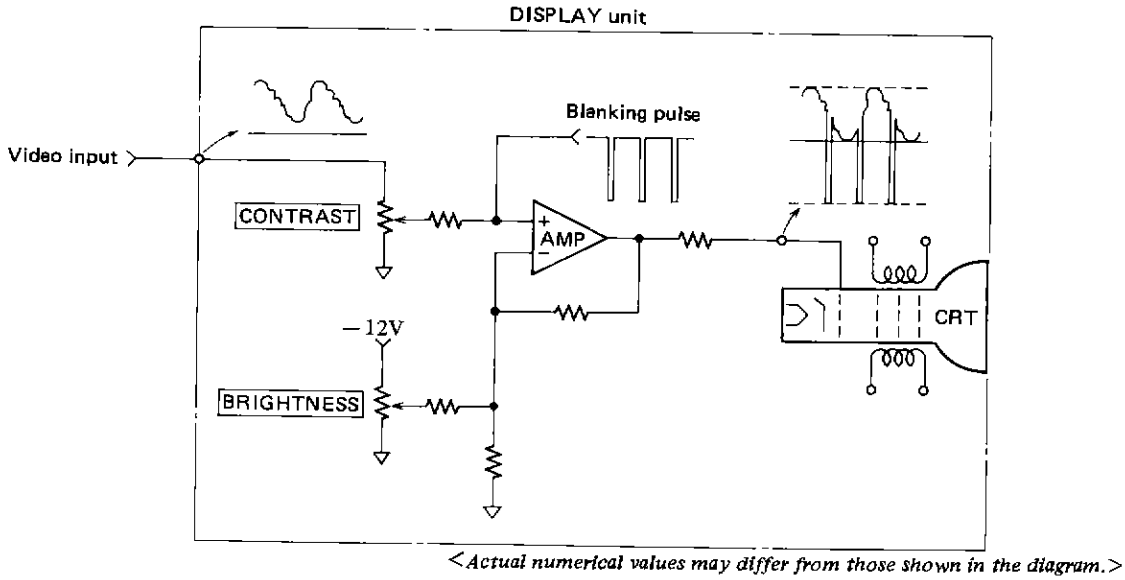


Fig. 1.45 Video signal circuit (2)

amplifier (AMP) and a CRT. The signal output from the SEI unit is displayed as a scanning image on the CRT. In this figure, video input signals are amplified by the AMP and modulated by blanking pulses (square wave pulses) and the resultant output is supplied to the control grid of the CRT. When there is no signal input, the CRT raster is illuminated without image display. When the control grid receives signal input, the electron beam current is modulated and the scanning image is displayed. The CONTRAST and BRIGHTNESS circuits, respectively, control the amplitude and level of signal waveforms supplied to the grid, and in turn vary the contrast and brightness of the image.

2 . SPECIFICATIONS